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UX and UI Design of data gathered from lifts

Investigating how a web-based interface visualising data gathered from lifts can be designed to fulfil needs from both property owners and lift service companies.

Master's thesis in Computer science and engineering

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Cover: Mockup of final lift monitoring interface.

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Abstract

Lifts are essential for allowing transportation and accessibility in modern buildings. As the field of property technology is increasing, the lifts have fallen behind. There are few solutions available on the open market that help analyse and track data from lifts. This project was done in collaboration with the company Host Mobility AB, and their product Host Complete PropTech Lift. The aim was to find an answer to the research question:

What requirements do Property Owners and Lift Service Companies have on a lift monitoring system, and how can an interface be designed to fulfil these?

The project followed the Design Thinking process, beginning with extensive interviews with stakeholders. The findings were analysed and formulated into a List of requirement consisting of 78 demands and wishes, describing stakeholders' needs and what the monitoring system should fulfil in order to create value. Multiple ideas were explored and a complete solution of a lift monitoring interface was prototyped. Usability tests were done in order to evaluate, rule out and refine different aspects of the prototype iteratively.

The project resulted in a List of requirements and a high-fidelity prototype of a lift monitoring interface, called Host Complete. It fulfilled 51 out of 78 requirements. Host Complete was evaluated with real stakeholders. It received positive feedback overall, with some added insights for further development. Stakeholders found the final prototype easy to use and thought it provided a good overview of all lifts. The List of requirements could be used as a base for future development of other lift monitoring systems. Possible starting points for future work are also suggested.

Keywords: UX, UI, Design, Lift, Monitoring, Data gathering, PropTech, CANopen-Lift, Dashboard, Internet of Things.

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Jonathan Boström & Norea Sandgren, Gothenburg, 2023-05-31

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List of Abbreviations

AI	Artificial Intelligence
HCPL	Host Complete PropTech Lift
Hi-fi	High fidelity
IoT	Internet of Things
IV	Information Visualisation
Lo-fi	Low fidelity
LC	Lift Consultant
LSC	Lift Service Company
PO	Property Owner
PropTech	Property Technology
UX	User Experience
UI	User Interface

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1

Introduction

In today's society lifts are essential for allowing accessibility in apartment buildings, workplaces and other public buildings. While they create freedom through allowing transportation of large and heavy objects and people who can not move in stairs, they have high safety requirements. Maintenance must be done regularly in order to ensure safe operation. Errors need to be fixed as soon as possible for the infrastructure of the building to function properly. Responsibility lies on the Lift Service Companies (LSCs), who work with maintenance and repairment of lifts.

The field of property technology (PropTech) and smart buildings is increasing. This allows optimising, monitoring and maximising efficiency for different parts of the property such as ventilation, lighting and doors (Zachary, 2021). However, the lifts have fallen behind in the digitisation of properties. There are few solutions on the market that do track and help analyse data from lifts and they all have their limitations. Some systems are not able to monitor all lifts, others do not collect enough information to be useful. For example, there is a system that can see that the lift has been standing still more than usual but it can not tell if the lift is unable to operate. The lack of PropTech solutions for lifts available on the open market is something that concerns both Property Owners (POs) and LSCs. POs often have multiple properties, including a variety of different lifts from different manufacturers, from different years of installation. This creates a problem of not being able to monitor all their lifts in one place.

Data gathering of lifts has potential to enable proactive service and lead to clearer communication between the PO and the LSC. Moreover, the PO could have a better overview of their lifts while LSCs could possibly troubleshoot quicker and work more efficiently. However, the data must be presented in a user friendly way in order to be valuable for users. Different users have different needs, and depending on context, a certain piece information should be more or less prioritised.

1.1 Research question

What requirements do Property Owners and Lift Service Companies have on a lift monitoring system, and how can an interface be designed to fulfil these?

1.2 Aim

The project is intended to result in a List of requirements displaying the needs of different stakeholders, and a high-fidelity (hi-fi) prototype of a web-based User Interface (UI) for desktop.

For the List of requirements, interviews and observations will be conducted to determine the needs of different stakeholders. The findings will be generalised and summarised to promote their use in future work in the field. They will also be used during the design process to ensure a user-centered interface.

The final prototype will be an interactive, hi-fi prototype of the interface. The interface is supposed to visualise information from lift data, according to stakeholders' needs, including both POs' needs, and LSCs' needs. Already existing guidelines for graphical interface design will be considered, as well as the identified needs of stakeholders. The main goal of the project is to fulfil the needs of different stakeholders through the final prototype. The interface aims to complement already existing data gathering hardware devices, created by the company Host Mobility AB, for their product Host Complete PropTech Lift (HCPL).

Other goals are:

- Create value for the different stakeholders
- Create transparent communication for different stakeholders

1.3 Scope

The interface will be designed to match the data gathering hardware devices, created by Host Mobility. While there are different kinds of lifts, the research of this project has been focusing primarily on the needs related to passenger lifts. The interface of the final prototype will be visualised for only the desktop version. For this project, only the Swedish market has been taken into account.

2

Background

The background chapter presents further context, the research area and the research problem that created the need for this project. It describes the current product from Host Mobility that the project is based on, as well as similar products on the market regarding lift monitoring. The process of repairing a lift and the different stakeholders involved in the process are presented.

2.1 Research area and research problem

The section explains the challenges and needs regarding service of lifts and the field of PropTech, and describes the motives for conducting this project.

2.1.1 Service of Lifts

If someone notices that a lift is not working as intended, they can call a service number often listed on the lift itself. Since many lifts lack data gathering and visualisation of the actual status, there is little knowledge of what the actual problem is, if there even is one. While some lift manufacturers do collect the data from the lifts, this is not the case for every company. This leads to LSCs not knowing beforehand what problem they will encounter when they arrive. Having this knowledge would give them the ability to make a decision on if it is an error that needs service by a technician, if a local janitor could fix a smaller problem, or if it is a false alarm. Sometimes the lift is already working at the time of arrival, leading to an unnecessary dispatch for the service company and cost for the PO. The car ride from the service is a small, but unnecessary strain on the environment.

There are multiple different kinds of lift service agreements available. Nowadays the agreements are based on specified requirements from the property company (Kone, 2018). The agreements range from including all services and dispatches to including only planned, routinised service visits and additional fees for every dispatch. An additional dispatch service costs around 2000-5000 SEK depending on company, travel distance, time required for service, day of the week, and time of the day (BRF Krickan, 2019; HSB, n.d.). This gives a mean cost of 3500 SEK. POs have around 3-7 dispatches per lift per year (Alsén, 2016). With the mean cost above, the yearly dispatch cost for a lift per year results in 10 500 - 24 500 SEK (between 3-7 dispatches). Familjebostäder is a PO with over 600 lifts, which means a total cost of

at least 6 300 000 SEK per year for lift dispatch services only (Alsén, 2016).

2.1.2 Property Technology

PropTech is the application of technology in the properties and real estate industry. It includes digital construction, property management, and building automation for example. The covid-19 pandemic has sped up the tech adaptation within the industry. PropTech can be used to simplify and digitise existing processes, facilitate remote work, and help companies visualise indoor space and floor plan for tenants (Zachary, 2021).

Investment within the PropTech sector has increased by over 300% during the past ten years. Technology, including artificial intelligence (AI) is developing quickly, and smart buildings can be linked with everyday objects. The technology is used to monitor, manage, and control access to building operations. 3D visualisations, 3D printing, robotic process automation, deep learning, and the metaverse are some areas that will continue to develop in the future. PropTech continues to rise due to advancements in other areas such as cloud computing, Internet of Things (IoT), open-source software, the sharing economy, and the everyday use of mobile devices (Hunt et al., 2023).

However, the real estate industry is quite non-transparent which means actors with market knowledge get a competitive advantage. Information is often collected manually and kept in different closed systems that actors keep to themselves. In this industry, knowledge means power. This situation could lead to PropTech development not being as efficient as if it would be completely open (Hunt et al., 2023).

2.2 Host Complete PropTech Lift - The product today

Host mobility is developing a product called Host Complete PropTech Lift (HCPL). HCPL is an IoT-system based on a data collecting hardware and a digital service that allows POs and LSC to digitally monitor their lifts. Two different types of hardware are currently being developed for the HCPL system: one for lifts using the open CANopen-Lift protocol, and one that covers all lifts that do not use the CANopen-Lift protocol.

For lifts using the CANopen-Lift protocol, a hardware device will be installed and connected to the controller of the lift. The CANopen-Lift system (further described in Section 3.4) gives access to various sensors, collecting data that can be presented to the user, to inform them about the status of the lift. With this type of monitoring device, large amounts of data can be obtained on a very detailed level.

For lifts not using the CANopen-Lift protocol, a hardware device will be installed and connected to the relays of the lifts (relays will be further described in Section 3.3). The device detects if the circuits are open or closed, determining the state of the connected components. It has eight measuring points, of which three are fixed

for controlling the lift up, down, and for resetting the controller. The other five measuring points have different meanings for different lifts depending on how the relays of the lifts are connected. This monitoring unit is more limited in what kind of data that can be collected, but has the benefit of enabling remote control and reset.

The hardware devices are connected to a web application running online through an open source platform called Grafana. The application includes a UI of selected lift data. There are two main views of the interface. The dashboard view shows real time information about the lift, see Figure 2.1. The map view gives an overview of all installed lifts and their status, either working (green) or not working (red), see Figure 2.2.

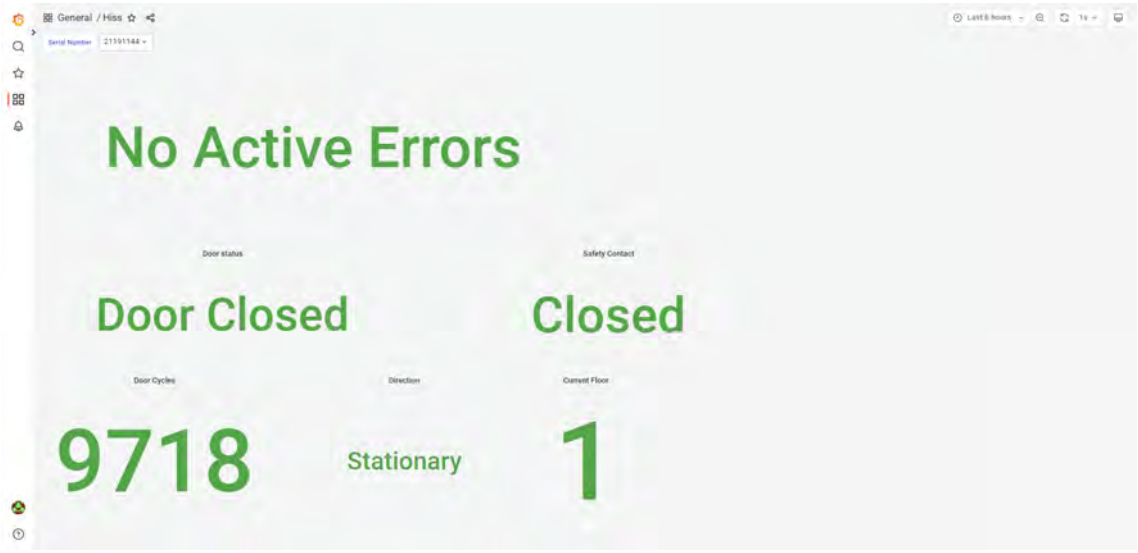


Figure 2.1: Dashboard of CANopen-Lift data for HCPL today.

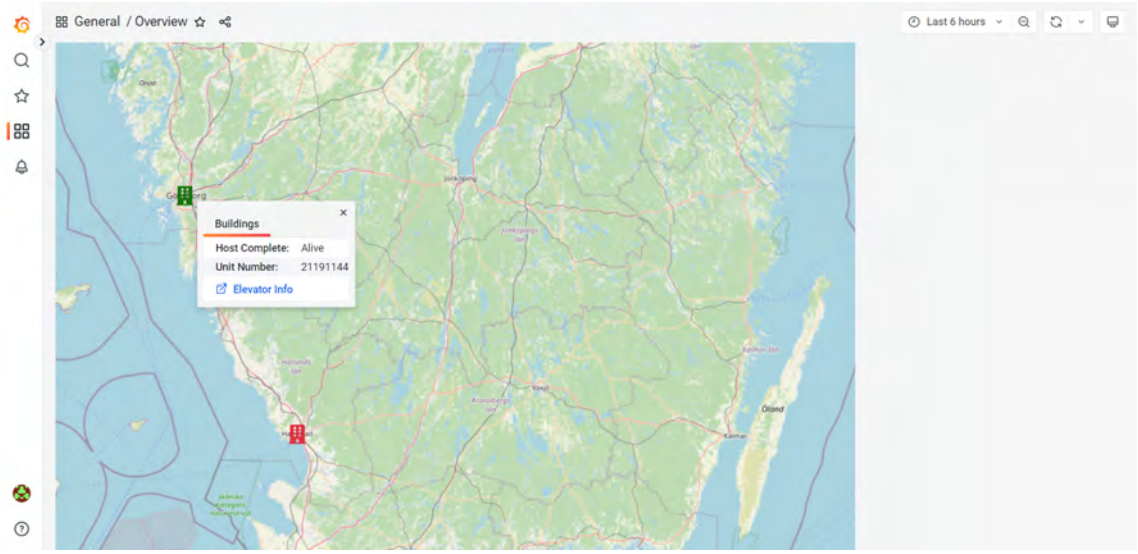


Figure 2.2: Map overview of lifts for HCPL today.

2.3 Stakeholders

There are many different stakeholders involved to different degrees when a lift is repaired and maintained. From the interviews and observation it was noticed that the process and the people involved differ between companies. In this section an overview and a generalisation of the different stakeholders are presented to give the reader without knowledge of the property or lift industry a better understanding. The description is based on interviews and observation that have been conducted during the project.

Lift user

Lift users are the people who use the lift for traveling. It can be tenants or people who work in the property, as well as occasional visitors. When a lift user notices that a lift is out of service, they can either contact their local janitor through personal contact, the PO administration through an internal system, or the alarm centre through a phone number located on the sign next to the lift. If stuck in the lift, they can press the emergency call button which connects them with the alarm centre.

Administration (PO)

The PO administration staff works at a local office where the different janitors are divided. They handle customer support, answering to phone calls and emails, and administrative work like conveying work tasks and information to the janitors when a tenant has a problem with their residence. If a tenant notices that a lift is out of service they either contact the LSC directly or the PO administration, who then either contacts the janitor responsible for that area or sends out a work order to the LSC.

Janitor (PO)

The janitor works with a wide variety of tasks when it comes to caretaking of the PO's facilities. The different facilities are usually divided into different areas, which different janitors are responsible for. It is common for a janitor to work with the same area for a long time, which gives him a good local knowledge of the facilities, the neighbourhood and the tenants. While janitors often get further education in different areas like less advanced plumbing and electric work, there are still scenarios where they have to call in professional help when a problem is outside of their area of competence. When it comes to lifts, a janitor has little knowledge and is because of the safety hazards not allowed to try to fix mechanical or electrical problems. There are however janitors that through the years of working in the same facilities have learned how to repair the lift to a further extent than they are allowed to.

Technical manager (PO)

The Technical manager has the main responsibility of the different technical systems found in the residences. This includes things like heating, ventilation and lifts.

Depending on the size and organisation the precise job description varies, but they are the company's expert on technical questions that support their coworkers with their knowledge. They rarely come in direct contact with the lifts, they receive the invoices from the LSC, and are one of the main voices at the company about modernisations of old lifts.

Purchasing manager (PO)

When a PO has a larger economic decision to take, the purchasing manager is the main responsible. While they do not come in direct contact with lifts, they are often the person with the final say in deciding if a lift should be modernised, or if resources should be prioritised elsewhere. The purchasing manager is also involved when handling procurement of what LSC is to be hired and what is going to be included in the agreement.

Alarm centre (LSC)

Alarm centres are usually run by a separate company, running the operation for multiple LSCs at once. They receive calls from lift users who report a broken lift either through calling the dispatch service number on the sign next to the lift, or through the lift's emergency phone located inside the car. A work order is then created, and sent to either the LSC administration or the technician depending on the internal structure of the company. The alarm centre has operators working around the clock in case of an emergency, like someone getting stuck in a lift in the middle of the night.

Administration (LSC)

At the office of the LSC, the administration handles the work orders, invoices and communication. They handle the internal business system, and communicate with both technicians and customers regarding different matters. At some companies they hand out work orders, while it is done automatically at others. Sometimes they also control and re-write the dispatch documentation from technicians, to ensure correct and appropriate language before sending it to customers.

Technician (LSC)

The technician is the person who executes the planned service visits, and dispatches when a lift is reported to be out of service. A technician can for example be on dispatch duty for one week and do planned services the week after, but the specifics vary between companies. When a lift is broken, the Alarm centre sends out a work order that the technician receives in an internal business system on their phone. Work orders contain information about what is known about the faults of the lift, which is often limited to that the lift is out of service. Arriving at the location he begins with controlling if the lift actually is out of service, since it sometimes already is working on arrival. The troubleshooting process then starts at the machine room, but is then different depending on if it is a modern or old lift, lift manufacturer, and other factors. The process generally includes looking through error codes and logs

of the control system, and test different relays. Larger lift manufacturers like Kone, Otis, Schindler and ThyssenKrupp have data monitoring on their own lifts, and some do on other lifts to a certain extent. This enables lifts to report themselves, and send an error code that the technician receives in his work order. All LSCs have technicians on-call duty at all times in case of emergencies.

Lift Consultant

When a PO wants an unbiased second opinion about their lifts, they contact a lift consultant (LC). They are like a middleman between the PO and the LSC, and help the PO interpret technical lift language and make sure that POs get what they ordered. LCs have long experience of previously working within the lift industry. Most of them have worked as technicians before. It is most commonly either the technical manager or purchasing manager that comes in contact with the LC when they have questions about pricing, agreements and technical information regarding their lifts. LCs also help with budgeting and procure agreements between the PO and the LSC. Some companies hire LCs to make a "status-list" of their lifts, which gives them an overview of the lifts' health, and their expected time for required modernisation. While they are not authorised to do the required inspections, they can be hired to do construction inspection after an installation or modernisation of a lift, to see if it meets the requirements of the agreement between the LSC and PO.

Lift Inspector

Lift inspectors work in companies with special approvals to do required inspections. Dekra is an example of an inspection company. If the lift fails an inspection, the lift is not allowed to be used until it has been fixed and passes a new one, otherwise the PO may be fined. There are three different kinds of inspection: First inspection after the lift is built, audit inspection after a lift has been modernised, and regular annual inspection (Stockholms stad, 2022).

2.4 The process of repairing a lift

The following section describes the process from when a lift stops working, until it is back in service again. The description is based on information from the interviews, the observation and the brochure 'Service guide for lifts and gates' (translated from Swedish) by Motum (n.d.). The process is visualised through a flowchart in Figure 2.3.

When a lift stops working it is almost always discovered by a lift user, commonly a tenant in apartment buildings or an employee in offices. Sometimes the lift user reports that the lift is out of service to the PO, either through an internal system, or contacting the administration. Depending on the PO, they can either send out the janitor responsible for the property or directly contact the LSC. Since janitors rarely have the competence to repair a lift, nor are allowed to do more than the most basic work due to safety hazards, the reports are in most cases sent to the LSC as

soon as it is received. If the janitor does not succeed in repairing the lift, the service company is contacted.

The LSC in most cases receives reports to their alarm centre, which creates a work order that is sent out to the assigned technician through an internal business system. The technician receives the work order, picks up the keys to the property and machine room, and goes to the lift to start troubleshooting. Once the lift is back in service, the technician writes a service log in the log book found in the machine room, and also documents the work digitally in the internal business system. Depending on the LSC, the PO can be given a brief description of the executed work.

While it is still only a small minority on the Swedish market, some lifts already have digital data monitoring. Depending on the installed monitoring hardware and software, different levels of problems can be detected. Some systems can tell exactly what is the current error of the lift, while others can only say that the lift have been standing still for an unusually long time.

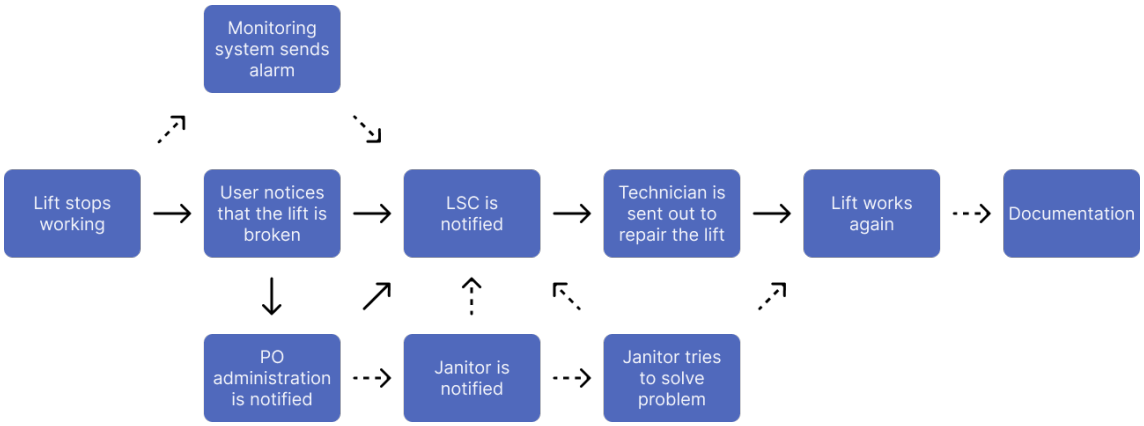


Figure 2.3: Flowchart of the process of repairing a lift. Solid arrows represent common steps, and dashed arrows represent processes that some companies work with, but not all.

2.5 Related products

There are a few products available on the market that enables monitoring of lifts. Two of them are described in this section.

2.5.1 SafeLine LYRA and ORION

SafeLine LYRA is a monitoring unit available on the open market, provided by the Swedish company SafeLine. LYRA can be used to gather data independent of the brand of the lift. The unit collects data about the movement of the lift through microsensors and vibration technology. It analyses the status of the lift through machine learning and sends the data through the cloud to ORION (SafeLine, n.d.-a). The software ORION lets the user monitor and overview all their lifts through a

digital, web based UI. The system lets the user plan proactive maintenance analyse usage patterns and see real time status (SafeLine, n.d.-b).

2.5.2 Schindler Ahead

Schindler Ahead is a digital service provided by the Swiss company called Schindler, that monitors lifts and escalators. The hardware component is called Cube, which enables wireless connection, edge computing, and remote monitoring. Lift data such as door status or life cycle utilisation are collected and transmitted to the Cloud Platform. A Cube component is placed in every lift, collecting data and sending it to an UI. There are two different types of Schindler Ahead. One is for POs, and is called Schindler Ahead ActionBoard, and the other is for technicians, called Schindler Ahead RemoteMonitoring (Schindler, n.d.).

Schindler Ahead ActionBoard provides an overview of operation information for all lifts and escalators of a customer. Real time status makes it easier to plan and prioritise in case of performance control, planning of service, data exchange or general statistics. A clear overview is supposed to help discover problems and prevent downtime. ActionBoard can be accessed through the web browser or separate mobile application. Important information is communicated by push-notifications but users can customise how and when to receive these. It can be tailored depending on different accounts, customers and buildings (Schindler, n.d.).

Similarly, Schindler Ahead RemoteMonitoring provides real time performance information about lifts and escalators. The ability to filter real time data is supposed to promote proactive service by facilitating overview, control, quicker and more precise identification of deviations. Examples of functions are sending service requests, handling of warning notifications, calendar service planning and sharing of information to tenants and visitors (Schindler, n.d.).

3

Theory

This chapter presents relevant areas, terminology and research that helps the reader understand the project. Explanations of technical information about lifts, design concepts, design guidelines, and design challenges are included.

3.1 Components of a lift

In order to better understand this paper, the main components of a lift are described in this section. An illustration of a traction lift and its parts can be seen in Figure 3.1 below. There are many more additional components of a lift, but only the most relevant for this paper are described here. There are different types of passenger lifts, where traction lift is the most common, followed by hydraulic lift. Traction lift is also called cable-driven lift.

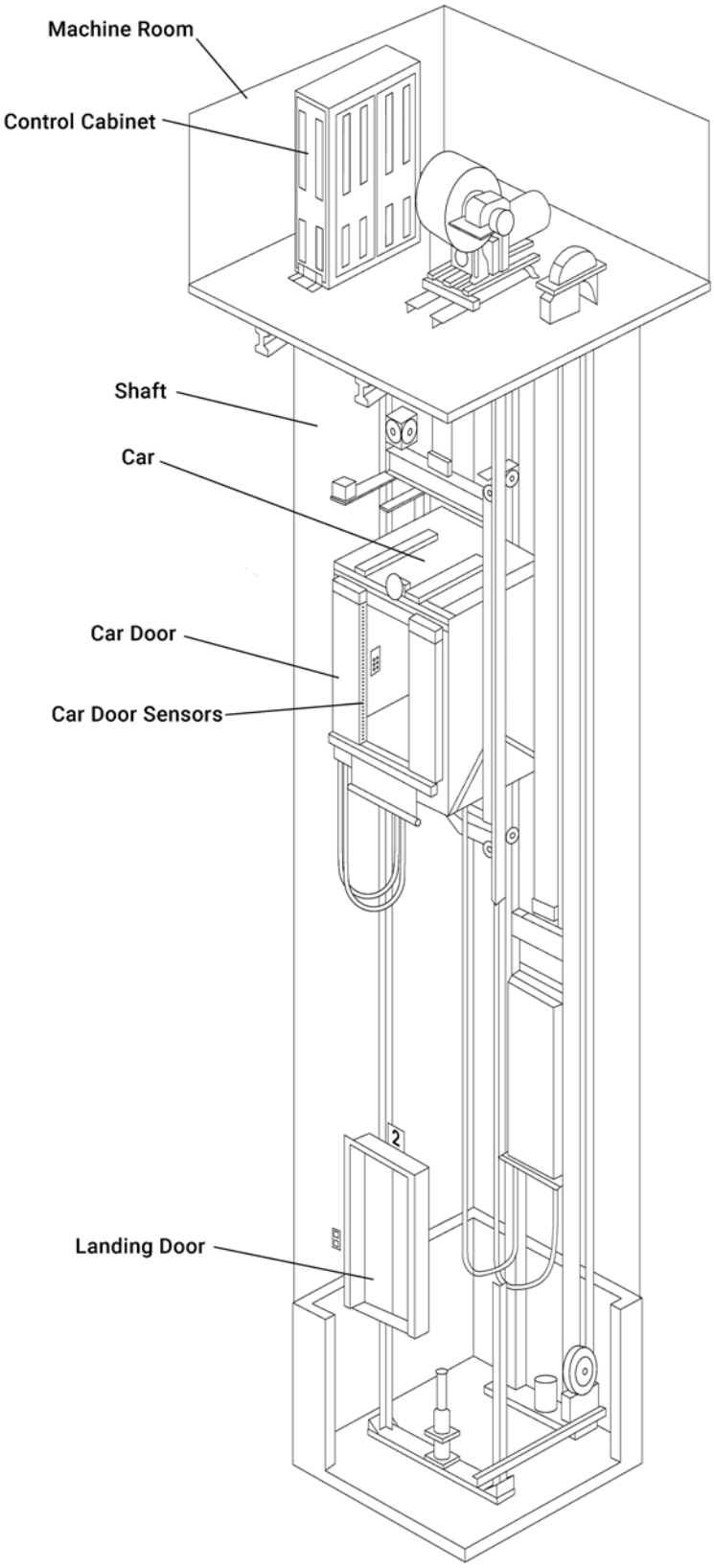


Figure 3.1: Illustration of traction lift and its parts.

Machine room

The Machine room is the area where technical lift equipment such as controller, machine, motor, electrical disconnects and the pump unit are located (Federal Elevator, 2019). It is usually placed directly above the shaft but can also be placed in the basement depending on building structure (TK Elevator, n.d.). In the machine room there is a physical log book containing handwritten information about all service visits. Usually there is documentation about the lift, such as technical specifications, circuit diagram and maintenance instructions. Only authorised people are allowed into the machine room.

Control cabinet

The control cabinet is the electrical equipment and signal control centre. Control cabinets have become smaller and more powerful over time. Today's control cabinets are often composed of PLC and inverter, or computer board controls (Wuxi Runlian Technology, 2017). In the control cabinet the relays can be found (relays are further described in Section 3.3). Images of control cabinets can be seen in Figure 3.2.

Figure 3.2: Control cabinets. Left: Photograph from lift fair. Right: Photograph from observation.

Shaft

Shaft or hoistway is the vertical space where the lift car travels (Collins English Dictionary, n.d.).

Car

The enclosed part of the lift that travels vertically in the shaft, and where goods and passengers are being transported (Eros Elevators, n.d.).

Car door

Car door is also called car gate. It keeps goods and passengers safely inside the car while the lift is in motion. The door can be operated both manually and automatically depending on lift type. Due to safety reasons, the lift is connected so that the lift can only leave a landing when the car door is closed (Symmetry Elevating Solutions, n.d.).

Car door sensors

The car door sensors are supposed to detect obstacles between the doorway when closing. If the sensor is blocked it senses that there is an object between the doorway. It will cause the doors to reopen and not close until the area between the doorway is free (Elevator Wiki, n.d. -b).

Landing door

Landing door or hoistway door is the door between the shaft and the floor landing that keeps people from falling down the shaft. The landing door is closed except when the lift has stopped at the floor for passengers to enter and exit the car (TheFreeDictionary, 2003). There are landing doors on every floor. So when a lift stops at a floor and the doors open, both the landing door and the car door open simultaneously.

3.2 Control system and remote monitoring

The control system is a lift's way of communicating through its different operating parts what is going to be done when. It takes input signals from sensors and buttons pressed by lift users, and sends output signals that direct the movement of the car, the opening and closing of the doors and light and sound signals (Electric ideas, 2017). Figure 3.3 shows a sample of the different parts included in the lift control system.

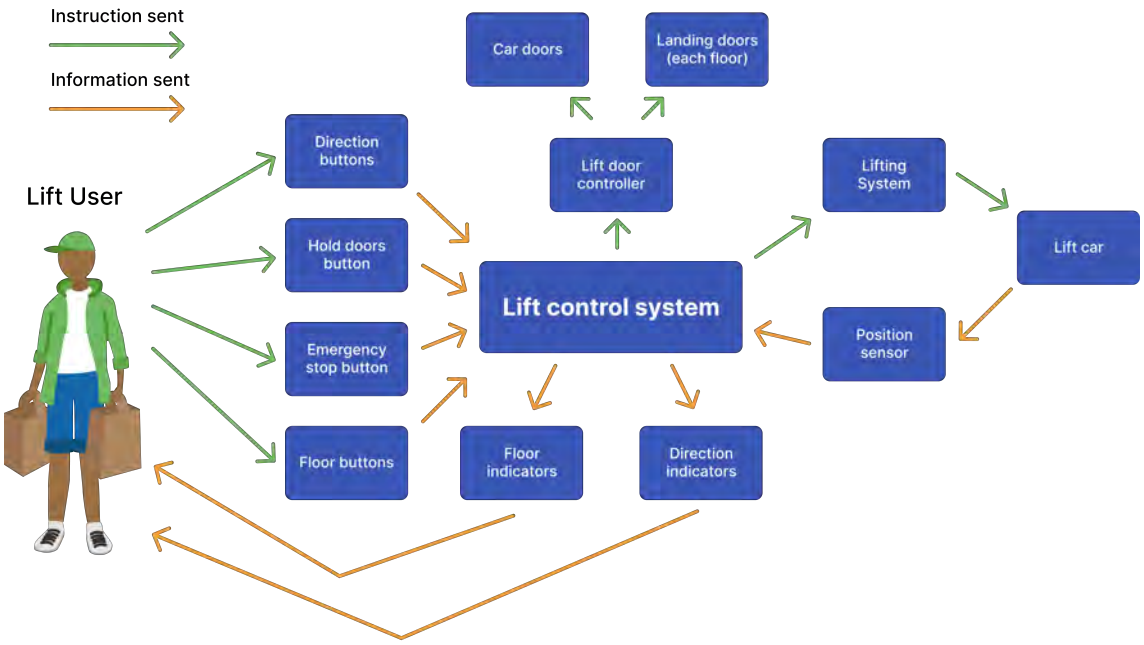


Figure 3.3: A sample of a lift control system.

Historically there have been different ways of controlling the movement of a lift, but the two types of systems used today are relay controlled and microprocessor controlled. The relay controlled control systems were introduced to the market already during the 1920s. Since then they have advanced into complex logical systems capable of controlling the doors, velocity and position of lifts. Since relay controlled systems does not use computer algorithms, but only electrical circuits and relays (see Section 3.3) to build up its logic, they do not have the same risk of encountering software or hardware errors. It however comes with the disadvantage of creating very complex logical circuits for lifts with many floors, as well as requiring high maintenance because of its many moving parts (Elevator Wiki, n.d. -a).

Ever since microprocessors were introduced into lift control systems during the 1970s, they have continuously increased in popularity, and are found in most modern lifts. They are smaller in size and have lower power consumption compared to their relay-based counterparts (Elevator Wiki, n.d. -a). The control system is managed by a hardware unit with a microprocessor found in the control cabinet (see Section 3.1), called the controller. Through input from buttons, sensors and safety switches the controller operates the lift system with its coded logic on its microprocessor (Electric ideas, 2017). Even though the logics and algorithms of microprocessor controllers are coded, they still use relays as in and output signals (Puntoflotante, n.d.). Images of control cabinets can be seen in Figure 3.4.

Figure 3.4: Left - Microprocessor controller Thor E2 by Hisselektronik (photograph from lift fair). Right - Microprocessor controller by Stegborgs (photograph from observation).

A problem in the lift industry is the lack of standards in components, resulting in a lack of compatibility between different manufacturers (Kvaser, n.d.). One of the benefits of using microprocessing units is the possibility of seeing error codes, and monitoring the past events before an unexpected stop. Data from door activity, car location and movement, interrupted sensors and load can be collected and used during troubleshooting. Many of the big lift manufacturers have systems where they have their lifts connected to the internet, so that they can monitor their lifts remotely (Elevator Wiki, n.d. -a). The lack of industry standards results in that the big lift manufacturers use their own control systems, which makes it difficult to connect independent devices from external companies to it. This is often called closed control systems.

3.3 Relays

A relay is an electrical operable switch, where the absence or presence of one current determines the status of another circuit. The relay is built up of a coil, a magnetic object and three wires. If the current C through the coil is active, it will create a magnetic field that attracts the magnetical object, which in turn pushes the middle wire outwards and opens circuit A, closing circuit B, see Figure 3.5. If on the other hand there is no current C through the coil, the magnetic object will not be attracted, which closes circuit A and opens circuit B (Evans, 2021).

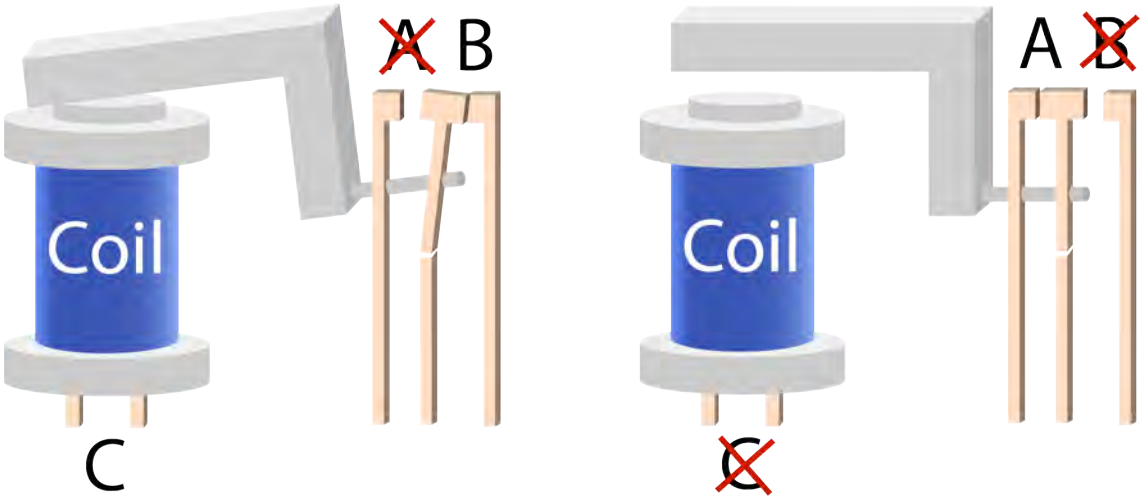


Figure 3.5: Illustration of how a relay works.

Relays are found in the control cabinet (see Figure 3.6) of lifts that are both relay controlled and microprocessor controlled, see Section 3.2. During the troubleshooting of a lift, the technician begins with checking the controller to see if there are any error codes that can be linked to the stop of the lift. If he can not find any, he measures the current through the different circuits of the relays to determine the state of the input and output signals from the system. Once the deviant currents through the relay have been identified, the technician checks the circuit diagram to interpret what parts of the lift is connected to what relays (see Figure 3.6).

There is not a universal circuit diagram for all lifts, but relays can show different amounts of information depending on how the lift is installed. In one lift, one relay can handle the circuit for all landing doors, while another lift might have a separate relay for each of them. Through the combined information of the circuit diagram and then identifying which relays have broken circuits, technicians can draw conclusions about the lift components' states. For example if a relay have a broken circuit and is connected to the car door, it can be concluded that the car door is not able to close. The technician then knows where to start the investigation (information from observation).

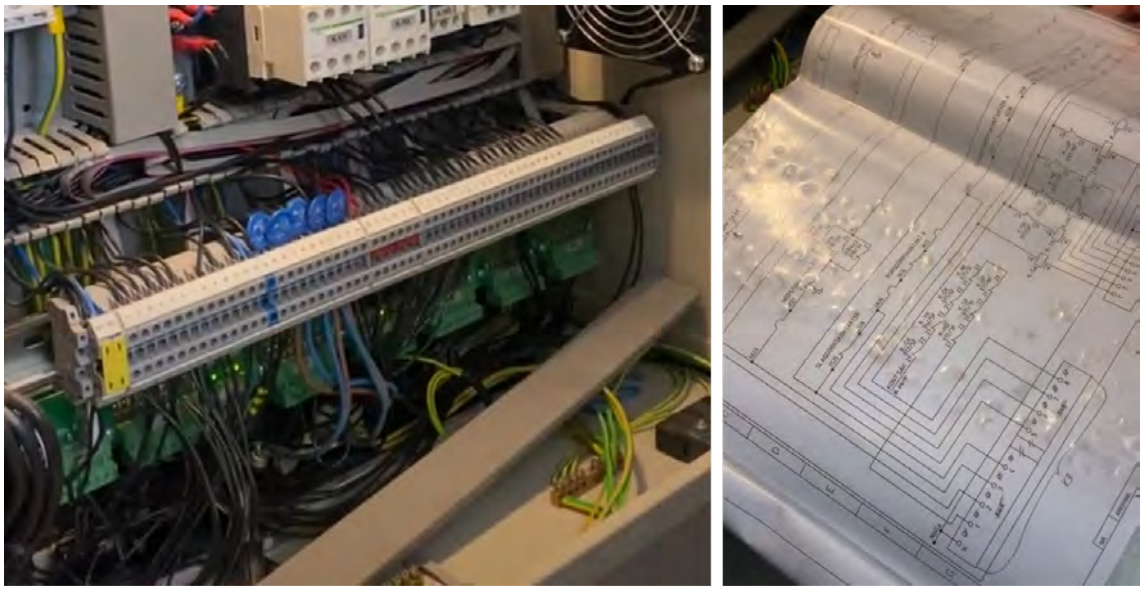


Figure 3.6: Left - Relays in a control cabinet of a microprocessor control system. Right - Circuit diagram of relays. Photographs from observation.

One of the two data monitoring units made by Host Mobility AB is connected to the relays of the lift. If circuits through the relays are changed, the unit recognises this and sends the information to the web-based system HCPL. Because of the binary data of a circuit being either open or closed, a limited amount of data can be displayed to the users.

3.4 CANopen-Lift

CANopen-Lift is a standardised open protocol that enables communication from different devices used in lift systems. It was developed in the early 2000s by CAN in Automation (CiA) on the request of different lift industry manufacturers because of the industry's problem with interoperability between different hardware components (Kvaser, n.d.). CiA is the international users' and manufacturers' group for Controller Area Network (CAN). CiA have their headquarter in Nuremberg, Germany but have over 700 members all over the world. Their aim is to provide an unbiased platform for future CAN-related specifications and standards (CAN in Automation, n.d.-b).

CANopen-Lift allows lift system designers to combine parts of different manufacturers using the protocol. The protocol standards lets independent providers produce software implementations, as well as enables open service and maintenance of the lift (Elevator Wiki, n.d. -a).

Kvaser (n.d.) describes the protocol benefits as better technical diagnosis and integration in lift control systems, as well as following:

- *Improved start-up.*
- *Easy diagnosis and debugging.*

- *Optimised speed and precise control of the equipment.*
- *Facility for preventive maintenance.*
- *Energy savings and control.*
- *It is possible to read measurement data for drive energy consumption over the CAN network.*
- *Increased data security and system availability.*
- *Remote maintenance and configuration of system through internet.*

(Kvaser, n.d., Advantages of CANopen Lift Technology).

One of the two data monitoring units made by Host Mobility AB collects lift data through connecting the the controller of CANopen-Lift-based systems. It reads and sends the data from the controller found in the lift, to the web-based system HCPL. This gives a large amount of data that can be displayed to the users, including many different data parameters.

3.5 Information visualisation and Dashboard

Information visualisation (IV) refers to presenting raw data in a visual and meaningful way. It can be found in fields such as human-computer interaction, visual design, computer science and cognitive science. The process of creating IV often starts with understanding the needs from the users who will see the data, and how it will be used (Interaction Design Foundation, n.d.-b).

Together with labels, colour, contrast, distance and size visual hierarchies are formed and creates a visual path of the information. IV is becoming more and more interactive, allowing manipulation of the elements for better adapting to users needs. For example users can more easily view topics from various points of views and get more of an explorative experience (Interaction Design Foundation, n.d.-b).

There are different forms of presenting data such as charts, diagrams, plots and flows. Depending on the user's needs, certain forms are more or less suitable. If a user wants to see differences or similarities between values, data can be visualised as a bar chart or pie chart for example. To show frequency, how data spread out over an interval or is grouped, more suitable forms are bubble charts and density plots. If a user wants to know how an object or system functions, then flow charts and illustration diagrams are suitable forms (Ribecca, n.d.).

A dashboard is a UI that displays various types of visual data on one screen, providing a birds eye view of the essential information for the user. A designer has to prioritise what information should be shown to a user in a dashboard, and what should be excluded. Different types of IV come with different benefits. Displaying data as a single number shows its most recent value, a trend arrow shows its current trend, and miniature charts show its long time progression, while consuming larger space and being more difficult to read the current value. Providing tooltips, scrolling, or

creating multiple pages content are different ways of accounting for the loss of data displayed on the main screen. While interaction might decrease the abstraction of the information, it may also require a larger screen space. The number of pages for the information, level of interaction with the data, required screen space and abstraction of the information all affect each other, and have to be balanced according to the requirements of the users (Bach et al., 2022).

3.6 UX challenges regarding IoT

This project involves UX and UI design of data gathered from lifts. User Experience (UX) is what creates value for the end user, for example by carefully considering usability, accessibility and interaction. User Interface (UI) is where the human-computer interaction happens, often focusing on visuals and how everything is presented to the user. Internet of Things (IoT) is a system of objects/things/devices connected to the internet. IoT solutions can include anything from controlling the lighting at home to monitoring power plants. There are clear guidelines when it comes to designing for web and mobile only, but involving other types of physical devices makes designing more challenging. The UX Lead Subramani Baskar (2017) explains six challenges with UX regarding IoT and proposes solutions on how to tackle them.

Diversity of interfaces and data points

Normally, an IoT solution gathers multiple types of data from multiple units in a UI. The end user must have access to simple and informative visualisations on any kind of device, like mobile, desktop, and tablet. There are many different types of users, for example technician, owner, and financier that have different needs. Such diversity increases complexity when designing UX for IoT. The connected units are often changing with new data points and upgrades coming online, or units are completely changed out. These changes affect the whole system that requires adaptable UX and UI (Baskar, 2017).

Get in deep on hardware

Usually UX designers do not get too deeply involved in the technical specifications of the hardware. However, the selected hardware affects user experience. For example a cheap processor might decrease the user experience due to its slow speed, which cannot be compensated by strong visuals in the UI. Therefore it is important to consider what is important to the user experience when selecting various hardware components (Baskar, 2017).

Connectivity plays a big role

Physical devices are often connected through many different networks. Some are fast, some are slow, and some can only handle limited amounts of data. It is important to choose the right connectivity for a certain operation. Many IoT solutions are located in remote environments with weaker internet connection which can cause loss of connectivity and valuable data. The UX designer should consider how the system

reacts to certain devices being offline for a short or long period of time. For some operations, it is necessary that the UI clearly states that the connection is down and data is missing. Sometimes it can be useful to fill the missing data points with realistic placeholders. In other situations it is enough to indicate that the data is processing and will be accomplished when connection is back again (Baskar, 2017).

Go beyond the basic platform modules

Most IoT solutions consist of hardware, connectivity, data collection, analytics, rules, actions and applications that work together. UX designers have to understand all different parts and how they impact the design. Many of these parts are not visible for the end user, which can lead to UX designers only focusing on the areas that users will see. A part that is not usually visible for the end user is the rules engine. The rules engine is the piece of software that determines what happens if a condition is fulfilled. For example, if the data reaches a certain value, a warning message will be shown. In a digitalised manufacturing facility, the machine operator might be dependent on machine performance data and real-time notifications in order to efficiently and safely handle the machine. The operator might not care about exactly how the rules are defined, but it is something that must be considered during the design process to enhance user experience (Baskar, 2017).

Third-party integrations are not seamless

Most companies use third party components for their IoT solutions. It can be challenging to integrate everything in a seamless user experience since many components are changing to newer versions. Users do not want to switch back and forth between different applications. They do not want a separate app for controlling their sound system and another app for controlling the lights. Ideally, it should be possible to control everything in one single app. UX designers should integrate new components or features into a broader experience rather than one piece at a time (Baskar, 2017).

Building trust

IoT brings the real world and the digital world together. It can be difficult to trust that a green flashing light on a dashboard means that everything is okay. Displaying the correct data can be crucial, which is why trust must be built into the UX of IoT. By providing transparency, detailed information, context and allowing users to go further into the data, trust will increase. These explanations should never be forced on a user, but users are more likely to be comfortable when they understand the root and underlying reasons (Baskar, 2017).

3.7 Usability guidelines for a Monitoring Tool Interface

An experimental study was conducted by Silveira et al. (2022), where usefulness of usability design guidelines were evaluated. The participants were all software developers and grouped into pairs, according to complementing skills. For the experiment, the pairs were supposed to prototype a network monitoring tool interface with the help of a catalogue containing 12 guidelines. The guidelines contained a description, example of how it should be used and when to avoid it. The researchers evaluated which guidelines were applied and to what degree they were applied correctly. Guidelines that were unused or applied incorrectly were reformulated by the researchers. The reformulated guidelines are as follows:

1. **Movements representing a situation change**
   Significant transition in movements indicates that something is going from one state to another. It improves cognition capacity, and shows the user that a change in state has occurred. This guideline is especially recommended for visualising the change of criticality or situation.

2. **Colours representing the state of elements**
   The colours green, yellow and red, helps with quickly directing the user's attention to states such as "ok", "caution" and "warning". But it is also important to consider colour blind people, so there must be some other way to allow the user to identify different states.

3. **Finding specific information in a large set of data**
   It should be easy to reduce excessive information and find specific elements. This can be done with a search bar or filters for example.

4. **Obtaining detailed information with the mouse pointer**
   Graphs can be highly detailed. It should be possible to see the exact value or detailed information when using the mouse pointer. Therefore the user does not have to filter a time range from the history or zoom in too much on the graph.

5. **Sorting information**
   Sorting information helps the user to immediately find upper and lower values. For example in tables, it is common to sort the data by clicking on the column header.

6. **Present summary before going deeper**
   To prevent information overload, a summary should provide a first overview and enable the user to find more information and direct the user towards where it can be found.

7. **Dashboard as a starting point on the home screen**
   A dashboard can be a good starting point of an interface by giving the user organised visualised data as a first view to analyse the current status of the system. Problem and incident counters can be used to help the user take

initiative.

8. **Use of metaphors to inform about status and incidents**
   Clear symbols can be used to represent the severity level of an indication, like normal, problem, or alert. Using symbols like this can decrease the times it takes for a user to correctly interpret a status of notification.

9. **Notifications**
   Pop-ups can often interrupt the user flow of an interface. Using non-intrusive notifications that appear in the corner of the screen avoids disturbing the user when informing about an important event.

10. **Explanatory text for filling in fields**
    If the user is supposed to fill in the text field in a specific way or format, a simple label is not enough. An explanatory text should be present when specific information or structure is expected from the user to avoid mistakes or misunderstandings.

11. **Display window with additional information**
    Giving the user access to additional information can in complex scenarios be necessary for better understanding of data. It is difficult for users to remember large amounts of data, so such content should only be visible when necessary.

12. **Suitably arranged data**
    If IV elements are of different sizes, some might be under prioritised leading to difficulties of correct interpretation. It is therefore important to consider users screen size and format to keep all data readable.

    (Silveira et al., 2022)

Although these usability guidelines were used for a network monitoring tool interface, a lift data monitoring interface might be similar. Most aspects of the guidelines are universal and suitable for any digital UI. Therefore the guidelines could be applicable for the prototype in this project as well, in order to maximise its usability. These guidelines were kept in mind when designing the UI of the final prototype.

4

Methodology

The Methodology chapter objectively describes the different methods and tools used during the project. Their definition, what they are used for and how they could be applied will be explained.

4.1 Methods

This section describes the different methods that was used during the project. Design Thinking, KJ Analysis, and Usability testing are some of them. The methods are presented in chronological order, as they were executed during the project.

4.1.1 Design Thinking

Design Thinking is an iterative design process commonly used in the field of interaction design and user experience design. It consists of the five phases: empathise, define, ideate, prototype and test (Interaction Design Foundation, n.d.-a). A schematic illustration of the Design Thinking process can be seen in Figure 4.1.

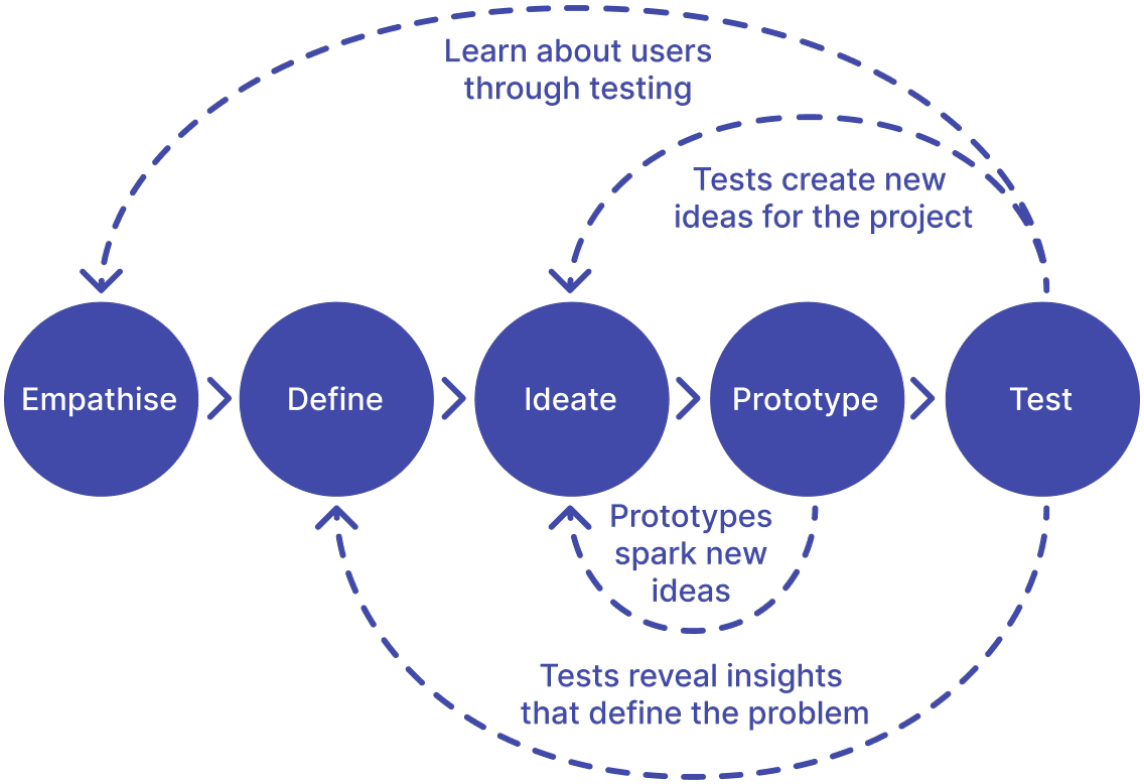


Figure 4.1: Illustration of the Design Thinking process.

Empathise

The first phase is about gathering information about the users' needs through empathetic understanding. It allows the researchers to get rid of assumptions and biases and view the problem from the user's perspective(Interaction Design Foundation, n.d.-a).

Define

The second phase is about compiling the data in the first phase in order to pinpoint and define the core problem and needs (Interaction Design Foundation, n.d.-a).

Ideate

The third phase is about coming up with ideas and suggested solutions to the defined problem. Preferably, ideas should be open and outside of the box (Interaction Design Foundation, n.d.-a).

Prototype

The fourth phase is about creating and refining the ideas from the previous phase to a scaled-down version of the final product, or shaping specific features of it. This is an experimental phase for exploring and investigating the generated ideas (Interaction Design Foundation, n.d.-a).

Test

In the last phase the prototypes are tested and evaluated against the stated problem or needs. It leads to some solutions being refined and others being ruled out. Although it is the final phase, insights from this phase often spark further iterations (Interaction Design Foundation, n.d.-a).

4.1.2 Interviews

An interview is a conversation between an interviewer and a participant, where the interviewer intends to understand the perspective and/or gain knowledge of a specific field from the participant. The type of interview should be selected based on the desired outcome. An interview type where the interviewer has more power of what is being discussed results in more concrete answers, and more easily analysed data. On the other hand, it might result in missing insights that could have been gained with less strict questions. The formulation of the questions define the type of the interview, which can be divided into structured, unstructured or semi-structured (Sharp et al., 2019).

Structured

In a structured interview, the interviewer follows a set script with standardised questions for all participants. A benefit of this is that it results in data that can easily be compared between the different participants. Structured interviews require the interviewer to have a deep understanding of the topic, to the extent that specific questions can be formed without losing valuable perspective of areas that were not thought of in the preparation (Sharp et al., 2019).

Unstructured

In an unstructured interview, the interviewer opens up a larger topic through an open ended question, that the participant then answers freely. The type and depth of answer varies a lot between participants, and it is common to get rich data with varied answers. Before the interview, the interviewer plans the main topics that are going to be discussed and uses probing questions like "could you explain what you meant with . . . ?" or "why do you think that?" to steer the interview in the desired direction. While unstructured interviews gather complex and often insightful data, it can be time consuming and difficult to analyse. A benefit of using this type of interview early on in a design process is that it allows for topics and problems to arise that the researchers had not yet considered (Sharp et al., 2019).

Semi-structured

Semi-structured interviews are, as the name suggests, a mix of the characteristics found in its structured and unstructured counterparts. A prepared script of questions is followed similar to a structured interview, but the questions are open ended allowing for less strict answers. The interviewer then uses probing to extract the relevant information of the question. For the prepared questions as well as the probes,

it is important to avoid phrasing the question in a manner that suggests an expected answer, like "you seem to prefer x over y because of . . . ", but rather ask "which do you prefer over x and y, and why?" (Sharp et al., 2019).

4.1.3 Observation

Humans do not always have an easy time explaining or describing their actions, especially not if they are not currently in the given situation. Observation is when a certain behaviour or activity is observed with the goal to understand the behaviour, the group who perform the behaviour, and the setting. The data collected often includes aspects that the participant takes for granted, and might have not been discovered through an interview or a survey. Depending on the outcome and situation, both qualitative and quantitative data can be collected(Sharp et al., 2019). Observations can be structured in different ways depending on the desired outcome, and divided into different types (Kwantlen Polytechnic University, n.d.).

Unstructured

Is when the observation takes place without a predefined plan about what specific factors should be examined. It allows the researcher to note down freely whatever they observe (Study Smarter, n.d.).

Passive

Passive or non-participant observation is when the observer does not participate in the activities that are being observed. The observer watches from a distance without interacting with the participant. At the opposite side of the passive, you have the participant observer who tries to interact with and execute the same tasks the participant does (Sharp et al., 2019; Liu & Maitlis, 2010).

Naturalistic

Naturalistic or direct observation is when the observation takes place in a real-life setting that the behaviour naturally takes place rather than a test environment (Kwantlen Polytechnic University, n.d.).

Overt

Observation is overt when participants are aware that they are being observed (Study Smarter, n.d.). Overt naturalistic observations aim to be as close to the real scenario as possible, and because of this it is preferred to avoid interrupting the participant with questions during the tasks (Sharp et al., 2019). However, choosing the passive approach does not completely remove the so-called observer effect, which is the impact of the participant acting differently than in a natural environment because he is being observed (Liu & Maitlis, 2010). Another common problem is that the observers can not know what is going on in the participants mind, more than guess based on what actions they do. To counteract this, researchers can use the think aloud technique, where the participant is asked to explain what they are thinking

while they are being observed. This limits the intrusiveness, but does not eliminate it (Sharp et al., 2019).

4.1.4 KJ Analysis

KJ Analysis is a method used for analysing large amounts of data and getting a holistic view of it. In a KJ Analysis the most interesting results from data gathering are written down on notes where every note holds a piece of data on a detailed level. Notes with similar content are placed next to each other so that clusters with different themes are formed. At the end of the analysis every group of clusters is given a name, describing their common theme. KJ Analysis is based on bottom-up principles, meaning that the details are studied first and thereafter the analysis goes more towards the whole (Kaulio et al., 1999).

4.1.5 List of requirements

In design, a requirement can be seen as a need that a product aims to satisfy. The requirements can touch upon for example functionality, aesthetics, capacity, usability, compatibility, and accessibility. They can be quantitative, meaning there are explicit numbers that can be used to measure if the requirement is fulfilled or not. They can also be qualitative, which is more about how users experience a product. Requirements can be used as a guide when entering the ideation phase of the design process, to make sure that the ideas are relevant. They can also be used in the evaluation process in order to verify whether the product meets the requirements or not. A list of requirements is a list containing multiple requirements. They can be categorised, sorted, analysed and prioritised. They usually come in the form of spreadsheets and documents (Niederhausen, 2019).

4.1.6 Persona and Storyboard

A persona is a fictional character used to portray an archetypical user. Personalising the character can help designers gaining a common understanding of users' needs, requirements and behaviours. The persona can be used in the ideation phase to generate ideas, but it can also be used in the evaluation phase to imagine how users will react to the solution (Wikberg Nilsson et al., 2017).

Storyboards are used to communicate a usage scenario as well as create empathy for the fictional persona. They illustrate how, where and why the users interact with a system, but also demonstrate important environmental and social factors. When creating a storyboard, the goal is not to create a piece of art, but to communicate the scenario as efficiently as possible. An abstract drawing is more suitable than a photorealistic drawing as it draws more attention to the context, and less to the details. Explanatory text can be used to give further details about the scenario that are too time consuming to create. A storyboard usually consists of three to six frames to display the scenario, focusing on a specific concept or part of an idea. If multiple ideas need to be communicated, they are best represented in multiple storyboards (Hanington & Martin, 2012).

4.1.7 Prototyping

In product development, design ideas need to be continuously tested and iterated. As fully developing a product before evaluating its strengths and weaknesses would be both time inefficient and expensive, creating prototypes is a way of exploring and communicating ideas (Dam & Siang, 2020). Creating interactive prototypes of a concept also enables teams to share and iterate on each other's ideas, rather than letting it stay as an abstract concept in their minds. Through developing and testing prototypes, designers improve their understanding of how real users of the final product would use it, and potential problems that might arise (Dam, 2021). Before creating a prototype, designers should consider the goal of the testing or communicating of the idea. Prototypes are usually categorised on a scale from low fidelity to high fidelity, depending on their level of functionality and detail (Dam & Siang, 2020).

Lo-fi prototyping

Low-fidelity (lo-fi) prototypes do not aim to replicate the final product, either in aesthetics or functionality. The goal of a lo-fi prototype is to test one or more factors of a design in the most time and resource efficient way possible. This makes them quick, cost efficient and easy to make. It can however be difficult to know where to draw the limit of what should be included in the prototype for a being able to viably test the idea (Sharp et. al, 2019). During testing with lo-fi prototypes it can be difficult for the participant to know what is a shortage in the imagined product, versus the limitations of the prototype. Even if the participant is aware of what is intended to work and what is not, it requires a lot of imagination to disregard the shortcomings of the prototype, and not the product.

Two popular techniques for lo-fi prototyping of graphical UIs are paper prototyping and clickable wireframes. In paper prototyping digital products can be prototypes without access to digital software, through using papers, pencils, and scissors to create the different parts of an interface. It is a quick and simple method that is easy to include people without experience and knowledge in design and design software. A drawback of paper prototyping is that once the basic layout is set, all elements have to follow the determined dimensions. Clickable wireframes, made in digital design tools like Figma (see Section 4.2.1) or Adobe XD, can more easily be reorganised without having to start from scratch. Parts from the lo-fi prototypes can also be reused during the hi-fi prototyping, decreasing the workload for the designers (Babich, 2017).

Hi-fi prototyping

High-fidelity (hi-fi) prototypes are intended to evaluate something as close to the final product as possible, without actually having to create it. Hi-fi prototypes are usually created towards the end of a design process when the team has a good grasp of the different stakeholders' needs and the usage scenario. The visual design in hi-fi prototypes looks as close to the end result as possible, the text content and information is realistic of what to expect in the final interface, and the interactions

found are as realistic as possible (Babich, 2017). These prototypes are commonly used either to present and demonstrate for stakeholders for approval of the design, or to evaluate with users (Hanington & Martin, 2012). Feedback gained from hi-fi prototypes are usually more meaningful, as users can act naturally and do not have to actively ignore or imagine some parts of what is being evaluated (Babich, 2017). Even though hi-fi prototypes are better for communicating and presenting ideas for external stakeholders, as well as user testing outside of the design team, it is important to not start too early with this during the design process since it is more resource intensive (Sharp et. al, 2019).

4.1.8 Usability testing

Designers often become blind to the flaws of the products they are developing. The evaluation method Usability testing helps the design team to pinpoint frustrating and confusing elements of their UI by testing it with end users. During the test a realistic scenario is described to the participant to give some context to why they are currently in the situation of using the product. A set of tasks are then given to the participant, on which the interface's usability is evaluated based on their success. To understand the process of thinking, the participants are typically asked to think-aloud. Hanington & Martin (2012) gives a list of user behaviours that researchers should pay extra attention to during evaluation.

- *Understands the task but cannot complete it within a reasonable amount of time.*
- *Understands the goal, but has to try different approaches to complete the task.*
- *Gives up or resigns from the process.*
- *Completes a task, but not the task that was specified.*
- *Expresses surprise or delight.*
- *Expresses frustration, confusion, or blames themselves for not being able to complete the task.*
- *Asserts that something is wrong or does not make sense.*
- *Makes a suggestion for the interface or the flow of events.*

(Hanington & Martin, 2012, p. 432)

4.2 Tools

This section objectively describes the two main tools used during the project, Figma and Midjourney. The tools are digital software tools that facilitate the creation of digital design.

4.2.1 Figma

When developing a graphical UI, creating interactive prototypes helps the design team to try their ideas and evaluate flaws and benefits with relatively low development costs. There are currently multiple different tools on the market for creating so-called clickable wireframe prototypes, of which the two most populare are Figma and Adobe XD. In this project Figma was used due to its possibility to remotely share interactive prototypes through web browser links, and as it was the software the design team had most previous experience with.

Figma (see Figure 4.2) is an online collaborative design tool primarily made for designing graphical UIs (Figma, n.d.). In Figma, designers can create wireframes, interactions in and between screens and animations without writing a single line of code. Through this, prototypes of digital interfaces can be designed and tested through an interactive prototype mode. There are also premade templates that can be used for some design methods, like creating flowcharts, empathy map and user persona.

During this project, Figma was the main tool, used as an interactive bulletin board during all stages of the process for different purposes. It was used during benchmarking to gather and compare different interfaces to each other. It was used during KJ Analysis to organise and structure quotes and insights gathered from the interviews and observations. During ideation it was used to quickly visualise and communicate ideas. It was used for lo-fi and hi-fi prototyping, and during usability testing to let users try the clickable prototypes.

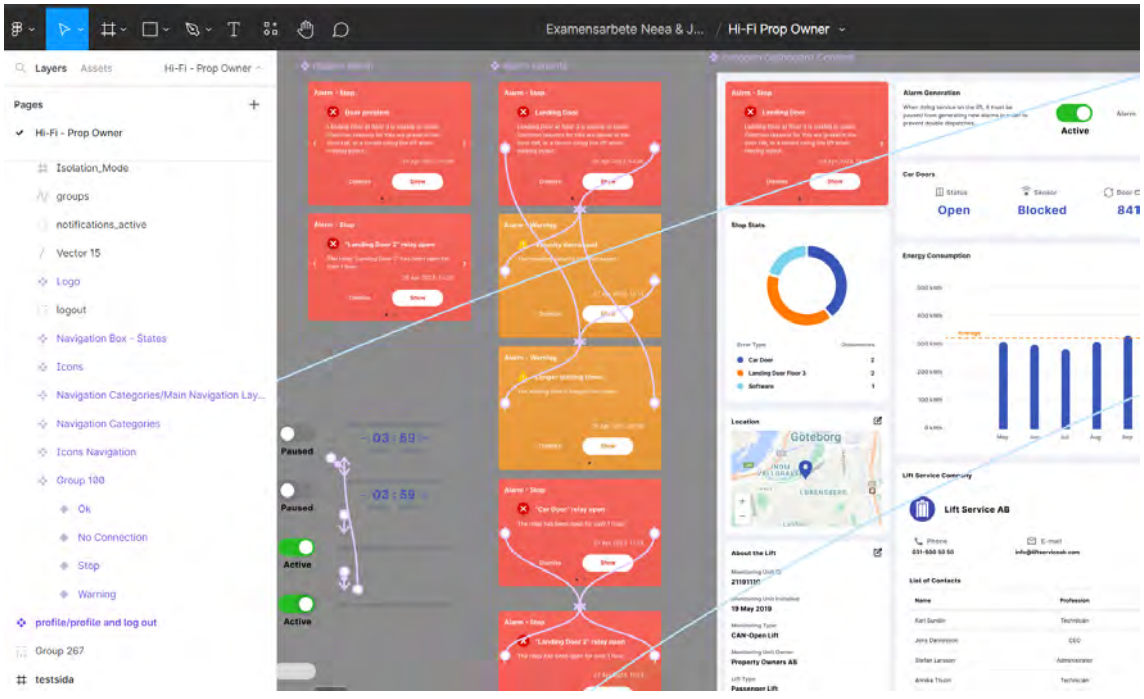


Figure 4.2: Building of the Hi-Fi prototype in Figma.

4.2.2 Midjourney

Midjourney is an AI-tool for text-to-image generation, where users write prompts to generate images through a bot on the communication application Discord. The prompts are built out of texts that describe the desired image, where it creates four different variations that can either be further varied, or upscaled for a higher resolution image (Midjourney, n.d.). An example of a prompt for Midjourney could be: "mood board, webdesign, monitoring software, security", which gave the result of Figure 4.3. It is also possible to use already existing images as part of a prompt for influencing colours, style, and composition.

Figure 4.3: AI-generated image from Midjourney using the prompt: "moodboard, webdesign, monitoring software, security."

A big benefit about Midjourney and similar tools is that it can generate detailed high-quality images in a short amount of time, no matter what input is given. This

is a new, emerging tool that allows users without prior art experience or skill, to create hi-fi artwork. However, Midjourney and similar tools have been criticised for how the images are generated. It can be difficult to define who the real artist is. The AI tool has been trained on a huge amount of images from databases with existing artwork, including both private and open, some of which are copyrighted works by professional artists. Many artists' work have been used for training the AI algorithm without their consent. Midjourney does not communicate how much of the generated image is taken from existing artworks, nor what artists are involved. AI tools also raise questions about the role of imagination and creativity (Artland, n.d.).

Jonas Oppenlaender (2022) describes AI tools as a paradigm shift similar to when photography was first introduced. During that time people believed that the art of painting was threatened by photography. Some artists, especially the ones specialised in painting photo-realistic portraits, were negatively affected. But for others, photography opened new opportunities. Generative AI today will probably raise similar questions and could affect the role of the creator, his tools, co-creative systems, and our relation to creative work (Oppenlaender, 2022).

For this project, Midjourney was used during the ideation phase. Its purpose was to spark inspiration for new ideas regarding visual design and to come up with hi-fi images quickly.

5

Process and execution

This project has followed the Design Thinking process, consisting of different phases including Empathise, Define, Ideate, Prototype and Test. The first section describes a summary of the project process. The other sections of this chapter are divided into the different phases and describes the process and execution of the activities for each phase.

5.1 Project process and timeline

During this project of 20 weeks, the Design Thinking process was followed. While many of the activities and processes were done iteratively, the project can be divided into five phases: Empathise, Define, Ideate, Prototype, and Test. The purpose of the phases was to establish the main focus for each phase and make sure that the project was progressing forward. Since the project had limited time and a clear end goal, some linearity was strived for to ensure progress. Meanwhile, several activities were performed iteratively in order to refine and improve. Activities in a later phase gave insights that sparked new ideas and alterations of results and activities in previous phases. A simplified schematic representation of the project process, timeline, phases, and activities can be seen in Figure 5.1.

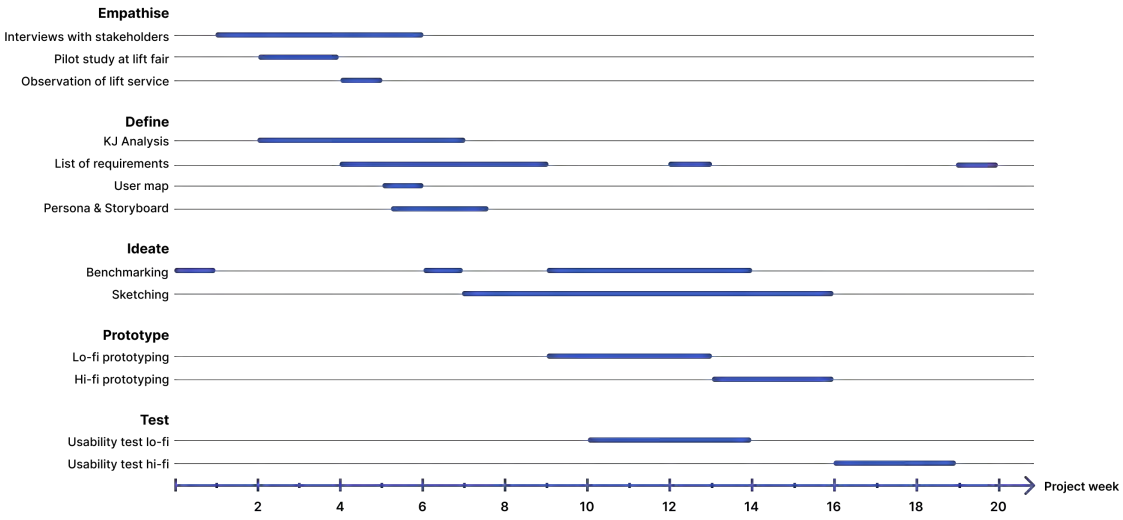


Figure 5.1: Schematic representation over project process.

5.2 Empathise

This section explains the activities performed during the first phase of the Design Thinking process. This phase was about empathising with users, understanding the current situation and needs from the different stakeholders. The main activity for this phase was to gather data about users' needs, opinions, and stories by interviewing POs and LSCs and LCs. A summary of the findings can be found in Section 5.2.4 which sets the foundation for how the final product will function and look like.

5.2.1 Pilot study at lift fair

During the annual lift fair called Nordic Lift Expo different companies in the industry gather to present their work, and make connections for future partnership. This was seen as an opportunity to gain insights and find potential participants for future user studies. Before the fair a question template was made for the visit to maximise the possibility of obtaining useful data. The companies were divided into categories based on their orientation, and questions were formed accordingly. Examples of orientations were spare parts, interior design, education, buttons, control systems, emergency lines, and business systems. These questions were later used as a structure for shorter semi-structured interviews, of which notes were taken. No audio recording took place because of the loud environment and out of respect for other people around that had not given consent to have their voice recorded. The fair helped the design team to get an overview of the market. At the fair, several existing monitoring interfaces were showcased, leading to inspiration for creating the design for this project. The fair was seen as a pilot user study to get a better understanding of the different stakeholders, and formed a base for the user studies that came after it.

5.2.2 Interviews with stakeholders

Semi-structured, in-depth interviews were conducted with participants who have knowledge in lifts, interact with them, or are responsible for them. POs, LSCs and LCs were interviewed. The POs' orientations included student housings, public housings, residential buildings and commercial properties. In total 4 LSCs, 2 LCs, and 7 POs participated in the study. All participants were men working in Sweden.

Participants were selected through convenient sampling. In order to gather participants, a standardised email explaining the purpose of the study and asking people to participate in an interview was sent out to companies from the different stakeholder groups. Among people who replied that they wanted to participate, a selection was made based on geographic location, type of company, and profession, in order to make the sampling as diverse as possible. At first, the response rate of POs was high while being very low from LSCs. To compensate for this, a second round of invitations to interview was sent out. Two lift consultants were included to represent the LSCs perspective since they had long previous experience in the field. In total 59 LSCs/LCs and 43 POs were contacted.

Participants were asked to do the meeting online, except if they were located within

commuting distance from the design team. If so, participants had the choice to be interviewed online or in person at their office. All interviews except two were held remotely through Zoom. Every interview began with a brief introduction of the study and sharing of consent form. When participants had consented, the meeting was audio recorded. The questions were semi-structured and the interviewer used a template with interview questions. Two different templates used, depending on if the interviewee was working for a PO or LSC/LC. The template iterated between every interview after gaining insights about what questions should be elaborated further. The interview templates can be seen in Appendix A for POs and Appendix B for LSCs/LCs.

In Table 5.1 below, every interview is listed in chronological order, including participants, their occupation and what kind of company they work for. Participants' occupations have been translated from Swedish to English which sometimes lack established equivalent in English, leading to direct translations.

I = Interview
O = Observation, see Section 5.2.3
P = Participant
PO = Property Owner (company)
LC = Lift Consultant (company)
LSC = Lift Service Company

Table 5.1: List over interviewees

Interview	Participant	Occupation	Company	Company orientation
I1	P1	Property developer	PO1	Student housing
I1	P2	Lift consultant	LC1	Lift consultancy
I2	P3	Technical manager	PO2	Student housing
I2	P4	Property technician	PO2	Student housing
I3	P5	Purchasing manager	PO3	Public housing
I3	P6	Procurement officer	PO3	Public housing
I4	P7	Technical manager	PO4	Residential properties
I5	P8	Lift consultant	LC2	Lift consultancy
I6	P9	Project manager	LSC1	Lift service
I7	P10	Sales manager	LSC2	Lift service
O	P9	Project manager	LSC1	Lift service
O	P11	Technician	LSC1	Lift service
I8	P12	CEO	LSC3	Lift service
I9	P13	Technical manager	PO5	Residential properties
I10	P14	Janitor	PO6	Residential properties
I11	P15	Technical manager	PO7	Commercial properties
I12	P16	Technician	LSC4	Lift service

In Figure 5.2 the geographical distribution of where the companies are located is shown.

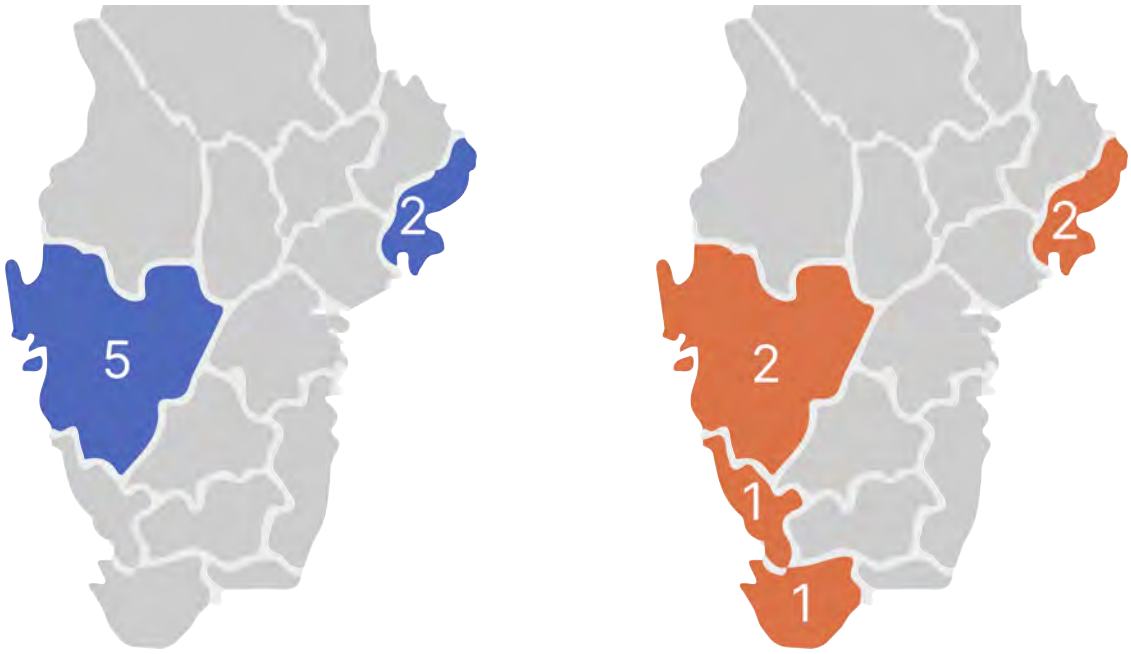


Figure 5.2: Geographical distribution of POs (left) and LSCs/LCs (right).

5.2.3 Observation of lift service

To get a better understanding of how technicians actually work, an observation of a lift service dispatch was conducted. The observation was done with participants P9 (project manager, former technician), who had been interviewed before (see Section 5.2.2), and P11 (technician) who had not been interviewed before. Both of them were from the lift service company LSC3. The observation was unstructured, non-participant, overt, and naturalistic.

The design team shadowed their work while participants demonstrated and explained how lift service usually is done. At the same time participants answered questions about what they were doing. The whole observation was video and audio recorded to be transcribed and further analysed.

The design team followed P9 in their car on their way to a service dispatch. During the car ride P9 were asked open questions about lift service in general. When arriving at the property P9 introduced the machine room and the different parts of the lifts, and the steps involved in the service process. Then P11 repaired the lift by replacing the broken parts. Their course of action, and what tools they used during the process were observed. The design team tried to get a sense of whether they found the work stressful or calm, difficult or easy. It was also important to see the real environment, what a machine room looks like, what kind of equipment is in there and how they affect technicians' workflow.

5.2.4 Findings about stakeholders' current situation

This section summarises the findings from all interviews and observations done in the first phase. It describes stakeholders' current situation, their interest in a lift monitoring system and what they expect from it. All statements are subjective expressions from the interviewees. This section is further divided into smaller headings that touch upon different themes and topics.

The lift industry today

Most technicians today use phone-based systems in their work, and interact with advanced technology from lifts in their everyday work. However, there are many older adults within the lift industry. Therefore it is important to take into account that some people have decreased eyesight and limited experience with the internet.

The biggest lift manufacturers in Sweden (Schindler, Otis, Kone, Thyssenkrupp) use closed systems, which means that it is difficult for external parties to access and monitor the lift data through the cloud. However, it is possible for external technicians to access the data as long as they are interacting with the lift on site. Closed systems sometimes mean that they require special spare parts that are not available on the open market, which are usually more expensive. The biggest lift manufacturing companies usually offer a complete solution where the company that manufactures the lift is the same as the one doing service. The bigger lift manufacturers have internal lift monitoring systems which they use to monitor lifts of their own brand. There are few solutions on the market that can gather data from all lifts.

Types of service agreements

There are different types of service agreements, listing what should be included in the price, and when service should be done. Damage caused by careless handling or intentional damage from lift users always costs extra for the PO, regardless of agreement. The same goes for upgrades of more modern spare parts, which count as modernisation, leading to extra costs for the PO. A common type of service agreement is Full Service Contract which means property companies pay a fixed price to the LSC to let them serve the lift anytime when needed in order to make sure that the lift is always working. With this type of agreement, the PO abdicates responsibility for the lifts and expects to be thinking about lifts as little as possible. Full Service contract makes budgeting easier since the price is fixed. Many POs that were interviewed had this kind of agreement and expressed that they have little or no interest in a lift monitoring system due to lack of economic incentive.

Another type of service agreement is Basic-Maintenance Contract. POs with Basic Maintenance Contracts pay a fixed price where a few service visits are included. Commonly, a fixed amount of routinised service visits are included per lift per year, depending on what type of lift and how often it is used, but usually four visits. On top of that the LSC assists during yearly inspection. Anything beyond, for example additional service, repairment and maintenance, the PO must pay extra for every

occurrence. With this type of agreement, both POs and LSCs said that a potential use case for a monitoring system could be for choosing the right amount of routinised service visits according to what the lift actually needs.

Not enough information after service

Something that concerns POs is that they do not get enough feedback from the technician after a dispatch or service visit. For many POs, the invoice is the first and only indication that a technician has been there. Some POs are not interested in feedback, they just want the lifts to work. But most POs want to have better feedback than today. One PO explained their previous experience with a monitoring system regarding the apparatus room.

> "*What does the subject line say? Error [Company Name]. It doesn't say [City Area Name], it doesn't say which address, it doesn't say if it's an appliance room. How do I know if it's a lift or a washing machine? It should say lift and the address directly in the subject line! If something happens we get a report, it can be apparatus, lifts, washing machines or whatever. So they ask where we want them to send it. In the beginning they asked 'where do you want the SMS, to what phone?' We don't want it in a phone, we want it in email, and not to an individual janitor, it must be to the customer service centre because it is constant. A janitor can quit.*"
>
> - P1 (Property Developer), PO1

LSCs say that their invoices must be double-checked before being sent to customers, due to spelling and the type of language being used. Sometimes technicians use too technical wordings that the customer does not understand, and sometimes the language could even be inappropriate.

Trust and communication

Although the stakeholders usually trust each other, there are situations when the PO feels that they do not have control of what is going on. The LSCs have superior knowledge about lifts which can make it difficult for the POs to question and understand. LSCs think that a possible reason for mistrust is that technicians are not clear enough in their communication. Many POs take help from LCs who become a middleman between POs and LSCs.

LSCs perceive that POs sometimes have unrealistic expectations of how long a lift will last and do not expect it to cost. An old lift tends to break more easily and spare parts become more expensive. At some point it becomes more economically beneficial in the long run to do a modernisation even though the one time cost is high.

POs perceive that LSCs tend to steer the work in the direction that is most economically beneficial for themselves. For example when old spare parts are not available anymore, technicians replace them with newer parts, counting as

upgrades, which the PO must pay for. Some POs think that technicians are not doing maintenance properly so things will break again after a short while, in order to get more work and more money.

> "*That's the thought many people have about lift service companies, that they do not repair, because then they might not get more money since they do not go there anymore. Or maybe it's just how lifts work, that they are being worn so much.*"
>
> - P3 (Property technician), PO2

But there are also POs who have complete trust in technicians. Damage caused by careless handling can only happen in the car, so therefore there is no reason to mistrust, they say.

> "*If they take care of maintenance, and keep the costs low, it becomes cheaper for them as well. Not until the bigger components such as the machine, control cabinet, and controller goes south, it starts to become pricey for the lift service company... It's not like a tenant can break something that is not inside the car, you know?*"
>
> - P7 (Technical manager), PO4

It is common to have operations meetings around one to four times a year. During these meetings technical managers, LCs and representatives from the LSC discuss the current situation on the lifts, and the service around them. Future modernisation is planned, and the different stakeholders discuss how they interpret how things are going. By checking the lifts' service history it becomes easier to determine which lifts require modernisation, which ones need more service visits and which ones need fewer service visits.

Dispatches where the lift is working on arrival

Another problem that both parties experience is when the LSC dispatches and the lift is already working at arrival. The PO will be charged a transportation fee even though no service was done. Interviewees were asked how often the lift is already working on arrival, out of all dispatches. Their answers ranged from less than 1% to 40%, but 10% was the most common number.

LSCs think that the most common reason those dispatches happen is when tenants are moving. Objects, like furniture, are placed in between doors so that they can not close. Tenants on other floors error report when they notice that the lift is not coming. It also happens that some people prank call the emergency phone or hold the emergency buttons by mistake. If a LSC dispatches during weekend nighttime it can cost 8000 - 10 000 SEK, according to one LSC. Both parties see that a lift monitoring system could prevent unnecessary dispatches from happening.

One technician had experienced a similar problem. The technician had used a monitoring system at one of the bigger lift manufacturers. In the system, lifts could error report themselves and request service. One problem is that when the technician

arrives on site they must tell the system, otherwise the lift will continue to report errors. Sometimes technicians forget it which leads to double dispatches, resulting in a technician going to repair a lift even though there is already another technician on site.

Consequences of more transparency

Both parties have expressed their wish for more transparency. Most POs want both the PO and the LSC to be able to see the same information. Smaller LSCs also see transparency as a potential selling point.

> "*I think that big lift companies will have problems when smaller companies get the opportunity to be more transparent, while their business seems even more closed. If we had a digital monitoring system I think it would've been even more clear, it would benefit all companies that are serious and do good. It would show in statistics directly, who actually fixes stuff. We do a good job, we know that, and we gladly show it. We have no secrets whatsoever, and I think it's in property owners' interest to keep track of their equipment and make sure that they get what they pay for. So I only see the gain from it.*"
>
> - P16 (Technician), LSC4

Information can however be misinterpreted and portray LSCs badly. For example an error might seem simple at first glance, but be very complex in reality. The PO might expect the error to be fixed quicker than possible. If the error code history for a lift manufacturing company went public it might look like the lifts from that specific company have errors all the time, even though it might be normal compared to lifts from other brands. Despite this, most LSCs are open for more transparency and showing more of their work.

> "*Well, I took over this company and I would be really uncomfortable with sharing the data with the customers, because I know that our technicians do not always do good. The data that we could show them is not really good enough, I'd say. If technician A misses a serious error and then technician B repairs it, then you probably don't want to show that A missed it. Otherwise I believe in transparency. Then if the company can't stand transparency, us in this case, because you don't do a good job, Darwin makes his point and we no longer exist.*"
>
> - P12 (CEO), LSC3

Lift service companies' need for a monitoring system

LSCs want detailed information that helps them with quicker troubleshooting, and going right on target to save time. It could also help them with sending technicians with the right competence to the right place. Another use case is for planning what spare parts could be bought along the way as well as doing more work remotely,

which could save travelling costs and reduce the environmental impact. People who work with lifts also believe that the data can help with discussions and uncertainties between parties, being used as support that shows what actually has happened.

Technicians made it clear that they want to see all data available. On the other hand they express that if they could only see very few parameters it would still be helpful. Door problems are the most common type of problem since they are used the most. Therefore door information is important.

> "*On a lift like this, you need to know if the doors are working. If you have four measuring points, you will get pretty far.*"
>
> - P9 (Project Manager), LSC1

They also found it interesting to see when and what floors lifts have been used the most, for planning where to put in extra resources. The information could also be used to plan service visits at more appropriate times, when the lift is used less.

Today, the control system of the lift continuously sends out error codes within the system, storing the latest ones locally. A majority of the error codes does not necessarily mean that something is broken, but rather information about what happens, for example a light sensor triggered a prevention from closing the doors. LSCs are interested in the error codes to get an idea of what is causing trouble. However, sometimes the last error code is not the reason for failure. Seeing the whole sequence of error history, including timestamps for each error would be helpful because some errors are difficult to identify. Especially the ones that are not present when the technician is troubleshooting on-site.

LSCs are interested in a monitoring system for proactive service in order to minimise the risk of critical failure and reduce downtime. It would help their workflow if the system could tell in advance if a part needs to be replaced or if the behaviour deviates. A monitoring system would help them do their work better, which will also be better for their customers, the POs. Even though the LCs do not repair any lifts, they help POs with planning and managing their lifts. LCs needs are similar to LSCs since they both have a lift expert's perspective and many LCs have worked as technicians at LSCs before.

Property owners' need for a monitoring system

POs see potential with a monitoring system for proactive service. Informing the technician in time so that they can fix the error before the tenant notices, is important for their customers' (tenants) satisfaction. Most POs want to have an overview of their lifts on a rather basic level. They are interested in knowing if the lifts are operating or not.

> "*The most important thing is that you can get an overview, that you see that all the lifts are moving, everything is working, then you can let it go for the moment.*"
>
> - P14 (Janitor), PO6

POs have clearly expressed that they want the system to be able to monitor all their lifts, regardless of brand and model. POs already have a lot of systems related to the property and adding another system takes time from other tasks. And learning a new system requires time and effort.

POs are interested in data that can be used for budgeting and planning their business. Many POs hire a LC for help with planning and budgeting. As mentioned previously, it is common for LCs (and some LSCs) to compile a "status list" of all lifts for a customer. The status list can include for example what errors have occurred and where, what lifts need modernisation, what it will cost, and a suggested plan for maintenance. However, compiling this kind of list is time-consuming, where the LC visits every lift on site in order to gather relevant information. LCs thinks that a lift monitoring system could reduce the amount of work required to be performed on site.

Information about when and where the lift is mostly used also indicates flows about how people move in the building. POs found it interesting since it can help them with decision-making when it comes to cleaning, and how to furnish and design the interior of the building.

POs showed interest in knowing the energy consumption from the lift, even though they did not have a clear idea what to do with the information. They said it could be used for analysing purposes, for mapping their energy consumption, and maybe even controlling their energy consumption. Another interesting parameter is to see the car load. Especially during stops since it indicates if there is a person in there. It is also interesting to see if an error occurred due to overload since it counts as damage caused by careless handling, which the PO must pay for.

5.3 Define

This section explains the activities performed during the second phase of the Design Thinking process. This phase was about defining and concretising the problems that stakeholders expressed during the previous phase. This was done by defining who are the actual users of the lift monitoring system. A list of requirements was created, stating what should be fulfilled in order to create value for users.

5.3.1 KJ Analysis

A KJ analysis was done in order to gather insights from all interviews in the same place and get an overview of the data. All interviews were transcribed and interesting quotes were highlighted. All quotes were written down on sticky-notes in Figma, with a comment about who said it and from what interview. Similar quotes were placed next to each other. As quotes were being reorganised, clusters of sticky-notes started to form. Every cluster was given a name, describing the common meaning or insight from all sticky-notes in the cluster, and not what topic was touched upon. However, at higher level of abstraction, multiple clusters were grouped together, and were given a category name that described the topic. The method was a bottom-up

process starting with the details in each quote, and analysing them to form a whole picture. It was not known beforehand what categories would be formed. Not having predefined categories promoted open-minded thinking, and reduced the risk of missing important nuances that would otherwise be diminished from being forced into a more general topic. The process was done in multiple iterations, where clusters were formed into different layers. In the end the KJ-analysis included 600 quotes with three different levels of categorisation. Figure 5.3 illustrates an example of the level distribution in the KJ analysis.

Figure 5.3: Category level distribution in the KJ analysis, with quotes for the level 3 category "Wants to be notified of errors/deviations", in level 2 category "Error codes & error codes history", in level 1 category "Data monitoring".

5.3.2 User map

Figure 5.4 shows different types of potential users that will use the lift monitoring system. It is based on a framework by Janhager, (2005). Users are categorised into four different kinds of users depending on how they interact with the product or how they are affected by it.

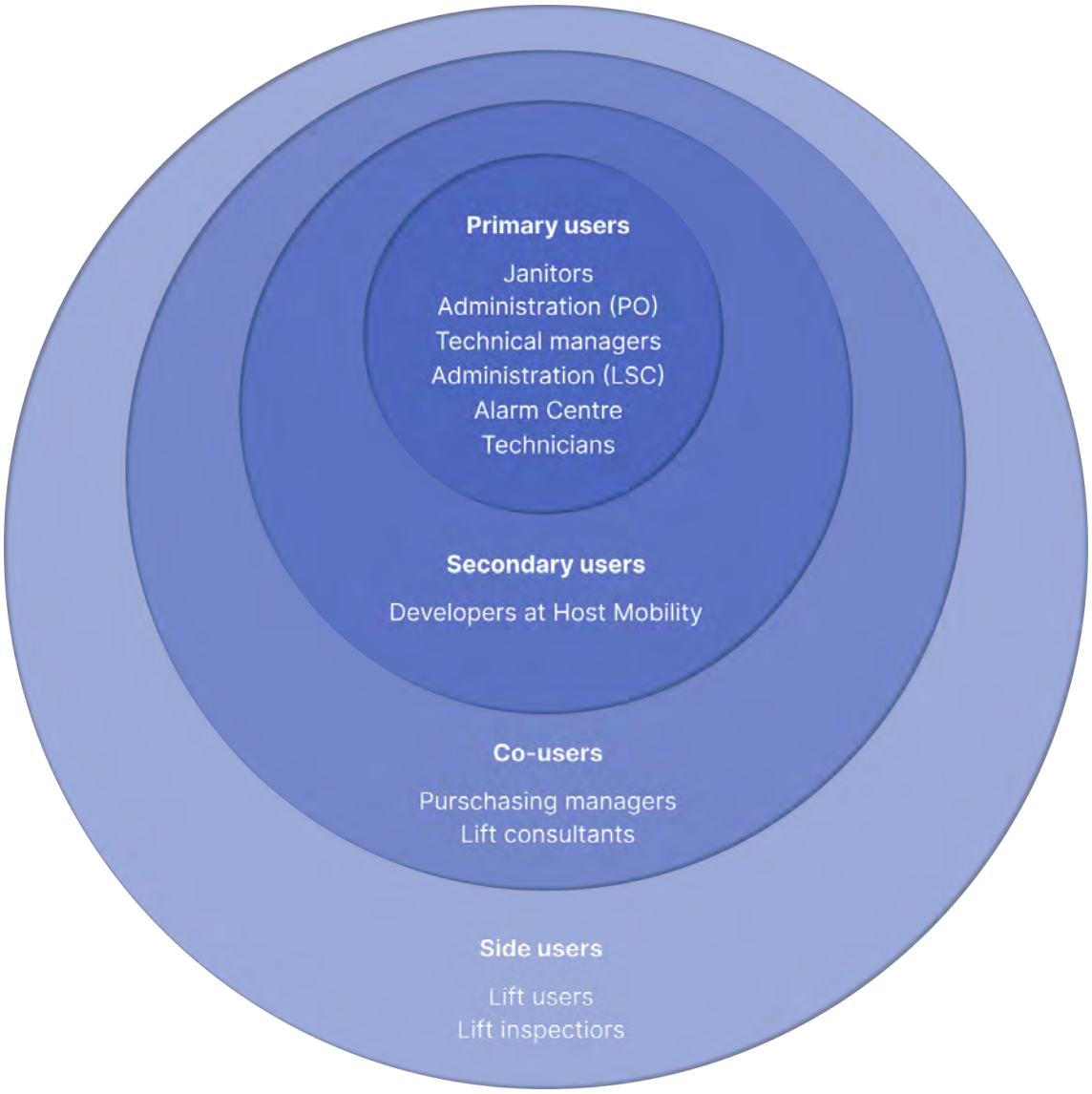


Figure 5.4: Different types of users of the monitoring system

Primary users

Interacts with the product for its main purpose. In this case the main purpose is to look up the lift status. A primary user is for example a janitor. Since the interface is web-based, the janitor could possibly look up the lift status on their mobile in order to determine if it is a small error that a janitor can fix. If not, they could call a LSC. The technician could also be a primary user. During dispatch they could look up lift information on their smartphone in order to troubleshoot quicker and plan their service.

Another example of a primary user is the administrator at the PO. They receive calls from tenants if something is wrong with the lift. In the interface they could look up the lift status on the desktop. If it is a small error, the janitor will be contacted to fix the problem. If it is a bigger error, a LSC will be contacted. The Administrator of the LSC, as well as the alarm centre are also primary users. They receive a call if

something is wrong with the lift. They could look up what kind of error it has in order to plan an eventual dispatch and send technicians with the right competences.

While technical managers are usually not interested in the real time data of the lift, they want to be able to access a summary of the history of the different lifts to be able to make the best decisions in the future based on the gathered data. This makes them primary users of the interface.

Secondary users

Interacts with the product but not for its main purpose, for example developers of the interface. They are not interested in looking at the data itself, rather provide a good service. Developers do maintenance of the system and implement changes if needed. They will also provide support if customers have any questions or something is not working as intended.

Co-users

Cooperates with other types of users and could possibly be all primary users since they inform each other about the status of the lift. Co-users can also benefit from the primary users' use of the interface. Neither LCs or purchasing managers are likely to be the main user when a monitoring system has been purchased. But they might be provided with the information from the technical manager to assist decisions in their work.

Side users

Do not interact directly with the product, but are still affected by it. For example people using the lift for transportation. They do not interact directly with the interface, but the system is affected by how they use the lift since the system collects data of lift usage.

5.3.3 List of Requirements

After the KJ analysis, a List of requirements was created in order to rephrase the insights from the KJ analysis into requirements. A table consisting of eight columns was created. The column headings were: Req. ID, Degree of importance, Category, User, Description, Solution example, Comment, and Quote English translation. One requirement was added for each row.

The Req. ID (Requirement Identity) column tells the identity of the requirement. Every requirement was given an ID, a number that makes it easier to refer and discuss it. The Degree of importance column described the importance of the requirement, ranging between D (Demand), W1 (Wish 1), W2 (Wish 2), W3 (Wish 3), and W4 (Wish 4). D is the highest degree of importance and W4 is the lowest degree of importance. A requirement was considered a Demand if it was necessary for a Minimum Viable Product. The grading of wishes was mainly based on the design team's intuition, and how many participants expressed the need. The W-requirements

were compared to each other and thoroughly discussed within the design team, and their gradings were reevaluated in further iterations.

The Category column described the topic that the requirement was about. The categories were: Accessibility, AI & Automation, Alarm & Notification, Cognitive resources, Communication between users, Data parameters, Ease of workflow, Economics & Analytics, Emotion, and Service logs. The User column described what user the requirement was directed towards. The Description column explained the requirement with a sentence or two. The Solution example column presented a few ideas of how the requirement could be fulfilled. The Comment column was made for leaving any notes about the requirement, for example regarding feasibility, purpose and potential risks.

For each requirement, a quote from the KJ-analysis expressing the need was added in order to justify the requirement, and also be able to derive where it came from. The profession of the quotee and what company they worked for were noted after each quote. Since all interviews were held in Swedish, the quotes had to be translated to English. Translation was initially done in Google Translate, and then translations were looked through by the design team in order to correct eventual mistranslations. The translations were placed in the Quote English Translation column.

Through an iterative process, insights gained from ideation, prototyping and testing were used to reshape old, and define new needs. The whole List of requirements can be seen in Appendix C, containing 78 requirements. Even though the List of requirements was a major part of the project, it had to be placed in an Appendix due to its size. A summary of the List of requirements is presented in Section 6.1. The List of requirements was later used in the test-phase to evaluate which requirements the final prototype did fulfil (see Section 5.6.2).

5.3.4 Persona and Storyboard

Personas and storyboards were created in order to empathise with an archetypical user. They are based on interviewees' profiles. Several personas were made in order to cover the different stakeholders that could possibly make use of the lift monitoring system, including technical manager, janitor, lift consultant and technician. The personas can be seen in Figures 5.5 - 5.8.

Figure 5.5: Persona, Technical manager

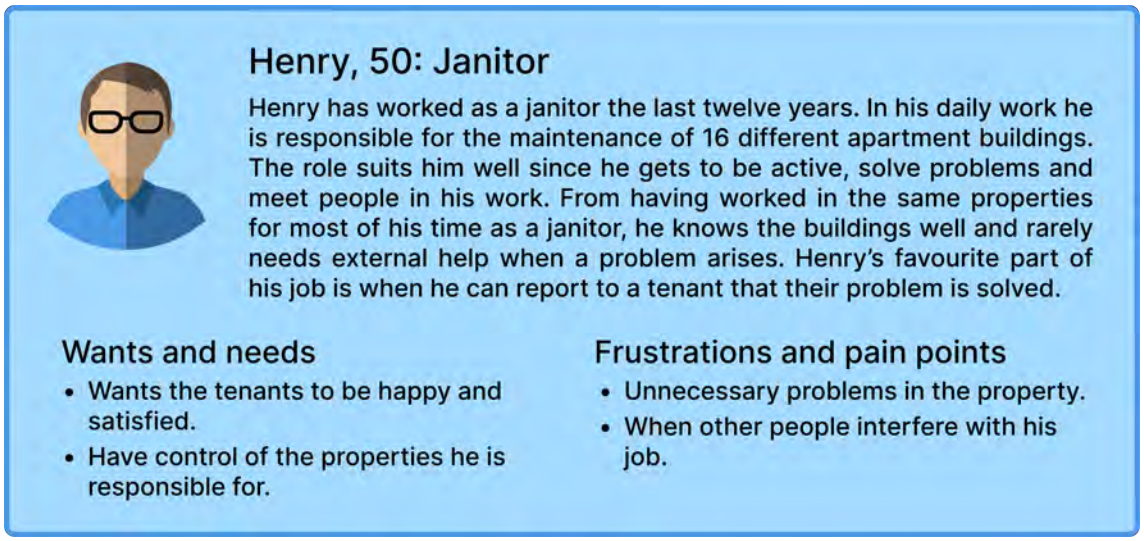


Figure 5.6: Persona, Janitor

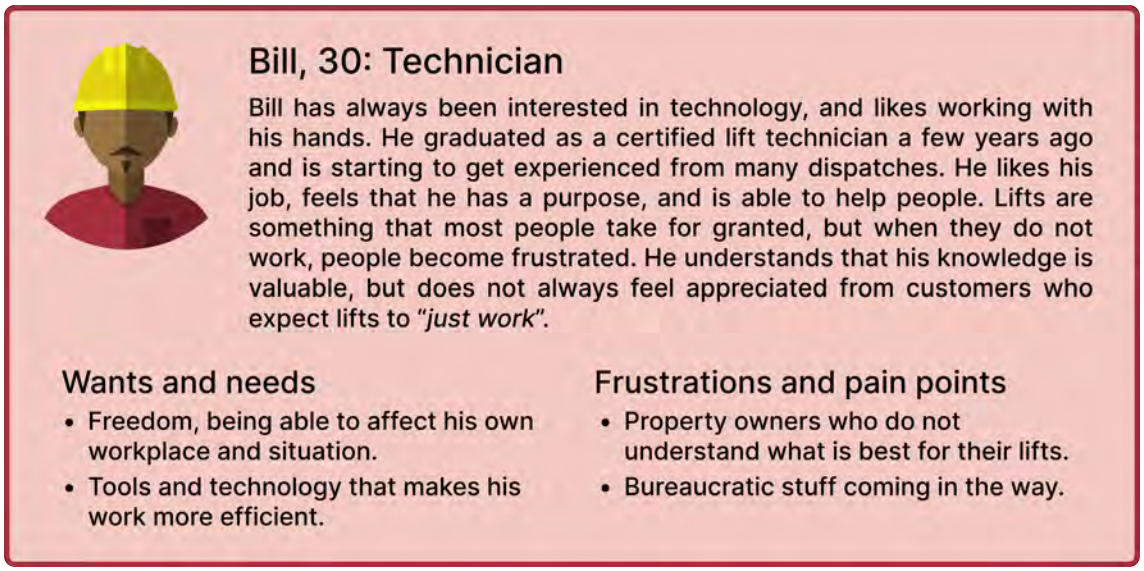


Figure 5.7: Persona, Technician

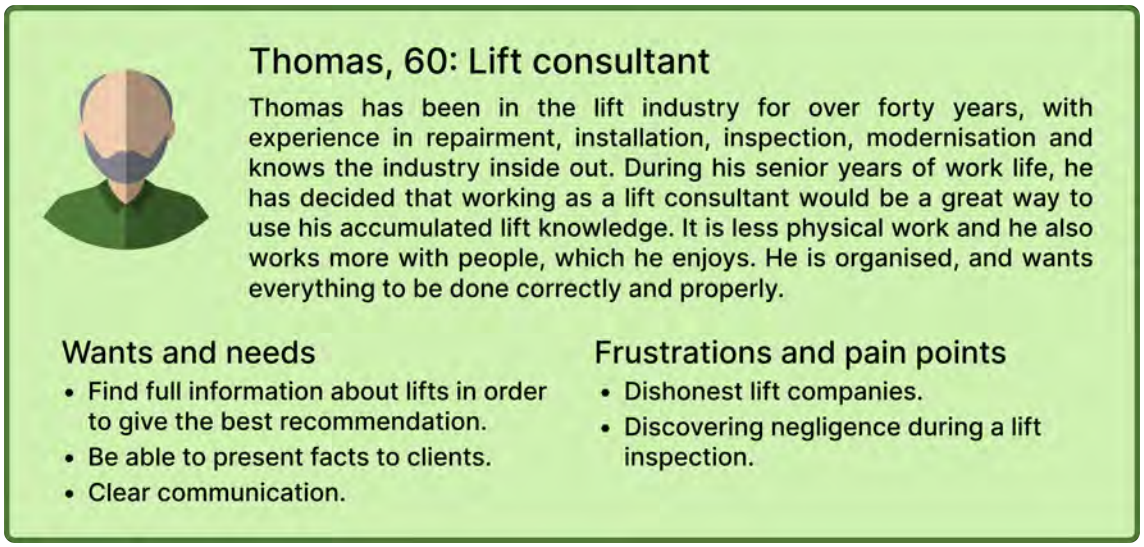
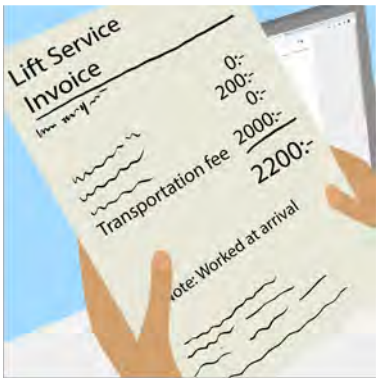


Figure 5.8: Persona, Lift consultant

Storyboards

Based on the personas, storyboards were created. All personas except the lift consultant were given their own storyboard. The reason is that lift consultants are not considered primary users, rather they work on behalf of the PO. It was seen as unlikely for a lift consultant to buy their own monitoring units. For each persona two storyboards were created. The "before-scenario" describes the current situation and the "after-scenario" describes how their situation changes after being introduced to the solution. The storyboards were used for ourselves to communicate the desired UX from the lift monitoring system. The storyboards are presented below in Figures 5.9 - 5.14.

Maria works as a technical manager for one of the biggest property owning companies in the city. The company is going to set aside a budget for next year, covering the costs from all their lifts. Maria provides support that can help them with budgeting.



She sits down to go through the invoices one by one. She notices that many of them say “Worked on arrival. Transportation fee: 2000kr”. She thinks that it is strange that there are so many invoices where the service company charges for transportation without repairing anything, and that many of the problems seem very simple to solve.

She looks at another invoice that says “Broken door belt. Purchasing and change of door belt. Test drive ok. Back in service. Three hours of work and purchase of material: 7000kr”. Maria does not really understand what it means, except that it is expensive. But her company pays anyway because the lift must work.

Was it really necessary to change the part completely? She looks at the date for the invoice. She doesn't even remember that the lift was broken at that time. Did anyone tell her? She recalls that she received an invoice but not more than that. Maria is not satisfied with their service, and contacts a lift consultant for advice. Should they change service company, or is there any way to get more control of what is going on with their lifts?

Figure 5.9: Storyboard - Technical manager before monitoring system

The company Maria works at has invested in a digital monitoring system of their lifts after their dissatisfaction with the service company and lack of control.

There they can see which lifts are working and which are out of service. It also says what part is causing an error and if it is a minor fix that Maria and her company might be able to solve by themselves.

They have decided to share it with their lift service company so that both of them can access the system. Maria has also hired a lift consultant that helps them with planning the future of their lifts. The lift consultant was also given access.

After half a year they have a review meeting together with the service company and the lift consultant. The system becomes a mediating tool that helps them speak the same language and view the lifts from the same perspective. This has increased their cooperation, and Maria feels more involved in what is going on with their lifts.

They have not got any “worked on arrival”-invoices recently because the lift service company can see in the system if it is likely that the lift is working and the door is currently blocked due to tenants moving in and out. It also turned out that “gravel in rail” could be fixed by the local janitors, which has also minimised the costs.

In the system they can generate a summary report, including what errors have occurred throughout the year and where. It turned out to be a useful tool for setting a budget, and also planning how many service visits each lift needs.

Figure 5.10: Storyboard - Technical manager after monitoring system

Bill works as a technician for one of the local lift service companies. He just finished repairing one of the most troublesome lifts in the city. Today it was just some gravel in the door rails on the entrance floor, but he also oiled the car doors while he was there since they are getting stuck frequently.

Bill suggests that modernisation is necessary for this lift because things are starting to get old and break very frequently. The property owner is not interested in a modernisation since it is too expensive. “What do you mean, the lift works just as intended?”, the property owner says.

Time for the next work order. This lift is outside of the city centre so it takes a while to get there. This time he does not even know what floor it is stuck on. So that is the first thing to check.

When he arrives he can see that something is wrong but he does not know what it is. He begins his normal troubleshooting routine, but he does not find anything.

After 5 hours the work day is over. He is frustrated that he did not manage to find what was causing the problem. He will discuss it with his colleagues tomorrow. If only the lift could give him more information...

Figure 5.11: Storyboard - Technician before monitoring system

Bill and his service company has access to a digital monitoring system that one of their clients is sharing with them. The system allows them to log in and see the status of the different lifts, and see what type of error they have.

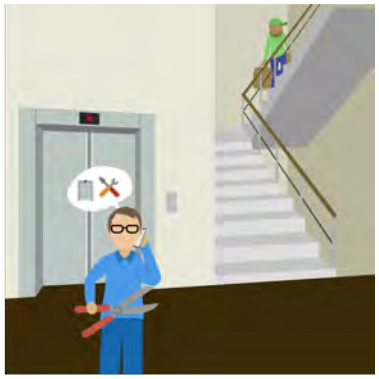
The system has helped them with quicker troubleshooting as well as shorter downtime which is very appreciated by the client. Bill is amazed by the fact that the lift can tell what part is causing error. It allows their technicians to plan what parts to buy and then go right on target.

The service company has had less arguments with the client since they got the system, and are not as mistrusted as they used to be. The monitoring system becomes a tool that helps them speak the same language and view the lifts from the same perspective.

Figure 5.12: Storyboard - Technician after monitoring system

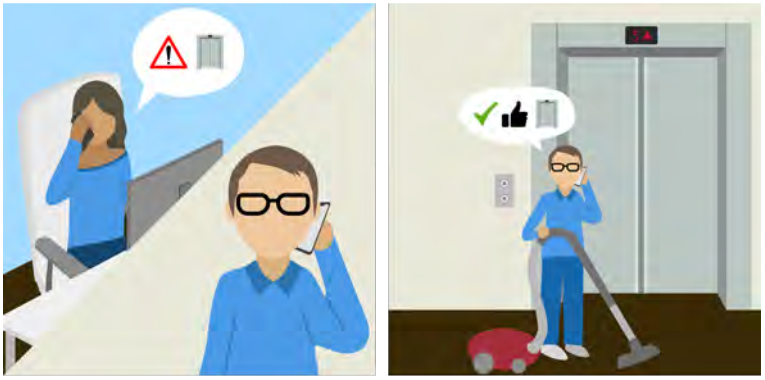
It is a sunny summer day. The janitor Henry is trimming some of the bushes outside. After a while he sees a tenant holding two bags of groceries approaching him. The tenant says: “There is a problem with the lift again. Would you mind taking a look at it?”.

Henry takes a look at it. He presses the buttons on the entrance floor and notices that the lift does not arrive. It is probably stuck somewhere. He assumes that solving it is outside of his competence.



Henry decides to call the lift service company. For the tenants’ sake it is important to repair the lift as soon as possible. He watches as the tenant struggles up the stairs to the seventh floor. The grocery bags looks at least twice as heavy as before...

Figure 5.13: Storyboard - Janitor before monitoring system



The company Henry works at has invested in a monitoring system for their lifts. He does not really understand why it is necessary but is not bothered as long as he does not have to sit still and watch a screen all day long. Suddenly he receives a phone call from the administrator. She tells him that "I can see in the monitoring system that there is a door problem with the lift at Storgatan 3B. The system suggests that we check if there is gravel in the door rails before calling an authorised service company. Would you mind having a look at it?".

Henry goes there to take a look at it. He notices that there is a lot of gravel in the entrance and also in the lift door rail. He uses a vacuum cleaner to remove it and then he presses the buttons to see if the lift is working. Voilà! Henry is happy to be able to solve the problem, and reports back to the administrator.

Figure 5.14: Storyboard - Janitor after monitoring system

5.4 Ideate

This section describes the activities performed in the third phase. This phase was about coming up with as many ideas as possible that could possibly solve the defined problems from previous phase.

5.4.1 Sketching

The ideation process began by doing paper sketches of different frames of the prototype. To find inspiration, benchmarking was done to see how existing interfaces and monitoring systems were designed. At this stage of the process, it was important to be explorative and come up with as many ideas as possible. Sketching the same screen multiple times allowed variation changes and refinements each time.

For every sketching session, the design team decided upon a motive (a screen or a function to ideate about), for example a list view that summarises status for all lifts, or a dashboard view that visualises the most important data parameters. After deciding upon the motive, the design team began with sketching individually without influence from the other. After a few minutes the sketches were discussed and analysed one at a time, identifying its strengths and weaknesses. The best parts from every sketch were brought to the next sketching iteration. After a few iterations, ideation reached saturation, a state where it was difficult to come up with new ideas. Then a new motive was chosen, and the process continued until the whole interface had been covered.

Eventually, new ideas arose at further stages of the design process which lead to sketching being a recurring method throughout the whole design process. At the end of the sketching process, the final sketches were brought to the prototype-phase. Every digitally created frame during prototyping had a corresponding paper sketch. Early paper sketches can be seen in Figures 5.15 - 5.17.

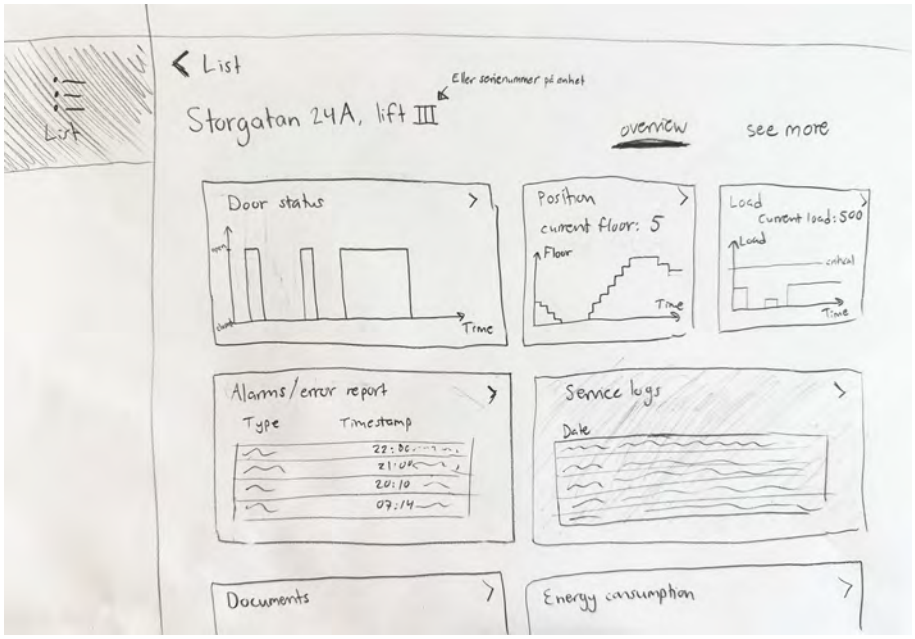


Figure 5.15: An early sketch of Dashboard.

Above an early sketch of the dashboard view can be seen, in other words the page that users see when they click on a lift. The page should visualise the most important data parameters and provide an overview of what is going on with the lift. The different parameters are summarised in containers which are ordered in a grid. This visualisation follows what dashboards usually look like. A “see more” tab was added in order to provide expert users with more detailed data.

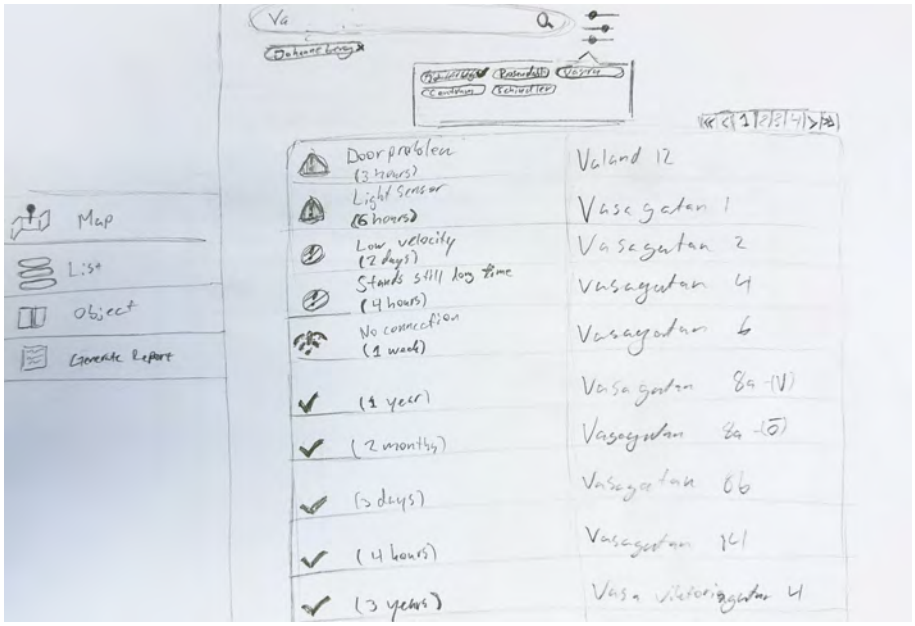


Figure 5.16: An early sketch of the Overview.

In Figure 5.16 , an early sketch of the list view can be seen. The purpose of the list view was to give a quick overview of many lifts at once. Stakeholders made it clear that the ones that are out of service are the most interesting. Lifts that are running as intended are usually uninteresting. Both LSCs and POs can have many hundred lifts. Some even have above thousands of lifts. By adding functions for sorting and filtering, the user can be shown the most relevant information.

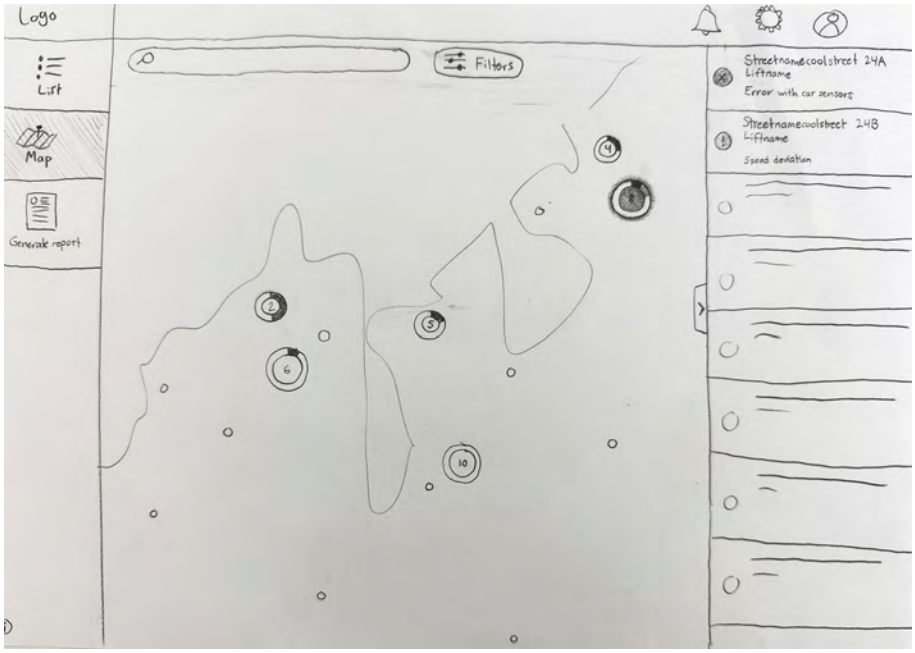


Figure 5.17: An early sketch of the Map.

Figure 5.17 shows an early sketch of the map view. The purpose of this view was to provide a geographical overview of the lifts. Both LSCs and POs said that they have different employees responsible for different geographical areas. The way of showing status, and grouping multiple items into one bigger circle was inspired by a software called Masora Cloud which was showcased at the lift fair. When clicking a circle, all the containing items are listed to the right, which was inspired by Google Maps.

5.4.2 Midjourney for inspiration

In order to spark new ideas and get new perspectives, the text-to-image generative AI Midjourney was used. It was mainly used for generating images of a particular frame, for example dashboard view. In one of the generations an empty, lo-fi version of the dashboard was created and used as an image prompt together with a text prompt. The input image can be seen in Figure 5.18 and the output images can be seen in Figure 5.19.

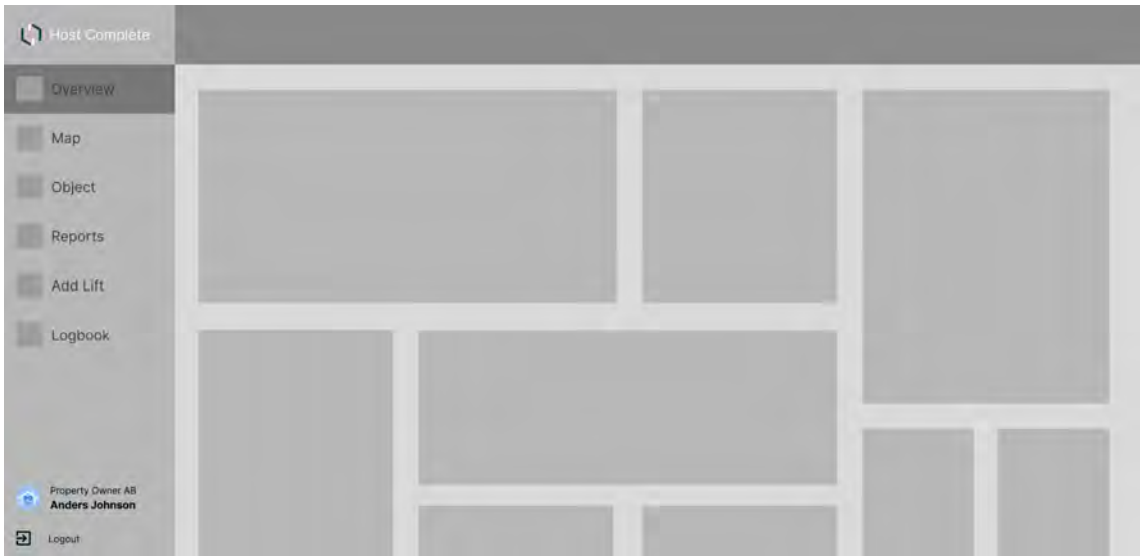


Figure 5.18: Input image for dashboard ideation with Midjourney.

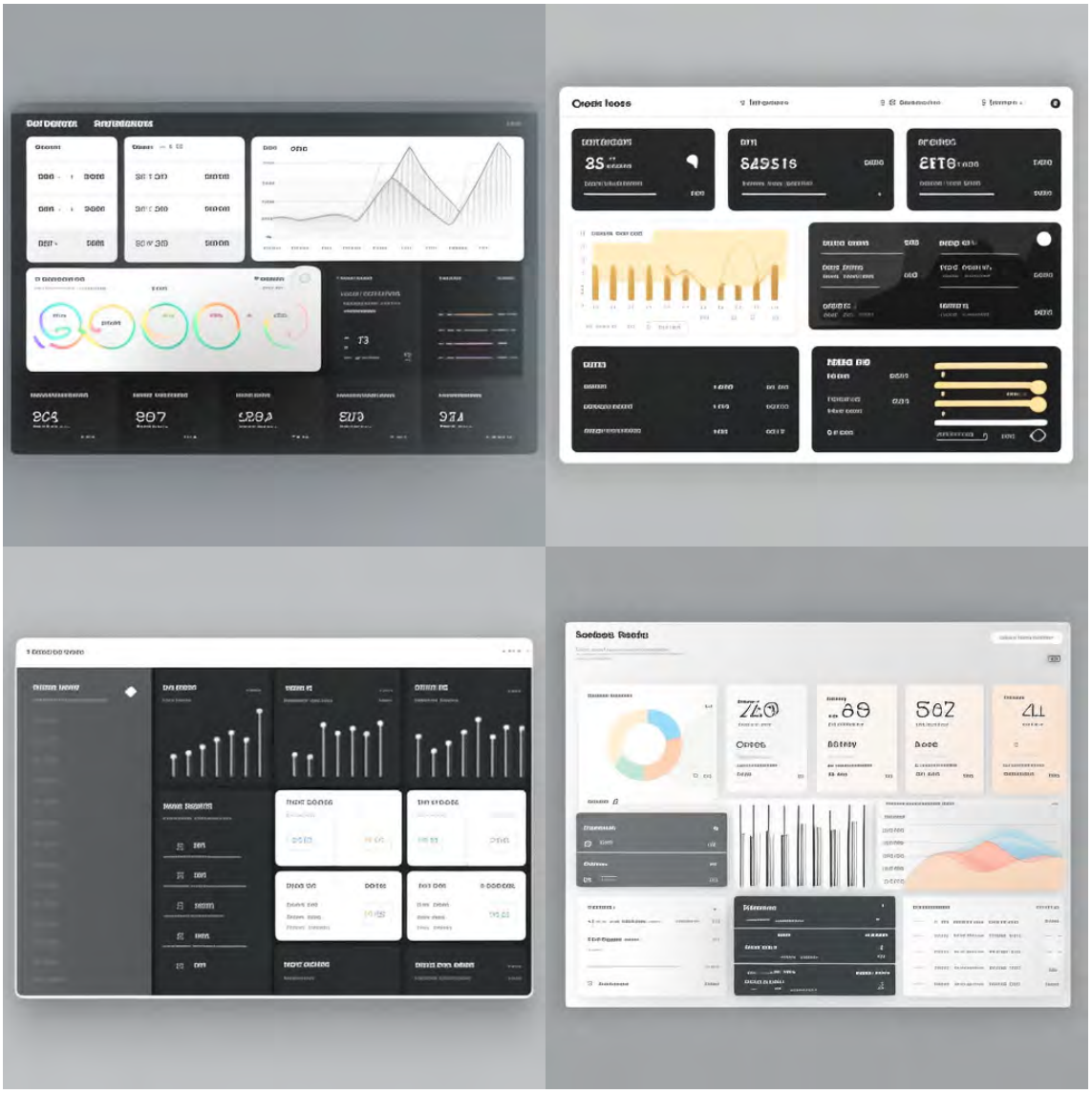


Figure 5.19: Output images of dashboard ideation with Midjourney with prompt: [url of input image] as Dribble, Figma, UX, minimalistic hq dashboard, data monitoring

Even though Midjourney was great for generating images of hi-fi screens quickly, the results were not very useful. The dashboard images were quite generic and not very applicable for a lift monitoring system, even though it gave certain inspiration. It was clear that it had been trained on images related to analytics and economics but not so much on lifts. For this project, the interface is very text-heavy where large amounts of advanced data are simplified in order to make sense for the users. Midjourney was good for creating visually appealing images but, not for creating designs that are intended to work in practice. Midjourney is not able to add communicative text to the images which is a considerable drawback.

Later Midjourney was used for inspiration when creating decorative graphics and illustrations. It was clear that Midjourney was better used for this kind of application, when there is less practical meaning involved in the image. It worked well as a base but the images had to be refined and edited in order to match the interface. The images had a tendency to be too detailed, which ended up looking rather messy. Early logotype ideas made with Midjourney can be seen in Figure 5.20.

Figure 5.20: Midjourney generated images with the prompt: Simple clean logotype, hexagon, black and white.

Midjourney was also used for generating an illustration for the home screen, based on PropTech, lifts and smart cities. Early ideas can be seen in Figure 5.21. For the final prototype an image generated by Midjourney was used for the login page. The final image can be seen in the log in screen of the final prototype in Figure G.1, Appendix G. The image was taken directly from Midjourney, and only the colours and the background were edited to better match the theme of the interface.

Figure 5.21: Midjourney generation with the prompt: playful clean proptech skyline vector art, blue –ar 3:2 –v 4 –q 2 –c 100.

5.5 Prototype

This section describes the activities performed during the fourth phase of the project. The prototype-phase was about creating, realising and giving form to the ideas from the previous phase. The aim was to create functional prototypes that could be explored, evaluated and tested in the last phase. Lo-fi prototypes were created first, and after evaluation, the best parts were refined when creating hi-fi prototypes.

5.5.1 Creation of lo-fi prototype

A lo-fi prototype of the lift monitoring interface was created in Figma. At this stage of the process, focus was on function, navigation and layout rather than aesthetics. The goal was to find proper placement of elements and components, and getting the right information in the right place. The prototype was made in greyscale with a few colours to represent status indication, for example red for error and green for okay.

It was made rough intentionally in order to steer away focus from the details. The prototype was made interactive, and included similar content as the final version because the lo-fi prototype was supposed to be evaluated through usability tests (see Section 5.6.1). It was important to do a rather extensive prototype at this stage of the process to make it easier when creating the hi-fi prototype. The lo-fi prototype was created over multiple iterations, meaning that smaller alterations were made after each usability test. Content was moved around between each iteration to test if information should be hidden, deeper in the hierarchy or visible directly as one of the main tabs. The overall layout from the last iteration was kept the same for the hi-fi prototype.

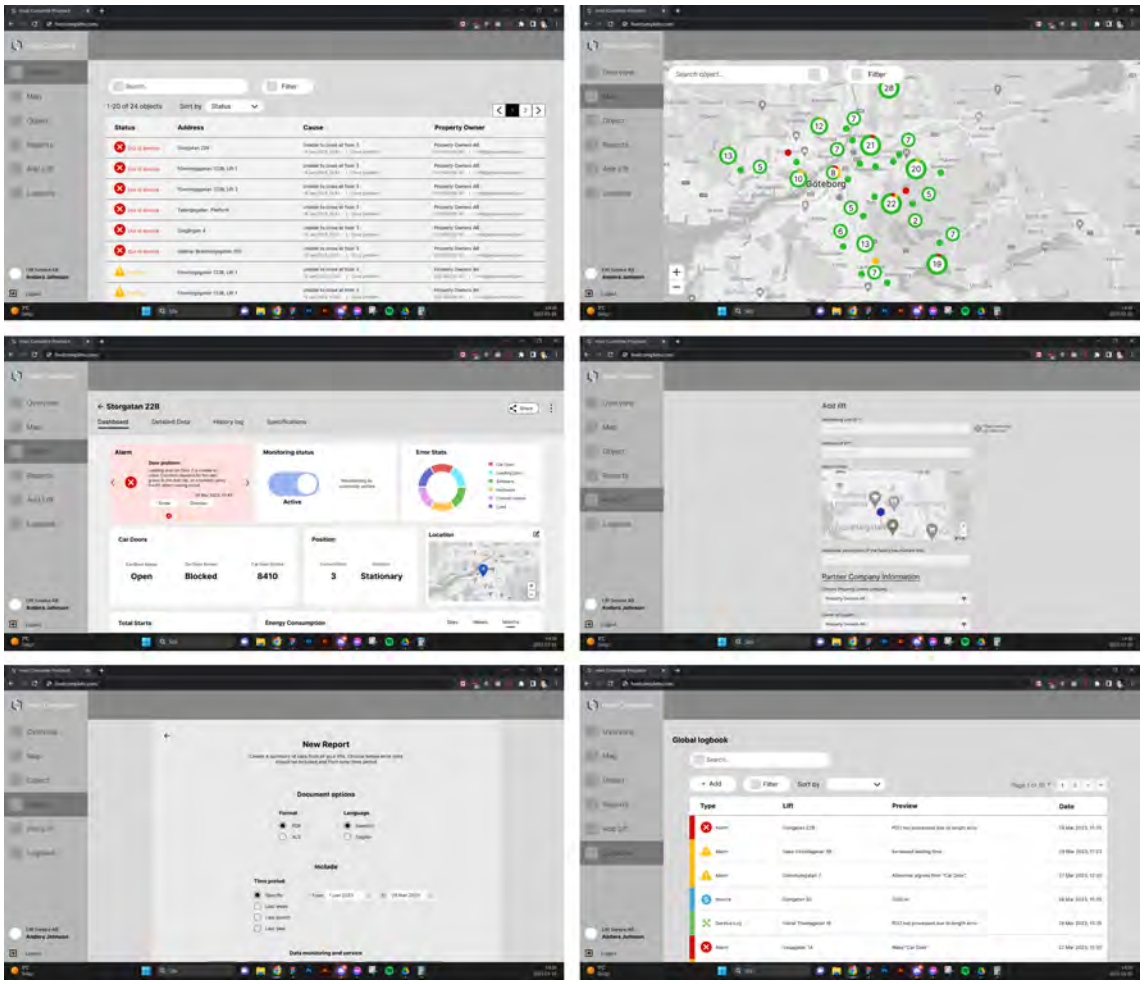


Figure 5.22: The last iteration of the lo-fi prototype.

5.5.2 Creation of hi-fi prototype

The hi-fi prototype of the lift monitoring interface was created in Figma as well. Unlike the lo-fi prototype, the purpose this time was to create a prototype that looks as close to a final product as possible. Many screens from the lo-fi prototype were used as a base when creating the hi-fi prototype, and some elements were copy/pasted from the earlier version while others were used for inspirations. The overall layout

was similar. In contrast to lo-fi prototyping, this time focus was on details, such as colours, shapes, aesthetics and typography. A design system consisting of a library of all necessary components in the right sizes and colours was created to increase consistency throughout the whole interface, see Figure 5.23.

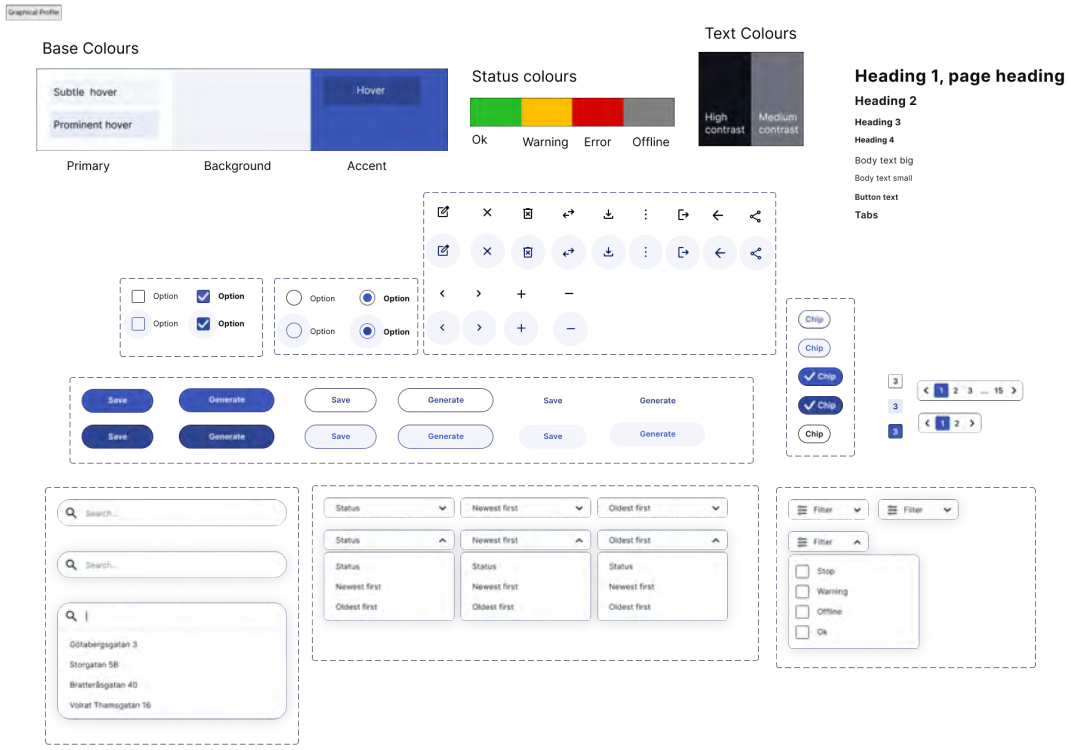


Figure 5.23: A selection of the component library used for the hi-fi prototype.

Two versions of the prototype were created. One for POs and one for LSCs. The purpose was to prepare the prototype for testing with different stakeholders. The two versions were identical except they logged in as different users. The POs logged in via a PO account and vice versa in order to make the situation as realistic as possible for the stakeholders. Some information is hidden or changed depending on who is logged in. For example the energy consumption is visualised on the dashboard view for POs but not for LSCs since the information is only relevant POs. The PO also had an extra function for transferring their lift to another LSC in case of end of service agreement, while it is not relevant for LSCs to do the opposite. A detailed presentation of the hi-fi prototype will be shown in Section 6.2.

5.6 Test

This section describes the activities performed during the last phase of the project. This phase was about testing, exploring and evaluating different prototypes in order to rule out and refine them. Formative tests were done with multiple iterations of the lo-fi prototypes, and with the final version hi-fi prototype.

5.6.1 Evaluation of lo-fi prototype

Formative evaluation over many iterations was done in order to receive qualitative feedback, refine the lo-fi prototype and make it as easy to use as possible. It was evaluated through usability tests with participants selected from convenient sampling. These tests were done with two friends, five employees at Host Mobility, and two LSC employees from LSC1 who participated in the last iteration. The employees at Host Mobility were all developers, except one person who was CEO, and were considered as secondary users. One of the LSC1 employees was a recurring participant, the project manager (P9) who had previously participated in an interview and an observation. The other LSC1 employee was CEO, having more administrative tasks. Both of the LSC1 employees were considered as primary users. Each usability test was done in person with one person at a time. The friends and employees at host mobility were asked to role play as a primary user during the test. A template of the test procedure was created in order to standardise the tests, and can be seen in Appendix D.

The procedure began with participants sitting down by a computer with the lo-fi prototype shown on the screen. Informed consent was given orally. If accepted by participants, the design team read aloud a scenario to make participants empathise with the role of a real stakeholder. Then they were asked to complete a set of tasks that were supposed to imitate real life situations. Some tasks are for example identifying what error a lift has, generating a report, changing notification settings and finding specific information in the interface. The participants were encouraged to think out loud.

During each test the design team took notes of what happened, where participants clicked and what they said. After all tasks were completed they were asked general, open-ended questions about the interface, for example what they liked and what could be improved. After each test the design team thoroughly discussed the findings and decided upon what changes to make before the next test. In total there were 4 versions of the lo-fi prototype and 9 tests. 2 tests for each iteration, except the last iteration which had 3 tests. See Table 5.2 and Table 5.4 for the results and changes of each iteration. After iteration 4, the design of the hi-fi prototype started.

Table 5.2: List over lo-fi iterations 1-2

Iteration	Participants	Insights	Changes made before next iteration
1	- Developer at Host Mobility - Interaction design student at Chalmers (friend)	- Inconvenient with two passwords required for login. - Map view does not have a search function. Difficult to find what you are looking for which leads to a lot of clicking. - The presented content on the home page feels irrelevant and repetitive. - The tab “Object” is unnecessary. - Participants do not like that they jump to the object-tab when they visit a lift-page.	- Removed the profiles during login. - Objects on the map made hoverable. - Redesign of lift page.
2	- Developer at Host Mobility - Software developer (friend)	- Unclear notification settings. Does not make sense to control how other users receive their notifications. - When generating a new report it was difficult to select chips since they were unorganised. - Tricky to find people’s contact information and it is unclear where and why oneself should write it.	- Redesign of notification settings. - Reorganisation of chips. - Clarification of contact information.

Table 5.4: List over lo-fi iterations 3-4

Iteration	Participants	Insights	Changes made before next iteration
3	- Developer at Host Mobility - CEO of Host Mobility	- Wording is long and difficult to understand - The alarms look like pop up ads that you want to remove. - When creating a new report it ends up under the tab “previous reports” even though it was just created. - The logotype should be clickable. It is common practice nowadays that you go to the home page by clicking the logotype. - Would be nice to have a global log book for all lifts.	- Change of terminology. - Redesign of alarms. - Redesign of reports-tab. - Clickable logotype for navigation to overview.
4	- Developer at Host Mobility - Project manager (P9) at LSC1 - CEO of LSC1	- Somewhat difficult to find the profile. - Having people’s contact information in the interface is unnecessary for technicians since the information is available outside of the interface. - Technicians already write service logs in their internal business system. It is inconvenient to enter the same information twice.	- Change placement of profile. - Remove the tab “object”. - Small alterations in layout and content for each page.

5.6.2 Evaluation with List of requirements

Evaluation of the final prototype was done with the List of requirement in order find out what requirements were fulfilled and not. A column named "Degree of fulfilment" was added to the table with List of requirements. For each requirement, the corresponding cell at the column was given a certain colour depending on if the hi-fi prototype fulfilled the requirement or not. Green meant 'fulfilled', yellow meant 'partly fulfilled', red meant 'not fulfilled', purple meant 'unclear' and grey meant 'out of scope'. Unclear meant that it was not possible to evaluate. A short note was added for all requirements commenting why it was fulfilled or not. The grading was based on thorough and critical discussion within the design team. In total 51 out of 78 requirements were fulfilled. Most D and W1 requirements were fulfilled while there were many W3 and W4 requirements that were not fulfilled, which can be seen in Table 5.6 below. Many W4 requirements were down-prioritised due to low degree of importance. The whole List of requirements with comments from the final evaluation can be seen in Appendix C.

Table 5.6: Requirements' degree of fulfilment

	Fulfilled	Partly fulfilled	Not fulfilled	Unclear	Out of scope	Total
D	10 (91%)	0	0	0	1	11
W1	16 (76%)	1	1	0	3	21
W2	16 (64%)	6	2	1	0	25
W3	7 (58%)	2	2	1	0	12
W4	2 (22%)	0	7	0	0	9

5.6.3 Evaluation of hi-fi prototype

A formative evaluation of the hi-fi prototype was done in order to see if stakeholders find it understandable and easy to use. It was done by usability testing two versions of the interface, one for POs and one for LSCs. The usability test was done with 4 participants, a property developer, a technical manager, a technician and a lift consultant. The former two participants tested the version for POs and the latter two tested the version for LSCs. Due to lack of participants the lift consultant was asked to take the perspective of a LSC since he had worked as a technician before. All participants were recurring, meaning they had been interviewed before. 3/4 usability tests were held online through a Zoom meeting, and one was held in the participant's own office since he expressed being uncomfortable doing the test online. None of the participants had encountered the interface before. No further iterations were made with the feedback and insights from this evaluation, due to the project approaching its end.

In Table 5.7 below every test is listed in chronological order, including participants, their occupation and what kind of company they work for. As mentioned previously, participants' occupations have been translated from Swedish to English which sometimes lack established equivalent in English, leading to direct translations.

Table 5.7: Participants for hi-fi evaluation

Test	Participant	Occupation	Company	Company orientation
T1	P1	Property developer	PO1	Student housing
T2	P7	Technical manager	PO4	Residential properties
T3	P2	Lift consultant	LC1	Lift consultancy
T4	P16	Technician	LSC4	Lift service

For the test with the hi-fi prototype, two similar templates were created depending on if the participant was working for a PO or a LSC. The tempelate of the tests with the lo-fi prototype were used as a base for these. This evaluation included both quantitative and qualitative questions.

The procedure began with participants sitting down by a computer. Informed consent was given orally. If accepted by participants, they were given a link to the hi-fi prototype which showed up on their screen when after being clicked. Participant were then asked to share their screen. One person from the design team read aloud a scenario to make participants relate to a real life situation where the system could be used. The participants began with clicking around freely and familiarising themselves with the interface for a few minutes before moving on to the tasks. When ready they were asked to complete a set of tasks that were supposed to imitate real life situations. Most tasks were the same for both stakeholders but a few of them were for POs only (P1 and P7 performed the tasks) and others were for LSCs only (P2 and P16 performed the tasks). While completing the tasks, the participants were encouraged to think out loud. The tasks and questions are described below:

Common tasks for both stakeholders

1. Find out what is wrong with a lift.
2. Find what a certain monitoring unit type means.
3. Find how many yearly service visits the system recommends for a lift and what it is based on.
4. Find out which floor the lift stops at the most, as well as which it stops at the least.
5. Find out what year the lift was built, as well as when it was last modernised.
6. Change notification settings.

Tasks specific for property owners

7. Find the energy consumption for a lift.
8. Find out what was done during the last service visit.
9. Generate a report with given properties.
10. Find out which elevator was the most expensive according to the report.
11. Transfer lifts to another lift service company.

Tasks specific for lift service companies

12. Find what error codes caused the last alarm.
13. Find out what floor the elevator last stopped at before the current stop.
14. Pause a lift from generating alarms.
15. Add a new service log.
16. Add a new lift.
17. Control the lift remotely.

The reason POs and LSCs had different tasks was to make the tasks as realistic and relevant as possible. They were assumed to use the interface in slightly different ways. Most tasks could possibly be done by both parties even though it was only listed for one of them. However, the interface was quite extensive with many functions to be tested. Another reason for divided tasks was to decrease the number of tasks that one participant had to perform in order to minimise the risk of fatigue. After each task participants had to scale from 1-10 how sure they were that the task was completed and how difficult it was.

Questions after each task

- On a scale from 1-10 where 1 is unsure and 10 is sure, how sure are you that you completed the task?

- On a scale from 1-10 where 1 is easy and 10 is difficult, how difficult was the task?

For the first question it is desirable that participants score as high as possible. For the second question it is desirable that participants score as low as possible. When all tasks had been completed they answered open-ended questions about what they thought about the navigation, what was good and bad about the interface, and if they felt that anything was missing. Then they had to scale their overall experience with the prototype through a semantic differential scale between 1-7. It was optional for participants to give a short motivation or comment for their chosen scale.

Semantic differential scale

Advanced (1) - Simple (7)
Predictable (1) - Surprising (7)
Innovative (1) - Conventional (7)
Unaesthetic (1) - Aesthetic (7)
Unreliable (1) - Reliable (7)

The semantic differential scale was followed by an open discussion about the interface where the design team answered eventual questions from participants. The whole usability test template can be seen in Appendix E for POs and Appendix F for LSCs.

6

Results

This chapter consists of three sections. The first one presents a summary of List of requirements, which was formulated to answer the first part of the research question. The second section presents the high-fidelity prototype of the lift monitoring interface, called Host Complete, designed to answer the second part of the research question. In the third section, the results from the final evaluation of Host Complete are presented.

6.1 Summary of List of requirements

While this project was done in collaboration with the company Host Mobility and their monitoring system Host Complete PropTech Lift, the different needs identified could be used for other monitoring interfaces in the lift industry. While not all, many requirements could also be used as inspiration during the development of other monitoring interfaces within the field of PropTech. The full List of requirements can be seen in detail in Appendix C. The requirements were divided into 10 different categories depending on topic. A summary of what is found in these categories is presented below:

- **Accessibility**
  The risk of unnecessarily excluding some user groups should be avoided, in order to aim for accessibility and inclusivity. For example, the system should be accessible on different types of devices, and for people with limited eyesight and colour vision.
- **AI and Automation**
  Through the use of AI, a monitoring system can provide the user with automatic functions to save time and manual work. For example, the system should interpret raw data and present it in a user-friendly manner, learn normative behaviour and identify deviations.
- **Alarm and Notification**
  The system should not require users to watch it constantly. It should send external notifications to users if alarms are triggered, and communicate their level of emergency to support decision-making. Users should be able to customise the notifications to better match their workflow.
- **Cognitive Resources**

Information should be visualised in a way that minimises users' cognitive load and guide their attention to deviations and errors. The system should provide an overview of all lifts, and an overview of the most important data parameters. But it should also be possible to view more detailed data about specific lifts and specific data parameters.

- **Communication Between Users**
  Today disagreements can arise between the property owner and the lift service companies. The monitoring system should work as a common mediating tool, supporting communication between the different stakeholders. Enabling the users to share lift data and guiding technicians to write relevant information during documentation, can assist in creating clear and transparent communication.

- **Data Parameters**
  Property owners want to get an overview without too much details, but are especially interested in seeing energy consumption and usage patterns of the lifts. Lift service companies on the other hand want to be able to see all possible parameters, but they are especially interested in information about doors and error codes. Both real-time data and historical data should be available.

- **Ease of Workflow**
  Implementation of digital systems comes with the risk of increasing administrative work, taking away valuable time from its users. The different available functions should assist workers in their current job tasks, rather than adding new ones. By gathering all lift-related information in one place, users can easily find what they are looking for. Displaying the error-code history can also help technicians to analyse current operational errors of a lift that is out of service.

- **Economics and Analytics**
  Implementing a monitoring system of lifts could be an investment to minimise the cost over time. However, it also comes with the cost of both the hardware, and software. Thus, the economic benefits of the different stakeholders should be clear. By gathering lift data, service agreements could be adjusted to suit the need for specific lifts. Allowing users to generate reports that summarise the lifts' performance can also be used to plan future preventive measures like modernisations.

- **Emotion**
  The lift industry is often described as conservative and closed by both lift service companies and property owners. Some from the different stakeholder groups are not prone to be very positive about implementing new technology, thus considerations should be made in order to respect users' worries. It is important that the system is interpreted as reliable, both in aesthetics and functions. Some technicians are worried about a monitoring system overstepping the boundaries of their integrity, therefore it is important to avoid monitoring specific individual workers.

- **Service Logs**
  It is common for property owners to feel uninformed about service and

dispatches of their lifts. Through a monitoring system shared between the different stakeholders, complete documentation about lift-related work should be accessible to all users to mitigate this feeling.

6.2 Host Complete

In this section the screens of the hi-fi prototype of Host Complete is presented. Design choices are motivated through usability guidelines (1-12) from Section 3.7, and the List of requirements concluded in the define-phase, see Appendix C. The application was renamed to "Host Complete" instead of "Host Complete PropTech Lift" since the design team preferred a shorter version of the original name, while still representing the main company Host Mobility.

Two different versions of the prototype were created, one for the view of LSCs, and one for POs. The two different versions are very similar, with only a few functions available for one stakeholder that do not exist for the other. The screens presented in the section below are of the version presented for the POs.

Links to the final prototypes can be found here:
Property Owners - `https://shorturl.at/amuvN`
Lift Service Companies - `https://shorturl.at/nqvwR`

Two types of monitoring units are used in Host Complete, CANopen-Lift based monitoring for lifts using the open protocol CANopen-Lift (see Section 3.4), and relay-based monitoring for lifts with control systems using other protocols. The benefits of CANopen-Lift monitoring is that the monitoring unit accesses all data available to the control system, which in turn leads to more advanced data that the system can use for analysis, and technicians use during troubleshooting. According to *Requirement 26. 'Display all information available from the data monitoring unit interpretable for a professional technician'*, all data that can be gathered should be available in the interface.

While technicians wanted as much information as possible, they meant that a lot could be achieved from a few data points. As only a small portion of the lift market uses CANopen-Lift currently, the relay-based monitoring system was introduced. One of the most important aspects of having a lift monitoring system is that it can include all lifts, expressed in *Requirement 4. 'Gather monitoring for all lifts at the same place, regardless of brand, type, age and control system'*. Because of this, the relay-based monitoring system was introduced. By having a monitoring unit measure the current through the circuits of the relays, all types of lifts can be monitored.

In the interface, a lift can have one of four different statuses: Stop, Warning, Offline and Ok, see Figure 6.1. This gives the user an immediate understanding of the lift's status according to *Requirement 34. 'Display different degrees of importance of an alarm by grading it'*. The different symbols and names aims to be clear and easily interpretable according to *Guideline 8. 'Use of metaphors to inform about status and incidents'*.

Stop: The lift has stopped and is out of service. It can be problems that a janitor

can solve, like removing gravel in the door rail, while it can also be a more complex problem that takes multiple hours for a technician to troubleshoot.

Warning: The lift shows deviating behaviour but is still in service. The purpose of this alarm type is to encourage proactive service, which lets users act before a critical failure occurs. It relates to *Requirement 58. 'Learn the normal behaviour of a lift over time and send out notifications when something is off'*, and *Requirement 16. 'Encourage proactive service'*.

Offline: The lift has lost connection to the monitoring unit, therefore no data can be collected.

Ok: No problems have been detected by the monitoring system and the lift is running as intended.

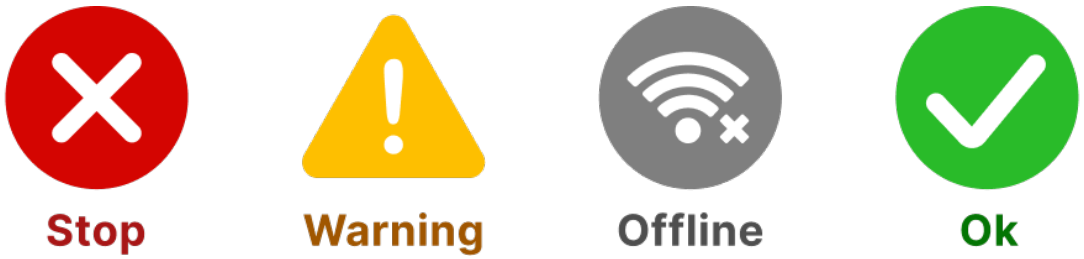


Figure 6.1: The four different lift statuses found in Host Complete.

In sections 6.1.1 - 6.1.10 screens from the interface are displayed. Additional screens of the interface, such as login page and pages in deeper hierarchy can be seen in Appendix G.

6.2.1 Overview

When logged in, users are immediately presented with a list of all their lifts. By default the list is filtered by status, with the most critical ones at the top. Stakeholders made it clear that getting an overview of which lifts are out of service, and which are working is the most valuable information. It fulfils *Requirement 18. 'Give an overview of most emergent lifts'*. The different states, Stop, Warning, Offline and Ok, are differentiated by *Guideline 2. 'Colours representing the state of elements'* The search bar allows for *Guideline 3. 'Finding specific information in a large set of data'*. The overview can be seen in Figure 6.2.

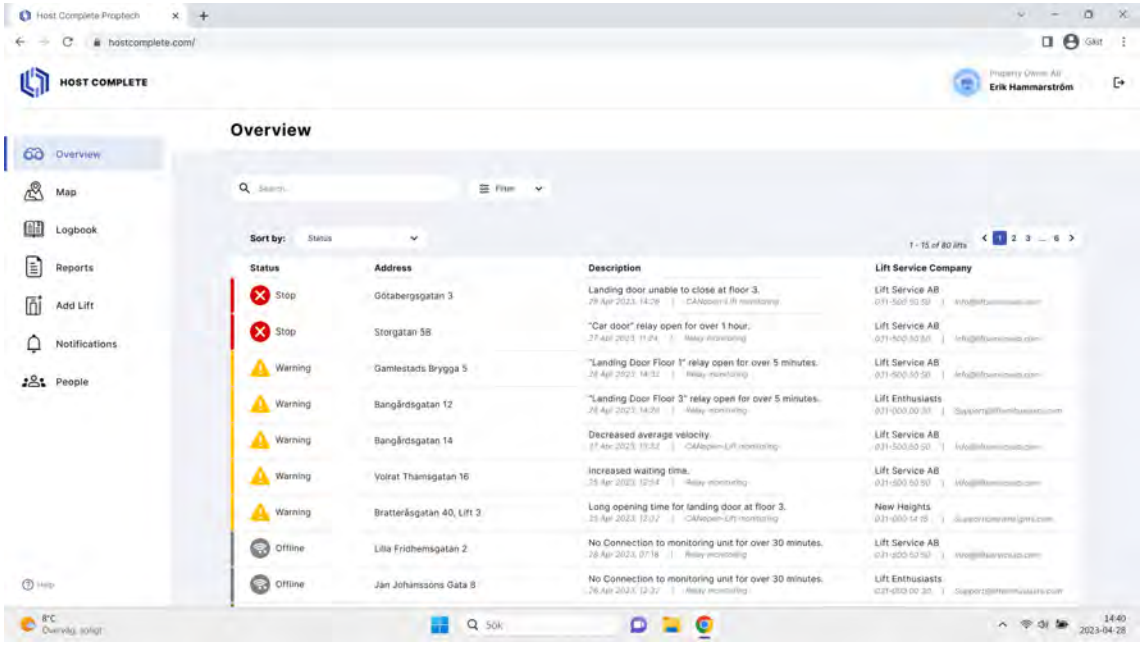


Figure 6.2: Host Complete - Overview

6.2.2 Map

The map view presents an overview of all lifts, where they are geographically located, and their status. Both stakeholders said that they can have many hundred lifts and a map view can quickly look cluttered. To prevent information overload, nearby objects are combined into a bigger circle. The number inside the circle tells how many individual lifts are geographically located within or nearby the circle. It is possible to filter by status, to choose which lifts are displayed. When clicking on a circle, a list with its individual lifts appears to the right. It also gives a quick explanation of what part is causing an error, and since when. The map view can be seen in Figure 6.3.

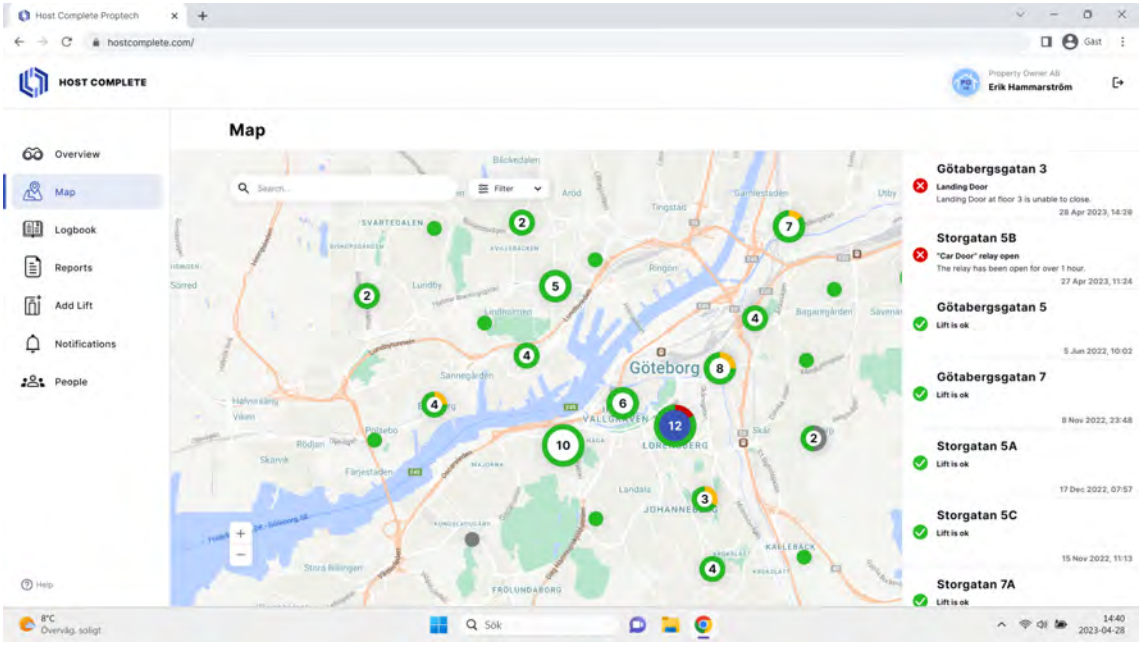


Figure 6.3: Host Complete - Map view.

For the map view, *Requirement 37. 'Give overview of geographic locations for lifts'* has been taken into account. Both LSCs and POs divide their companies into areas, where employees are responsible for different geographical areas. It suggests that a map view is sometimes preferred over a list view. While hovering a circle, a summary list showing what lifts that are not working is shown. For this, *Guideline 6. 'Present summary before going deeper'* was taken into account. See Figure 6.4.

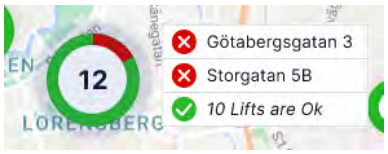


Figure 6.4: Host Complete - Hovering on a circle on the map.

6.2.3 Logbook

The Logbook summarises alarms, invoices, service logs and inspection logs in one place. There is a Logbook on a global level, containing all lifts. See Figure 6.5. But each lift also has its own, local logbook which holds logs regarding that particular lift. The logbook is a solution for gathering lift-related information in one place. It is possible to filter by type if a user only wants to see invoices for example.

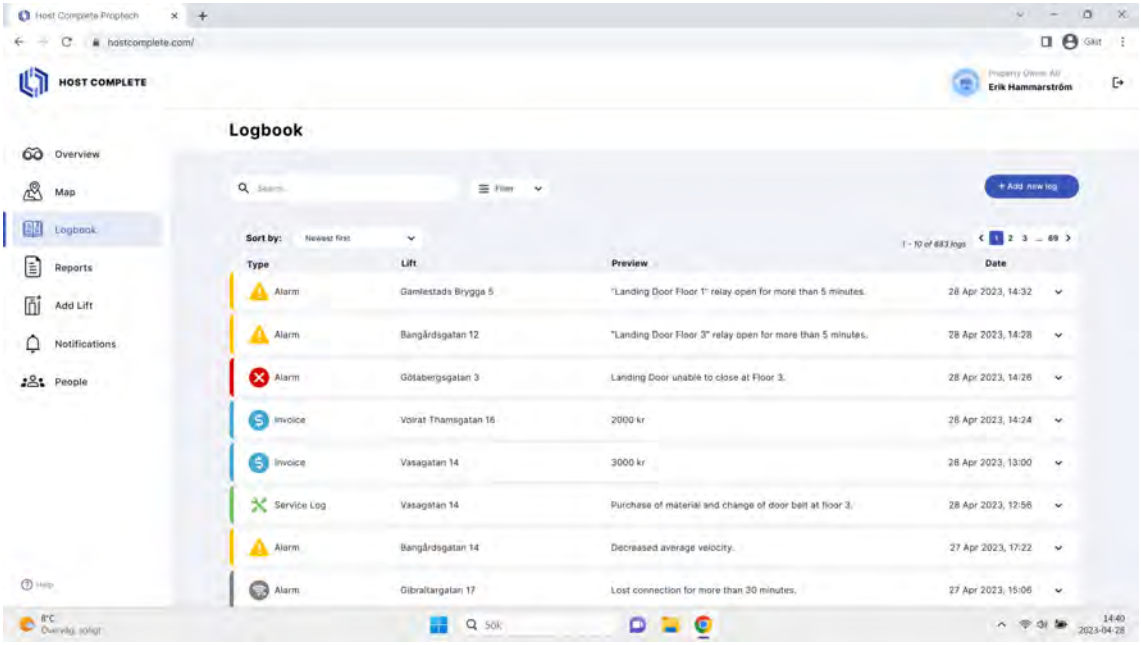


Figure 6.5: Host Complete - Logbook

The logs show what type they are, what lift they are regarding, a preview on the available information, and when the log was added. By clicking a log, it expands and more information is displayed according to *Guideline 6. 'Present summary before going deeper'*, see Figure G.3 in Appendix G.

The process of adding a service log is designed to fulfil *Requirement 38. 'Promote users to write relevant and appropriate amount of information during documentation'*. By adding relevant labels, descriptive placeholder text and character counter, the user is encouraged to write relevant information, according to *Guideline 10. 'Explanatory text for filling in fields'*, see Figure G.4 in Appendix G. Since many POs think that the amount of information received after service is not enough, *Requirement 54. 'Enable complete information about a specific dispatch/service'* was considered by giving the stakeholders a shared location of service logs.

6.2.4 Reports

As described in section 5.2.3, many POs are interested in receiving status lists over all their lifts. The status list can include for example what errors have occurred and where, what lifts need modernisation, what it will cost, and a suggested plan for maintenance. They are most often created by LCs, but are time-consuming to create since every lift has to be visited on-site in order to gather its information.

In Host Complete such lists can be automatically generated by anyone in the Reports-page. When entering the page a list of previously generated reports is shown, including date, file properties and content, see Figure 6.6. This function was implemented in order to fulfil *Requirement 30 'Generate lists/reports of status in order to summarise events'.*

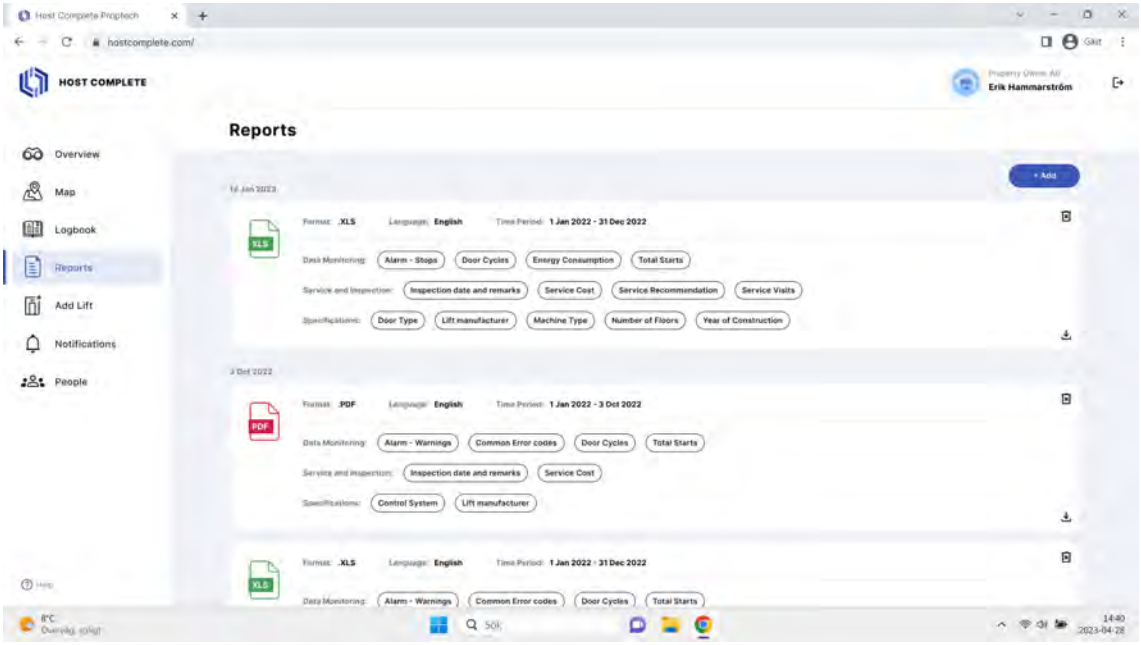


Figure 6.6: Host Complete - Reports.

When adding a new report, it is possible to select document settings such as file format and language. It is possible to choose what lifts should be included and from what time period. There is a variety of different chips to select from depending on what properties, specifications or data parameters that the user wishes to include in the report, see Figure 6.7.

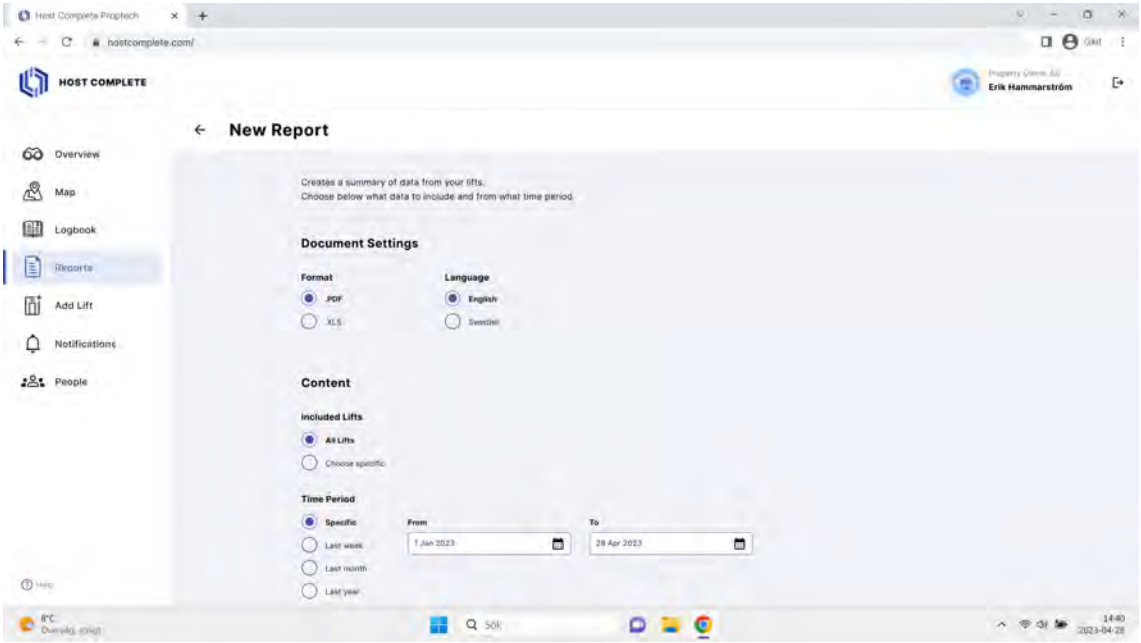


Figure 6.7: Host Complete - Creating a new report.

The reports are saved online in the interface and can be previewed in a separate tab and downloaded locally on users' computers. An example of a generated report can be seen in Figure G.5 in Appendix G.

6.2.5 Add Lift

Lifts are added to the system by entering the monitoring unit ID (serial number). Users can point out where the lift is located on the map if the address does not exist in the map. This is relevant for new constructions where it can take a while until the address is visible on google maps or apple maps for example. Users also enter who is the PO and who is the LSC. The listed companies will both have access to the lift's data. It is important that the right companies have access to the right lifts even though the monitoring unit is swapped to another lift or the PO changes to another LSC. Both *Requirement 3. 'Enable the possibility to swap the data monitoring unit to another lift'* and *Requirement 1. 'Allow the change of LSC while maintaining data gathering'* has been taken into account. The page for adding a new lift can be seen in Figure 6.8.

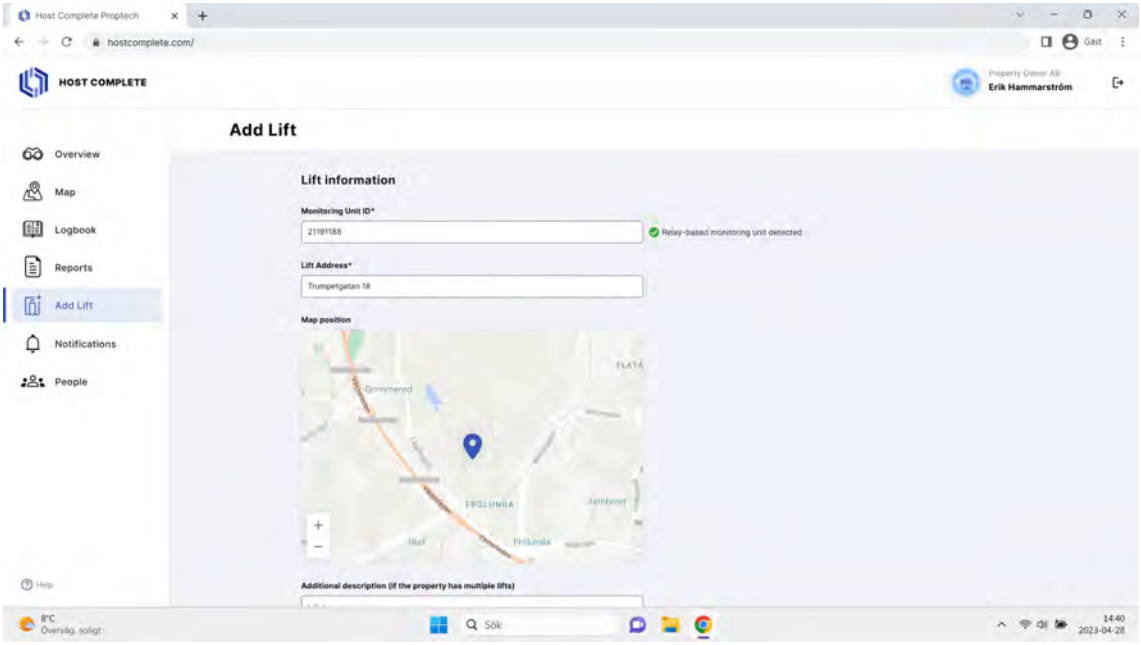


Figure 6.8: Host Complete - Add Lift.

After a new lift has been added to Host Complete, the system detects if the monitoring unit type is CAN-open Lift or relay-based. If relay-based, the user is redirected to a page where the relays are defined. The page for defining the relays can be seen in Figure 6.9.

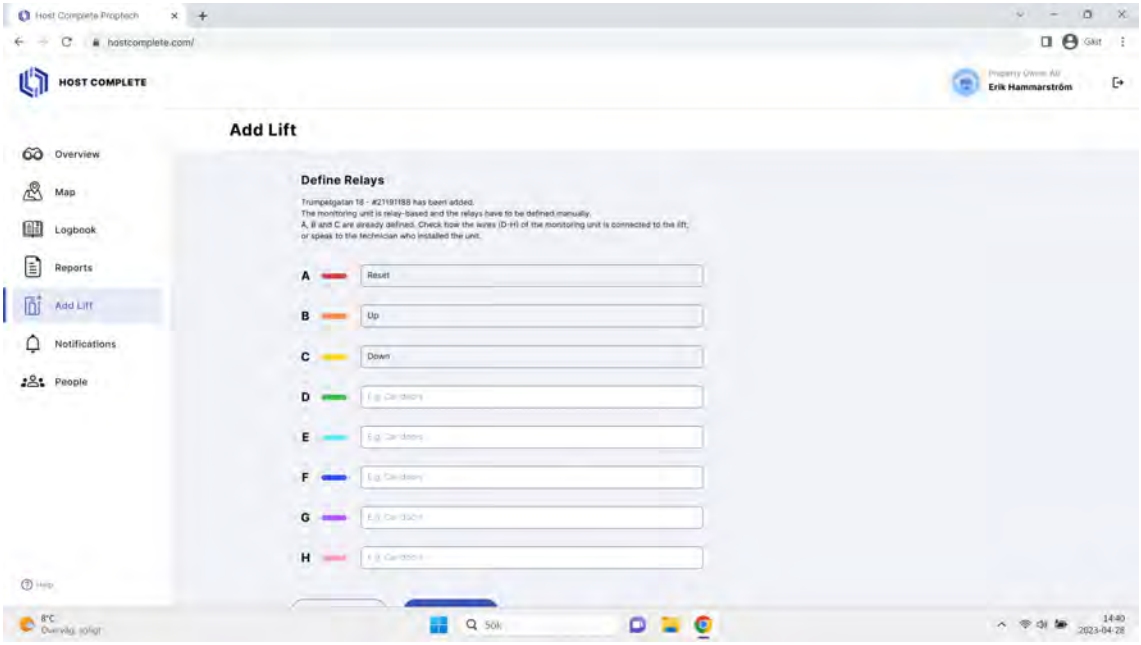


Figure 6.9: Host Complete - Define relays.

6.2.6 Notifications

Users can choose to receive notifications through e-mail or SMS, which fulfils *Requirement 6. 'Possibility to be informed about errors outside of the interface'*. On this page it is possible to change settings for notifications, which fulfils *Requirement 7. 'Possibility to change settings for notifications'*. Users can adjust notifications so that they become as helpful as possible, minimising the risk of spam. They can choose to turn on/off a certain type of alarm or turn off notifications completely for specific lifts. It is also possible to be notified when the lift is back in service. The user can enter what email and phone number the notification should be sent to. The notifications page can be seen in Figure 6.10.

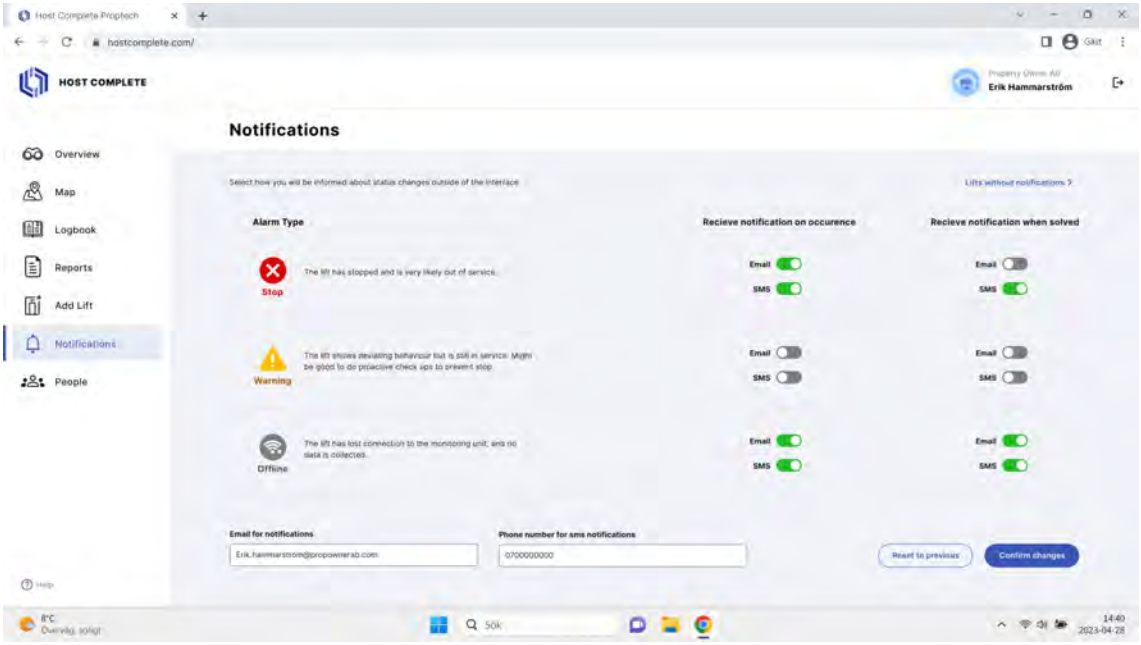


Figure 6.10: Host Complete - Notifications.

6.2.7 People

On the page "People" (Figure 6.11) it is possible to see companies, including partner companies and the logged in user's company. Under the first tab "Lift Service Companies" users can see what lifts are shared with whom, as well as contact information to the company or specific employees. POs can transfer their lifts to another company in case they switch to a new LSC, see Figure G.8 in Appendix G.

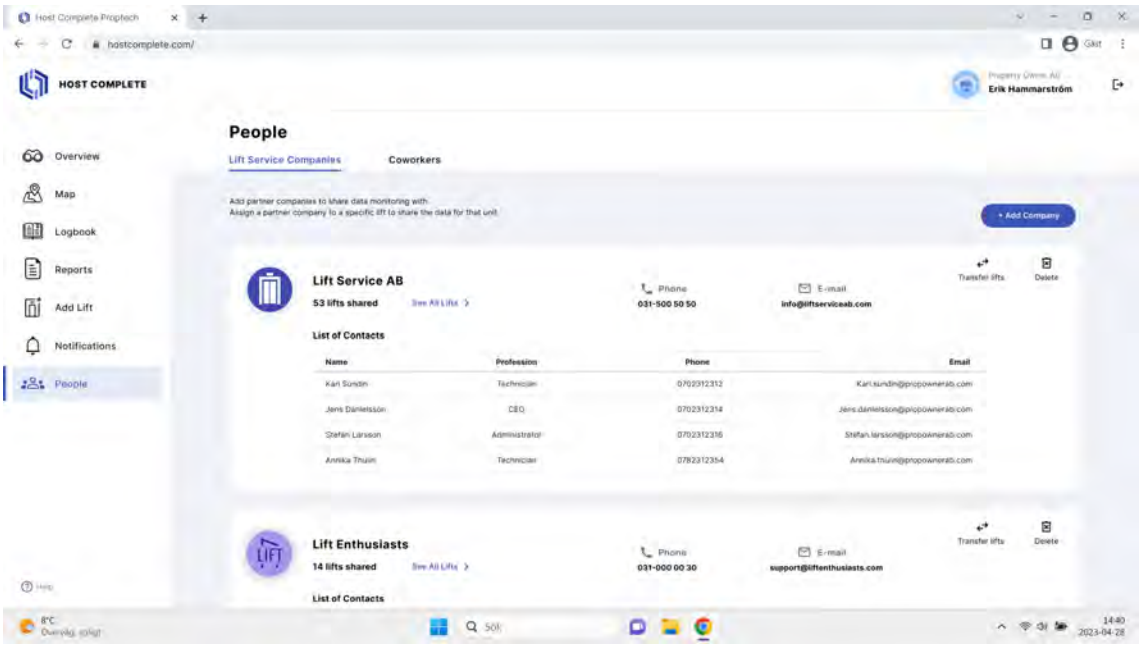


Figure 6.11: Host Complete - People.

Under the second tab "Coworkers" there is information about the logged in user's company and the coworkers. The page can be seen in Figure G.9 Appendix G.

6.2.8 Lift page: CANopen-Lift

Users can navigate to a lift-page through clicking on a specific lift either in the overview, or the map view. As the data monitoring units differ in the type of data collected, there are some differences between the lift pages of CANopen-Lift devices and relay-based devices, as described in Sections 3.4 and 3.3. Common for both lift-pages is that they both have four tabs, where three are the same. "Dashboard", "Local Logbook" and "Specifications" are the same for both. The other tab is called "Detailed Data" for CANopen-Lift devices and "Relay History" for relay-based devices. The dashboard for CANopen-Lift can be seen in Figure 6.12.

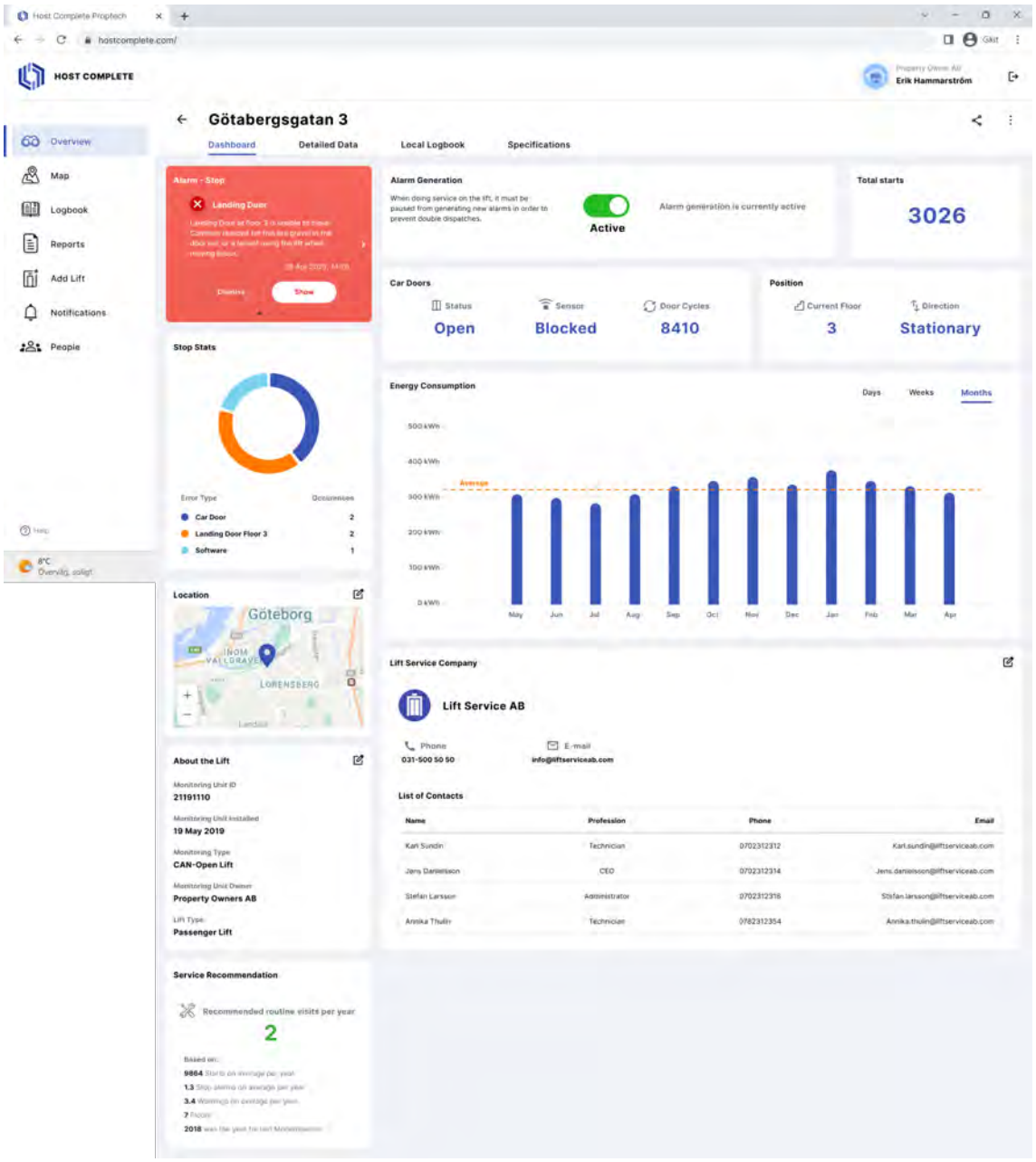


Figure 6.12: Host Complete - CANopen-Lift dashboard.

When navigating to a lift page, the first thing a user sees is the dashboard according to *Requirement 8. 'Give an overview of the most important data parameters for a lift'*. The most relevant information has been designed to be presented further up on the page so that it becomes more easily accessible, for example door information, according to *Requirement 25. 'Prioritise information about doors since door problems are the most common type of error'*. Dynamic values are blue, which shows real time status and data.

In the upper left corner the status indicator can be found. It draws the users attention through it´s placement and colour. Depending on the status of the lift, the colour changes, following *Guideline 2. 'Colours representing the state of elements'*.

The text conveys when the alarm happened, according to *Requirement 11. 'Show operation status. If it is currently out of service, it should tell since when'* and a short description of the problem according to *Guideline 6. 'Present summary before going deeper'*. The show button enables the user to get a more detailed description of the current problem. An example of status information can be seen in Figure 6.13.

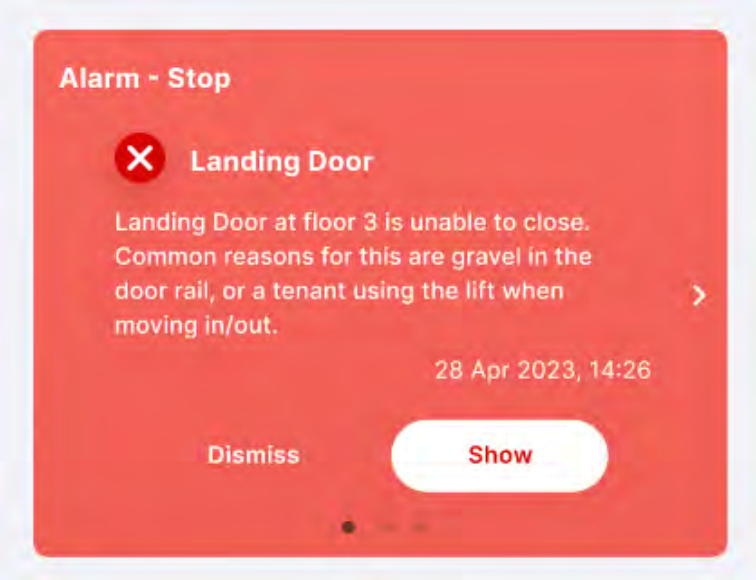


Figure 6.13: Host Complete - Dashboard, status indicator.

A switch for pausing alarm generation was added, according to *Requirement 13. 'Avoid sending an error when a technician is doing lift service'*. By default, no alarms will be generated for the next four hours, but it is possible to increase or decrease the timer countdown if the service takes longer or shorter than expected. The alarm generation switch can be seen in Figure 6.14.

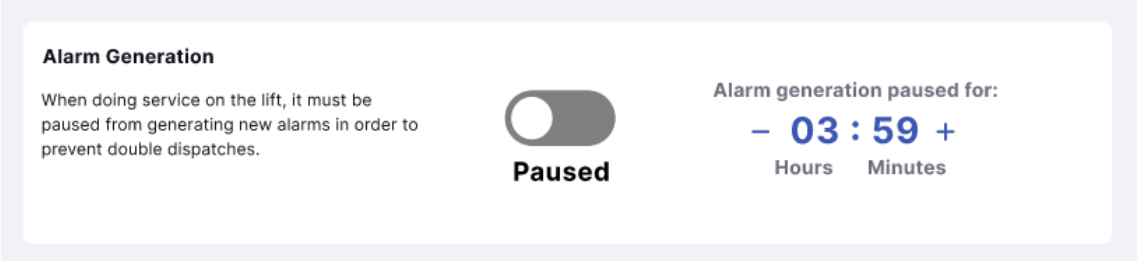


Figure 6.14: Host Complete - Dashboard, alarm generation switch.

"Stop Stats" displays the distribution of the error types that have caused the lift to stop since installation according to *Requirement 51. 'Communicate the distribution/statistics of what errors have caused a stop/dispatch and how many'*. This gives the user the ability to quickly see if a problem is recurring. Stop stats can be seen in Figure 6.15.

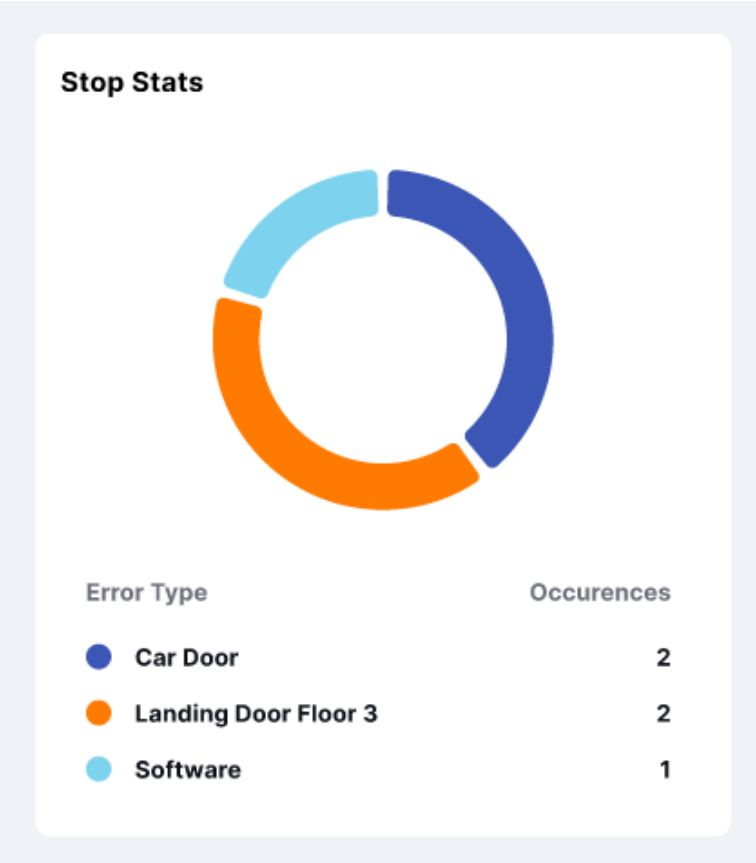


Figure 6.15: Host Complete - Dashboard, Stop Stats.

As the POs expressed big interest in viewing the energy consumption during the interviews, resulting in *Requirement 43. 'Visualise energy and power consumption of lift'*, it was chosen to be displayed directly on the dashboard. Through hovering over a specific bar, the chosen value and the average of the time period is displayed according to *Guideline 4. 'Obtaining detailed information with the mouse pointer'*.

During the interviews, participants expressed that personal contact with partner companies was important to them, as well as being worried over the potential of a monitoring system eventually damaging this aspect. This resulted in the contacts of the partner company being displayed directly on the lift page, following *Requirement 62. 'Encourage human contact'*.

Information regarding the lift and its monitoring type can be found under "About the lift". By clicking on the monitoring type, more information will be displayed according to *Requirement 45. 'Communicate to what level of detail the information is presented, depending on the type of monitoring unit'*.

One of the economic incentives to monitor lifts would be to customise the service agreement so that all service visits are distributed depending on the need of every lift. A recommendation of annual routine service visits was given according to *Requirement 67. 'Give a recommendation of how many service visits a lift needs based on historical error and usage statistics'*. See Figure 6.16.

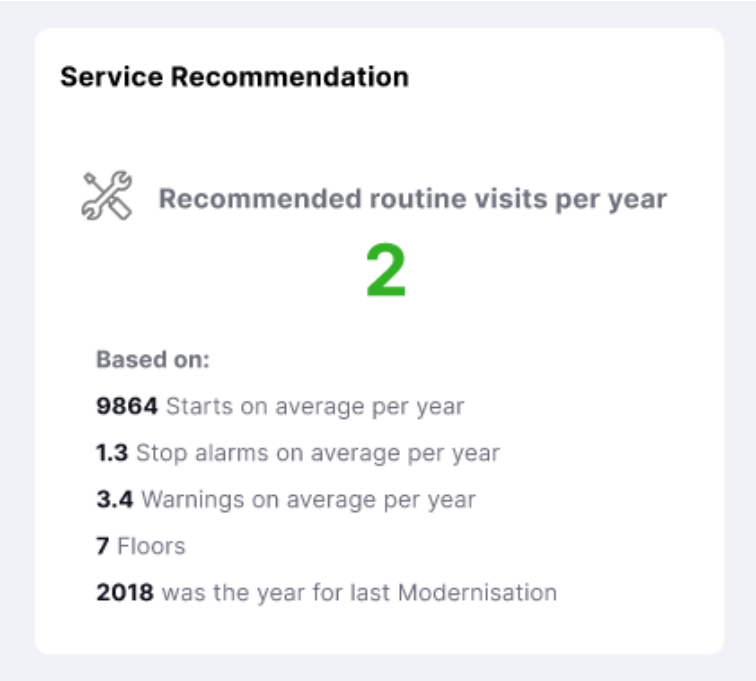


Figure 6.16: Host Complete - Dashboard, Service Recommendation.

As CANopen-Lift monitoring allows for many different data parameters to be gathered and analysed, displaying all different parameters on the lift page's dashboard would have resulted in an unreasonably large page that would have been difficult to navigate through. As *Requirement 26. 'Display all information available from the data monitoring unit interpretable for a professional technician'* highlights however, technicians are interested in having all data available in their work of troubleshooting a lift. To follow the *Requirement 28. 'Present a moderate amount of information to avoid overloading cognitive abilities of users'*, the tab "Detailed Data" was created to allow the user to access all data in a more manageable way. All data parameters that could possibly be monitored are gathered here.

In technicians' workflow of repairing a lift, the access to recent error codes is a valuable tool. In Figure 6.17, the data parameter of "Error Code History" can be seen. This view provides a log of when error codes, displayed together with the most common error codes during all time, compared to a chosen time period. As many of the displayed error codes might be irrelevant during troubleshooting of a specific problem, the filter function allows the user to limit what categories and error codes are displayed. The error codes are also translated into a concrete description of what they mean, to ease the work of the technician.

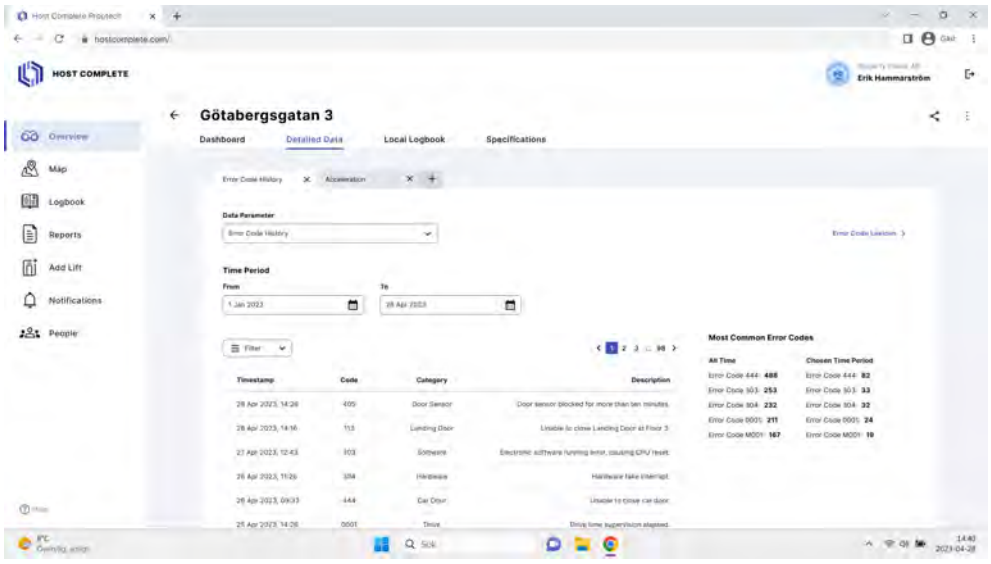


Figure 6.17: Host Complete - Detailed Data, Error Code History.

Under the tab "Local Logbook" the page is similar to the global logbook presented in section 6.1.4, but only includes logs for the specific lift. The local logbook can be seen in Figure G.2 in Appendix G.

In "Specifications", technical information about the lift can be added according to *Requirement 65. 'Communicate up-to-date technical information about a lift'*. Technicians can choose to fill in those fields that they find relevant for the specific lifts. Important documents about the lift such as the documentation about installation, modernisation and electrical circuits can be uploaded on this page as well according to *Requirement 42. 'Enable possibility to upload relevant documents'*.

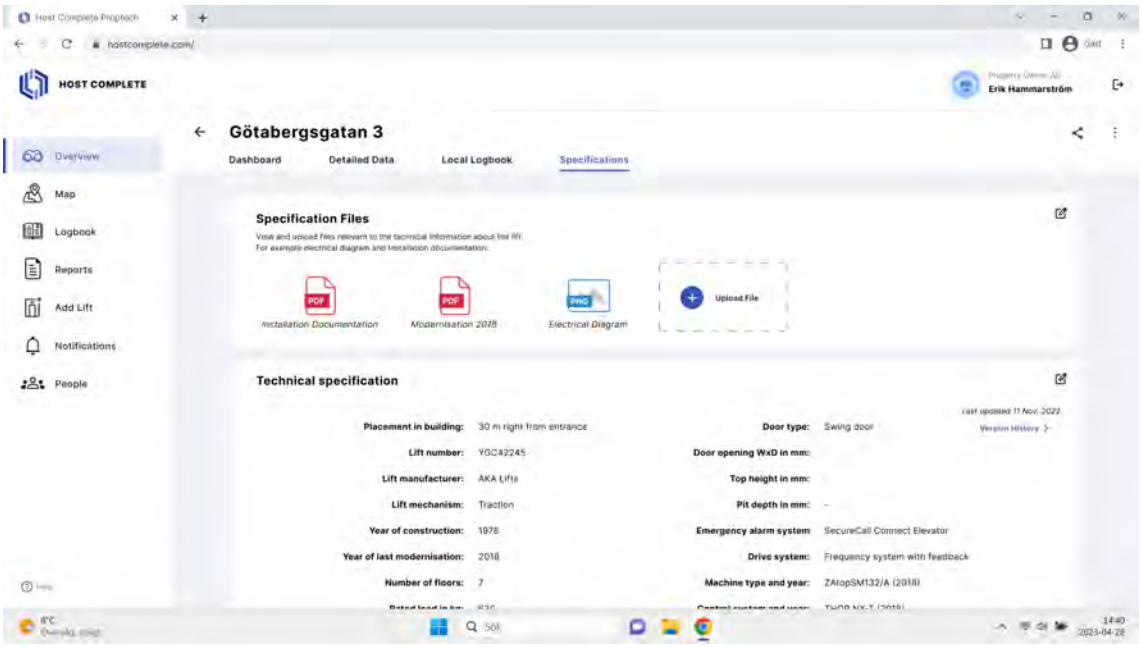


Figure 6.18: Host Complete - Specifications.

6.2.9 Lift page: Relay-based

On the dashboard of lifts with relay-based monitoring there are three major differences compared to the CANopen-Lift counterpart: the absence of the widget "Energy consumption", the widget "Relay Status" (substituting the widget "Car Doors" and the widget "Position") and the widget "Remote control". As monitoring the relays of a lift makes it impossible to read more detailed data, therefore some widgets that are present for lifts using CANopen-Lift are excluded for relay-based lifts. The dashboard for lifts with relay-based monitoring can be seen in Figure 6.19.

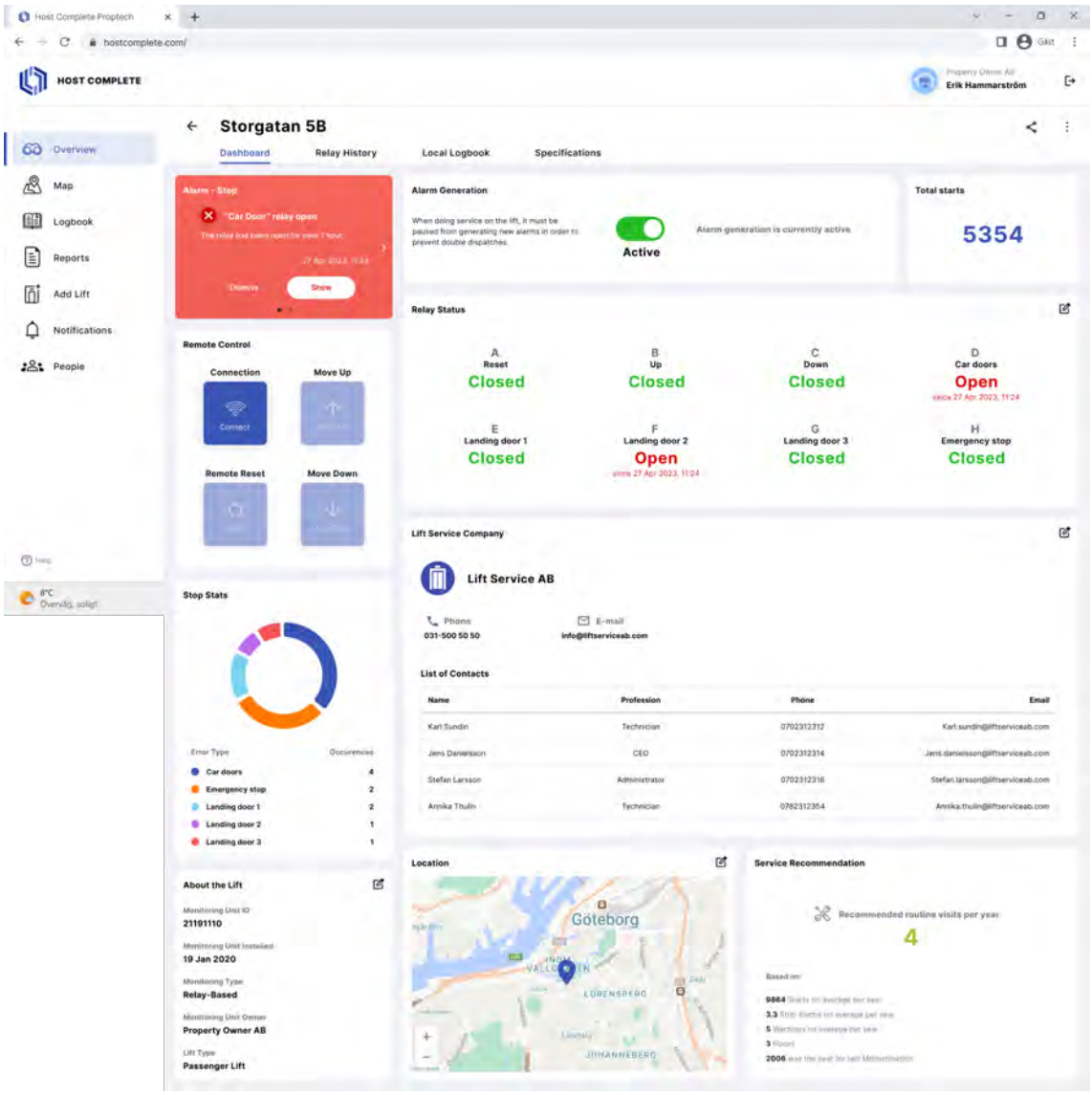


Figure 6.19: Host Complete - Relay-based dashboard.

The "Relay Status" widget shows real time status of all relay readings. As the signals are binary, the circuits are either closed or open. If a circuit is open the interface communicates for how long, following *Requirement 11. 'Show operation status. If it is currently out of service, it should tell since when'.*

Through the relay-based monitoring unit, remote reset and moving the lift up and down is possible, following *Requirement 66. 'Allow remote reset and control'*. This enables users of Host Complete to see if the lift is able to move without having to be in location, decreasing the risk of unnecessary dispatches. See Figure 6.20.

Figure 6.20: Host Complete - Remote control.

As relay-based monitoring does not give access to error codes, the tab "Relay History" displays the history of when a circuit has opened, and when it has closed. By tracking the relay history prior to a stop, a technician gains some information of what happened, see Figure 6.21.

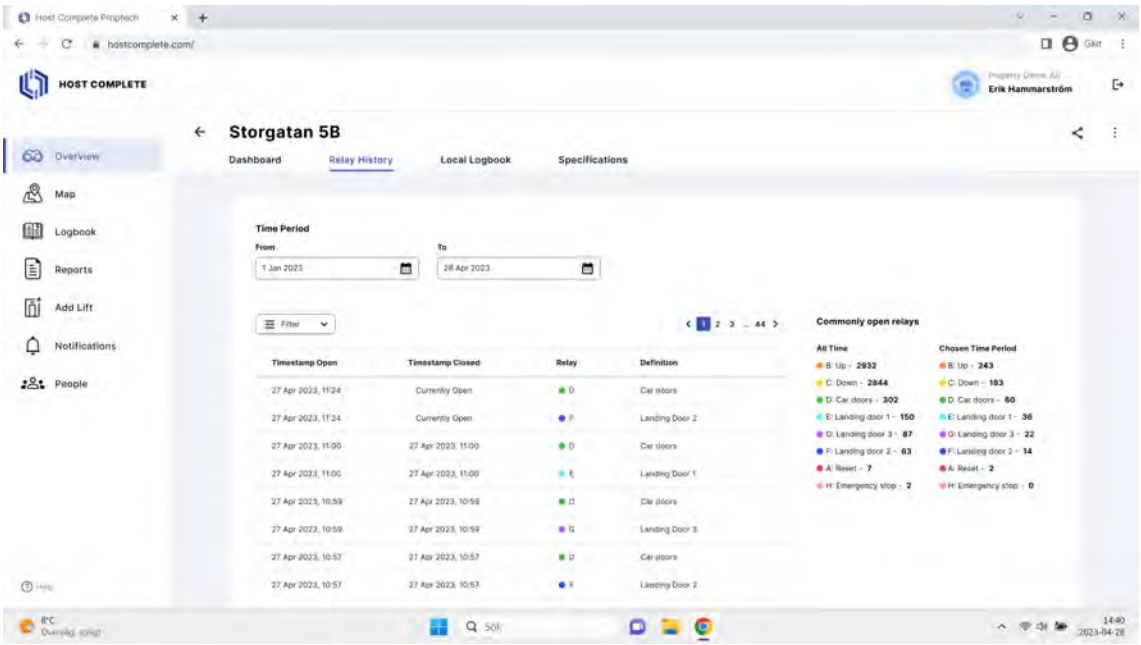


Figure 6.21: Host Complete - Relay history.

6.3 Results from evaluation of hi-fi prototype

This section presents the results from the usability tests for the final evaluation of the hi-fi prototype. The evaluation resulted in both qualitative feedback and quantitative feedback. How the test was conducted in detail is described in Section 5.6.3.

6.3.1 Quantitative results

The final prototype was evaluated through usability tests, done with four participants, P1, P2, P7, and P16. Two participants, P1 and P7 tested the POs' version of the interface. P1 was a property developer, and P7 was a technical manager. And the other two participants, P2 and P16 tested the LSCs' version of the interface. P2 was a lift consultant and P16 was a technician. See Table 5.7 in Section 5.6.3 for more information about the participants. As mentioned previously, the participants were asked to perform different tasks in the interface depending on what version of the interface they used. Some tasks were common for both stakeholders. After each task they were asked the two following questions:

- On a scale from 1-10 where 1 is unsure and 10 is sure, how sure are you that you completed the task?

- On a scale from 1-10 where 1 is easy and 10 is difficult, how difficult was the task?

The participants' answers to the first question can be found in Appendix H. They have been moved to the appendix due to low value for discussion. Participants' answers to the second question can be seen Figures 6.22, 6.23 and 6.24 below in this section.

Common tasks for both stakeholders

1. Find out what is wrong with a lift.
2. Find what a certain monitoring unit type means.
3. Find how many yearly service visits the system recommends for a lift and what it is based on.
4. Find out which floor the lift stops at the most, as well as which it stops at the least.
5. Find out what year the lift was built, as well as when it was last modernised.
6. Change notification settings.

Participants' percieved difficulty of Task 1-6 can be seen in Figure 6.22.

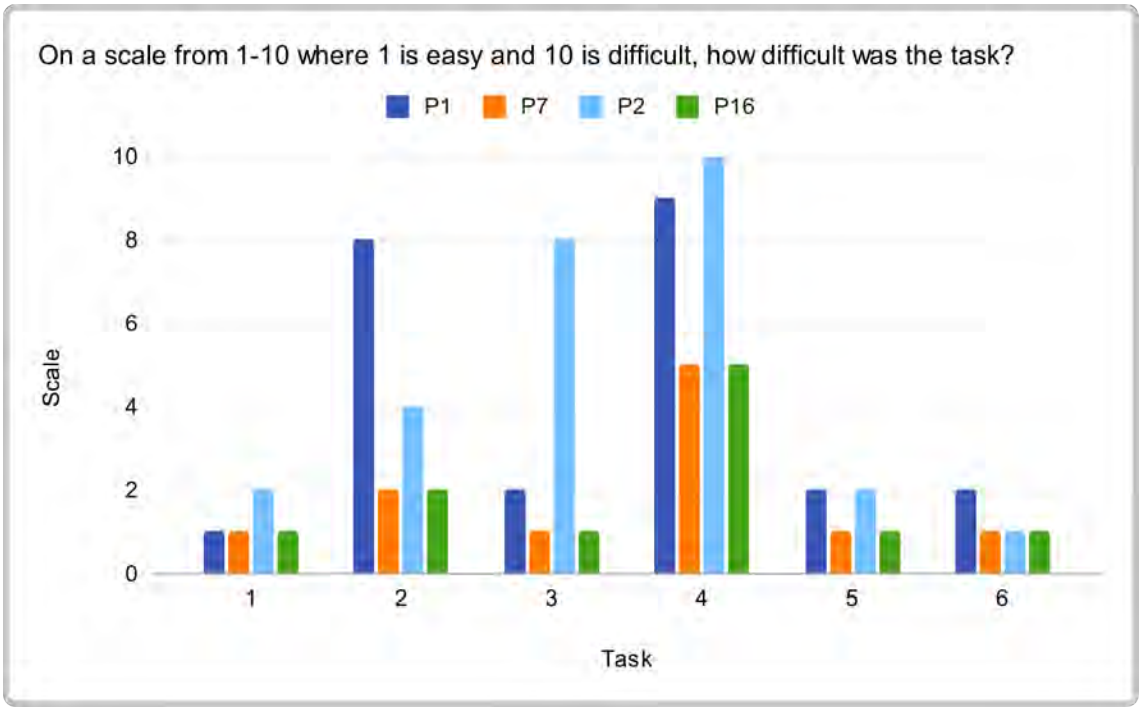


Figure 6.22: Bar chart over Task 1-6, difficulty of task.

Tasks specific for property owners

7. Find the energy consumption for a lift.
8. Find out what was done during the last service visit.
9. Generate a report with given properties.
10. Find out which elevator was the most expensive according to the report.
11. Transfer lifts to another lift service company.

Participants' percieved difficulty of Task 7-11 can be seen in Figure 6.23.

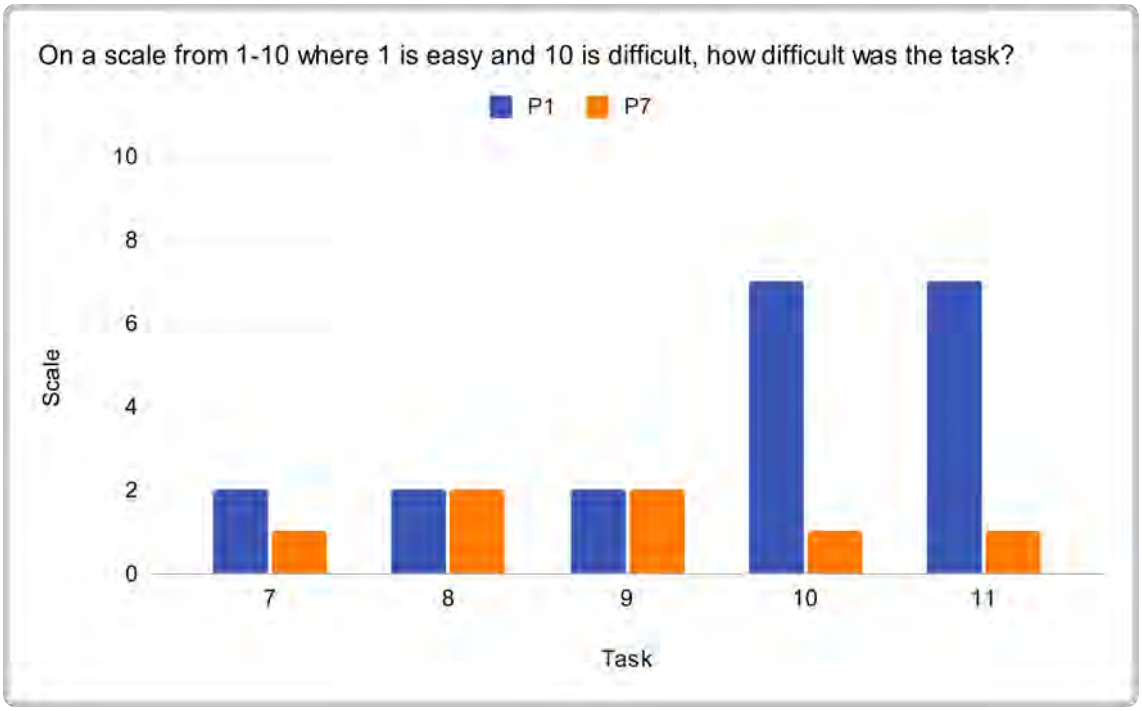


Figure 6.23: Bar chart over Task 7-11, difficulty of task.

Tasks specific for lift companies

12. Find what error codes caused the last alarm.
13. Find out what floor the elevator last stopped at before the current stop.
14. Pause a lift from generating alarms.
15. Add a new service log.
16. Add a new lift.
17. Control the lift remotely.

Participants' percieved difficulty of Task 12-17 can be seen in Figure 6.24.

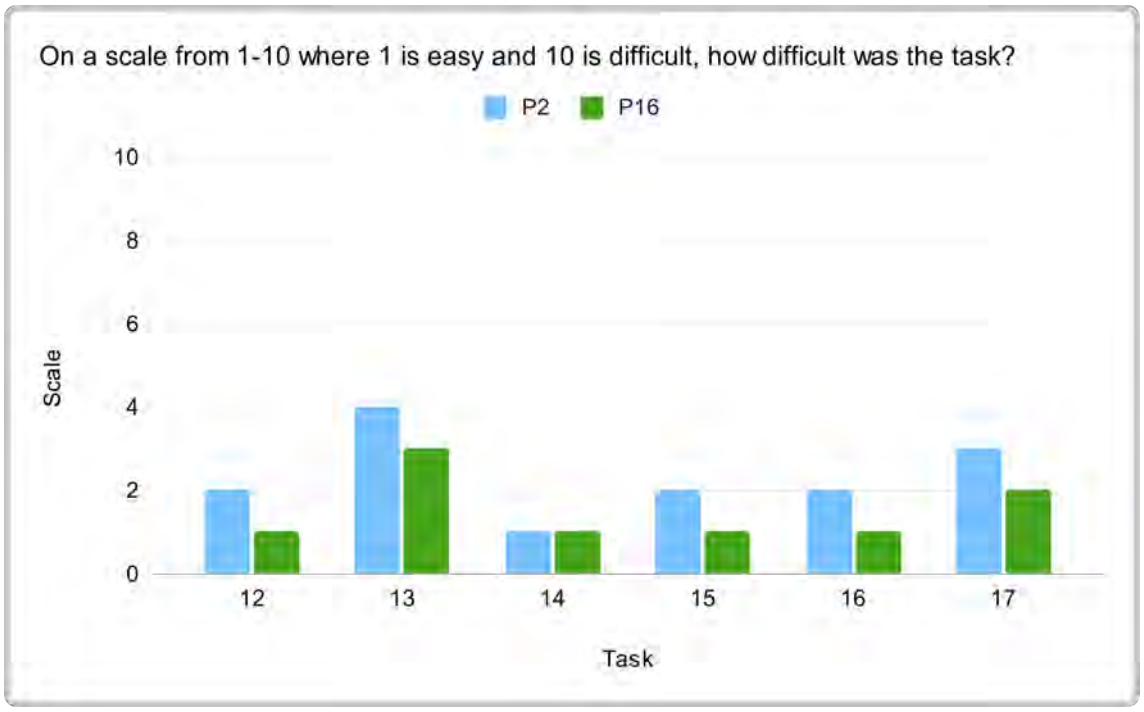


Figure 6.24: Bar chart over Task 12-17, difficulty of task.

Semantic differential

After participants had completed all tasks, they had to scale their overall experience with the prototype through a semantic differential scale between 1-7 regarding the five attributes:

Advanced (1) - Simple (7)
Predictable (1) - Surprising (7)
Innovative (1) - Conventional (7)
Unaesthetic (1) - Aesthetic (7)
Unreliable (1) - Reliable (7)

Participants' responses to the semantic differential can be seen in Figure 6.25.

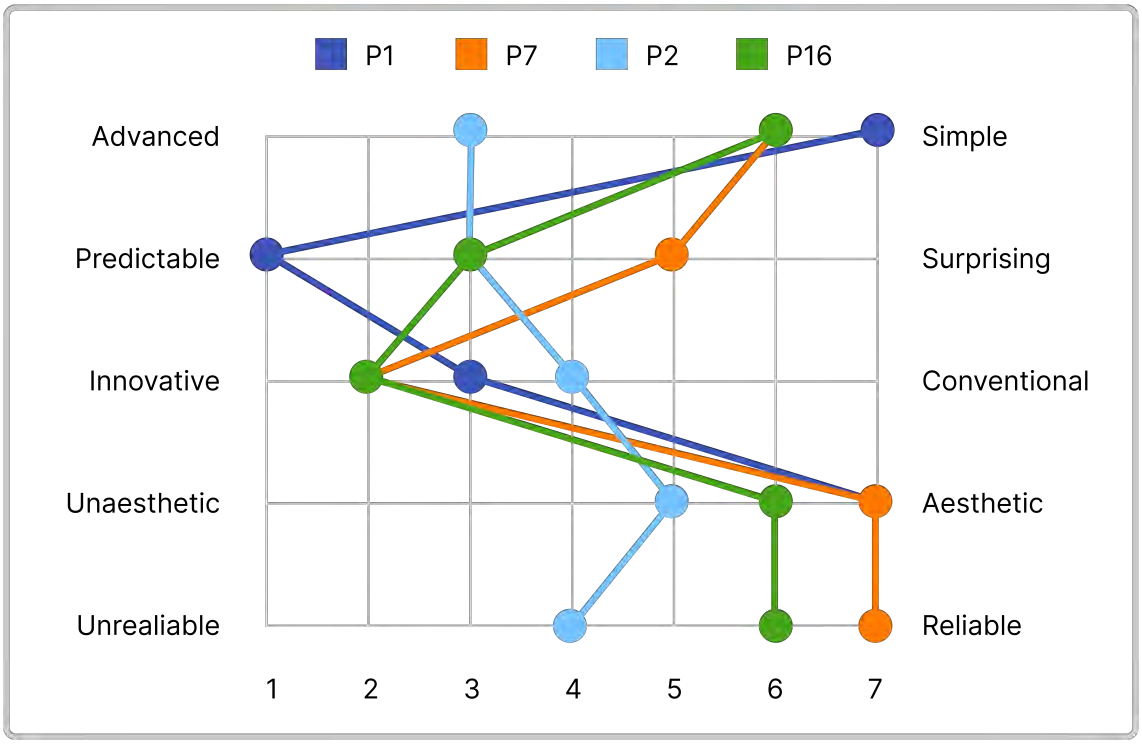


Figure 6.25: Semantic differential answers.

6.3.2 Qualitative results

This section presents qualitative results from the usability tests for the final evaluation of the hi-fi prototype.

Navigation and usability

All participants appreciated the interface, saying that it felt good to navigate and was easy to use. P1 said that it was simple and clear, most information was easily accessible, it was easy to perform actions and the interface felt well-considered. P2 said that it was relatively easy and a useful tool once you learn how to use it. P7 said that it resembles other monitoring systems, and provides a good overview, especially the map view. According to P16, there was a good amount of information on every screen, making it easy to find what you are looking for. The different colours make it easy to understand the status of the lift, P16 said. All of them commented that it would probably be even easier if they had more time to explore it freely and really learn how it works. Three participants expressed that they were unaccustomed to the fact that the interface was in English since Swedish is their work language.

Generating reports

Three participants expressed strong liking for the report function. P7 said that it was "fantastic", since it gives a good summary overview of all lifts. Currently, P7 receives a yearly summary of error history for their lifts. "But with this report function it is possible to follow in real time and plan more proactively", P7 said.

P1 finds it valuable to generate reports with lift data and statistics quickly before meetings regarding planning and maintenance. P2 thought that the way the report was presented could have been done differently. P2 wanted more information about every individual error, when it happened, what happened and why. P2 wanted all events to be sorted by date rather than having all the events summarised and presented for one lift at a time.

Missing and excessive information

Three participants said that they do not feel that anything was missing in the interface. On the other hand, they found it difficult to come up with something on the spot. They said that they would probably need to use the system for a longer time before thinking of something. P2 thought that the status of the emergency phone, if it is working or not, should be presented more clearly. The same goes for lift fire service. P2 wanted to see if the fire service is working or not. Under the tab "Specifications", P2 thought that the labels "door opening", "top height", "pit depth" and "shaft size" might be uninteresting to some users, while it could be interesting for others. P2 also mentioned that it would be nice to list the inspection expiration month. P2 was not sure what "Lift number" meant and suggested it should be renamed to "Registration number".

Dividing lifts into smaller company areas

P1 expressed that they wish to be able to filter by different areas. It is important that the right people see the right lifts. Especially for big POs who are responsible for over thousands of lifts. It can become overwhelming to see all. There might be some people who want to have an overview of all lifts at the company. Others might only be responsible and interested to see a few lifts, for example lifts regarding a certain area. On the other hand P1 commented that they do not want to lose the global aspect of it. It must still be possible to see all lifts at the company for people working with the company at a larger scale. P1 also commented that the POs should not be allowed to control the lift remotely due to safety reasons.

Placement of data

Sometimes participants felt that the information was misplaced, or hidden. They sometimes expected information to be presented in a different way. P2 said that the widget "Property owner" on the dashboard should not be that big. For example "Service recommendation" is more important and should be further up. Two times participants were distracted by the fact that the text in the interface was not realistic. P2 were distracted by the date of the different timestamps. P16 commented that a lift had a weird type of error in relation to its door type.

Design for different stakeholders

P16 said that the interface felt somewhat more oriented towards technicians since there was a lot of information on a rather detailed level. P16 liked that under "Specifications" they could choose to only fill in the fields that they want that

are relevant for themselves. P16 thought that the POs are more interested in the dashboard while technicians are interested in error code history. It is good that all information exists, but it is important to learn where to find information when needed. P16 thinks that the system would be very beneficial for smaller, open LSCs. It would be useful for both stakeholders, making it easier for lift companies to bill their customers but also for the POs, knowing what they actually pay for. P16 commented that once someone starts using a system like this, positive effects regarding operation and communication will emerge. It will become like the internet, where there will be a need for it so that we cannot live without it, P16 said.

Business model

P7 asked how the monitoring units will be connected to the internet. His company would prefer to not have SIM-cards for every unit since there will be too many of them, P7 currently have Full-Service Contract for their lifts so therefore they do not have the need for a monitoring system. They prefer to not be responsible for the lifts and that the LSC does everything for them. However, P7 suggested a basic version for the system that does not have all functionality, for example only giving access to the report function could be useful

Semantic differential

P1 was not sure how to interpret the semantic differential and asked if we meant "simple" as simple to use, or that the interface was simple and limited so that you can not get anything out of it. P1 left a comment that they interpreted it as the first alternative.

7

Discussion

This chapter critically discusses the project, including process and execution, results, ethical concerns, and future work. Why the outcome turned out the way it did, the eventual risks, and the potential benefits of the system will be discussed.

7.1 Process and execution

This section discusses how the process and execution affected the final results. Alternative courses of action and their possible consequences are presented.

7.1.1 Interviews

Even though over 100 different companies were contacted, the number of participants were quite low. One reason for this was that it was not feasible to interview everyone due to time limit. As mentioned before, a selection was made based on geographic location, type of company, and profession, in order to make the sampling as diverse as possible. However, due to the qualitative nature of the interviews, the design team felt that saturation was achieved and the number of participants was enough.

There is a risk that LSCs' interview responses became biased when told that the project is in collaboration with Host Mobility, since they might sense some kind of business competition. This might attract certain types of companies. Companies that are already open and willing to share information are probably more likely to participate.

Eventually it might have been beneficial to reach the bigger, closed LSCs since they have stronger influence in the lift industry. While all of them were contacted, only one person from one of these companies participated in the interviews. This was because of a lack of response, likely because of competitive reasons. This could possibly have been prevented by not mentioning that the project was done in collaboration with Host Mobility. On the other hand, it is important to honestly inform participants about the purpose of the study. Contacting LSCs outside of Sweden could eventually remove the sense of rivalry since they are not competing in the same market. For this project however, the Swedish market is the most relevant because that is where the product has been released, and other countries might differ in their needs and work processes.

Another consequence is that the sample is not a true representation of reality. For example only one PO was responsible for commercial buildings, the majority of the companies were from Gothenburg, and not a single woman was interviewed. This can lead to bias in the final product. However, the design team assumes that the needs related to lift service are not significantly different among different genders, geographic locations, and types of properties.

A challenge during interviews was that many interviewees found it difficult to express what they wanted in a monitoring system. A potential reason could be that there are very few lift monitoring systems available on the open market so users do not know what to expect, because of their lack of experience.

7.1.2 Evaluation of lo-fi prototype

During the evaluation with the lo-fi prototype, 7 out of 9 participants were not primary users. Participants who were familiar with testing of interactive prototypes were chosen in order to eliminate the risk of users being distracted by the limitations of the prototype or that things are not 100% realistic. Another reason for not choosing the main stakeholders as participants was to save them for the final evaluation. For this, we wanted participants with no experience with our previous prototype in order to prevent learnability effects.

Consequences from this sampling is that the main stakeholders' opinions were not considered to a high degree, which can lead to important insights gone missing for the hi-fi prototype. No PO was evaluated with at this stage which risks that their perspective was neglected for the hi-fi prototype. Many participants knew members of the design team on a personal level. While this could lead to a lack of critical feedback, it could also lead to the opposite. Since they knew the design team they were not afraid of giving critical feedback to the creators of the interface. Therefore it was not necessarily a drawback to include them in the sample.

One risk of doing iterations continuously between every second test is that participants' opinions might be overvalued. There is a risk of adding functions to the interface that are not useful for the actual end user. On the other hand it was valuable to continuously receive feedback, and easier to implement changes while the prototype was still in an early stage.

7.1.3 Evaluation of hi-fi prototype

For the final evaluation, the sample included 4 participants only. This could be a factor that lowers the reliability of these tests, making it very difficult to generalise the results. It can be seen from the results that some questions or tasks received similar feedback, while others were more spread out. A larger sample size would have been needed to reliably generalise the results.

One of the evaluations was conducted in person, while the three others were online. The reason for this was that the participants had the option to choose the environment where they felt the most comfortable. This might have impacted the result, since

the feeling of having two people observe you over your shoulder can be perceived as more stressful than sharing your screen in an online meeting.

Key stakeholders were chosen to participate, people who had good knowledge in the field and were perceived as more progressive and interested in a system like this. These participants were expected to give more valuable feedback than people who are not interested. On the other hand, it might have been beneficial to have more critical eyes.

Having more participants for the lo-fi evaluation were prioritised, since the feedback could be used for implementation in the final prototype. Feedback from the evaluation of the hi-fi prototype were valuable and insightful but not as useful as from the evaluations of the lo-fi prototype, since no iterations were made afterwards.

During the test it was clear that the conditions were unnatural for the participants. In a real situation they would probably not just jump into an interface, trying to solve tasks without any context or previous knowledge of the interface. It is possible that if they had been able to familiarise themselves with the interface and interact freely for a longer time, the tasks would have been perceived as easier. Neither would they share their screen and be observed online. The feeling of being watched might have been a stressful or disturbing factor.

7.2 Result

The following section discusses generalisation of the identified requirements, as well as the design of Host Complete. The strengths and weaknesses of the prototype are discussed, as well as what requirements are met, and why not all were.

7.2.1 Project scope

Host Complete has been designed with both LSCs and POs in mind. The project's scope was rather large, designing a lift monitoring interface completely from scratch. Due to the complexity and extensively of the interface, it is expected that some parts of the interface would require more iterations before settling on a final design. Limiting the scope by for example including less functions, focusing on one monitoring type only, or designing for only one stakeholder, would probably have decreased the complexity in the system, leading to a more clear and simple interface. The two different stakeholders had very different needs, often conflicting. And the amount of data that could be collected from the two types of monitoring units were very different. These challenges often arise when UX design meets IoT as described by Baskar (2017) in Section 3.6.

7.2.2 Generalisation of list of requirements

As previously mentioned, this project was done in collaboration with the company Host Mobility and their monitoring system HCPL, but the different needs identified

could be used for other monitoring systems in the lift industry or the field of PropTech. However, it could be discussed to what degree these findings can be generalised.

The List of requirements has big potential to be used as a base during the development of other lift monitoring systems. While the interface design of Host Complete was based on the specific hardware units developed by Host Mobility, the List of requirements was not. It is therefore easily generalised and usable to other companies in the lift industry. The *Requirement 3: "Enable the possibility to swap the data monitoring unit to another lift."* is however based on that a monitoring unit is an external hardware that could be removed, and reinstalled at another location. Controllers can be designed to enable the possibility of remote monitoring without external hardware. In that case, that specific requirement should be ignored.

Whether these needs can be used in other fields of PropTech is not as clear. Since POs use many different systems regarding their properties, their requirements are more likely to be applicable in other PropTech fields. But the requirements of LSCs tend to be more specific and limited to the lift industry. On the other hand, there are expert users within other fields of PropTech as well, having more technical knowledge. A plumber might have an expert perspective similar to that of a lift technician. When developing a plumbing monitoring interface, it is likely that the plumber wants to have more detailed data, similar to a technician. However, some specific data parameters, like "car position" are not applicable to a plumbing monitoring system at all. Further research is needed to identify field-specific needs.

7.2.3 Evaluation of interface with List of requirements

The List of requirements was very helpful in the process of creating a user-friendly interface, focusing on what stakeholders actually need. Table 5.6 of fulfilled requirements can be seen in Section 5.6.2 . The complete List of requirements can be found in Appendix C. The amount of fulfilled requirements for the different Demands and Wishes are: D 10/11 (91%), W1 16/21 (76%), W2 16/25 (64%), W3 7/12 (58%) and W4 2/9 (22%). The interface successfully fulfils the majority of the most important requirements. Almost all Demands were fulfilled except one. The only demand that was not fulfilled was *'Requirement 2. 'Be accessible and adjusted to different types of devices (desktop and mobile)'.* However, other unfulfilled requirements were not fulfilled for a reason, where the design team constantly balanced added value and added complexity during the project. This was done in order to create the best possible UX. The future work in regard to the list of requirements is discussed further in Section 7.4.2.

7.2.4 Feedback from final evaluation

Overall, the final prototype received positive feedback. Participants found the majority of the tasks easy, see Figures 6.22 - 6.24 in Section 6.3. The navigation, and overview prioritising lifts out of service was appreciated from all users. All participants found the task of finding what lift stands still, and its current problem, to be very easy. This was the most essential part of the interface, and given the

many different functions, this was a success.

Reports

Another tool that was appreciated by the participants was the report function. 3 out of 4 participants expressed specifically that this tool would be very useful during the recurring operations meetings, see *Trust and communication* under Section 5.2.4. These three stakeholders were people who usually participate in those meetings, which was seen as promising results. P2, the lift consultant, gave some valuable feedback on how the information could be presented differently to be even more useful from his perspective. It was suggested that stops, dispatches, alarms, and service visits should be presented with more information, like what happened and the regarding date. Even though the function was seen as a success, a couple more iterations would be useful to perfect it.

Detailed data

Some tasks required the user to go a few steps deeper in the navigation hierarchy, and these tasks were perceived as more challenging for the users. *Task 4: "Find out which floor the lift stops at the most, as well as which it stops at the least"*, required the participant to go into "Detailed Data" and choose "Floor History" in the drop-down menu. This was according to the results the most difficult task, which was also expected. During the evaluation, the first time interaction with the interface was tested without any instructions provided. Navigating and analysing detailed data is not expected by a novice user, but is something that technicians experienced with the interface would do.

Dashboard

Task 2: "Find what a certain monitoring unit type means" was also perceived as a bit more difficult than other tasks. This was likely because it is not intuitive how the different monitoring units work, as it requires a bit of technical knowledge of lift control systems to understand. The concepts of the different monitoring types were presented briefly and discussed at the end of the usability test sessions, and once explained the participants understood it. Knowledge of the two different monitoring types is a quite important part of the interface, but can at the same time not be expected to be discovered and understood by a first-time user. Some kind of introduction to the interface for novices would be beneficial.

Further iterations of the dashboard would be useful to determine if the prioritisation and placement of information could be more optimised. For example, contact information for the responsible company takes up too much space. This resulted in P2 having a difficult time finding the recommended service visits in *Task 3: "Find how many yearly service visits the system recommends for a lift and what it is based on"*. Service recommendations might be interpreted as hidden when placed at the bottom. Some information on the dashboard might be better suited for the “Specifications”-tab, and vice versa. A larger sample size would have been useful to determine what information is expected to be found where from a majority of users.

During the final evaluation, P2 mentioned that it would have been useful to see the state of the fire service on the dashboard. This function had not been mentioned before and had therefore not been taken into account whatsoever. For future work, it could easily be added to the list of data parameters under "Detailed Data". The technical feasibility to monitor this is however not certain and needs to be investigated further.

7.2.5 Realistic information in prototype

Filling the interface with reliable and realistic content required us as designers to immerse ourselves in how a lift works and get to know the technical terms. Not all aspects were understood in detail, leading to the gaps being filled with the design team's conceptual ideas. During the final test, P16 commented on something that did not make sense in reality. In the prototype the lift had a certain door type, and it would be unrealistic to have the type of error shown in the prototype. For the same reason, there is a risk that the interface is slightly more oriented toward POs. We as designers probably find it easier to empathise with POs rather than LSCs since we do not have the expert perspective of a technician. Observing P16's way of using the different lift data during the troubleshooting of a lift impressed the design team. It gave the insight that technicians might be able to draw conclusions from a monitoring system in ways that the desig team had not foreseen.

7.2.6 Language in the prototype

During the evaluation of the hi-fi prototype, 3 out of 4 participants expressed that they were not used to English in their daily work. To compensate for this, they could ask for translations when they felt they needed it. It is however likely that some of the tasks were a bit more difficult since the participants did not know what words to search for in the interface, and had to focus on translation. English was chosen in the interface since this was the language of the final report, and to increase the accessibility to non-Swedish speaking readers. Since the usability tests were done with exclusively Swedish participants and the monitoring application is planned to be released in the Swedish market, doing a variation in Swedish might have been valuable. Creating two versions of the interface, one in English and one in Swedish could possibly have been done. However, since the interface is quite text heavy, it would have led to much time being spent on translation. Due to lack of time, only one language was selected for this project.

7.2.7 Semantic differential

For the three first scales in the semantic differential (Advanced - Simple, Predictable - Suprising, Innovative - Conventional), there was no objectively better option, since it depends on how users interpret the question. However, for the two last scales (Unaesthetic - Aesthetic and Unreliable - Reliable), it was very clear that one of the features was more desirable than the other. Aesthetic and Reliable are considered to be more desirable features.

The semantic differential in Figure 6.25 shows that 3 out of 4 participants think that the interface is more simple than advanced, more predictable than surprising, and more innovative than conventional. All participants think that the interface is more aesthetic than unaesthetic. 3 out of 4 participants think that the interface is more reliable than unreliable. The feedback indicates that their experience with the interface was positive. However, the sample size was small and it is possible that the overall result would have been different with more participants.

7.3 Ethical concerns

This section discusses ethical considerations that could arise from using Host Complete. Topics such as misuse of data and safety hazards are brought up.

7.3.1 Misuse of data

An ethical concern for this project might be how the lift data is used and why. Most likely lift data on its own cannot be linked to specific individuals. But combined with other information, such as a person's GPS position, it can possibly violate their integrity. There is no GPS position for individuals in Host Complete, but the information can be accessed in other ways, outside of the interface. Lift data could possibly reveal sensitive information that some LSCs are not ready to share with the open public.

Data can both be sensitive and valuable, therefore it is important to determine who is the owner of the data so that it does not end up in the wrong hands. To counteract this, the design team chose the solution where the owner of the monitoring unit is also the owner of the data, and has the control over who they share it with. Therefore it is displayed in the interface who is the owner of the monitoring unit. This does however allow owners of the monitoring units to use the data with malicious intent, but how to avoid this further was not an easy task to solve.

Lift data could be used in legal implications, as evidence showing what actually has happened. However, there is a risk with relying too much on data without context. From the interviews it can be concluded that many POs today feel that the information about the lifts is non-transparent. One aim of the project was to mitigate this feeling, and create a tool for the stakeholders to have an even playing field of accessible information about the lift data. While this is the goal, giving the POs too much information might give them the incentive to analyse the performance of LSCs rather than the lifts.

The interface does not directly present numbers that compare the performance of different LSCs. However, users can draw their own conclusions by adding up smaller pieces of information. For example, it can look like that one LSC has more errors than the other. Even though it might be true, it can lead to conclusions without thinking about underlying reasons. For example one reason could be that one LSC is responsible for more worn out lifts, which are more prone to breaking. This was trying to be prevented by not clearly showing summarised statistics of specific LSCs

in the interface.

7.3.2 Safety Hazards

Only licensed technicians are allowed to go into the machine room of the lift and repair it after a stop. From our interviews it is however clear that there are some janitors of the POs who ignore these regulations and try to solve the problem themselves. Giving the POs lots of information about what the specific parts of the lift is the problem, might give unlicensed janitors an incentive to try to repair it themselves. In worst case scenarios this might result in people using the lift to be injured, or even cause fatalities. When designing the interface it is important to not give the janitors an idea of doing work outside of their area of competence. To prevent this, recommended courses of action are not described in detail. In this final prototype it is possible for the PO to control the lift remotely. It is a crucial function that the PO should probably not have access to. However, we chose to include it in the interface to be able to show it to the POs and discuss it with them.

7.3.3 Midjourney

Midjourney is a tool that was used during the ideation phase. Even though it was not used to a great extent, it is a new tool that can be perceived as controversial, which is worth discussing. A general critique about AI is that it lacks imagination, only being able to create artwork that is similar to what it has been trained with, resulting in the generated images becoming an "average" of its trained data. On the other hand, some people argue that artwork produced by humans are not created from void either, rather they are based on experience and inspiration from previous artworks as well. This implies that the role of AI in artwork creation is not very different from searching for inspiration online, but AI makes the process easier. AI should be seen as a tool that can augment and support human creativity rather than replace it.

For this project, Midjourney was used for minor graphical illustrations used in the interface, including the logotype and the login page. For the logotype, Midjourney was only used for inspiration, resulting in the final logotype being created by us from scratch. However, for the login page, the image was taken directly from Midjourney, and only the colours and the background were edited. It is problematic since we do not know how much the image contains of already existing artworks. If Host Mobility was about to release this prototype a new illustration should be redesigned from scratch in order to prevent any copyright issues.

7.4 Future work

This section describes the potential of future work regarding Host Complete. It suggests possible starting points for continuing iteration.

7.4.1 Refinement of Host Complete

Host Complete is hopefully a step in the right direction to further digitise the lift industry. The prototype from this project can be used for benchmarking, inspiration, and as a mediating tool. It helps with concretising the different parameters of the lift and visualises what could be possible in a system like this. Even though the prototype of Host Complete received overall positive feedback, iterations must continue in order to make it ready for commercialisation. By continuing iteration based on the feedback from the final evaluation, Host Complete will be further improved.

Costs and benefits of a lift monitoring system

One challenge with lift monitoring systems is that the attitude towards it is still quite conservative. Many people have not yet realised the benefits of having a lift monitoring system. Some of the interviewed POs had full-service agreements and are therefore not interested since they pay a fixed price for service of their lifts. To be able to commercialise a lift monitoring system, the economic benefits must be clarified for the stakeholders. A lift monitoring system means extra cost, responsibility, and administration for the companies who choose to invest in it. On the other hand, it could reduce unnecessary dispatches, increase effectiveness, and encourage proactive service, leading to lower costs overall and higher customer satisfaction. How much it could actually save should be investigated further. Someone needs to take the first step and really explore the potential from lift monitoring systems. When the others realise the benefits, they will become inspired and follow their footsteps.

Pausing alarm generation

A toggle switch was added for pausing alarm generation to prevent double dispatches when a technician is doing service. This solution already exists in other lift monitoring systems but interviews revealed that it is not foolproof. There is a risk that technicians forget it. Therefore it would be beneficial to complement it with something automatic. For example a tag that is placed in the same key chain as the lift keys. When the monitoring device senses that the tag is nearby it is triggered to pause alarm generation. An analog switch on the monitoring unit with a timer is another option. It could be more convenient than logging in to a website, but comes with the same problem as the current solution since people might forget to turn on/off the switch.

Large quantities of lifts

In the prototype there are 80 lifts in the system. The interviewed companies said that they have between hundred to over a few thousands. The reason there were only 80 lifts was mainly for prototyping reasons, becoming easier to handle. However, the number might be too low compared to real companies. We have not investigated how the number of lifts affects the UX and usability of the interface. We also do not know how it would be using Host Complete with real data from real lifts. A prototype of the actual Host Complete website, including both front-end and back-end programming, should be tested in its entirety. It is something that could be investigated further in future work.

Parameters in Detailed Data (CANopen-Lift)

Future work should also concretise what parameters is actually possible to monitor and what should be included under "detailed data". In this prototype, only Error code history and Floor history was clickable. Next step should determine exactly what parameters can be monitored through CANopen-Lift monitoring, which are valueable for the different stakeholders to display, and to design the pages for every parameter.

7.4.2 Unfulfilled requirements

The final list of requirements included 78 different demands and wishes, of which not all were fulfilled due to lack of time or feasibility challenges, see complete list in Appendix C. Not all of them were important and including all of them at once would probably make the interface more complex and less consistent. The list of requirements leaves room for future work when developing a similar interface, allowing focus on those requirements that were not fulfilled this time. However, there are some requirements that would clearly add value for the users, if fulfilled, making the interface more competitive.

Host Complete on different devices

To make the interface useful for many types of situations, it is important that it is responsive and compatible with many different devices and not desktop only. Many users use phone-based systems in their work. Focusing on *Requirement 2: 'Be accessible and adjusted to different types of devices (desktop and mobile)'* for future work would probably make it easier to access "on the go". During the observation and interviews, it became clear that technicians do not have access to a computer during their daily work. Since they are primary users of the interface, a mobile version is required. However, it was prioritised to focus on iterating and developing the prototype for one device over creating multiple prototypes that felt half finished. A lift monitoring system like Host Complete should be accessible through different devices, even though it was not investigated further in this project.

One system for all lift data

According to *Requirement 29: 'Integrate all lift-related systems/software so that they are gathered in one place'*, it is desirable to have everything related to lifts in one place. But one question is how much Host Complete should overlap or take over already established systems. In this prototype, all lift related content outside of the interface has to be added manually. This is inconvenient and leads to lots of manual work. LSCs already have their own business system for managing work orders and creating invoices. Lift technicians are not very motivated to manually write the same service log multiple times in different systems. At the same time, the inspection organ has another business system. If there is a way to connect all those systems to a common API so that service logs, invoices and inspection logs are added automatically to Host Complete, that would increase the efficiency. Then users do not have to enter multiple websites or gather information manually.

Many PropTech systems for property owners

During interviews, many people working at POs expressed that they currently had lots of different systems to use in their organisation, like monitoring of heating units. While they all contribute in some way to increasing efficiency in different ways, a big problem is that it requires time. For every system that is added time is lost from practical work, as well as adding another username and password that is to be remembered. This resulted in the definition of *Requirement 57: 'Enable the possibility to integrate PropTech regarding other parts of the property'*. If fulfilled, managing and monitoring the different parts of the properties would be more efficient for POs since they can do it in one place.

Lifespan of different lift parts

Another requirement with high potential is *Requirement 59: 'Calculate total cycles of different parts, and give estimated date of exchange'*. The reason it was not fulfilled this time was due to complexity. Even though CANopen-Lift calculates cycles for doors, it does not track cycles of individual components. On the other hand, it might not be necessary to do so since door cycles are a relevant indicator of how much the lift has been used, which affects all components of the lift. With today's technology, in order to fulfil this requirement, all parts must be added manually in the system. Their date of installation must be added, and users must enter what factor determines the end of the part's life cycle, for example reaching a certain number of door cycles or a certain age. Based on the number of cycles so far it could calculate the recommended date of exchange. The amount of manual input required is not manageable. However, if fulfilled it would lead to complete control over the condition of different parts of the lift, allowing for effective and accurate planning.

Dividing lifts into groups

One challenge is that both POs and LSCs are responsible for very many lifts. Usually many hundred lifts, but sometimes over thousands. Both parties usually divide their lifts into several areas, and their employees are often responsible for only one area. Therefore *Requirement 78: 'Be able to only view those lifts that a user is responsible for'* was defined. But in this prototype the lifts are only divided at the company level, meaning all users at a company see all the company's lifts. It would be beneficial to be able to divide lifts into different areas so users could filter by them, or assign users to certain areas. During this project some solutions were explored, such as adding tags, drawing areas on the map, and creating folders for different lifts. However, the solutions were not seamless and the design team decided to disregard this requirement in favour of others. The function would need more ideation and iteration in order to become useful

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Conclusion

The purpose of this thesis has been to research the users' needs, and design for different stakeholders of lift monitoring systems. As the project was done in collaboration with Host Mobility and their current monitoring system Host Complete Proptech Lift, their current monitoring hardware was used as a base. One of the monitoring hardware units connects to the controller of lifts using the open protocol CANopen-Lift. The other to the relays in the control cabinet, allowing data monitoring of a lift regardless of its control system. The research question of the thesis was:

What requirements do Property Owners and Lift Service Companies have on a lift monitoring system, and how can an interface be designed to fulfil these?

The first part of the research question, *What requirements do Property Owners and Lift Service Companies have on a lift monitoring system?*, was discovered through participation at a lift fair, interviews, and an observation. The data was analysed, and presented in a List of requirements (see Appendix C). In total, 78 requirements were prioritised as demands or wishes depending on their importance, and divided into the different categories:

- Accessibility
- AI and Automation
- Alarm and Notification
- Cognitive Resources
- Communication between Users
- Data Parameters
- Ease of Workflow
- Economics and Analytics
- Emotion
- Servive Logs

A summary of the requirements and the different categories is presented in Section 6.1. The different needs are generalised, and applicable to other lift monitoring systems as well. Parts of the list of requirements may also be used as a base for other monitoring systems within the field of property technology.

The second part of the research question, *How can an interface be designed to fulfil these?* was explored by visualising different ideas and evaluating them in formative usability tests. The final hi-fi prototype of Host Complete was designed as a suggestion of a possible solution.

Other goals of the project were:

- *Create value for the different stakeholders.*
  - This was done through continuously working with both stakeholder groups in both data gathering and evaluations, requirements were formulated in order to create a meaningful product for all users.
- *Create transparent communication for different stakeholders.*
  - This was done by designing an interface where no information is hidden for the other stakeholder group, meanwhile acknowledging and actively preventing unfair comparisons and monitoring of lift service companies.

The final hi-fi prototype of Host Complete was evaluated through comparison with the list of requirements, and usability tests. While not all requirements were fulfilled, a convincing majority of the more prioritised ones were. Some of the requirements that were not fulfilled were out of the project scope. Others were down-prioritised to minimise the complexity of the system, for a better user experience.

Host Complete received mainly positive feedback, while also giving some suggestions for further work. More iterations on some parts of the interface would be beneficial for optimised prioritisation of displayed information. The identified requirements in combination with Host Complete serves as a stepping stone for future development in the field of lift monitoring systems and contribute to the ongoing advancements in property technology.

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A

Interview template for property owners

Who are you and what is your current role?

- What does your company do?
- How many lifts do you have?

When do you encounter lifts and why?

Could you describe the process from someone noticing that the lift is out of service until service is done and the lift is operating again?

- What people are informed, and about what?

Are you informed when the lift starts working again?

- Through what means of communication are you informed?
- How do you prefer to be informed?

What lift service companies do you have contact with?

- What is your experience with them?
- Do you experience any difference between different lift service companies?
- What makes you choose a certain lift service company?

What do you know about the status and wellbeing of your lifts?

- Do you know what needs to be done if there is anything wrong?
- Do you have any tools that provide an overview of how all your lifts are doing?

How are service visits documented?

- Is there any difference between how repairment from dispatches are documented compared to routinised, preventive service visits?

To what extent do you fix problems with the lifts yourself, without help from a lift service company?

- When do you fix it on your own and when do you need help?
- When you get help, do you feel afterwards that the help was necessary?
- After you get help, do you think that you get enough information about what caused the error and how it was solved?

How commonly do you experience that the lift service company dispatch and then the lift is already working at arrival?

- What is the reason they happen?

- How could they be prevented?

Have you ever been in contact with a lift consultant?
- Why/why not?

Do you have a digital monitoring system for your lifts?
- Why/why not?
- Do you find it interesting as a property owner or do you prefer that mainly the lift service company should have access to a system like that?

What are the pros and cons of having a digital monitoring system for your lifts?
- Are there any risks?
- At a property owning company, who would use a system like that? I.e. administrators, janitors or technical managers.

What is your thought about showing real time data such as:
- Lift position and direction
- If doors are open or closed
- Speed and acceleration
- Vibration level
- Current load in the car

What is your thought about showing historical data such as:
- How many times the doors have opened
- What floor the lift most commonly stops at
- History over previous service visits
- Calendar over planned future service visits
- Statistics and comparison with other lifts
- Energy consumption

What is your thought about the system being able to tell the reason for error and a recommended course of action?

What is your thought about showing technical specifications such as year of installation and what parts the lift consists of?

B

Interview template for lift service companies and lift consultants

Who are you and what is your current role?

- What does your company do?
- How many lifts are you responsible for?

When do you encounter lifts and why?

Have you worked with service and dispatches?

- What do you usually know about a lift and its eventual error before a dispatch?
- What is good to know about the lift before arriving at the property, and why?
- How do you find out what is wrong with the lift?

Could you describe the process from someone noticing that the lift is out of service until service is done and the lift is operating again?

- Do you inform the property owner both before and after a service dispatch?
- Do you think they are interested in being informed?

How commonly do you experience dispatches where the lift is already working at arrival?

- What is the reason they happen?
- How could they be prevented?

How is the communication usually between the lift service company and the property owner? What means of communication?

- Who do you speak with?
- What do you tell them?
- Is there anything that you usually do not tell?

How are service visits documented?

- When are they documented?
- What level of detail?
- What is the documentation used for afterwards?
- Does the documentation go directly from technician to customer?

Do you experience that the property owner and the lift service company have different opinions?

- When does it happen and why?
- Do you have any ideas on how to get along better?

Is there anything that a janitor could solve but that is usually fixed by the lift service company?

- Would it be legal?
- Are there any janitors that do work on lifts even though it is outside of their area of competence?

Have you encountered a digital monitoring system for lifts?

- What was the purpose of the system and who used it?
- What are the pros and cons of a system like that?

Imagine you could obtain all possible information from your lifts. What information are you interested in knowing and why?

- Mention the five most important parameters.
- How would you use the information in your everyday work?
- During what situations would you use a system like that? I.e. before or after service, at the office or at the lift?
- Would you rather have the information on a desktop or a mobile?

Describe your dream system!

Describe your nightmare system!

In what way do you think that lift data needed for a property owner is different from what lift companies need?

- What data do you think is most important for a property owner?

Are there any consequences from giving property owners access to lift data?

What is your thought about showing real time data such as:

- Lift position and direction
- If doors are open or closed
- Speed and acceleration
- Vibration level
- Current load in the car

What is your thought about showing historical data such as:

- How many times the doors have opened
- What floor the lift most commonly stops at
- History over previous service visits
- Calendar over planned future service visits
- Statistics and comparison with other lifts
- Energy consumption

What is your thought about the system being able to tell the reason for error and a recommended course of action?

What is your thought about showing technical specifications such as year of installation and what parts the lift consists of?

C

List of Requirements

Req. ID	Degree of importance	Category	User	Description	Solution example	Comment	Quote English translation	Degree of fulfilment
1	D	Accessibility	Everyone	Allow the change of lift service company while maintaining data gathering.	A function for managing and assigning different accounts to different lifts.	Important to think about cyber security and sharing the information with the right people.	If we are going to sell your stuff (monitoring devices), we have to in some way sell a system that.. When they are not interested in us as a service company anymore, that they still have access to the system. - Project Manager, LC3	Fulfilled There is a button for transferring lifts to another company.
2	D	Accessibility	Everyone	Be accessible and adjusted to different types of devices (desktop and mobile).	Responsive, web-based or app-based.	Administrators are likely to use the desktop version, and technicians most often have access only to a mobile device.	We are already today, all of our technicians and myself, working in a phone-based system. So that's a big reason to also be able to apply this in a phone-based environment. - Technician and Co-founder, LC6	Out of scope Due to limited time.
3	D	Accessibility	Everyone	Enable the possibility to swap the data monitoring unit to another lift.	Give one use the possibility to change all information in the interface, even the address.	Might be something that users can configure in the interface.	In the future, we will have to charge if the monitoring device should stay there. Otherwise, we place it somewhere else. - Technician and Co-founder, LC6	Fulfilled Possible to delete, change or clear lift data.
4	D	Accessibility	Everyone	Gather monitoring for all lifts at the same place, regardless of brand, type, age and control system.	Show information based on relay readings for closed lift systems, or other data reading methods that access closed lift systems.	Practically depending on hardware. When designing the interface it can be assumed that the hardware is comaptible with all lifts.	Everyone's weakness is that they do not have a system for our customers who have 10 Otis lifts, 20 Schindler lifts, and 600 old lifts. You have to be able to cover all the lifts, that's the whole point. - Project Manager, LC3	Fulfilled There are two types of relay monitoring units that covers all lifts.
5	D	Accessibility	People with color vision deficiency	Express differences between objects and priorities in other ways than colour.	Difference in shape and text.	Especially important in a male-dominated industry because of the higher percentage of colour blindness.	- none -	Fulfilled Differences in shape and text
12	W1	Accessibility	Older adults	Can be used by older adults affected by decreased sight (40+).	Large components, texts and icons.	Larger components means less contents on every frame -> more frames.	Nowadays things must be quick and be easy, with big icons for old eyes. - Technician and Co-founder, LC6	Fulfilled Big sizing has been taken into account.
57	W1	Accessibility	Everyone	Enable the possibility to integrate proptech regarding other parts of the property.	Save space for other views/buttons to switch to monitoring of other parts of the property like for example heat, ventilation and doors.	Future work.	With every system you add, you take time away from something else. Then you have to learn that system and soon there will be no time left to do anything. - Technical Manager, PO7	Out of scope Complex and difficult to realise.
31	W2	Accessibility	Lift consultant	Enable information from the system for lift consultants.	Either give them an account, or a button to share the information they need to execute their work.	Lift consultants have expressed that they find monitoring systems very useful.	I see it (monitoring system) as an extremely good tool for me as a consultant to be able to do a better job for my clients, and also save money. Instead of driving 100 - 200 km to a property, I can look at and print the data instead of going there. - Lift Consultant, LC2	Fulfilled They can either create their own account or be shared information.
56	W3	Accessibility	Alarm centre	Enable information from monitoring to alarm centre administration.	Give the alarm centre an account with limited access (can not change some information). Might not need all parts of the system.	It should probably be up to the lift service company if they want to share the information with the alarm centre or not. For future work, alarm centre staff could be interviewed to identify their needs.	But when we receive the error report. It's treated by a group of administrators who monitor different services. They enter the error into a portal, our business system. - CEO, LC5	Fulfilled They can either create their own account or be shared information.
13	W1	AI & Automation	Everyone	Avoid sending an error when a technician is doing lift service.	Business system informs the monitoring system when a visit is planned.	Difficult to solve, but important.	Then it sent automatically. When I did an emergency opening (during a lift service dispatch), it sent out a work order to the person who ran the errors. Then he went there, and it was just me who stood there. You had to go into that app and say you were at the lift. - Technician, LC3	Fulfilled There is a switch for pausing alarm generation.
14	W1	AI & Automation	Everyone	Interpret data for the user and presents it in a user friendly manner.	AI, or help from a technician to analyze different error combinations of sensors/data. Communicate level of complexity of the problem. Do not encourage unauthorised people to do work that requires the competence of a technician.	Might be easy to design, but difficult to implement.	We don't send "error code 507" that points to the door. What we do is write in plain text that "this was gravel at the threshold". So that the property owner receives this code in Swedish and in plain text, not as an error code - Sales Manager, LC4	Fulfilled Descriptive text that presents complete context.

Req. ID	Degree of importance	Category	User	Description	Solution example	Comment	Quote English translation	Degree of fulfilment
59	W2	AI & Automation	Everyone	Calculate total cycles of different parts, and gives estimated date of exchange.	The system can not read how many cycles it have gone through before device was installed, but can calculate through knowing when a part was installed and multiplying it with the daily average 1000/day * 30 000 days = 30 000 000 cycles.	Future work. Manual data input is required in order to calculate expected cycles in the future.	The expected lifespan of belts and the door's wheels and contacts and rails and such. It's the number of cycles that determines it. So it's important to know. - Technician and Co-founder, LC6	Not fulfilled Lots of manual input is required. Will be extensive since a lift has many parts.
58	W3	AI & Automation	Everyone	Learn the normal behaviour of a lift over time and sends out notifications when something is off.	Through machine learning/AI. Communicates how trustworthy the AI has become (I am 70% sure).	Some lifts are not used to the extent necessary to identify a normal behaviour.	If there's an error, I can imagine the system detecting that "oh now it's taking five seconds longer to go this trip, then there's something wrong". Then it should present it. - Lift Consultant, LC1	Fulfilled Warning-alarms
60	W3	AI & Automation	Everyone	Indicate a recommended wait time before dispatch request.	30 minutes if a door is being blocked, and 0 seconds if no human can have triggered the alarm.	To avoid the lift working on arrival if someone just held up the door while moving.	Well, maybe it was the case that at that time someone was moving on the fourth floor, and held the door open because they were carrying stuff. And then someone comes on floor seven and notices that "the lift is not working and I have been waiting a long time, I will report the error". - Sales Manager, LC4	Partly fulfilled Delay is built within alarm generation but someone can still request dispatch during that time.
61	W3	AI & Automation	Everyone	Indicate estimated time of exchange for parts.	Takes the expected number of cycles, current cycles, and calculates when the part should be exchanged.	Time should not be too specific since it is just an indication. Quarter-wise is probably enough.	Me, who handle the object, want to know before the error actually occurs. I believe that both parties are interested in that. - CEO, LC5	Partly fulfilled In "specifications" it is possible to write model year for certain parts.
6	D	Alarm & Notification	Everyone	Possibility to be informed about errors outside of the interface.	Notifications. Send a link with information to a user's email or through text message.	Noticing errors should not require constant monitoring.	You want to be quick about things, even when it's not a direct error. You also want to receive a push notification when something has happened so that you can be on the spot quickly. - Technician and Co-founder, LC6	Fulfilled Notifications
7	D	Alarm & Notification	Everyone	Possibility to change settings for notifications.	Type of error, how often, when, what form (sms/mail/notification), summary report.	The preferences of whom to be notified, and through what medium differs between companies.	Some property owners want feedback through e-mail /.../ and some want a phone call, others don't give a shit. - Project Manager, LC3	Fulfilled Notification settings
15	W1	Alarm & Notification	Everyone	Avoid false alarms (false positives).	High thresholds before alarm is being sent.	For false negatives, tenants can report errors manually.	You can get into situations where you have a system that says the lift stands still when doesn't. So you would need to know if it stands still or not. It's the alpha and the omega. - Project Manager, LC3	Fulfilled Built in timer between error is detected to alarms are being sent out.
16	W1	Alarm & Notification	Everyone	Encourage proactive service.	Generate an alarm with lower priority when a none emergency is noticed: C - Alarm. Notify about deviations as early as possible.		For example, show when it's time to change things in advance. A little more detail about what is causing the trouble, of course, would've been interesting to see. - Property Developer, PO1	Fulfilled Historical data available. The system sends out warnings before critical failure.
32	W2	Alarm & Notification	Everyone	Inform automatically when the lift is back in service.	Send an e-mail or text message according to set notifications.	Should be possible to turn it off. Not everyone wants feedback.	They're not always great at giving feedback. Even if it's something we push a lot, because we want to be able to get back to the tenant who has also reported the fault in turn. - Technical Manager, PO4	Fulfilled A notification setting
33	W2	Alarm & Notification	Lift service company	Inform assigned technician if the lift starts working before arrival.	Technician receives notification to prevent unnecessary dispatch.	Might be difficult for the system to inform the technician correctly. This is mainly to avoid the times where the lift works on arrival.	It's so common that we even have an abbreviation, it's WOA, Worked On Arrival /.../ Out of a hundred calls, it's not 10, but more than 5. Somewhere in between. Let's say 7%. - Sales Manager, LC4	Partly fulfilled It is possible to recieve notifications for when lifts starts working again. The interface can not control if it reaches "the right person" or not.

Req. ID	Degree of importance	Category	User	Description	Solution example	Comment	Quote English translation	Degree of fulfilment
34	W2	Alarm & Notification	Everyone	Display different degrees of importance of an alarm by grading it.	ABC alarms as an example, safety hazards are prioritized (A). None-normative bahaviour are shown but not prioritised (C).	Helps the different stakeholders prioritize the importance/emergency of the problem.	It depends on what kind of alarm it is. In normal cases, you have an ABC alarm. A-alarms might be that the lift stands still. B-alarm may be that it is some other shit. Maybe it has been stipulated in the agreement that they only dispatch when it does not move, and maybe not if something else happens. - Property Technician, PO2	Fulfilled Different gradings; warning, alarm, and offline
8	D	Cognitive resources	Everyone	Give an overview of the most important data parameters for a lift.	Dashboard view, different parameters as widgets.		On a lift like this, you need to know if the doors are working. If you have four measuring points, you will get pretty far. - Project Manager, LC3	Fulfilled Dashboard view
17	W1	Cognitive resources	Everyone	Direct user attention to errors in dashboard view, list view and map view.	Take up more screen space and be presented directly on the screen. Bold colors. Realtime information is higher up on the page when lift is broken compared to when it is working.	The user should be able to detect defections of normal behaviour with easy without being accustomed to what is normal lift behaviour.	Getting a display that lifts are running and stuff like that, it's not like an industry or something with lots of machines everywhere. There you might need to see how it works. Not so with lifts. But we really want to know when it doesn't work and why. - Property Developer, PO1	Fulfilled Bold colours for alarms.
18	W1	Cognitive resources	Everyone	Give an overview of most emergent lifts.	List view - lifts out of service are prioritised on the top.	A list view gives a more clear depiction of what lifts require attention compared to a map view. Easier to eye-scan and view multiple objects at once.	The most important thing is that you can get an overview, that you see that all the lifts are moving, everything is working, then you can let it go for the moment. - Janitor, PO6	Fulfilled The overview page is sorted by status by default.
19	W1	Cognitive resources	Everyone	Present notifications in a useful and easily interpreted way.	Contain the most relevant information, with links to more details if needed.		What does the subject line say? Error [Company Name]. It doesn't say [City area name], it doesn't say which address, it doesn't say that it's an appliance room. How do I know if it's a lift or a washing machine? It should say lift and the address directly in the subject line! - Property Developer, PO1	Fulfilled Notifications include what lift, what type of error, and a link to the lift in the interface.
20	W1	Cognitive resources	Everyone	Present a moderate amount of information to avoid overloading cognitive abilities of users.	Present the most relevant information.	Conflicts with technicians' wish that they want to see as much as possible.	It's a balance for the customer not to present too much and confuse, but finding the most important thing. - Lift Consultant, LC2	Fulfilled Lots of white space and not too much content on every page.
21	W1	Cognitive resources	Novice user / Propery owner	Usage is intuitive and quick for a novice user.	Clear navigation structure where advanced functions are hidden and the most used are prioritised in presentation.	Property owners are expected to use the interface on sporadic occasions.	Kudos to Apple, they have managed to make a phone work in a very simple way. I can give it to my mother, she's almost blind, and she's able to use it. - Technical Manager, PO7	Fulfilled Usability tests have shown that it is easy to understand.
78	W1	Cognitive resources	Everyone	Be able to only view those lifts that a user is responsible for.	Assign different lifts to different users. Be able to create geographical areas for lifts.	Important since different employees are responsible for diferent areas. This is relevant for both property owners and lift companies.	Since we have so many lifts and are quite spread out geographically we have divided it into four different areas. - Procurement Officer, PO3	Not fulfilled Future work. Difficult to solve in a user friendly way without adding too much complexity.
35	W2	Cognitive resources	Everyone	Consider mental models of the user through terminology and concepts.	Right wordings. Follows the user's mental model of how a monitoring tool works. Like ABC - alarm system, commonly used for properties.	Some users have limited experience with digitalisation, and navigation in a new type of system might be more difficult for them.	- none -	Partly fulfilled Followed user's mental model but has not been properly evaluated if the "lift language" is correct.
36	W2	Cognitive resources	Everyone	Enable view of full details or more information without too much navigation.	Interactive information that shows details when clicked for details of a specific data parameter over time (graph). A broader detailed view of information for professionals could be toggled through a switch in a corner.	Important to find a balance of having enough information while not overloading the user.	We also have a lot of nightmare systems... Not for lifts, but I mean when there are a lot of functions that you have zero use for and it's difficult to navigate. - Technical Manager, PO7	Fulfilled Graphs are interactive. Alarms redirects users to relevant information.

Req. ID	Degree of importance	Category	User	Description	Solution example	Comment	Quote English translation	Degree of fulfilment
37	W2	Cognitive resources	Everyone	Give overview of geographic locations for lifts.	Map view - shows where the lifts are located on a map.		We have divided... Because we have so many lifts and we are quite geographically spread out, we have divided it into four different areas. - Purchasing Manager, PO3	Fulfilled Map view.
38	W2	Cognitive resources	Lift service company	Promote users to write relevant and appropriate amount of information during documentation.	Informative and intuitive text forms, checkboxes of executed work (with categorisation of different statuses).	Not certain who will be the one who fills this in, maybe either the administration or the technician.	Some write "lift stop" and the date, while others almost write a whole memoir. But the most common thing is they write very little. - Lift Consultant, LC1	Fulfilled Relevant labels, Placeholder text and word counter.
39	W2	Cognitive resources	Everyone	Enable customisation of what data should be shown, where and for whom.	Similar to graphs of Avanza, "monitoring". Default views for different types of users.	Takes time to set up customised visualisations.	But for my own sake, I'd prefer to have the Host Mobility system where we get all the information, so you can sort yourself what you want. - Technician and Co-founder, LC6	Partly fulfilled Different views for different users but they can not customise it to a considerable degree
9	D	Communication between users	Property owner	Service/dispatch can be requested from property owner to technician without an alarm being detected by the system (in case of non detectable problems).	"service dispatch request"-button. Allow lift users to report lift errors outside of the system.	Locking the users out of the current way of interaction would cause major problems.	- none -	Fulfilled Users can still contact each other outside of the interface.
22	W1	Communication between users	Everyone	Presented data enables concrete and clear discussions and decisions from different stakeholders.	Comunicates potential consequenses, comunicates reason for an error/breaking of spare part.	Works as a mediating tool to decrease the Property owners feeling of not having any gound in a discussion.	I don't know anything about lifts, so I wouldn't have any ground to stand up against a lift company if they say we have to do something. - Property Developer, PO1	Fulfilled Presents data that shows what actually has happened.
40	W2	Communication between users	Lift service company	Avoid negative representation of specific lift companies.	Avoid information connected to the manufacturer or service company that can be misinterpreted.	It is important to not start false rumors, and if companies are afraid of their data being presented by the system they are less likely to co-oporate.	Then it could be that it came out on the market that [Company Name] as a company has a lot of error codes on a certain thing. That would be harmful for the company worldwide, regardless of whether it's an actual error or a misunderstanding - Sales Manager, LC4	Fulfilled No tracker of lift companies' performance.
41	W2	Communication between users	Everyone	Enable sharing of specific information with another user.	Share button (as youtube videos) to give access to a limited amount of data, without giving full access through an account.		Before at the other place, I ordered a lot of stuff from them to see the history of the lifts. And then you got lots of links that you clicked on and then you got the work order via the web. - Technical Manager, PO2	Fulfilled Share-button.
42	W2	Communication between users	Everyone	Enable possibility to upload relevant documents.	Documents after modernisation, inspection, invoice, reparations and other technical specifications.	Is a flexible way to save gather lift related documents at one place if needed. Some companies might prefer to keep everything divided into separate systems.	In the order system we use, we will have a customer portal. So that even as a customer you will log into it and follow your lifts, see if there are any ongoing orders, when it is time for an inspection, if there are any remarks, the latest inspection report, the service report that we deliver, completed orders, ongoing orders. Simple, clear, a compilation in our system. - Technician and Co-founder, LC6	Fulfilled Possible to upload general related files as well as invoices and inspection history.
62	W3	Communication between users	Everyone	Encourage human contact.	Encourage a technician to give a janitor a phone call over sending an automatically generated log.	People working in practical occupations often dislike over digitalisation.	It's people who use the lift, it's people who should talk to each other and so on./.../ We might lose a bit of this customer contact. - Sales Manager, LC4	Fulfilled People's contact information is easily accessible.
63	W3	Communication between users	Lift service company	Comments and descriptions about a dispatch should be checked before sent to customer.	They are sent automatically to administration accounts. They must review and accept before sent to customer.	In case of incorrect/ inappropriate language.	Preferably, I'd rather not show action texts before they've been reviewed. For example, it is varying what level of Swedish the technicians have. It is not unusual for them to write "The bitch on the second floor was extremely annoying, but now the lift is working". That must not reach the customer. - CEO, LC5	Not fulfilled Down-prioritised since implementing a solution will be more complex in comparison with how important it is.

Req. ID	Degree of importance	Category	User	Description	Solution example	Comment	Quote English translation	Degree of fulfilment
65	W3	Communication between users	Lift service company	Communicate up-to-date technical information about a lift.	A list/document with technical information about the lift, including circuit-diagram, motor, control-system. Can be easily updated by the service company.	Time consuming to keep it updated, and unclear whose responsibility it is. But probably helpful if it is up-to-date.	We have many houses, we have to go into the right house and into the exact specification document for when the house was built, to find out the year of construction or from which year it is. Then if we have exchanged the lift, we must find that document. It would be great to have it collected, as it saves us a lot of time. - Technical Manager, PO5	Fulfilled Specification-tab for each lift where it is possible to enter relevant data. Shows when it was last updated and saves old versions.
70	W3	Communication between users	Lift service company	Error reports and information from the system reach the person intended to solve the problem.	Send reports to administration accounts instead of technicians. Link about specific information decided by a human, or automatically generated links according to reported lift.	Difficult to automate so that the information reaches the right person directly. It is up to stakeholders to share the information to the right people. Might be out of the monitoring system's control.	Now someone has called our alarm centre. And they have sent the error to our troubleshooter who has the central area. Then he receives it on his phone that "you have an error on [Street Name]", it's in the middle of the city. - Project Manager, LC3	Unclear Is out of the interface's control.
71	W4	Communication between users	Everyone	Allow for customised forms of documentation after service/dispatch.	Give the property owner and lift service company the possibility to determine what should be written in the documentation, and to what degree of detail.	Might be useful if a PO have specific requirements about what they want to know after every dispatch.	- none -	Not fulfilled Down-prioritised since implementing a solution will be more complex in comparison with how important it is.
72	W4	Communication between users	Everyone	Display a difference in dispatches/services that are included in the agreement.	Give property owners an understanding of what ratio of the dispatches a full-service agreement covers. Can then be used to evaluate if a full maintenance agreement has been profitable or not.	Likely, the system will not be used by property owners with full-service agreements however, so might be unnecessary.	- none -	Not fulfilled Down-prioritised since implementing a solution will be more complex in comparison with how important it is.
73	W4	Communication between users	Property owner	Give an indication to the property owner about the level of complexity of a dispatch.	Could be purely qualititive from the text forms, but could also be quantitive with a grading scale.	This is to create transparent communication, where the property owners are not oversimplifying the work of the technician.	"You only have errors on floor 2, the lock, that's what my data says", but it could be a huge error that takes 20 hours to fix. It can create more trouble than it solves, if the customer has that information. So it's easy to misinterpret. - Project Manager, LC3	Not fulfilled Down-prioritised since it is difficult to objectively rate them. Unclear how helpful the information really is.
10	D	Data parameters	Everyone	Display address.	"Storgatan 3b". Give the user the option to name specific lifts in case of multiple lifts in one building.		Super important. On a scale 1-10, 11. (how important it is to show the address of the lift). - Property Developer, PO1	Fulfilled The address is the name of the lift.
11	D	Data parameters	Everyone	Show operation status. If it is currently out of service, it should tell since when.	Graph, timeline/time. Shows a time for an errormessage, so a dispatcher can see if something have been occurring for 30 seconds or 5 hours.		As a property owner it is not as strict, but I think that you are most interested in if the lift is operating or not, and how long it has been out of service. - Project Manager, LC3	Fulfilled Map, overview and alarm show when the error occurred.
23	W1	Data parameters	Everyone	Communicate historical data.	Show parameters in a graph with time as x-axis.		If you have ten lifts in a property and lift number two runs a lot more than the others, then it's the one you start with when you're about to do modernisations or similar. So it becomes like the evidence of the condition of how the lift is doing. - Technical Manager, PO4	Fulfilled Possible to see data in graphs over time. Possible to change the time period.
24	W1	Data parameters	Everyone	Give information about what part is causing an error.	"Error of light sensor".	How specific the information can be depends on lift type and what sensors are installed.	Yes, it would be great if we knew what's wrong before we go there, but it also explains the required action. If the window is broken, you replace it. - Project Manager, LC3	Fulfilled An error category is mentioned for each alarm and error code.

Req. ID	Degree of importance	Category	User	Description	Solution example	Comment	Quote English translation	Degree of fulfilment
25	W1	Data parameters	Everyone	Prioritise information about doors since door problems are the most common type of error.	Door information is presented higher up, with bigger components.		Door related problems stands for... About 40% of all lift errors that comes in. - Sales Manager, LC4	Fulfilled If a problem with the doors arises it will be prioritised in the Alarm status widget on the dashboard, and shown on the map view and overview.
26	W1	Data parameters	Lift service company	Display all information available from the data monitoring unit interpretable for a professional technician.	A special view for technicians visualising all lift parameters.	All technicians were very clear about that they wanted to be able to see everything.	I'm biased due to my profession so I want to see as much as possible. - Technician and Co-founder, LC6	Fulfilled All information can be found under detailed data for CANopen-lift monitoring. Relay based monitoring does not have the same level of data, but all information can be found under Relay history.
27	W1	Data parameters	Everyone	Indicate if the emergency phone is in service.	Text describing last time it was controlled.	The emergency phone line checks itself every third day, but in between it can still be off.	If the emergency phone is not working they will be charged 92 000 in fines. - Technician and Co-founder, LC6	Out of Scope Unclear if it is technically feasible with the current hardware.
43	W2	Data parameters	Property owner	Visualise energy and power consumption of lift.	A widget for energy and power in the dashboard view for a lift.	Nearly all property owners were interested in it, although they were not sure what to do with the information.	How much energy is used, and power, that's also interesting. We get more and more electricity tariff in our houses. - Property Developer, PO1	Fulfilled Visualised on the dashboard of the lift page for property owners, and found under detailed data for lift service companies.
44	W2	Data parameters	Everyone	Indicate if there is a person in the lift currently.	A widget showing load, light and sensor status in the dashboard view for a lift.	Load in a car does not always mean that it is a person in there.	If someone is in the lift car, there is load in the car, and the lift is stuck, then you know that someone or something is in there. - Technician and Co-founder, LC6	Partly fulfilled It is possible to see load over time, but the information is not clickable in the prototype. The interface does not know if it is a person specifically, or heavy object.
45	W2	Data parameters	Everyone	Communicate to what level of detail the information is presented, depending on if the lift uses an open system, closed system or relay based system.	On the lift page, show what type of communication system the lift uses. An expandable "i"-icon for information explains what kind of information can be taken out from the different systems.	Is important to show so that users understand why the level of detail in information is different for every lift.	- none -	Fulfilled Found in the dashboard of the lift page, under "about lift".
64	W3	Data parameters	Everyone	Communicate if an error occurred due to overload.	Show history of when overload has occured. If load was high before error occurred, include it in the system generated error report and leave a comment like "strain in wire, most likely due to overload in car".	Errors due to load counts as man-made damage which property owners have to pay for. Showing this might help stakeholders agree on when lift service companies should charge.	(What you want to see) Maybe even the weight ratio. We have a bit of a problem, with these fancy old lifts as I say. There are delivery companies that come and drive in with piles of stuff to be delivered to the offices and sometimes they load quite a lot of KG into the lifts, and unfortunately, they damage the lift car. - Janitor, PO6	Fulfilled Information found under "detailed data", as well as in the alarm information on the dashboard, and the generated alarm log in the logbook.
74	W4	Data parameters	Everyone	Comunicate what type of operation the lift works for.	Text describing if it is for example a school or hospital. Different icons on map.	Should be further investigated if this information is useful, and what it can be used for. Might help PO with budgeting and help LC with planning services.	Experience-based. Jumping in lifts and stuff, it's hard to get around for a school. In this case, it was solved by having key control in that lift. Someone who is disabled, teacher or student, they will receive a key or tag. And other students can use the stairs and get some exercise in return. - Technical Manager, PO7	Not fulfilled Down-prioritised due to lack of importance.

Req. ID	Degree of importance	Category	User	Description	Solution example	Comment	Quote English translation	Degree of fulfilment
28	W1	Ease of workflow	Everyone	Enable quick access to information through simple login.	Login with already existing service, work email, facebook, google, apple. An app where you are kept logged in. An application-based system does not require a login in the way a web application does.	This might be difficult to implement on people´s work phones and computers.	You want an app environment for example, not something web-based, because then you have to find the website and it's a bit more complicated to add to the start page, and you have to log in, and it's a little slower. It should be quick and easy. - Technician and Co-founder, LC6	Partly fulfilled Quite quick if "remember me" -box is checked. But it would be even quicker with an app.
29	W1	Ease of workflow	Property owner	Integrate all lift-related systems/software so that they are gathered in one place.	Include inspection, service, business system, monitoring, status list. Upload relevant documents to the same place.	Difficult to enter the market with an all-in-one-solution since there are already seperate systems for everything.	As it works today, there are a lot of them (lift related systems). You have a service and inspection company, there are a few different technicians who do service, and I see the benefit in combining everything into one. It is more natural to have it with your lift supplier. - Technician and Co-founder, LC6	Out of scope Unclear how it would work in practice. Difficult for this system to replace other, already established systems/softwares.
46	W2	Ease of workflow	Lift service company	Allow preperation before dispatch such as buying spare parts and sending the right technician.	Be presented relevant and detailed information about the lift error before dispatch.	Depending on how detailed the information is in the monitoring system, it is up to the lift service company what they will do with the information.	Say we have 35 people who work in the aftermarket who work with service and maintenance, and of them 5 are very competent. They are incredibly talented. Those 5 I want to save as much as possible, send them to the right things. - CEO, LC5	Partly fulfilled Allows technicians to do so by providing detailed information about an error. Is up to the technician to actually do it.
47	W2	Ease of workflow	Lift service company	Allow shorter average trouble shooting time compared to having no monitoring system.	Specify what part of the lift needs maintainance.	Requires many sensors to give a complete picture.	Fundamentally speaking, you're dependent on the error report that someone has called in. It could be a tenant who has called and quite commonly the lift isn't moving. Then a follow-up question is "which floor then?" Sometimes you only have the information that an lift is standing still as an error report. - Lift Consultant, LC2	Unclear Will not be able to evaluate.
48	W2	Ease of workflow	Lift service company	Display error-code history.	Give the possibility to analyse the whole sequence of events if it is not the latest generated error code that is the problem.	This might be difficult to implement on people´s work phones and computers.	(What you want to see the most) Error statistics, i.e. the error memory so to speak, just before the error occurs. So the error code that is listed, it is very rarely that one fault lies behind. Rather it's a sequence of things that happen before the lift breaks and then an error code comes up, which is very often the case. - CEO, LC5	Fulfilled Found under "detailed data" for lift CANopen-lift monitoring, and relay history can be found as an own tab in relay-monitoring.
66	W3	Ease of workflow	Lift service company	Allow remote reset and control.	Buttons for controlling it remote.	Potentially the lift can also restart automatically for a stop.	From 1st of April, [Company Name] connects all its lifts to a so-called technical operation center where we monitor all lifts. And we can even do that, not for the very oldest lifts, but there we can do a remote restart. And it will be a huge saving for our customers that we don't have to do these. - Sales Manager, LC4	Fulfilled Function available on dashboard of lifts with Relay based monitoring.
69	W4	Ease of workflow	Property owner	Allow users to change settings/information about multiple objects at once, and add a new object to another framework of settings.	Change contact information, notification settings, and editing rights in the system for multiple/ all objects to fit according to the agreement with a service company. Also, possibility to add an object into the same conditions as other objects.	Companies usually have one company for most maintenance after the 5 year warranty time.	Yes, we have the same (lift service company) for all (lifts) except where there is a warranty on the construction. That contractor then retains the guarantee for five years. Then we transfer them to the company we hire. - Technical Manager, PO2	Fulfilled "Transfer lifts" enables the property owners to move all or multiple lifts from one service company to another with ease.
75	W4	Ease of workflow	Lift service company	Enable planning of service to disturb lift users as little as possible.	Show times with highest and lowest usage.	Might be ignored. Important to fix the error directly. Lift service companies do not want to "wait" for work orders. Most lifts are probably used the same time of the day.	If you had obtained all these statistics, we would've been able to time our service visits, partly in terms of time of day so that we would disturb as little as possible for those who use the lift. - Technician and Co-founder, LC6	Fulfilled Floor history found in "detailed data" allows property owners and lift service companies to adjust their work to the usage patterns of the lift.

Req. ID	Degree of importance	Category	User	Description	Solution example	Comment	Quote English translation	Degree of fulfilment
30	W1	Economics & Analytics	Property owner	Generate lists/reports of status in order to summarise events.	Generate a status-list, possibility to control over what timeframe and what should be included (costs, start cycles, door cycles, dispatches).	From interviews, it can be concluded that it is a very useful function. Since many participants were Technical managers or responsible for purchasing, this might be conveyed more than other more frequently used functions.	That one (status list over all their lifts) I use it as a basis for budgeting every year. - Technical Manager, PO4	Fulfilled Through the "Reports" function.
49	W2	Economics & Analytics	Lift service company	Convey economical benefits of the system for the lift service company.	Take out information that shows how technicians can work more efficiently, or gets more service agreements	Many lift companies are not convinced the system will profit them, and might see the system as opposing their business.	But this (monitoring system) would also be better for us since we can save money and time in the same way as the customer and have a more profitable operation (why the digital monitoring system was developed) - Sales Manager, LC4	Not fulfilled Unclear how and what should be shown.
50	W2	Economics & Analytics	Property owner	Convey economical benefits of the system for the property owner.	Take out information that can be used for setting a budget.	Include numbers of costs if possible.	But then you need to do the analysis how will it be used, who uses it, how to make use of the available statistics, etc. So that analysis must be done before you decide to buy a digital system, so that you don't buy something that won't be used, and that you have resources for it. - Purchasing Manager, PO3	Fulfilled Through report generation over time and recommended service visits, a propety owner can see the change, and adjust their service agreement to suit their needs.
51	W2	Economics & Analytics	Everyone	Communicate the distribution/statistics of what errors have caused a stop/dispatch and how many.	"4 out of 11 errors were door problems". Compare to an industry standard / key number.	Show a representation of recurring errors.	It's good to be below 2 errors per lift and year, it is like a key performance number within the industry. And we are usually around 1,4 errors per lift and year. As long as we are below 2 we are happy. - Technical Manager, PO7	Fulfilled Information displayed on a liftpages dashboard.
67	W3	Economics & Analytics	Everyone	Give a recomendation of how many service visits a lift need based on historical error and usage statistics.	Based on historical error and usage statistics, according to the juridical demands.	Might be difficult to solve because big amount of history is needed. Probably requires some kind of AI, automation and calculation.	If one would optimise it further and conclude that some lifts only need 2 service visits per year and some need 6 visits, then the estimation becomes even more clear, so that would be economically justifiable. - Purchasing Manager, PO3	Fulfilled Information displayed on dashboard and in generated reports.
76	W4	Economics & Analytics	Everyone	Communicate if a lift is under warranty time.	Icon, tag, text description	Lifts under warranty time is an economic risk for lift service companies. They might be extra sure to make those lifts work as intended.	We have a german supplier that we have bought from (a digital lift monitoring system), but we mostly use it to monitor our own warranty lifts actually, not for presenting data to the customer. - CEO, LC5	Not fulfilled Down-prioritised due to lack of importance.
52	W2	Emotion	Everyone	Convey trust and security through aesthetics.	Selection of color (blue), and shape language (More masculine/sharp).	Feeling that the service is realiable and professional.	- none -	Fulfilled Participants from evaluation percieved the interface this way.
53	W2	Emotion	Everyone	Prevent monitoring of individuals.	No GPS for individuals. No enforced time tracking.	This includes both technicians but also tenants.	(Talking about why some technicians don't start the timer when they initiate a work order in their internal business system) No, it happens that they don't give a shit about it because they feel observed. Because then you know what they are doing. - CEO, LC5	Partly fulfilled There is no GPS for indivual or clock in/clock out, but afterwards the technician leaves quite detailed information about time.
54	W2	Service logs	Everyone	Enable complete information about a specific dispatch/service.	(Time for alarm, Time for requested dispatch, Time for arriving at location, Time for service, Reason of alarm, Earlier occurrence, Identified problem, Solution, Cost of service, Responsible person, Invoice).	Writing a service log might overlap with stakeholders' internal business systems. Inconvenient to write the same information multiple times.	- none -	Fulfilled Service logs found in the global and local logbook convey the required information.

Req. ID	Degree of importance	Category	User	Description	Solution example	Comment	Quote English translation	Degree of fulfilment
68	W3	Service logs	Everyone	Communicate which service log is connected to a certain alarm and how the monitoring contributes to proactive service.	Service logs are connected to the reported error codes that occurred close in time. Shows a visual difference of system reported errors vs lift user reported errors.	Show the proactiveness of the system, and that the lift users do not notice lift problems to the same degree.	It's quite cool if someone goes to a lift, presses the button and it's not working. Then they are about to call, and the technician walks into the door because he recieved it before the tentant even noticed. "How the heck did you come here so quickly?" - Property Developer, PO1	Not fulfilled Difficult since multiple errors can be solved from one service visit.
55	W4	Service logs	Everyone	Enable possibility to show planned date of service.	Calendar with upcoming services.	From interviews it can be concluded that upcoming service is not as important as past service.	Then it would be nice if you could enter some intervals so that the service is done within the right interval. Similar to a car. When it´s time to change oil, time to change washer fluid, to make the lift feel as good as possible. - Technical Manager, PO7	Not fulfilled Low reward. Will probably contribute to a more complex interface.
77	W4	Service logs	Everyone	Allow possibility to see pictures of the lift before and after it has been repaired.	Function for embedding pictures in service and dispatch logs. "Upload"-button.	Might be unclear what the picture shows, and too much effort to add pictures. The function might be very useful if used properly.	I'd like to have a portal where you can see your errands, and before and after pictures of what has been done. - Technical Manager, PO5	Not fulfilled Down-prioritised since we assume that users will find it time consuming and inconvenient to use the function.

D

Usability test template lo-fi

Scenario property owner:
You are Annie Johnson, CEO for a property owning company called Propowner AB. You have received a notification through E-mail that your lift monitoring system Host Complete has detected that your lift at Storgatan 22B is out of service. You enter the web application of Host complete to further investigate.

Tasks:

- Log in to the website and give yourself an overview of the status of your lifts and where they are located geographically.
- Navigate yourself into the lift page of Storgatan 22B.
- Find if the door sensor is currently blocked
- Investigate if the max speed have been stable within the last hour
- Determine the exact speed at 8:19
- Read the latest alarm log and find out which error codes are related to the stop.
- Read the latest Service log and the cause of the dispatch, the course of action and responsible technician
- Find the dimensions of the lift car.
- Generate a report with following properties:
  - PDF-format
  - English
  - Time period between 1 Jan 2023 - 20 Mar 2023
  - Include all lifts
  - Include the number of unplanned stops, number of service visits, cost of service, alarm, lift manufacturer, building year, and year of latest modernisation
- See what lifts had the highest cost during this period.
- Add a new lift

- It is relay-based so you have to interpret the meanings of the relays. The monitoring unit has different wires with different colors. Each wire is connected to a relay, which represents different parts of the lifts. Interpret the relays by filling in the text fields with their meanings.
- Restart the new lift remotely.
- Your company has some lifts that the company Lift Enthusiasts are responsible for, find the number to their CEO Henrik Staffansson.
- Currently, you receive notifications when a lift loses connection with the monitoring system. You have noticed that the service company takes care of it and you don't have to worry about it. Turn off notifications for you when a monitoring unit loses connection.

Scenario lift technician:
Let us pretend that you are a technician working for a lift service company instead. You have received a notification that says that one lift is out of service. You are about to dispatch and repair the lift, and you use the lift monitoring system during your service visit.

Tasks:

- Pause monitoring for the lift so that it does not send out alarms while you are repairing it.
- Service is done. Add a new service log that describes what you did.

Questions after evaluation:

- What do you think about the navigation and flow?
- Was there anything that was unclear? How could it be improved?
- What was good about the interface and why?
- Was there anything you wanted to do that you could not?

E

Usability test template hi-fi property owners

Scenario:
Your name is Erik Hammarström and you are a newly hired administrator at the property company named Property Owner AB. For a couple of years now, your company has used the lift monitoring system Host Complete, which is a system where you collect and analyse data from your lifts. When you open your job email, you see that you have received a notification regarding a lift at Götabergsgatan 3. You open the email and go to Host Complete's web application to investigate further.

Tasks:

- Log in with your account on Host Complete's web application.

Now you can click around and familiarise yourself with the interface for a couple of minutes before we start with the rest of the tasks.

- Go to the elevator page for Götabergsgatan 3 and investigate what is wrong with the elevator. How would you act based on the given information? (Call lift service or janitor?)

On a scale from 1-10 where 1 is unsure and 10 is sure, how sure are you that you completed the task?

On a scale from 1-10 where 1 is easy and 10 is difficult, how difficult was the task?

- You already know that Host Complete works with two different types of monitoring units for your lifts, which type is used on this particular lift and what does that mean?

On a scale from 1-10 where 1 is unsure and 10 is sure, how sure are you that you completed the task?

On a scale from 1-10 where 1 is easy and 10 is difficult, how difficult was the task?

- How many yearly service visits are recommended by Host Complete for this particular lift, and what is it based on?

On a scale from 1-10 where 1 is unsure and 10 is sure, how sure are you that you completed the task?

On a scale from 1-10 where 1 is easy and 10 is difficult, how difficult was the task?

- How much energy did the elevator use during April? Can you see the exact value?

On a scale from 1-10 where 1 is unsure and 10 is sure, how sure are you that you completed the task?

On a scale from 1-10 where 1 is easy and 10 is difficult, how difficult was the task?

- Find out which floor the lift stops at the most, as well as which it stops at the least.

On a scale from 1-10 where 1 is unsure and 10 is sure, how sure are you that you completed the task?

On a scale from 1-10 where 1 is easy and 10 is difficult, how difficult was the task?

- Are any more of your elevators than Götabergsgatan 3 standing still? In that case, go to it. Find out how long the technician was on site during the last service visit for Storgatan 5B, and what he did.

On a scale from 1-10 where 1 is unsure and 10 is sure, how sure are you that you completed the task?

On a scale from 1-10 where 1 is easy and 10 is difficult, how difficult was the task?

- Find out what year the lift was built, as well as when it was last modernised.

On a scale from 1-10 where 1 is unsure and 10 is sure, how sure are you that you completed the task?

On a scale from 1-10 where 1 is easy and 10 is difficult, how difficult was the task?

- You have been tasked by the company's management to present a compilation of errors and service costs for all your elevators so far this year. Generate a report with the following properties:
  - PDF-format
  - In English
  - All your lifts
  - Time period between: 1 January 2023 - 28 April 2023
  - Included tags:
    * Alarm - stops
    * Alarm - warnings
    * Service Cost
    * Service Visits
    * Lift Manufacturer
    * Year of Construction
    * Year of last Modernisation

On a scale from 1-10 where 1 is unsure and 10 is sure, how sure are you that you completed the task?

On a scale from 1-10 where 1 is easy and 10 is difficult, how difficult was the task?

- Find out which elevator was the most expensive during this time period according to the report.

On a scale from 1-10 where 1 is unsure and 10 is sure, how sure are you that you completed the task?

On a scale from 1-10 where 1 is easy and 10 is difficult, how difficult was the task?

- Right now you receive notifications when an elevator loses connection to the monitoring system. You have noticed that this usually resolves itself without you having to do anything about it, turn off notifications for when your monitoring devices lose connection (Notice if participants remember to press the save-button).

On a scale from 1-10 where 1 is unsure and 10 is sure, how sure are you that you completed the task?

On a scale from 1-10 where 1 is easy and 10 is difficult, how difficult was the task?

- Previously, you had 14 lifts with the service company Lift enthusiasts. The agreement has now expired and you are not completely satisfied with the service you have received. Therefore you want to transfer these lifts to Lift Service AB, which takes care of the majority of your lifts.

On a scale from 1-10 where 1 is unsure and 10 is sure, how sure are you that you completed the task?

On a scale from 1-10 where 1 is easy and 10 is difficult, how difficult was the task?

Questions after all tasks have been completed:

- What do you think about the navigation and flow?
- Was there anything that was unclear? How could it be improved?
- What was good about the interface and why?
- Is there anything that you want to be able to do in a monitoring system that is not possible in this prototype?

Rate your overall experience with the interface:

Advanced 1 2 3 4 5 6 7 Simple

Motivation or comment:

Predictable 1 2 3 4 5 6 7 Surprising

Motivation or comment:

Innovative 1 2 3 4 5 6 7 Conventional

Motivation or comment:

Unaesthetic 1 2 3 4 5 6 7 Aesthetic

Motivation or comment:

Unreliable 1 2 3 4 5 6 7 Reliable

Motivation or comment:

F

Usability test template hi-fi lift service companies

Scenario:
Your name is Erik Hammarström and you are an administrator at the lift service company Lift Service AB. In recent years, your customers, the property owners, have started digitising their lifts. They use a lift monitoring system called Host Complete, which you at Lift Service AB also get access to because you are responsible for the maintenance of your customers' lifts.

When you open your job email, you see that you have received a notification from Host Complete that an elevator at Götabergsgatan 3 has stopped. You decide to go to Host Complete's web application to investigate further.

Tasks:

- Log in with your account on Host Complete's web application.

Now you can click around and familiarise yourself with the interface for a couple of minutes before we start with the rest of the tasks.

- Go to the elevator page for Götabergsgatan 3 and investigate what is wrong with the elevator. How would you act based on the given information?

On a scale from 1-10 where 1 is unsure and 10 is sure, how sure are you that you completed the task?

On a scale from 1-10 where 1 is easy and 10 is difficult, how difficult was the task?

- What error codes caused the last alarm?

On a scale from 1-10 where 1 is unsure and 10 is sure, how sure are you that you completed the task?

On a scale from 1-10 where 1 is easy and 10 is difficult, how difficult was the task?

- You already know that Host Complete works with two different types of monitoring units for your lifts, which type is used on this particular lift and what does that mean?

On a scale from 1-10 where 1 is unsure and 10 is sure, how sure are you that you completed the task?

On a scale from 1-10 where 1 is easy and 10 is difficult, how difficult was the task?

- How many yearly service visits are recommended by Host Complete for this particular lift, and what is it based on?

On a scale from 1-10 where 1 is unsure and 10 is sure, how sure are you that you completed the task?

On a scale from 1-10 where 1 is easy and 10 is difficult, how difficult was the task?

- Find out which floor the lift stops at the most, as well as which it stops at the least.

On a scale from 1-10 where 1 is unsure and 10 is sure, how sure are you that you completed the task?

On a scale from 1-10 where 1 is easy and 10 is difficult, how difficult was the task?

- Are any more of your elevators than Götabergsgatan 3 standing still? In that case, go to it. In that case, go to it. Find out what year the lift was built, as well as when it was last modernised.

On a scale from 1-10 where 1 is unsure and 10 is sure, how sure are you that you completed the task?

On a scale from 1-10 where 1 is easy and 10 is difficult, how difficult was the task?

- Find out what floor the elevator last stopped on before the current stop.

On a scale from 1-10 where 1 is unsure and 10 is sure, how sure are you that you completed the task?

On a scale from 1-10 where 1 is easy and 10 is difficult, how difficult was the task?

- One of your technicians, Karl Sundin, will dispatch and repair the lift at Storgatan 5B. You do not want alarms and notifications to be sent out while he is working with the lift, due to the risk of double dispatches. Before the service visit, pause the lift from generating alarms the next few hours.

On a scale from 1-10 where 1 is unsure and 10 is sure, how sure are you that you completed the task?

On a scale from 1-10 where 1 is easy and 10 is difficult, how difficult was the task?

- Now the technician is done with the service visit. Add a new service log that describes what was done.

On a scale from 1-10 where 1 is unsure and 10 is sure, how sure are you that you completed the task?

On a scale from 1-10 where 1 is easy and 10 is difficult, how difficult was the task?

- Right now you receive notifications when an elevator loses connection to the monitoring system. You have noticed that this usually resolves itself without you having to do anything about it, turn off notifications for when your

monitoring devices lose connection (Notice if participants remember to press the save-button).

On a scale from 1-10 where 1 is unsure and 10 is sure, how sure are you that you completed the task?

On a scale from 1-10 where 1 is easy and 10 is difficult, how difficult was the task?

- One of your customers, Property Owners AB, has set up a new property with address Trumpetgatan 18 which has a platform lift. They have purchased a monitoring unit that one of your technicians has installed. Add this device using the information provided by the technician.

On a scale from 1-10 where 1 is unsure and 10 is sure, how sure are you that you completed the task?

On a scale from 1-10 where 1 is easy and 10 is difficult, how difficult was the task?

- Go to the page for the new elevator. Do a remote restart, and try running the lift up and down.

On a scale from 1-10 where 1 is unsure and 10 is sure, how sure are you that you completed the task?

On a scale from 1-10 where 1 is easy and 10 is difficult, how difficult was the task?

Questions after all tasks have been completed:

- What do you think about the navigation and flow?
- Was there anything that was unclear? How could it be improved?
- What was good about the interface and why?
- Is there anything that you want to be able to do in a monitoring system that is not possible in this prototype?

Rate your overall experience with the interface:

Advanced 1 2 3 4 5 6 7 Simple

Motivation or comment:

Predictable 1 2 3 4 5 6 7 Surprising

Motivation or comment:

Innovative 1 2 3 4 5 6 7 Conventional

Motivation or comment:

Unaesthetic	1	2	3	4	5	6	7	Aesthetic

Motivation or comment:

Unreliable	1	2	3	4	5	6	7	Reliable

Motivation or comment:

G

Additional frames of the final prototype

Login Screen

The login screen of Host Complete shows the logotype of the application and an illustration of a city created by Midjourney. The user logs in by entering their account information in the text fields. See Figure G.1.

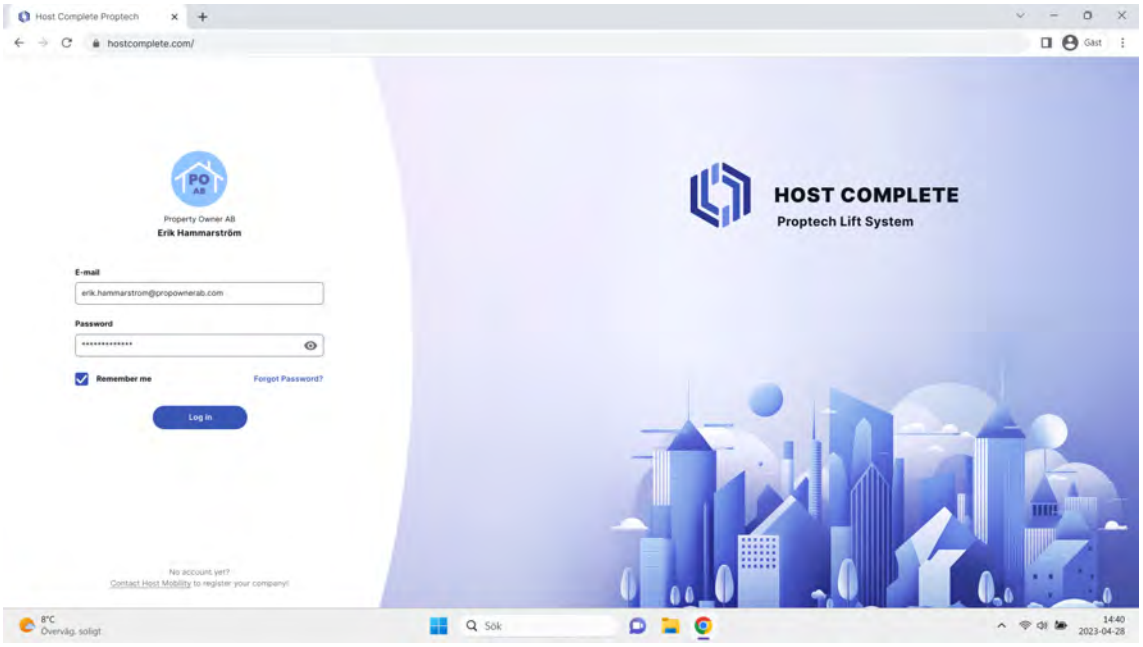

Figure G.1: Host Complete - Login screen.

Local Logbook

Every lift has its own local logbook. It is similar to the global logbook but only include events and documents from the specific lift. See Figure G.2.

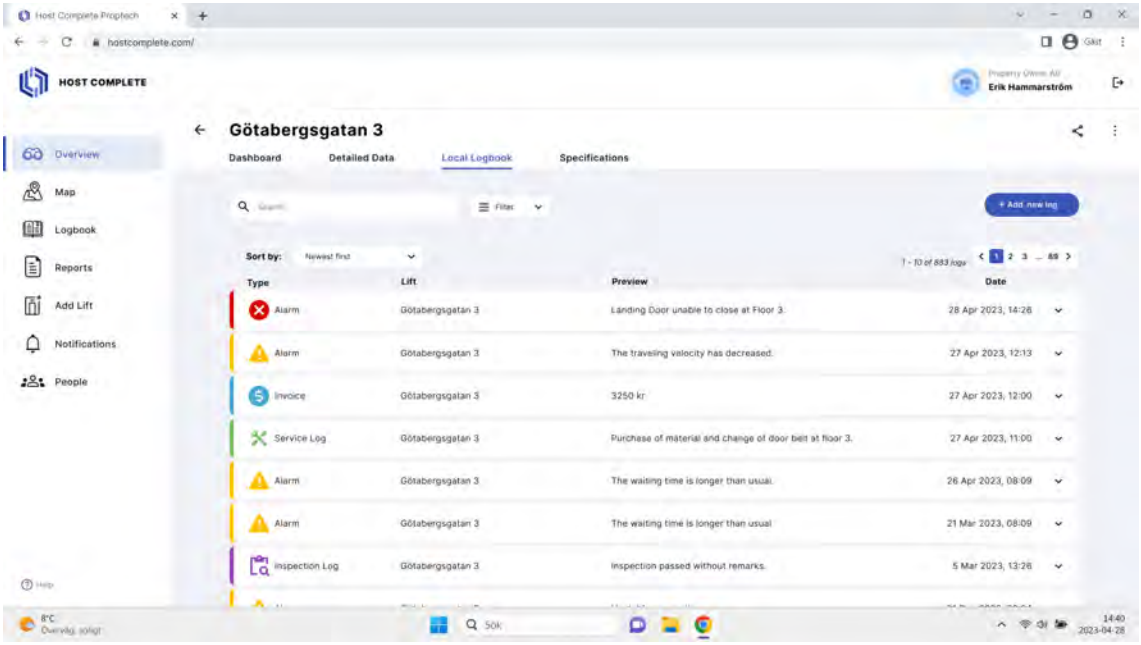

Figure G.2: Host Complete - Local Logbook.

Expanded Log

When clicking on a log, it expands and shows more detailed information about what happened. Information such as when the technician arrived on site, identified problem and course of action is presented. This is for property owners to feel that they receive sufficient information after service. See Figure G.3.

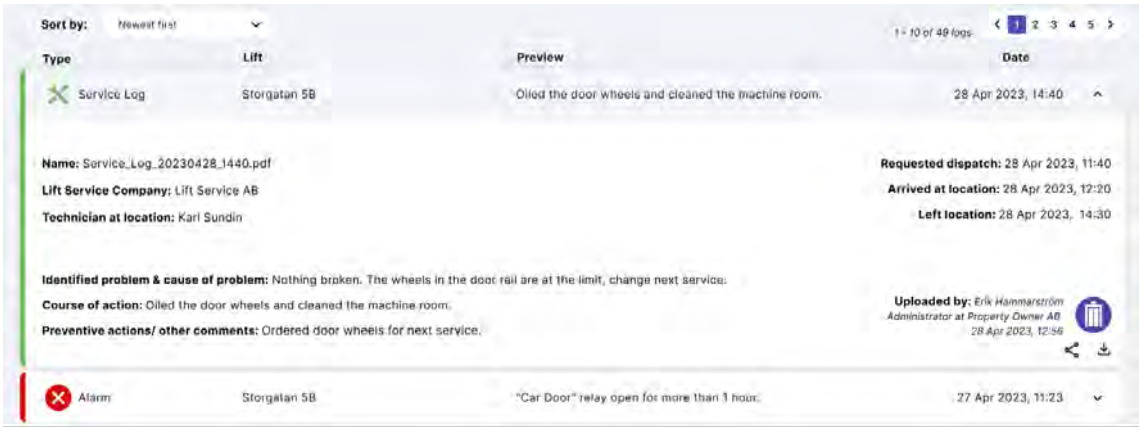

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Figure G.3: Host Complete - Expanded log.

Adding a service log

When adding a service log, it is designed to promote users to write relevant and appropriate amount of information. By adding relevant labels, explanatory placeholder text, and character counter, the user is guided in how much information and what information should be written. See Figure G.4.

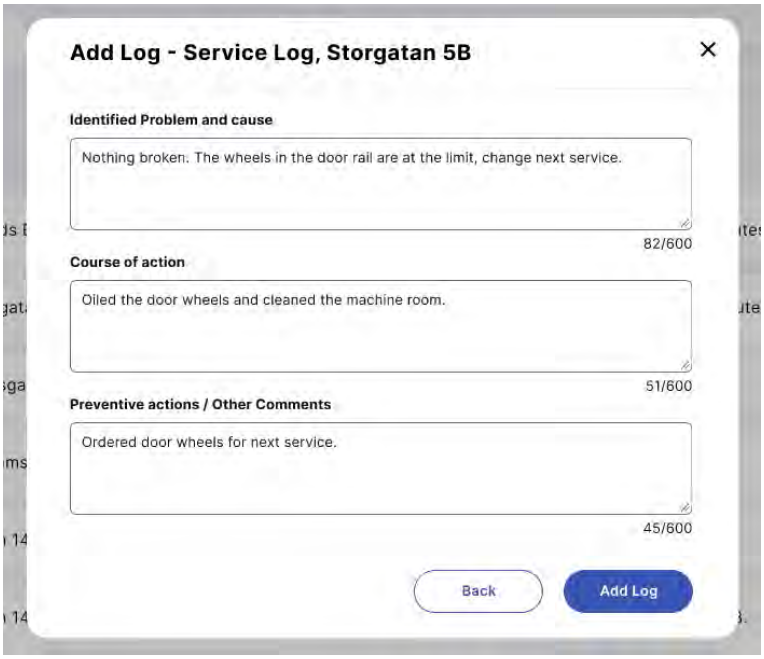

Figure G.4: Host Complete - Adding a service log.

Report preview

Users can generate reports that summarises important parameters and events of their lifts. An example of a generated report can be seen in Figure G.5.

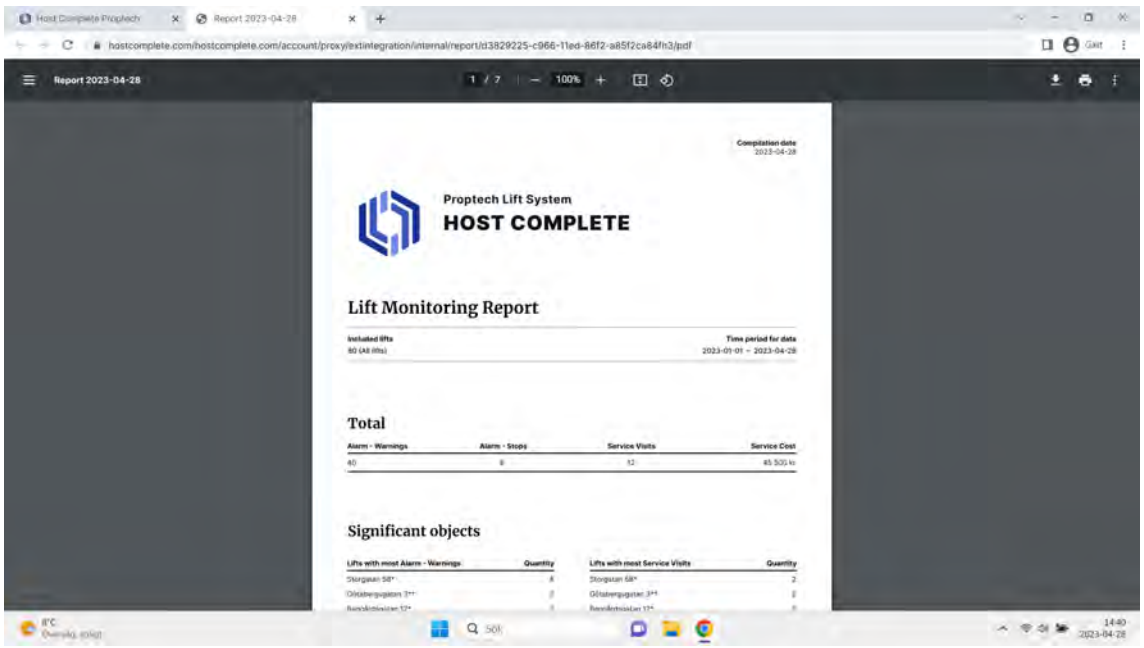

Figure G.5: Host Complete - Report preview.

Floor History

In Figure G.6, the data parameter of "Floor History" is displayed. Through displaying the time periods where the lift is used, the lift service company has the possibility to plan their service visits accordingly. Property owners have also said that they are interested in seeing patterns and flows in the buildings. It is possible to filter by specific time periods. The most common floor stops of all time are listed, compared to the chosen time period. These are stops during normal operation, and not stops due to errors.

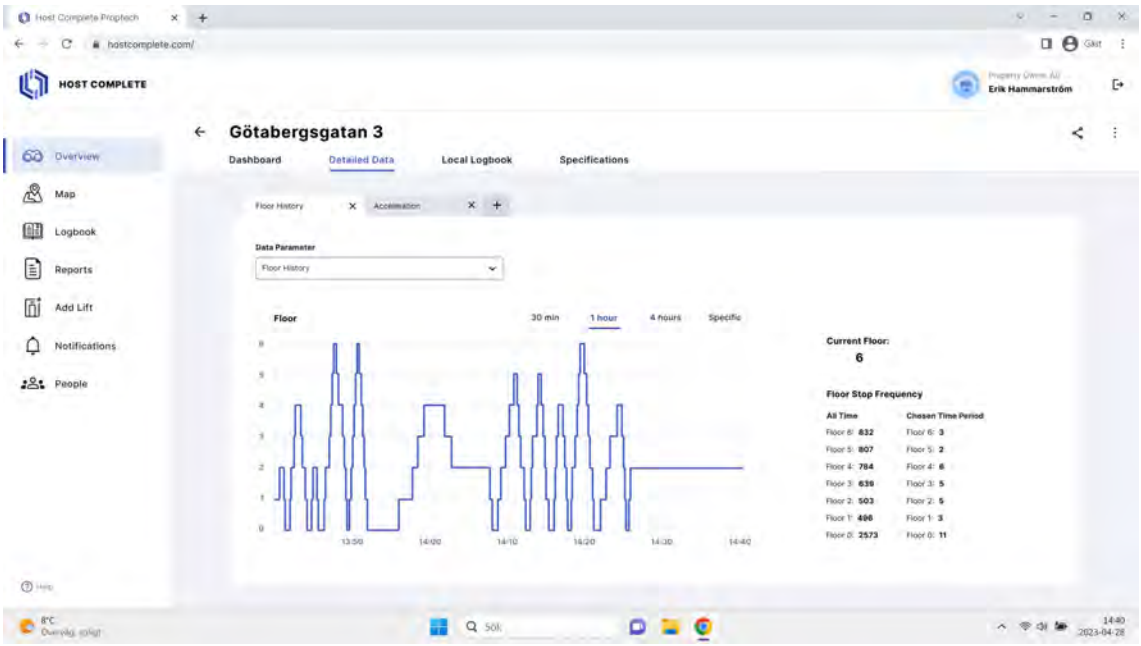

Figure G.6: Host Complete - Detailed Data, Floor History.

Error Code History

The specific data parameter displayed is chosen through the dropdown menu, see Figure G.7. As the exact data points that could be monitored had not yet been determined, an assumption was made about some possible parameters that could be found in a lift monitoring system of CANopen-lift. Floor History can be seen in Figure G.6 and Error Code History in Figure 6.17.

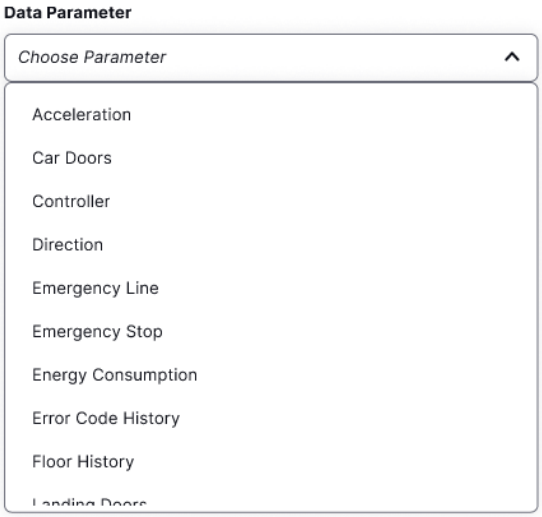

Figure G.7: Host Complete - Detailed Data, data parameter drop down selection.

Transfer Lifts

To allow the change of lift service company while still maintaining data gathering, a function for transferring lifts was added. By using this function all lifts assigned to a certain service company are assigned to another service company. The previous service company will lose access to those lifts' data while the new company gains access, see Figure G.8.

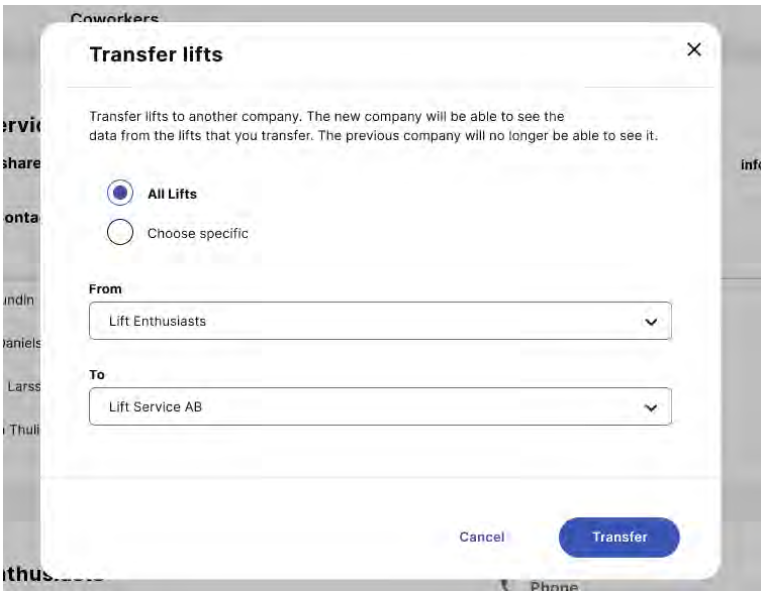

Figure G.8: Host Complete - Transfer lifts.

Coworkers

At the page "Coworkers", information about the logged in user's company and their coworkers can be found. It is also possible to invite new people and edit other people's account depending on the logged in user's level of permission. The page "Coworkers" can be seen in Figure G.9.

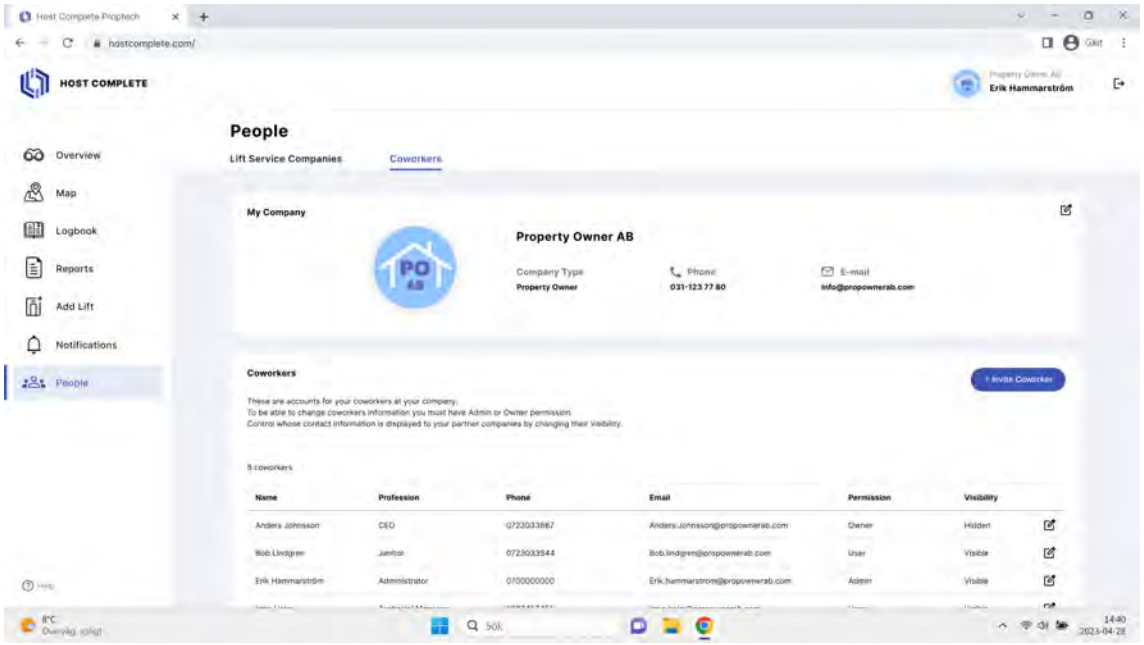

Figure G.9: Host Complete - Coworkers

When editing a user, their contact information, level of permission and visibility status can be changed. See Figure G.10.

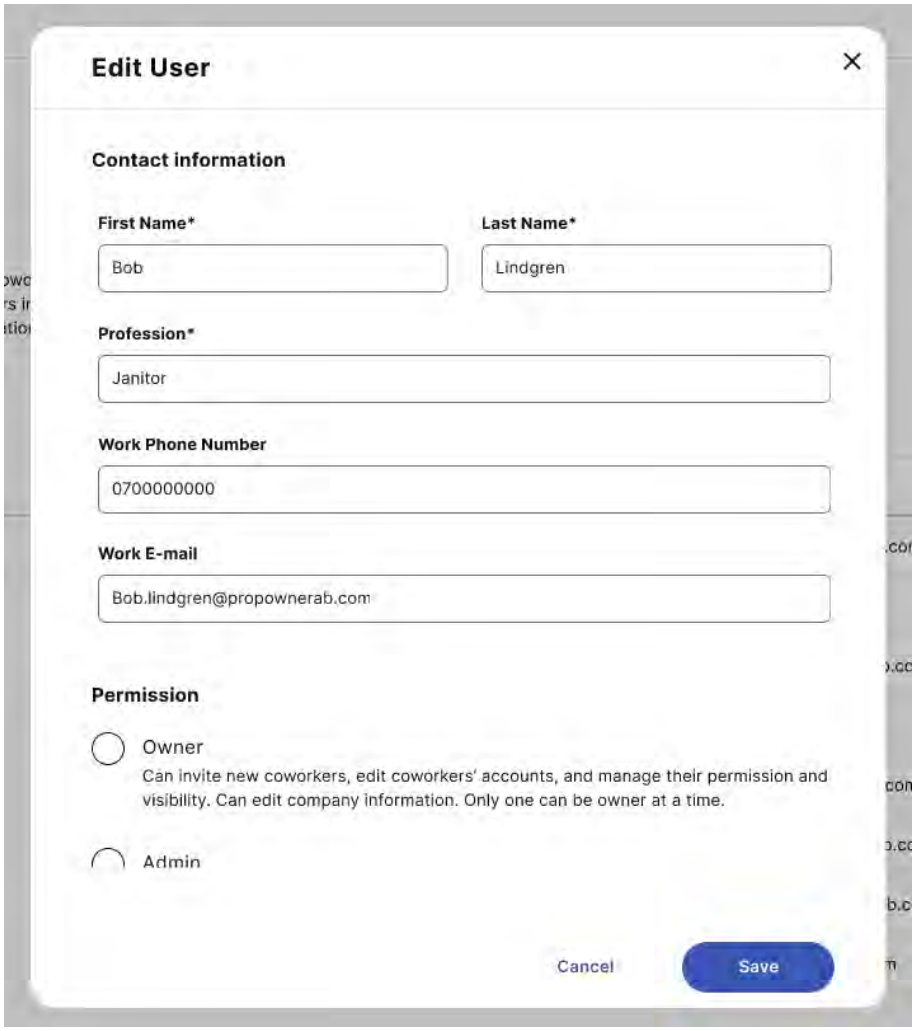

Figure G.10: Host Complete - Edit User in Coworkers

Profile

Under "Profile" information about the logged in user's account can be found. Here the user can change account settings and terminate their account. See Figure G.11.

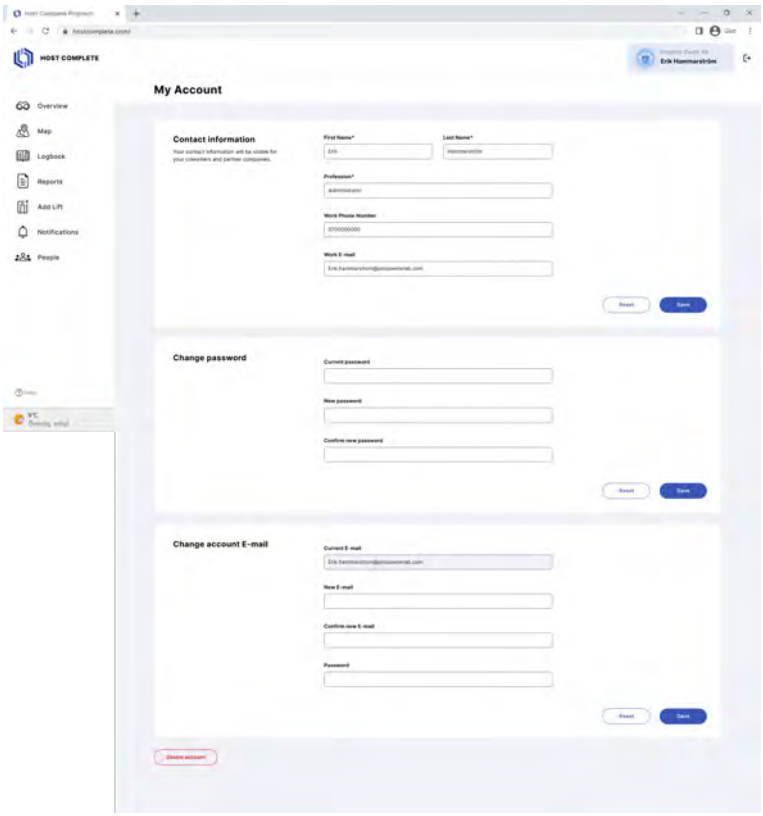

Figure G.11: Host Complete - Profile

H

Certainty of completing task

During usability tests with the hi-fi prototype participants were asked: "On a scale from 1-10 where 1 is unsure and 10 is sure, how sure are you that you completed the task?". These results were excluded from the Result-chapter due to low value for discussion. Participants' certainty of completing Task 1-6 can be seen in Figure H.1

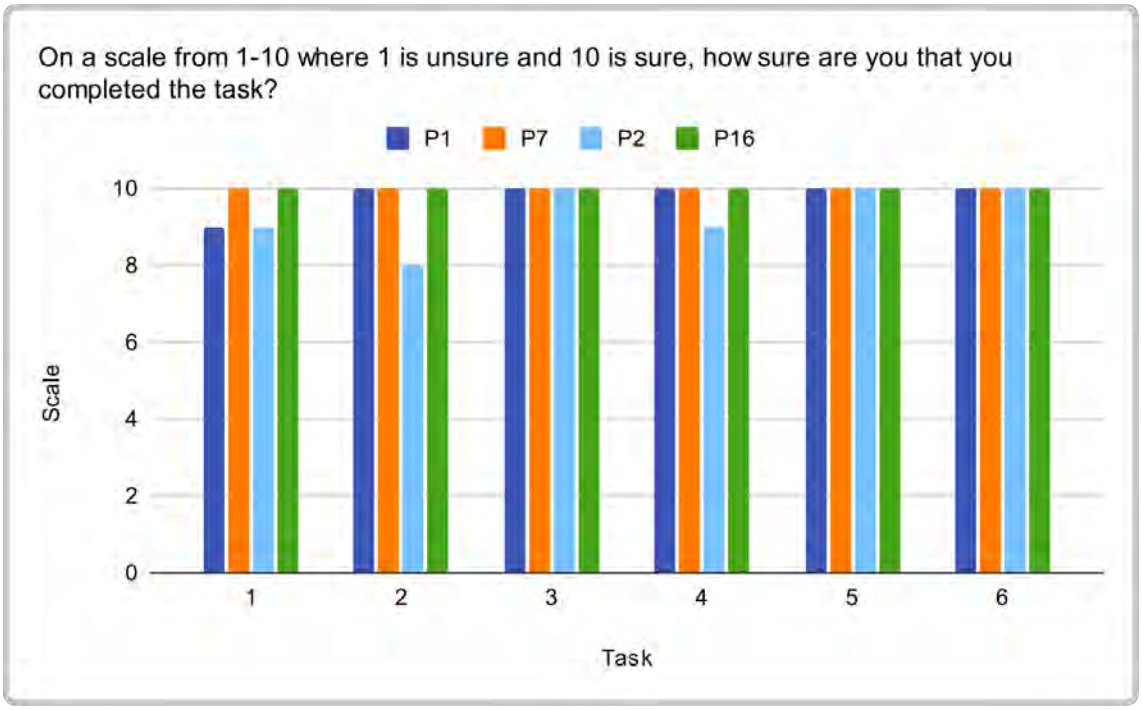

Figure H.1: Bar chart over Task 1-6, certainty of completing task.

Participants' certainty of completing Task 7-11 can be seen in Figure H.2

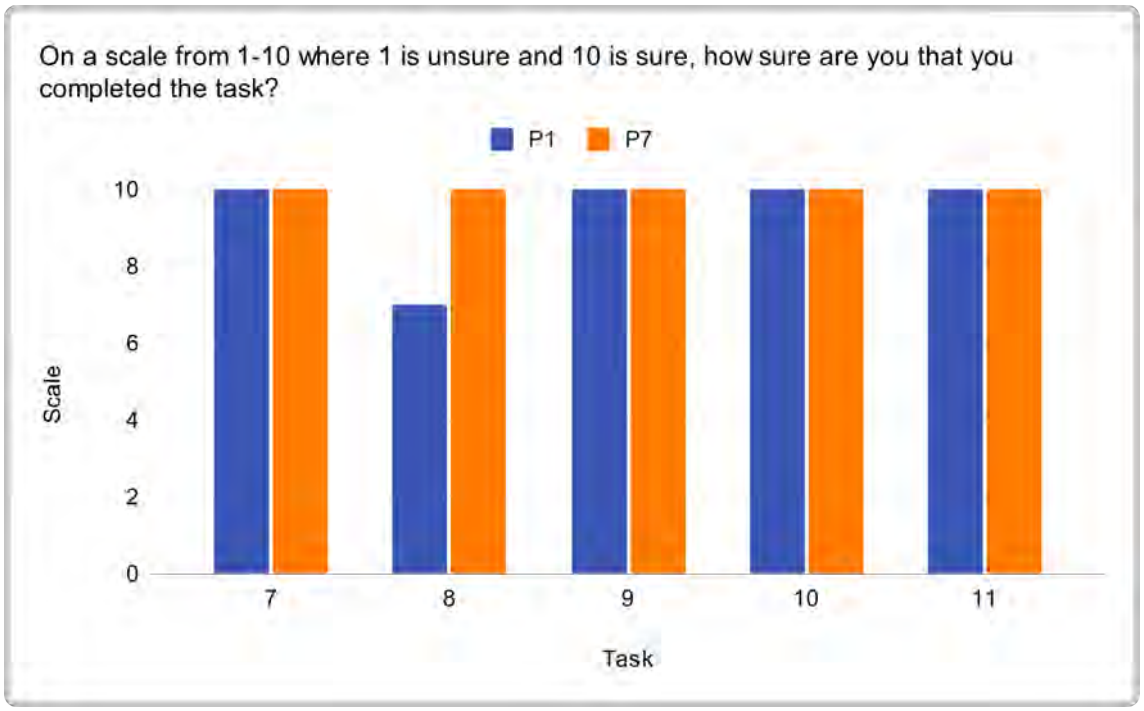

Figure H.2: Bar chart over Task 7-11, certainty of completing task.

Participants' certainty of completing Task 12-17 can be seen in Figure H.3

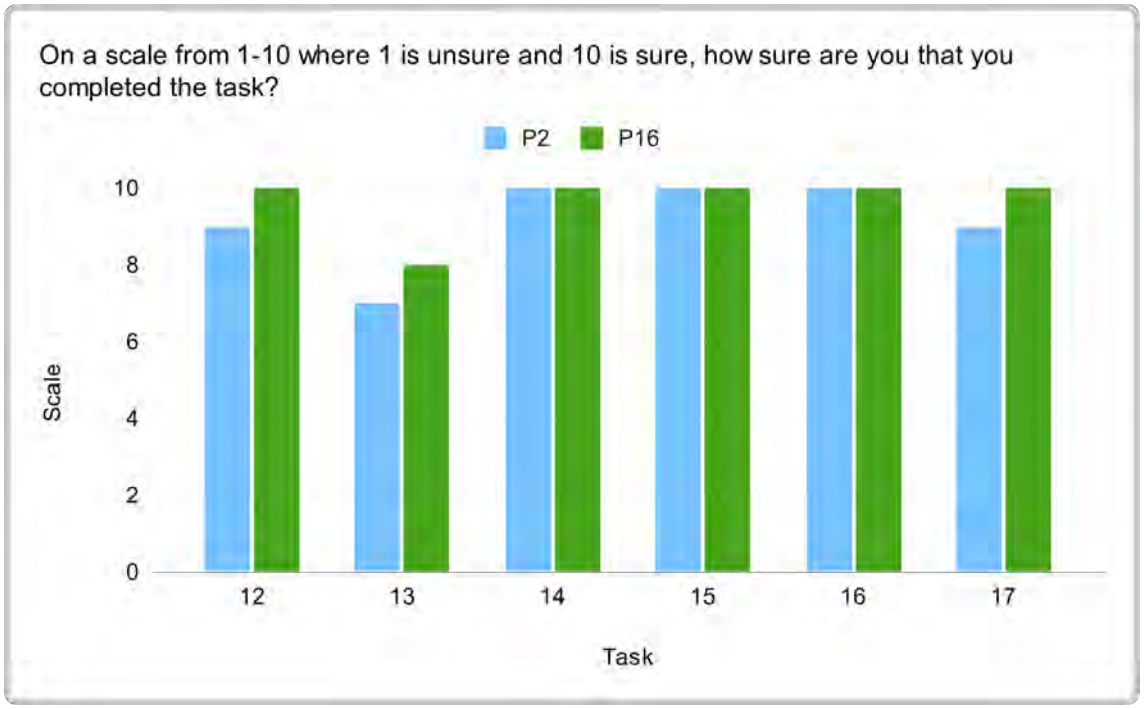

Figure H.3: Bar chart over Task 12-17, certainty of completing task