Drones for medical supply deliveries

Designing Intuitive Interfaces for Nurses Managing Drone Deliveries

Master's thesis in Computer science and engineering

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Department of Computer Science and Engineering
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2024

Master's thesis 2024

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Cover: Drone standing on the ground waiting to take off during the test flights toghether with Västra Götalands Region in the sunset.

Typeset in LaTeX
Gothenburg, Sweden 2024

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Abstract

With a focus on optimising the user experience for nurses, this Master's thesis investigates the design of interfaces for managing drone take-off and landing operations. The research aims to identify critical factors essential to the design of such interfaces in the context of medical staff handling drone deliveries. Through a service design process, including data collection, thematic analysis, co-design workshops, prototyping and user testing, key insights were gathered.

Eight key factors (KF1-KF8) were identified to guide designers and stakeholders in the development of interfaces for drone operations. These factors cover a range of considerations, including minimising mental effort, ensuring safety during drone interactions, addressing challenging climatic conditions, establishing trust in human-drone interaction, considering attitudes towards drone use, maintaining information balance, emphasising clarity and simplicity in the interface, and providing flexibility in managing drone deliveries.

The conclusion acknowledges the uncertainties surrounding the feasibility of implementing drone services in Sweden, mainly due to regulatory limitations, and highlights the need for further research to assess the actual improvement in nurses' working conditions. Overall, this research provides valuable insights for the development of interfaces tailored to optimise the user experience of drone operations, while also highlighting areas for future research.

Keywords: Drone delivery, User experience, Interface design, Healthcare logistics, Service design, nurses, Human-drone interaction, Usability testing, prototyping

Acknowledgements

First of all, we would like to thank our supervisor Dr. Sara Ljungblad for her valuable guidance, insightful feedback and support throughout the course of this research project. Her expertise and encouragement has been the driving force behind our efforts and has always been available whenever we were in need of help.

We are also grateful for all the words of wisdom, support and encouragement we received from Anna-Lena Alvekrans and Mikael Svensson from the Västra Götaland Region throughout this work.

We would also like to thank the organisational managers who made it possible for us to conduct our interviews and user tests. We would also like to thank everyone who participated in our interviews and user tests and gave us their honest opinions, which helped us to create a good platform for this project.

Last but not least, we would like to thank ourselves for keeping up the good discussions, supporting each other and having fun together.

Louise Granquist Karlsson & Helena Naumburg, Gothenburg, 2024-06-17

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Introduction

This chapter will present an introduction to the project and research opportunity followed by the chosen research questions.

1.1 Social Integration of Drones

Human drone interaction (HDI) is a growing area within the Interaction design field [1]. Wulfovich et al.[2] compares drone technology to the establishment of the internet in 1980ŧs. He means that there is a common understanding how the drone works, but the society has not yet exploited the fully potential of the drone technology. Wulfovich et al. [2] continues to point out that the technology has the very last few years reached a level of maturity and accessibility and because of this now starting to get adapted into several fields in our society [2]. Already 2017 there were several news regarding new and innovative applications for drones in the society, some were even considered to be a bit futuristic and crazy. Some of these new applications are using drones for food deliveries, documenting crimes as a way of having higher level of surveillance from police services, deliver medicine and vaccine, fly over sports arenas and film from up close, filming news more from up close, drones as ambulances, track down poachers and transporting people. Today we can see that some of these applications has been successful [3]. For example, drones has been introduced in the Norwegian police services as a means for assisting police officers to get a clearer view of reported incidents [4]. Since several years back drones has also been used as a way of transporting blood samples in Rwanda [5].

Västra Götlands Regionen (VGR) initiated the project "Drones in the Archipelago" in order to investigate the possibilities for replacing their existing car transport to having drones transporting the blood samples from the islands in the archipelago outside of Gothenburg to the mainland. Their aim is to investigate whether there is an economic case for using drones. By using drones, potential traffic obstacles can be avoided to get the samples analysed faster. The drones will primarily transport the routes between the mainland and Island A as well as Island C. Health centers at these island are relatively small and opening hours vary. The drones will be packed directly at the health centers by medical personal and then sent away to a laboratory located closer to the center of the city.

The aim with this study is to design a usable and effective interface for the medical personal to handle the drones, giving them enough support and help in their daily

working routine. Focus will lie on investigating what such and interface could look like, both regarding the visual appearance and the information flow. As well as making sure the interface has a high level of usability.

1.2 Research Opportunity

The objectives of this project is to examine key factors when designing human-drone interaction. This will be investigated through the design of an intuitive interface for medical personnel handling the drone takeoff and landing. Drones have been utilised commercially in other countries, however, there is limited research concerning the application of commercial drones transporting blood samples in Sweden. Especially since the intended geographical area for the routes in this project has particular unique conditions.

The reason for selecting this subject is based on the technology's significant relevance in society. It is highly debated, and opinions regarding drones varies across different segments of society [6]. VGR's project is current, and by contributing to it, we can participate in providing something beneficial to society. Keeping this context in mind, we have formulated a research inquire, as follows:

What are important factors for designing the interface controlling drone takeoff and landing to optimise the User Experience for medical personnel during drone deliveries?

2

Background

This chapter will focus on introducing the background for the project. Firstly, a basic definition for the concept of drones are made. Followed by an introduction to the project "Drones in the Archipelago" and the situation of the current medical supply delivery process. Lastly, important stakeholders are introduced together with rules ans regulations regarding drones in Sweden.

2.1 Definition UAS & UAV

Unmanned aircraft systems (UAS) are according to the *International Civil Aviation Organization* (ICAO) an aircraft operated without a pilot [7]. UAS are the legal and the technical correct term, but are more commonly known as drones outside of the aviation field [8].

The most used term for describing any unmanned aerial vehicle is drone. However, this definition also includes vehicles traveling in water or on land. Therefore, there is a need to distinguish different types of drones. An *unmanned Aerial Vehicle* (UAV) refers to an aircraft that can fly autonomously or remotely. This definition only includes the vehicle itself, not the surrounding systems and equipment. *Unmanned Aerial System* (UAS) is the term used for the vehicle itself including the surrounding systems such as the GPS module, ground control module, transmission system, camera, software and the person on the ground, controlling the drone [9].

2.2 Existing process: Medical supply deliveries

VGR has currently 260 healthcare centers that need to transport medical supplies. The transports are carried out by Regiontransport that distributes 43 vehicles that transports diagnostic samples to the laboratory. The drivers arrive according to a coordinated timetable to the healthcare centre, and pick-up and drop-off at an agreed on location inside of the healthcare centers laboratory. This means that the healthcare staff do not need to interrupt their work when the driver comes in to collect the samples. The region has an extensive geographical area and it includes a large portion of sparsely populated areas with long transport distances, resulting in a few stops [10]. This implies that drivers operate significant distances on a daily basis to reach remote health centers, located all around the region [11].

Furthermore, all the transports that are carried out in the archipelago are not being picked up or delivered directly at the health centers. The reason for this is the distance between the location of the health center and the ferry station. This means that they are either dropped-off or picked up by a medical staff at the ferry, or the blood samples needs to be transported by medical staff to Torslanda, which is were the intended main drone hangar will be located. A driver collects all blood samples at Torslanda and transport them further before being sent to different laboratories in the region, for example to the laboratories in Mölndal and Skara, depending on specific requirement for different samples. Not only is this time inefficient, but it can also compromise the safety from handing the blood samples over to the personnel at the ferry, which is the case for Island A [12]. Furthermore, the transportation is highly dependant on acceptable driving conditions. Both regarding weather and traffic flow. Deliveries going to the laboratory in Mölndal need to arrive before 16:00, otherwise the laboratory will start the analyse process without the samples. When this happens, chauffeurs will often notify the personnel at the laboratories about the delay and the samples can be analysed the day after [11].

2.3 "Drones In the Archipelago"

VGR currently has five drone systems for transporting defibrillators as part of a first-response initiative and sees potential for expanding these capabilities to include the transportation of diagnostic samples with drones integrated into the region's existing transport setup. There are two different scenarios for the drones to pick-up and drop-off the samples: either with winching down items such as blood, emergency medicine, or defibrillators; or landing at specific locations such as healthcare centers in the archipelago. Since drone systems in present-day come with high costs for the customer due to specialised industry setups, VGR could contribute in promoting scaling for the manufacturer. As collaboration takes place with the region's 49 municipalities and initially around thirty of the region's 260 healthcare centers, this represents not only the potential of the region but also several parts of Sweden [12].

As the current delivery of blood samples is expensive and time consuming, VGR's aim with this project is to explore the possibility of using drones to deliver blood, as this potentially could solve logistical problems that would lead to more efficient use of time and reduced costs. They do not want to glorify the use of drones, but rather explore the possibilities. By utilizing drones, they will also be able to avoid potential traffic obstacles during emergency transports, which, in some cases, have a maximum lead time of 30 minutes between sampling and analysis. It is also crucial that the system is robust for challenging wind and weather and to have a drive range of 40 km. Another crucial aspect is that there should be an existing set of regulations that support aviation during different conditions. For this scenario to work, it relies on a certain number of scheduled transports per day, and that the drones load capacity should be at least 5 kg to minimize the number of scheduled trips. This will also require new packing procedures and packaging at the laboratory facility [12].

Figure 2.1: Drone that was used during test flights with VGR.

If this project were to be implemented, it is possible that the delivery process would change both organisationally and logistically. It is possible that the biggest change will be for the nurses, as they currently do not need to interact with the transport personnel, but will most likely need to interact with and pack the drone. As the drone will be about three metres between wings, the project leaders are considering a corral of five by five metres to avoid any accidents with people in the area where the drone will arrive. In early January 2024, VGR conducted test flights of a drone with wingspans of about two metres, as shown in Figure 2.1.

As the drones will be responsible for transporting the blood samples, an external stakeholder will be involved in the transport process, as a pilot will need to be connected and monitor the drone remotely. The drone recharges its batteries in a drone hangar and can fly autonomously, only requiring the pilot to monitor it in case something goes wrong. Once the drones have delivered the samples to the collection point, a van will pick up the blood samples and take them to the laboratory [11].

2.4 "Social Drones"

This project is being carried out in parallel with a research project at Chalmers about drones in the society, named "Social drones". VGR and Chalmers are conducting the projects separately but are cooperating at several different levels. This project has a broader point of view than what this master thesis has and are more generally related to the attitudes of drones in the society. Investigating the impact of drones and the design of drones, in the society and on individuals. The research project are led by Sara Ljundblad and Morten Fjeld.

2.5 Aviant

Aviant is an Norwegian drone service company within the field of autonomous logistics and on-demand transport of cargo. Their expertise lies in the field of healthcare and specifically managing logistic issues connected to transporting blood samples, specifically COVID-samples and water samples [13]. The company got its start thanks to the pandemic; it was during the lockdown period that the founders began thinking about ways to facilitate healthcare work. They started with transporting COVID-samples to hospitals from remote locations in Norway. Today they are doing flight operations all over Norway, together with some operations in Sweden and the rest of Europe.

Aviant are responsible for delivering the drones for the project in close collaboration with VGR. In relation to VGR, Aviant has the role of the expert, contributing with general aviation knowledge and specific knowledge about drones. Aviant are responsible for doing test flights with drones for the intended routes between the islands and the mainland. One pilot from Aviant were present during the test flights and operated the flights. After the test flights, the pilot were responsible for conducting a report showing deviations from the intended flight route. Less than half of the scheduled flights were cancelled. According to their report, wind together with sight and to low cloud base were the main reasons for not flying the drone [10].

When it comes to our project, Aviant are contributing as a main resource for our data gathering regarding drones in general. By having a lot of experience with handling drones, their expertise is highly valued when it comes to key design points when designing for a non-expertise target group.

2.6 Regulations: Drones

In Sweden *The Swedish Transport Agency*(STA) are responsible for establishing rules and regulations regarding UAV's [14]. They are working to establish a good accessibility, high quality, secure and environmentally aware air transport. Additionally establishing regulations regarding drones and ensuring that they are being adhered by authorities, companies, organisations and citizens [14]. 2021 new rules were established in EU regarding drone certificates, all active drone flyers need to have the drone certificate and the person responsible for the flight need to register as an operator, and in the beginning of 2022 there were 28 000 registered operators [15]. According to the Swedish Armed Forces there are around 500 000 civilian drones active in Sweden [16].

In Sweden there are two types of airspace: *controlled C-class* airspace located nearby airports and *uncontrolled G-class* airspace. Depending on how the drone is intended to be flown and utilized, it is classified into three distinct categories, *open specific* and *certified*. When flying in the *open* category in an *uncontrolled G-class* area, the highest flight altitude is set to 120 meters and the drone must remain within visual line of sight for the pilot operating the drone and in a manner that does not pose a risk for other aircrafts, individuals, animals, the environment, or prop-

erty. All flights that exceed the prescribed limit falls in the category *specific* and are considered a higher risk for external individuals. Flying in the *specific* category also require permission from STA. Conducting flights with high risk for external individuals require permission and the drone need to be registered. Flights involving transportation of individuals or drones operating over large crowds fall within this category [14]. All drone flights must be conducted under the supervision of a responsible drone operator, responsible for how the drone is utilized. The operator also needs to select a responsible remote pilot. The remote pilot is required to take a brief course, including a theoretical exam [17].

The Swedish state-owned public enterprise Luftfartsverket (LFV) are responsible for providing air navigation services. Among these services are the national drone map, displaying all UAS zones, all unmanned civil and military aviation in the upper air-space, along with restricted and forbidden geographical areas [18].

2021 a new type of area called UAS zon was introduced. STA are authorized to decide on permitting, restricting or prohibition geographical UAS zones. This can be done for several various reasons, regarding safety, aviation-safety, personal integrity or the environment. There are three different zones and these are permitted zones, restricted zones and forbidden zones. All zones have different requirements and specific conditions, to fly in one specific zone all requirements and conditions need to be fulfilled by the drone and the drone operator [19].

Before flying with the drone it is important for the pilot to be aware of the regulations on the specific area that the drone will fly on. NOTAM stands for "Notice To Airmen" and are used to alert the pilots about potential hazards along a flight route or at a specific location that could affect the safety of the flight. All types of aviation pilots need to take possible warnings and no-go-areas into consideration [20].

When it comes to commercial use of drones in Sweden there has been several studies conducted. The Swedish Sea Rescue Society in Gothenburg has been investigating the use of drones for better information about incident reports [21]. Sahlgrenska University Hospital in Gothenburg has investigated the possibility of using drones equipped with defibrillators for cardiac arrests in more remote locations [22]. More recently VGR initiated a project for investigating medicine deliveries with the help of drones, and more specifically transporting blood samples from islands in the archipelago outside of the city.

The 26th of January 2023, a new concept with digital services regarding drones were established by the European Union (EU), under the name U-space. The first rules were introduced to ensure a safe and effective access for drones to the airspace in Europe. U-space will provide a digital platform that enables drone flights in the airspace together with the necessary interfaces for the integration towards manned aviation, air traffic control, and authorities [23]. The U-space regulations enables digital traffic management for larger volumes of drones in the same airspace as manned aircraft [12]. This concept is highly discussed within the field of drones and aviation and considered an important part of the conditions since it highly affects the feasibility of implementing such a service. However, U-space is more related to getting access to the correct airspace and will therefore be considered a delimitation

in this project.

3

Theory

This chapter introduces the fields of interaction design and human-drone interaction. Followed by a section about drones in the society. Lastly, drones within the healthcare field are described.

3.1 Interaction design

According to Sharp et al. [24] interaction design can be described as *designing interactive products to support the way people communicate and interact in their everyday and working lives* [24]. It can be understood as the design between users and products.

There are several dimensions of interaction design. Firstly, labelling buttons correctly and easily understood, together with being visual understandable. The physical objects the user interacts with are as important, what type of physical element are most relevant. Time is also an important dimension, as it affects moving element such as animations, videos and elements that change over time. Lastly, the behaviour of the user are important. How the users operate the product and what kind of interactions are possible. These dimensions are tightly related to usability. Usability is often used in a design perspective and refers to how easy and efficient it is for users to interact with and use a product or system to effectively achieve their goals. Some of the key aspects to consider are how easy it is for users to understand how to use the product or system, which includes factors such as intuitive design and easy navigation [25].

By minimising the number of steps or actions required to complete a task, it can reduce unnecessary cognitive load, and by providing shortcuts or aids for faster navigation, the user can complete tasks more efficiently. Research has shown that mobile devices can be sensitive to cognitive overload due to size limitations and multiple task settings. [26]. Another aspect of good usability is minimising the occurrence of errors and providing clear ways for users to correct their errors [27]. Lastly, it is also important to ensure that users have a positive experience when using the product, which involves considering aesthetics and the emotional response to the design. It could also include designing with consistency and in familiar patterns that help users recognise how to perform certain tasks [28].

The aim of designing for users is to create a design that is user-centred. It should

make it easy and enjoyable for users to do their job without frustration or confusion. Based on the user feedback from iterative testing, the designer can ensure that the design meets the needs and expectations of the target audience [29]. One study, conducted in 2021, looked at the usability of touch screen interfaces in the context of the self-ordering of beverages in food service outlets. The aim was to understand how different age groups interacted with the touch screen and how factors such as age, experience and gender affected the ordering process. The results of this study showed that experience and age were two of the main factors influencing the time taken to order. The study also highlighted the importance of considering user characteristics and experience levels when designing touch screen interfaces to improve their usability and user satisfaction [30].

3.2 Human-Drone-Interaction

Human-drone-interaction (HDI) is an emergent multidisciplinary field with roots from two well established fields, human-robot-interaction (HRI) and human-computer-interaction (HCI)[31]. HDI focuses on designing and investigating interaction happening between a human and a drone. HRI and HDI are closely related due to the fact that a drone can be categorised as an robot [32].

Several different ways to interact with drones has been explored, and one of these are by using a gesture based system. drone.io was developed by Cauchard et al. [33] in order to investigate possibilities with using a gesture- and visual-based interface for communicating with service drones. A projector-camera system were placed on the drone and projected a circular visual menu on the ground around the user to interact with. By using your hands and arms the user could communicate with the drone, without prior knowledge or any additional hardware. Different gestures were implemented into the system, to dwell and point using a flat hand towards the interface and secondly push by using a 90 degree rotated hand. The study results showed that participants would have preferred using both hands for interaction and some even preferred using feet also. Participants felt interacting with the airborne drone to be safe and natural in an outdoor environment. However there were a few potential improvements regarding the interface, such as implementing a function for the shadow of their hand. The study shows that the developed system was easy to use, enjoyable and highly reliable when used in an outdoor environment [33].

3.2.1 Safety

Exposed drone blades are a big concern regarding the safety of the user when interacting with drones. To address this, design of drones has moved towards a safe-to-touch design [34]. Abtahi et al. [35] conducted a study to investigate whether or not users choose to touch a safe-to-touch designed drone. In their study two different drones were used, one of them being airborne in a protective corral, the other being airborne without a protective corral. The participants were told to interact by doing a few tasks, these interactions could either be touch-, gesture- or sound-based. In some cases a combination of these several modalities occurred. Participants were divided

into two groups, one of them interacting with the safe-to-touch drone and the other the unsafe drone. The study shows that 38.9% used touch based interaction with the safe drone. The unsafe drone had 1.9% of the participants interacting by using touch. Interacting with the safe-to-touch drone were reported to be less mentally demanding than the unsafe drone. Majority of the user felt safe when interacting with the safe-to-touch drone [35].

3.3 Drones in the society

In Rwanda medical drone deliveries have been used since 2016 and are today an integrated part of Rwanda's medical supply infrastructure. Doctors throughout Rwanda order the desired blood in an application on their smartphone or tablet. The blood is then subsequently dispatched from a central distribution center to all hospitals across the nation. Traditionally the medical supply deliveries involves driving several hours or even days, with a cooler full of blood while terrain is often challenging to navigate and sometimes even impossible. Hospitals are located within the reach of 75 kilometers and with the help of GPS systems the drones can easily navigate towards their goal. Using drone services as the primary medical supply transportation solves the problem with blood having noticeable short lifespan. It is also vital in emergency situations when extra blood is needed [5].

The Norwegian Police Departments has now implemented drones in their daily work after doing a one-year trial between 2019-2020 to investigate benefits and challenges with the technology. Three out of twelve police districts participated in the trial. Police officers were trained and educated in police-specific drone use. The drones were implemented in several different areas within the police-services, such as using drones for getting a better perception of incidents and based on that have a more efficient and better decision-making process. In some cases, the drone could create a better perception by filming the incidents from above. At the same time the footage from the drone still need to be analysed by the human eye and in some cases it was difficult to determine what the footage showed. The main reason for using the drones was to collect important information and therefore gaining a better basis for decision-making. Furthermore, they concluded that there is indeed several benefits with using drones within the police-services, but most importantly it requires training in judging images [4].

The Swedish Sea Rescue Society (SSRS) has been working with a project with drones over five years. By getting moving pictures from an accident a few minutes after receiving the alarm, they can adapt their resources to handle the accident better and more efficient. Drones could potentially be the first thing being sent when an accident is reported. They are equipped with cameras and depending on what the pictures shows, resources are being more adapted to the situation. Since SSRS are a nonprofit organisation, they have had help from other organisations, companies and students contributing to the involvement of their drones and their system. The goal is to build a network with centrally controlled drones, to operate more effectively and reach their vision "no one should perish at sea" [21].

3.4 Drones in the Healthcare Field

In June 2020 Schierbreck et al. [22] conducted a study in Gothenburg to investigate the possibilities of using drones to deliver automated external defibrillators (AED) in order to shorten the time to defibrillation in case of cardiac arrest. The study aimed to explore the feasibility of using AED delivery with drones for real-life cases of Out-of-hospital cardiac arrest (OHCA). Results show that there is a time benefit compared to ambulance transporting AED:s and the drones has a successful delivery rate of 92%. Schierbreck et al. describes a full methodology for deploying AED drones in a real-life setting and that it is feasible to integrate a complete drone system, from emergency call being received to flinging the drones to the delivery site [22]. However, they discuss possible concerns regarding AED delivery with drones. Firstly, flying above populated areas might cause an extra safety risk, harming people nearby, which also limits the possible delivery cites. Second, the performance of the drones were concerning regarding the rainy and windy climate, higher speed and better wind-durability would lead to a higher effectiveness [22]. Data from the Swedish register for CPR shows that if the time from call to the start of the defibrillation would increase with <8 min, several life's could be saved [36].

Cawthorne and Wynsberghe (2019) investigated the ethical considerations and design principles involved in creating a drone for transporting blood samples, with emphasis on integrating the ethical values into the technology design. The ethical framework Value Sensitive Design (VSD) was used as a bases for the study. It involves five key principles that are discussed in relation to the drone design, these principles are; beneficence, non-maleficence, human anatomy, justice and explicability [37]. Their drone design was designed to prioritize beneficence and efficiently transport blood samples by reducing the waiting time and potentially also saving costs. Non-maleficence is related to the focus on minimizing harm and risks associated with transporting blood samples. Safety measures were implemented in their design to ensure secure transportation. Human anatomy is respected in the design by considering important privacy decisions related to individual privacy. Further, the justice is related to ensuring benefits are well distributed and considered among all the stakeholders. Explicability is implemented in the design through transparency and accountability. Stakeholders are well informed about functionality and potential impacts [37].

In another study, published in 2022, researchers wanted to test whether the quality of blood transported by UAVs could be maintained. The study focused on describing the effectiveness of using UAVs for transporting blood. This meant that they had to make sure that the UAV could maintain the temperature requirements for red blood cells, which is 2°C and 6°C. The study was carried out by testing and gradually increasing the distance of the UAV while monitoring the temperature of the blood sample. Using lactate dehydrogenase, they were able to see the effect of the flight on the blood samples. Their conclusion from this study was that the lactate dehydrogenase was not significantly different between the non-flying and flying samples. However, although the variation was within a safe range, the drones were not completely able to maintain the temperature requirements [38].

3.5 Ethical considerations of implementing healthcare drones

In terms of ethical concerns related to drones, the use of drones could have an impact on people's privacy, as many drones are equipped with cameras [39]. This can raise concerns about surveillance, data collection and potential misuse of the information collected. Depending on whether the drones are unmanned, they could potentially pose a safety risk if they malfunction or lose control, which could lead to accidents. Furthermore, there could also be ethical concerns if there is a lack of clear regulations and guidelines for the use of drones, leading to various legal challenges [40]. Drones could also have a negative impact on the environment due to noise pollution, disturbance of wildlife and energy consumption [41].

There are various ethical aspects that need to be considered regarding drones flying Beyond Visual Line of Sight (BVLOS). If the drone were to lose contact with its pilot and crash uncontrollably, there is a risk that its location cannot be determined. This would be problematic, as certain deliveries may contain samples with harmful infections that could spread. Another risk is that if one would be able to link which patient the blood sample belongs to, it would disrupt the patient's confidentiality in case of drone accidents[40].

Cawthorne and Robbins-van Wynsberghe [37] states the importance of implementing ethical guidelines focusing on healthcare drones in the society. Their ethical framework are based on the four bioethics principles. By using this framework as a tool to uncover ethical issues, researchers can bring them to debate and discuss possible solutions [37]. A few of these could be highly relevant in this project. Firstly, *privacy* is a big concern regarding drones flying above inhabited areas, as drones often are equipped with cameras. This is also highly connected to the next concern which is *safety*. Since the drones are flying in inhabited areas they propose a threat to people on the ground, in danger of getting hit by a drone in case of an accident or malfunction. There are several differences between commercial aircraft's regarding safety. People traveling with commercial aircraft are explicitly accepting the risks when they board the aircraft. In the case of a drone flying above a crowd, there is no way of accepting the risk that people might get hit. When it comes to *security* and drones, there is a high risk of being exposed to a cyber attack. The drones could potentially transport sensitive cargo, in the case of this project the drones can transport medical supplies such as blood samples [37].

While drones can potentially offer *environmental benefits*, it could potentially also posses a threat to local wildlife. There is limited research on bird-drone-interaction. Drones could have a negative influence on all flying species, since a collision is possible [41]. However, research show that most birds are visibly unaffected by drones, but drones are causing increased stress-levels for birds [37].

Another critical aspect is *informed consent*. This means that people exposed to new technology should be aware of the presence and give approval to the use of it. Meaning that people on the ground should be aware that their is drones flying above them. Correctly identifying all challenges and risks would be difficult since it

is a new technology. This highly correlates with issues of responsibility. The drone operator are responsible when flying, but the drone is most likely not in visual line of sight for the pilot [37].

Trusting new technology is something highly sensitive, it requires vulnerability and that we place a high amount of trust into the technology. Drones operating in the medicine or healthcare field are seen as a highly trustworthy technology, since it is seen as contributing to doing good for the society [37].

4

Methodology

This projects examines the key factors for when designing an interface for handling drone takeoff and landing with the nurses as the primary user. This chapter presents the relevant methods, design framework and activities for such a project. Firstly, qualitative research are introduced followed by service design. The relevant methods are structured in a chronological order starting with the research phase. Followed by ideation, prototyping and the final phase, the final prototype. Lastly, ethical considerations for drone interaction and for this project are presented.

4.1 Qualitative Research

There are two different types of research that can be conducted, one is *quantitative* research and the other is *qualitative* research method. Quantitative research involves the researcher collecting measurements of data collection and statistical data analysis. This is used to find relationships between different variables, cause and effect. Qualitative research methodology involves the collection of so-called "soft" data. This is often obtained through observation and interviews [42].

4.2 Service Design

Service design can be chosen as the frameworks for this project, as it focuses on the end user and the experience the user has with the system. The finalised project can also be seen as a service for handling drone interaction for the medical personnel.

Service design is an approach that can help designers to create sustainable solutions and optimal experiences for all parties involved [43]. To meet the needs of the user and stakeholders this methodology focuses on being user-centered, collaborative, interdisciplinary, iterative, and a set of easy-to-use activities and visualisation tools to design and co-ordinate experiences that meets the requirements [44]. Service design can contribute to a variety of areas of service research, such as service management, as well as technology-related areas within information systems and interaction design [45]. Through the use of this methodology, it can help to solve key challenges faced by organisations and assist in the creation and improvement of services, making them more usable, useful and appealing to users [44].

When applying a service design process there are a few different tools and methods

to choose from, the most common ones are: customer journey maps, personas and service blueprints. Other tools that are used within service design are: business model canvases, value proposition canvases and system maps [44].

4.3 Research

This section will firstly introduce the methods for data gathering followed by the methods for visualizing the data.

4.3.1 Literature Review

A literature review are beneficial in the beginning of a project to get a overview of the field, to be an expert in the chosen subject. The literature review should give the researcher an understanding of the state of art, important issues and challenges. It is also crucial to keep a neutral and critical approach [46].

4.3.2 Questionnaires

Questionnaires can be used in this project to collect demographic data and users opinions. They are similar to interview as it can be closed or open-ended, but can also be distributed to a larger about of people than an interview. Participants in more remote locations can also be part of the questionnaires. It is also beneficial for collecting data from a larger group target group [24].

4.3.3 Interviews

When it comes to gaining insight, interviews are one of the most important sources in research [47]. The purpose of qualitative interviews is to discover and identify characteristics of something, such as the interviewee's perceptions and thoughts about a phenomenon, by asking open-ended questions [48].

Semi-structured interviews instead of *structured interviews*, allows a more flexible and exploratory approach. As it allows the interviewer to prepare a list of different topics that need to be covered and therefore does not have a clear list of questions to be followed. The choice of semi-structured interviews could be suitable in this case as it allows both the interviewer and the respondent to ask follow-up questions. As the interviewer is not as controlled by the prepared questions and can act more freely during the interview[42].

Group interviews are beneficial when the aim is to get a perception of a specific question from a certain target group. They can be structured or semi-structured, depending on the purpose of the interview. Often the purpose of a group interview is to get a perception of the common opinion among the target group [46]. Depending on the group dynamic, the outcome of the interview might get negatively influenced [42].

When it comes to selection of interview participants, there are two possible choices. *Convenience sampling* refers to the selection of respondents based on their ease of access to the study. The results of convenience sampling studies can not be generalised, but may be suitable for a pilot study. *Snowball sampling* involves the researcher establishing contact with interviewees who are relevant to the study, and then using these contacts to contact other people to interview [42].

4.3.4 Observations

Observation is useful for gathering information in areas related to behaviour in natural situations. It is also a good way to complement the information gathered by other techniques [42]. When it comes to the role of the researcher, the observation can be *structured*, *unstructured*, *participatory* or *non participatory*. The chosen approach depends on the specific goal of the observation and the context [46].

4.3.5 Personas

Personas are fictional characters and are used to represent a specific segment of a specific target group [49] and is a good way to capture the users needs and business requirements [50]. They are used to describe the goals and observed behavior patterns among potential users, and can explain key factors and help the designers to understand the users need based on their goals and behaviors [51].

Personas can play a crucial role in user-centred design by ensuring that the end product is tailored to meet the expected needs of the intended users. By creating personas, design decisions become more focused and aligned with the user's preferences. [52]. It is also an effective communication tool that can be a simple and relatable representation of complex user data. Using personas within the design team can ensure a consistent understanding of users throughout the design process. [53].

4.3.6 Journey map

Journey maps can visualise a person's experience over time, for example, a customer's experience with a service. What they do and what they feel at certain points in the experience and also what information they have access to when. They are a good tool to help designers identify gaps in the customer experience and explore potential solutions. Journey maps represent different aspects of an experience or service with an end-to-end experience. [44]. The use of journey mapping is a combination of visual design, storytelling and understanding the user. By using journey mapping, it allows the design team to have internal conversations and prevent incorrect assumptions. [54].

4.3.7 Service blueprints

A Service Blueprint is an extension of a Customer Journey Map, but goes into more detail about each interaction a customer has with an organisation during their life

cycle [55]. Service blueprints are part of the service design process and ensure that the different elements are mapped out to form an overall picture of the system, as this helps to make it easier to understand and identify strengths and weaknesses. It is similar to a flowchart, showing the progress over time and all the links between the steps. This method can be used in the early stages of the design as it helps to understand an experience in detail and to make improvements clearer [56].

4.3.8 System Maps

For this project, system maps could be used as a method as they are a visual representation and are typically formulated using shapes and words to visualise the process within a system, showing how they are connected to each other by arrows. It is a good tool to illustrate and communicate important factors that may be of interest [57]. As system maps can be used not only for existing systems but also for future scenarios, it can help to understand the impact of decisions and new components [44]. It can also be important to share a common understanding of a system, which system maps can contribute to as an effective communication tool for stakeholders and decision makers [58]. The visual representation of the system map can help to identify how different elements can influence each other and to address potential problems within the project [59]. Creating system maps for this project could help to understand the different parts and stakeholders of the organisation.

4.3.9 Thematic Analysis

Thematic Analysis is a qualitative research method used to identify, analyse and report on patterns within data. The process begins with familiarising oneself with the data, which involves transcribing (if necessary), reading and rereading the data carefully, and taking note of initial ideas. The next stage involves generating initial codes by systematically coding interesting features across the data set and collating relevant data for each code. The researcher then looks for themes by grouping these codes into potential themes and collecting any relevant data. The themes are then checked to ensure that they accurately reflect the coded extracts and the data set as a whole, and a thematic map of the analysis is produced. The definition and naming of the themes involves an ongoing analysis to refine the specifics of each theme, producing clear definitions and names that captures the essence of each theme. The final stage involves the selection of illustrative and persuasive data extracts, a final analysis of those extracts, and relating the analysis back to the research question and existing literature [60].

Affinity diagram is a type of thematic analysis and a simple and cost-effective systematic method for analysing qualitative data. By collectively go through the data, participants create post-it notes with interesting observations or specific problems. These post-it notes are then collected on a wall and grouped in different cluster, each cluster representing specific themes [56].

4.4 Ideation

During the ideation, several sessions with different ideation methods can be conducted to generate as many ideas as possible to address the design challenge. To have a productive ideation session, dedicated participants are important to investigate all possible perspectives. Before starting the ideation, a clear defined design challenge is crucial to guide the participants. This project can focus on different ideation sessions such as at least one sketching session, along with brainwriting and co-design with our target group [61].

4.4.1 Sketching

Sketching can be used as a method in this project as it helps in generating new ideas as well as quickly generating multiple ideas and iterations [62]. Sketching is a good tool to use as it can help the design team communicate ideas and achieve a common understanding of the outcome of the design [63]. The use of sketching as a method is a fundamental step in the design process. As it guides designers to brainstorm, visualise and iterate on concepts before moving on to more detailed prototyping [64].

4.4.2 Brainwriting

Brainwriting is a form of brainstorming and can be used in this project as it ensures that all participants have an equal opportunity to contribute ideas. It promotes inclusively and encourages introverted or shy individuals to share their thoughts in the project. Brainwriting can be used as one of the first steps in this project as it aims to stimulate creativity at an early stage of the design process. The session can begin with a general discussion of the problem area, ensuring that everyone is on the same page and the session theme is aligned. The brainwriting process is usually set up with six team members generating three ideas in five minutes. At the end of this five-minute cycle, members pass their paper to the team member on the left. In the second round, each team member can read the previous round's submission and generate three new ideas in the second round, based on the idea from the row above [56]. As the team for this project consists of only two members, this method can be called 2-3-5 instead of 6-3-5.

4.4.3 Crazy 8's

This method is widely used within Design sprint methods, where it is ideal to sketch fast and produce a quick result. The main aim for the method is to challenge people in sketching eight ideas in eight minutes. Ideally the goal is to develop your first ideas into innovative solutions for the design. This method is suited even for people without a design background [65].

4.4.4 Co-design workshop

Co-design refers to the collective creativity of several people, often designers and people not trained in design working together in the design process. The user then

often gets the role as the expert of the experience, contributing with knowledge, ideation and concept development. In some cases the user can also take the role as an co-designer, depending on expertise, passion and creativity. Users then becomes part of the design team and needs to get appropriate tools to take on the role [66].

During the design process, two different co-design workshop can be done with designers and the intended target group. Normally all stakeholders are represented during this kind of workshop and the team should be diverse [67]. Due to logistic challenges an adaption of this approach can be done. One workshop with the project leaders at the innovation platform at VGR and one with the medical personnel working at the health centers. These workshop aims to harness the collective knowledge and expertise from everyone involved, to further innovate and develop the service. This approach leads to more effective, sustainable and ethical solutions [67].

4.4.5 Storyboard

Storyboards is a method that utilises the foundations of comics to explain design interactions between people. Either they are presenting an existing solutions or a futuristic one and they can have a digital or a physical appearance. The character of a storyboard very much resemblance the typical comic series, with rectangular frames presenting a shot, speech bubbles are often added to enhance dialogues. Characters in the storyboard is often fictive and based on the data collected in the earlier stages of the project [56].

4.5 Prototyping

This section contains the different prototyping techniques followed by the methods for testing out the prototypes.

4.5.1 Low-fidelity Prototyping

Low-fidelity prototyping is used to visualise design ideas in the very beginning of a design process [68]. It is a measure of how realistic or how authentic a prototype is when compared to the final design or service. They are often focused on discovering the layout and the terminology of the prototype [69]. There is no specific characteristics to determine whether or not a prototype is low-fidelity or not. However, when a person cannot distinguish the prototype from the finalized design or service, it is almost always considered to be a high-fidelity prototype [70].

Low-fidelity prototypes are often very simple and the development process is fast paced. Paper and similar materials are often use as the base, instead of any digital tool [68]. The project can apply this method in the form of a paper prototype for discovering more in detail how to design the finalized interface.

4.5.2 High-fidelity prototyping

High-fidelity prototypes often have complete functionality and are interactive, often being used for exploration and conducting different tests. The prototype has full functionality, and should behave as if it was the final product. By doing tests with a fully developed prototype, the user can take informed decisions on how to improve the design. End-user can also be helpfull to improve the prototype, since changes can be made quite quickly. End-users can also be seen more as contributing members of the design instead of evaluators [69].

4.5.3 Usability testing

This method can be used in this project as it can help to ensure that the final product meets the expected needs and requirements of the users. When conducting user testing, it is important to ensure that all participants feel comfortable in order to obtain valid results. When conducting usability testing, three aspects should be measured; efficiency, which can be measured by recording the time taken to complete the task, effectiveness, which is measured by whether the user can complete the task, and satisfaction, which is often measured by recording the participants as they interact with the product. For this project, usability testing can be carried out by five participants as it can reveal at least 80 percent of the design issues [56].

4.5.4 Wizard of Oz

This method is used to allow designer to prototype complex technical solutions without having to build them. By having a person play the role of the system, designers can simulate more complicated functions quickly and at a low cost. It is highly useful when conducting user tests at an early stage, where the prototypes are still at the beginning of the development [71].

4.5.5 Think Aloud

Think aloud is a method often used in usability testing as it allows designers to access the participants' thought process as they interact with the product or service being tested. This method can be used during usability testing as it can show whether the participants understand how to use the product when they verbalise their thoughts. For some people, talking out loud while using a product can feel unnatural, which could affect the validity of the results, which also needs to be taken into account. A solution to this problem could be to have two participants interact with the product, as this could lead to a more natural conversation about their experience [56].

4.5.6 Cognitive Walk-through

This method involves simulating the steps a user take when interacting with the design and performing one specific task. The method focuses on the cognitive aspects and specifically the ease of learning. The participants are given a few tasks to do within the design and at the same time asked to talk out loud what they are doing

and thinking. Compared with the heuristic evaluation, this method focuses more on identifying specific user problems in detail [24].

4.5.7 Heuristic Evaluation

This method is useful for collecting feedback on mock-ups. It is very time efficient and there is no need for a lot of preparations. Unlike other methods, heuristic evaluation involves expert users. By using their knowledge within the field, they can help to decide whether or not the design choices are accurate for the usability principles. The method is performed by using a checklist of elements. The list includes visibility of system status, match between the system and the real world, user control, consistency, error prevention, recognition, flexibility, aesthetic, error recovery and help options. The experts use the design and find places where the design does not follow the heuristics [56].

4.5.8 Informed Consent

To ensure privacy and confidentiality, informed consent needs to be considered [46], where respondents agree to take part based on the information given to them. Informed consent avoids harm to the respondents, including ensuring that their privacy is not invaded and that they are not misled about the aims of the research [72].

As part of the informed consent process, respondents can be kept confidential within the research report, which means that it would be difficult for others to identify them. Respondents can also consent if they wish to be recorded [72]. It is also important that the respondent is aware of what he or she is contributing to by participating in the research [42].

5

Process

The research project began with participation in test flights on the islands of Island A and Island C, where observations and notes were taken. A literature review was then conducted to gather information on HDI and drone regulations. Interviews with medical personnel and stakeholders were conducted digitally using Zoom. Thematic analysis of the interviews led to the identification of eight key factors, which have guided the design process. Co-design workshop and usability tests were conducted to iteratively develop both low-fidelity and high-fidelity prototypes of a mobile application for managing drone deliveries in healthcare settings. Stakeholder and user feedback was incorporated into the design, resulting in a final prototype with features such as two-factor authentication, step-by-step checklists and package traceability.

5.1 Research

The first part of the process contains the research part, where we have conducted an extensive data collection by doing observations, interviews and a literature review.

5.1.1 Data Collection

Observation: Test Flights

The project began with participating at the test flights together with the project leaders from VGR and the drone pilot from Aviant. The test flights where planned by VGR and took place on the Island A and Island C. During the period of the flights, we participated at four different occasions. Two of these occasions were cancelled while we were on the island due to strong winds and low cloud base. Despite the fact that two of the four planned test flights were interrupted because of poor climate conditions, we were still able to gain valuable data from being on the island. What was clear was that the decision as to whether a flight was a go or no-go was often an on the spot decision. During the test flights we observed everything that happened and took notes. The test flights began with the pilot ticking off a checklist, and one of the tasks was to call SMHI to check the weather forecast to see if conditions were right for flying the drone. If all was well, the pilot went on to check that the drone's navigation was correct by positioning the drone 90 degrees horizontally four times. The pilot also had to check that the drone was balanced. One of the last

tasks was for the pilot to call the Säve air traffic control tower to get the OK to fly. If everything was all right, we all had to stand at least 100 metres away from the drone in case something happened, since the damage could be quite critical. The drone was monitored by the pilot with an iPad. Later we discussed these notes and summarised the key takeaways, one of which was the safety perspective and that it was crucial to avoid the propellers of the drone.

Literature Review

The next step was to get an overview of the field by conducting a literature review. We did this by reading through relevant articles and reports within the field. For finding relevant material, Google Scholar together with Chalmers library database was used with the keywords "human-drone-interaction, healthcare and drones." For finding relevant reports about drones STA was used as a starting point, continue with looking through reports at the official website of European Union Aviation Safety Agency (EASA) to get a background regarding rules and regulations for drones both nationally and internationally. The literature review gave us a solid knowledge base about the field of drones, both within the research field HDI and rules and regulations regarding drones.

Interview

The project continued by starting to prepare for the main data collection method, interviews. Our scope for this project was to investigate what a drone blood delivery interface could look like and to identify key factors to consider when designing for this type of application. VGR already had a vision for the intended target group, primarily nurses but also other personnel that might be available, for example sanitation or maintenance workers. However, we decided to focus on one specific target group nurses. When the target group was decided, the medical personal working at a healthcare center in the archipelago of Gothenburg that were going to participate in the test flights was contacted for the data collection. The nurses were selected using a snowball sampling, as we took contact with nurses we thought would fit this study and through these contacts we got into contact with others[42]. All together, six interviews were made, with 14 participants, as seen in the table 5.1. Three of these interviews were with nurses, two interviews with one nurse each and one group interview. Three of them were with other relevant stakeholders, the manager for one of the health centers, a drone pilot from Aviant and lastly the project leaders at VGR. Due to logistical and geographical difficulties, all interviews were conducted digitally on Zoom. They were all recorded on a tape recorder and all participants were asked for permission to be recorded for the purposes of the project.

Furthermore, it was beneficial if the participants were already involved in the project, but not mandatory when the selection of interviewees were made. Most of the interviewees were already involved in the project and had prior knowledge about the aim. Before starting all the interviews, participants were given the consent form together with information about our study, to ensure proper procedures regarding

Nurse	**N1**	Nurse	**N8**
Nurse	**N2**	Nurse	**N9**
Nurse	**N3**	Nurse	**N10**
Nurse	**N4**	Organisation manager	**OM**
Nurse	**N5**	Project leader at VGR	**PL1**
Nurse	**N6**	Project leader at VGR	**PL2**
Nurse	**N7**	Dronepilot at Aviant	**P**

Table 5.1: Codes for the different interview participants and there role in this project.

privacy, confidentiality and informed consent when collecting data [46]. For those who had no prior knowledge regarding the project, the interview began with giving the participant information about the project conducted by VGR, continued by an introduction to our project and also a short introduction to the consent form and the meaning of it. The interviews were semi-structured too have a more flexible and exploratory approach, with the opportunity to ask follow-up questions [42]. In the end of each interview the participants were given the chance to ask questions and if there were any concerns that had appeared during the interviews. One of the interviews were a group-interview with seven nurses at the health center on Island C. After finishing the last interview. The interviews were read through to ensure we had proper overall knowledge of the content in preparation for the next part of the project, start working on the different models.

Interview: Project Leaders VGR
At the beginning of the project, we held an information meeting combined with an interview where VGR could tell us more about the project and their expectations of our work, and where we had the opportunity to ask questions. This meeting gave us a thorough overview of all the stakeholders involved and their role in the current blood transport process, as well as what it could look like if the drone project were to be implemented. They also provided us with contacts to approach the rest of the interviewees.

Interview: Drone Pilot Aviant
At the beginning of the project, an interview was conducted with the pilot responsible for the flight tests in order to get a clear insight into important aspects and to clarify some uncertainties. The interview was conducted by us and two other master students, as our project topics overlapped and to avoid that the interviewee to have repeat his answers. The interview was divided into three parts, the first part consisted of common questions, the second part was for the other students to ask their questions and the last part was for us to ask our questions. We were also able to pick up on some of the things the interviewee mentioned from the other two students' questions.

Interview: Medical staff
After interviewing VGR and the drone pilot, a total of three interviews were conducted with nurses, i.e. two individual interviews and the third was a group interview. During these interviews the participants were asked questions about their work tasks, stress levels and attitudes towards drones, see Appendix B. The decision to conduct one of the interviews in a group was due to the fact that the nurses at this health centre had little time to spare and could only be available during this time. Furthermore, an interview with the organisational manager at one of the health centers were conducted. This interview helped us gain insight into the structure and process of the blood transportation process and the requirements needed.

5.2 Defining Stakeholders, Process and Organisation

The next phase are focused on visualising the organisational structure, the processes and the stakeholders and there roles. A few models were made to help understanding these factors and finally the target group and there needs were investigated.

5.2.1 Visualising the Organisational Structure

To get a common understanding of the organisation and the different stakeholders influencing the field, models similar to a *Rich Picture* was made. A rich picture visualises the entire organisation including important stakeholders, processes and concerns, to create a common perception for the visualised organisation [73]. This was done on a whiteboard with symbols, pictures and text. The models explains the different stakeholders and the relations between them. Moving forward, a *Process Model* was used to understand the current blood transport process. This method helped us to gain a common understanding and to identify the start and end points of the current process, see Figure 5.1, larger figure can be found in Appendix C.1. The Process Model was visualised using the program YED.

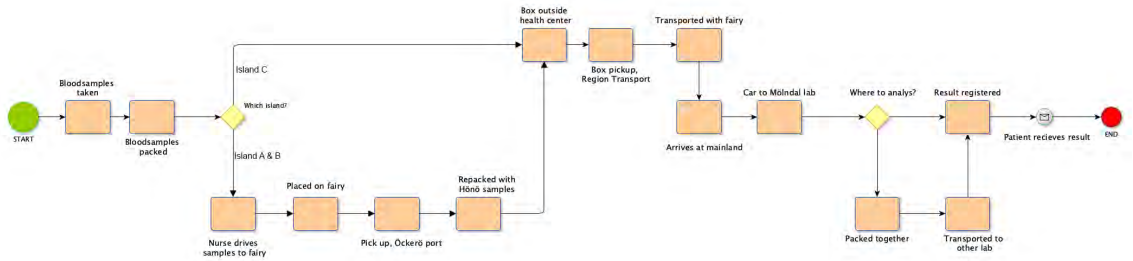

Figure 5.1: Process model visualising the current blood transport process from start to end.

5.2.2 Thematic Analysis

The interviews were subjected to thematic analysis. The thematic analysis was conducted using a bottom-up approach, which means that the themes emerged from

the analysis of the data [56]. This method was used to discover themes from the interviews by collecting a list of short words and phrases and writing them down on paper. From this list, the words could be grouped in into three different categories in Figma: key words, functionality and emotional feelings. These were then staked out into several different themes.

Insights & Themes Drawn From the Thematic Analysis

From the thematic analysis, different insights could be drawn. After the themes had been finalized they were revisited to further stake out the content for each theme. Each of the themes were then described and summarized to be used as base for the design.

The following themes are related to the overall feeling and structure of the interface, and can be seen as key words or value words for creating the design.

T1: Support a Safe Human-Drone-Interaction for the User

This theme is related to overall safety for the user interacting with the drone, as drones can potentially be harmful and create a dangerous situation. It is important that the interface supports the safety regulations needed when handling drones along with contribute to users feeling a high level of safety. The nurses expressed there concern about safety, especially regarding their current process and that the new implemented solution need to obtain same level of safety. The users also need to know when it is safe to interact with the drones as well as how to do it.

One insights based on this is regarding the importance of designing the interface according to the safety regulations. It should be designed to fully support the safety regulations in such a high degree that it is nearly impossible to make a mistake.

T2: Simplicity

This theme relates to the importance of keeping the interface as simple as possible. Meaning that the learning curve should be short and with a high degree of intuitively. When interacting with the interface it has to be simple and straight forward. One insight learned from the analysis is the variation of age of the nurses and medical personal. Previous experience and knowledge of drones and technology are varied and therefore an important factor to consider for the design.

T3: Accessibility

This theme refers to the accessibility of the interface, it should be accessible on a portable device, to be able to use during the process of packing the drone. For example, the readability need to be taken into consideration. Depending on the different health centers different devices are available and the preferred device are highly related to individuals preferences. One insight drawn from this is that the interface should be easy adapted to different devices. Different devices in this case refers to mobile telephones and tablets.

T4: Time Efficiency

This theme regards to the time efficiency needed in the process of managing the drone. One insight gained from this is the various climate of the health centers from day to day. The number of patients are very different and also difficult to predict. The schedules of the nurses are already under considerable pressure, placing high demands on the interface to maintain an efficient way of managing time and have a high degree of adaptability. At the same time the drone need to be effective in order for the interface to be useful.

T5: Stability & Reliability

This theme refers to the stability and the reliability of the interface and the drone. The system will potentially be used on a daily basis, which demands a high degree of stability. Both regarding the connection between the interface and the drone and regarding the smoothness and connection of the interface. Meaning that it should be smooth, steady and dependable without any system errors.

Another insight drawn from this is the importance of having a reliable interface, since the interface is a significant aspect for the nurses to feel confident during the interaction with the drone. Several different factors influence this, among these are the guidance.

T6: Provide and Receive the Correct Information

This theme is related to the level and amount of information provided by the interface to the user. The nurses need to have sufficient information at the right time. One insight drawn from the analysis is the balance of having enough information. To only provide the most sufficient information and make secondary information accessible if needed.

The following themes are more related to actual functionality for the interface based on the data analysis.

T7: Schedule & Structure

This theme relates to the need for a structured interface where there is a well though out schedule with the planned flights. The nurses need to have access to a structured overview of the planned flights, where they can monitor the planned time plan for the flights.

T8: Clearance for Departure

This theme is related to the functionality of having a clear confirmation to the pilot before every takeoff. Meaning that the nurse packing the drone need to confirm when the process is complete and the pilot can start the drone. It is important to ensure that the medical personal are out of sight when the drone starts to avoid any dangerous situations or accidents.

T9: Attitudes

One insight drawn from the analysis is the different attitudes towards employing drones for commercial purposes. The analysis showed a varied distribution between positive, neutral and negative attitude. The positive attitude as connected to drones in healthcare expressed as excitement for the project. The analysis also revealed a neutral perspective on drones, signifying that drones are perceived as a novel technology which may pose initial challenges but, just as any other technology, will gradually integrate into the everyday work. Lastly, there were a more negative attitude connected to concerns regarding the rough weather seen in the archipelago at winter, both regarding the temperature and the high level of wind. There were also concerns about how the wildlife will be affected by the drones, especially how it potentially will affect birds negatively.

The analysis made from collected data also revealed that a few of the attitudes changed after they had been present at the test flights in January. This was related to the amount of rules and regulations that prevents this project from being implemented in the near future and also how the drone was affected by the tough weather climate of the winter in the archipelago. The medical personnel present during the test flights were not fully aware of the difficulties of flying with drones in Sweden, related to the rules and regulations. Neither were they aware of the high level of consideration needed for the climate conditions. Meaning that there attitude changed towards more neutral and a bit more negative.

5.2.3 Understanding the User Group

The project continued with doing personas, which included two personas that were based on the nurses from the interviews and observations by using Figma. By understanding the users it was possible to deliver a result based on their area of use and knowledge that could contribute to a good user experience [51]. One of the personas would have more work experience and the other was a little younger to represent two different age groups. The personas were also created for this project for journey mapping purposes to provide the user's point of view. Based on the personas and assumptions about user behaviour, five *Customer Journey Maps* were created using Google Sheets. The journey phases are then described with high level stages of the user journey, where the user's behaviour was encountered throughout the journey stages. The insights gained from the journey mapping results allowed us to identify important design aspects [54].

Two system maps were also created using paper and pen, one visualising the current delivery process and the other a futuristic system map to understand what factors would need to be considered when implementing drone deliveries. In addition, *Service Blueprints*, which are an extension of a customer journey map, were created as they go into more detail about the customer's interaction with the product and help to understand an experience in the early stages of design. This method was used for this project using Figma [56], see Figure 5.2, larger figure can be found in Appendix D.1. By doing the system map, we gained a clearer understanding of the current system and the different factors included. When visualising the possible futuristic

system map, we could easier see the necessary changes to implement, in order to reach the futuristic system map.

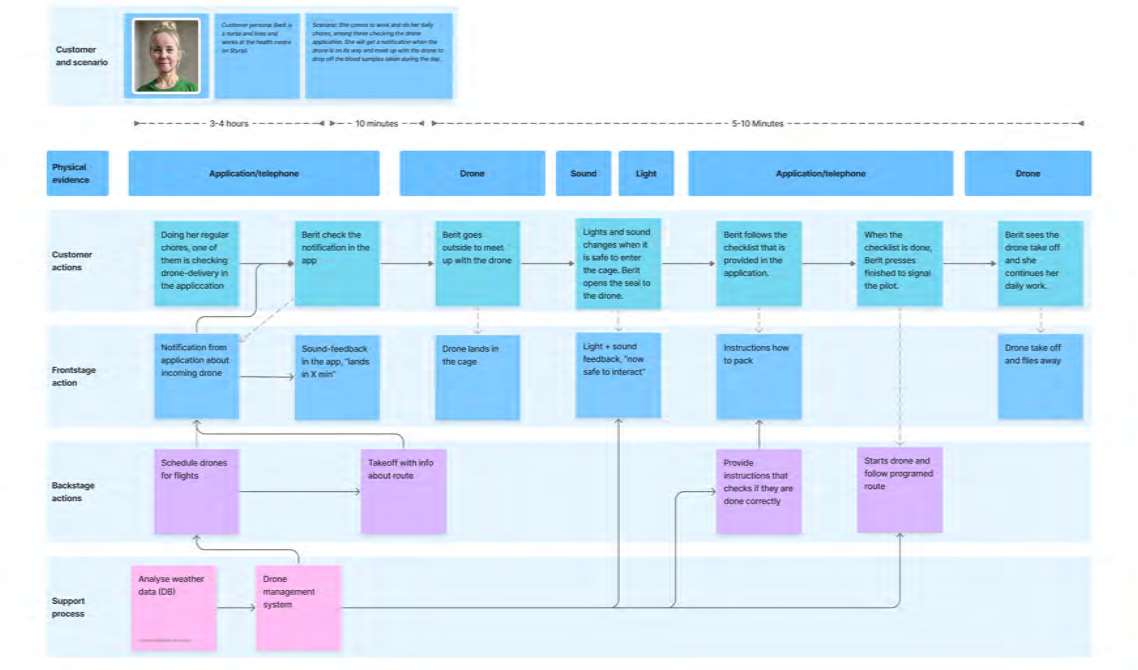

Figure 5.2: Service Blueprint that reflects how a normal day might look like.

5.3 Ideation

The ideation phase consisted of a co-design workshop were we brainstormed a lot about possible solutions for the design of the interface. Afterwards we sketched a lot of ideas, based on what was said during the workshop.

5.3.1 Co-Design Workshop

The project progressed with a combined meeting and co-design workshop with the VGR supervisors to harness the collective knowledge and expertise of all stakeholders to further innovate and develop the service[67]. It started with a meeting where they were shown the models and data that had been developed and gave input on changes. The other half of the meeting was the co-design workshop, where the supervisors were asked to write down important information on post-it notes during each step of interacting with the drone and application, with pictures of each step as a preference on the whiteboard, see Figure 5.3. After about 15 minutes, they placed their post-it notes on the pictures on the scenarios, as shown in Figure 5.4. The workshop continued with all four of us using the post-it notes and sketching for 10 minutes how the application could look like.

Figure 5.3: Co-design workshop with the supervisors from VGR. Pictures visualising the different stages in the process of packing the drones were put on a whiteboard.

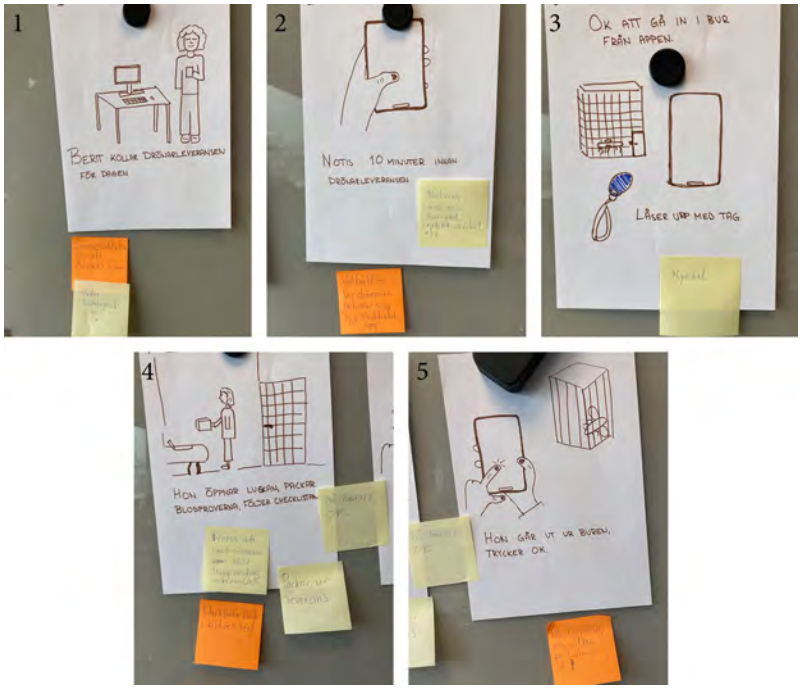

Figure 5.4: The stakeholders from VGR set up the post-it notes on the given scene during the co-design workshop. The different post it notes consisted of important functions and information flows that needed to be included in the different scenes shown in the figure.

5.3.2 Brainstorming and Sketching

From the co-design workshop we were able to start sketching on paper how we wanted the application to look on different pages of the application. We took 10 minutes to sketch each page and after each sketching session we discussed what information

and how the application should be distributed. This resulted in a common sketch for each page. One method that could have been used at this phase is brainwriting, which was not used as we already felt we had a good understanding of how we wanted our application to look from the co-design workshop and sketching.

5.4 Prototyping

In the prototype phase, a design solution was created, tested and refined though several iterations. The following section describes how we worked with prototyping, from the very first sketches, down to the finalised prototype.

5.4.1 Low-Fidelity Prototype

From the sketchings could a low-fidelity prototype application be developed using Figma. All information that had been discussed during the brainstorming session and co-design workshop was taken into consideration. The low-fidelity prototype was developed to make it possible to have an early user test. The functionality of the prototype was very limited and only contained basic functionality for most of the screens. Using squares to represent different functionality and components.

5.4.2 Usability Test Island C

Subsequently, a usability test was carried out at the health centre on Island C. Two different scenarios were created, one with the application and one without the application. These scenarios was based on the data collection made, specifically the customer journey map and service blueprints.

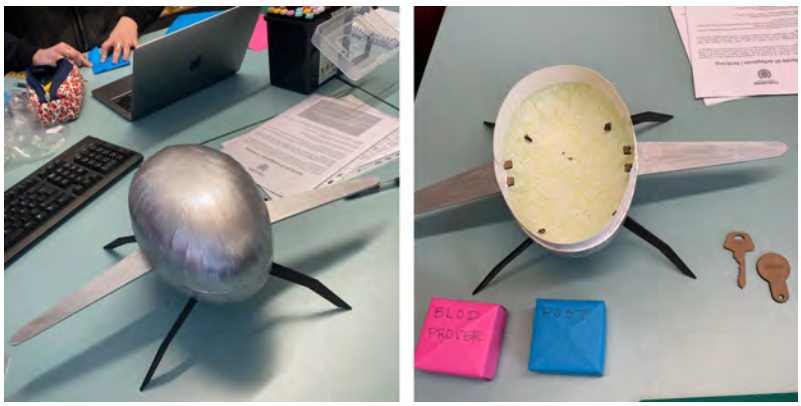

Figure 5.5: Picture of the drone that was used during the user tests. The drone was made by using a painted Easter egg and laser-cut legs and wings.

We were given a room in the health centre where we could set up our scenarios. To represent the corral we used tape on the floor and room partitions that could represent the walls of the corral. On one of the partitions we taped a poster with information about when you could and could not enter the corral. To represent the

drone in the scenario, we had created it using an Easter egg and used the laser cutter to represent the wings, propellers and legs, which can be seen in Figure 5.5. Some of the functionality was represented using Wizard of Oz.

For the scenario with the application, the nurses were given a phone with the low-fidelity prototype, which they could navigate through the scenario and follow a checklist provided in the application. For the scenario without the application, a poster with a checklist was taped to one of the room partitions. After both scenarios, the nurses were asked a few questions about what they thought about the different scenarios and if they had any input. We were hoping to test all the nurses working there, but unfortunately the test could only be done on three nurses as they all had a busy day.

Insights From Low-fidelity Testing

The reason we chose to have two different scenarios was that we saw potential problems with using a mobile application, such as nurses not wanting to hold a mobile phone in bad weather, and that, depending on the weight and size of the blood sample box, it could be inconvenient to hold a mobile phone and the box. However, they did not see this as a problem. Uncertainties and questions that the nurses could not answer, were how many tasks could be memorised before they felt that they would like to have a checklist provided.

Figure 5.6: Low-fidelity testers were used to see how the application interacted with the drone.

From the testing, two of the nurses preferred the app and described it as foolproof. They felt it would be safer to use a mobile application since the guidelines contained quite a few steps. The third nurse felt that the app was superfluous as she felt that

the tasks were quite obvious. What we observed during the testing was that the test participants performed the tasks more carelessly in the scenario without the application. In Figure 5.6 shows how it looked like when one of the nurses tested the low-fidelity application. We then made the conclusion that it was safer to have an application with a confirmation button securing that each step was conducted carefully. Instead of only relying on the human memory and posters.

Iteration 1

From user testing on the low-fidelity prototype, were numerous changes made. As it was in the early stages of prototyping, many parts were wire frames and therefore had no colouring other than white and grey. This changed to a navy blue colour theme. One feature that was removed from the application was the ability to see the probability of the weather, the reason for this was to avoid the nurses feeling the pressure of having to keep an eye on the drone. Another big change made from the low-fidelity testing was the ability to see the delivery history as well as having a profile page.

Figure 5.7: Picture illustrates how the low-fidelity prototype looked like. It had a simple and white and gray coloring. Picture 2 illustrates the changes made from the low-fidelity prototype. When the changes were made, the prototype had a different way of numerating the tasks and the color theme are blue and white.

A number of changes were made to the checklist, some of which were that the checklist did not have an animation to support the task text. Another major change made was to the header, which showed what task the nurse was doing and can be seen in Figure 5.7.

5.4.3 High-Fidelity Prototype

The high-fidelity prototype consists of a graphical interface suitable for a mobile device to be used by the personnel handling the drones. The colour theme of the application is inspired by the colours of VGR, e.g. dark muted blue and white background. The interface is created using the design programme Figma, the wireframes were created and presented in a physical phone to mimic a realistic scenario, in addition all the planned interactive elements in the design were clickable to further contribute to the feeling of a realistic scenario.

5.4.4 Difficulties Discovered During the Creation of the High-Fidelity Prototype

During the design phase, a few concerns regarding the design were discovered. These will be presented in the following section.

The temperature graph from the thermometer placed inside the drone during the test flights clearly showed that the temperature was disturbingly low. In the process of transporting blood samples, one of the key factors are to maintain an approved temperature in the container for the samples to be useful. In order to keep an approved temperature, the fluctuations need to be monitored and, if a critical temperature is reached, act upon. However, the temperature data could potentially be incorporated into the design, letting the medical personnel receive real time temperature data. By doing so, the information opens up for some additional concerns. More pressure are put on the personnel handling the drones and it assumes that they have accurate knowledge about approved temperatures for blood samples. It is also important that the interface clearly describes what to do when the temperature is above or below the approved temperatures.

Another difficulty discovered during the prototype phase is the possibility for joint packing with other goods, such as the mail. This could be a part of the interface but adds potential difficulty how this should be integrated into the interface.

5.4.5 Usability Testing High-fidelity Island B

Usability testing on the high-fidelity prototype was conducted at the health centre on Island B, see Figure 5.8. At the testing the nurses were to test three scenarios; one without the application and the other two with an application.

Figure 5.8: Nurse tries out the high-fidelity prototype.

The two scenarios with the application was played out in an optimal scenario and the other scenario similar to the low-fidelity tests i.e. one scenario without the application and the second scenario, the nurses were exposed to frost buildup on the wings, where they were tested on whether they understood what to do. In order to ascertain which approach would be most appropriate for this task, it was decided to create a scenario with an application and a scenario without an application.

Insights from High-fidelity testing

From the testing of all scenarios, it was noted that some of the nurses were eager to enter the enclosure before starting the checklist in the application. The nurses found that both approaches were easy to understand, but all agreed that they preferred using the application to the approach without the application, mainly because it felt safer and more foolproof, especially as the application and drone were integrated. In the event of incidents such as frost buildup, they liked the fact that the drone and the application would be integrated, as it would feel safer with updates and notifications from the application.

One of the nurses would have liked to see information about whether the drone was flying or not. Many of the nurses also commented that some of the important information text was too small. There were also requests to be able to call regional transport from the application.

Iteration 2

From the user tests, we took into account the comments made by the nurses as well as the observations made during the tests. Adjustments were made based on this information. One of the changes was based on the fact that there was some confusion when starting the checklist as the start button for the checklist was called "pack". This button was renamed "start" as some nurses associated the word "pack" with packing the bag used to transport the blood samples. We also changed the font size on some information texts as it was considered to be too small.

5.4.6 Usability Test High-Fidelity Island C

The second high-fidelity user test where executed at the health centre on Island C. The nurses were tested on two scenarios with the application; the optimal scenario and the scenario with frost buildup on the wings. They were not tested on the scenario without the application since some of them already had done that scenario during the low-fidelity testing. In Figure 5.9, one of the nurses performed the user test with the focus to see if the "start" button change was clearer to the nurses and if the text size was improved.

Figure 5.9: Nurse tries out the high-fidelity prototype.

Insights from test High-fidelity prototype

During the tests at Island C, the nurses were also eager to enter the corral before starting the checklist. When asked whether they would like to be able to choose between the checklist in a list view or step-by-step, they favoured the user not being able to see the next task until the given task had been completed. One of the reasons for this was that if there were error messages or updates, these would be more evident.

Iteration 3

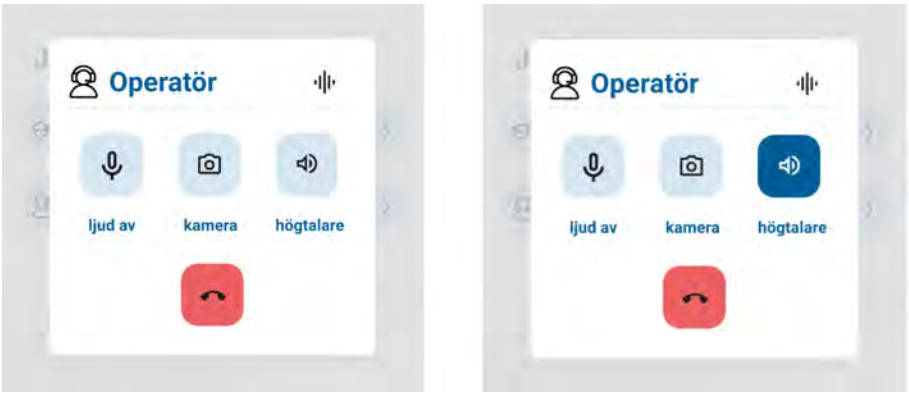

Figure 5.10: When the nurse needs to call for help and wants to talk on the speaker. They can activate it by pressing the "högtalare" button, as seen in the left picture, and the right picture shows what it looks like when the button is activated.

During the tests at Island C, some of the nurses pointed out that they would have liked to be able to go back in the checklist if they accidentally went to far without completing their task. This was added to the checklist. There was also a request for some sort of confirmation that the drone had been delivered to the site. Another thing that was changed in the design was when the user pressed on the sound icon

while talking to the drone pilot, as this was considered to be confusing for the nurses, see Figure 5.10. Finally, we also changed the colour of the cards in the archive from light blue to light grey to make it clear that they are in the archive.

5.4.7 Usability Test with Stakeholders from VGR

Usability tests was conducted with two of the stakeholders from VGR. During the meeting a short usability test was made together with a short meeting about the progression of the project. The stakeholders got to familiarise with the interface and then try out the different functions available, such as going though the checklist for packing the drone.

Insights from meeting with VGR

During the usability tests three discussion points were raised; two-factor authentication, the different steps of the checklist for packing the drone and the traceability of the different deliveries. Two-factor authentication was discussed as an additional feature, to have a high security level and to follow internal guidelines at VGR.

Figure 5.11: When the drone has landed on its destination, it is possible for the nurses to start packing by pressing on the button named "Starta"

Secondly the steps of conducting the guidelines for packing the drone were discussed more in depth, and specially the first step of the checklist which involves the button for starting the checklist in the interface marked as "start", as shown in Figure 5.11. This button were considered to be a bit confusing and could be misinterpreted as a button for starting the drone. Thirdly, the traceability of the interface was discussed, more specifically the need to have a high level of traceability for the blood samples. Incorporating package-id were given as an example how to do this. By having additional information about the specific package transported inside the drone makes it even more reliable and traceable. Similar to what can be found in the system used by Region transport. A function for scanning the package before putting them into the drone would need to be added.

Iteration 3

After meeting the stakeholders from VGR, two-factor authentication was added to the interface and the login page was changed to match the criteria for that. Instead of having a personal code with numbers for entering the interface, the users need to type their VGR-ID together with a personal password consisting of both letters and numbers. Secondly, the process of starting the checklist was discussed and small changes were made. The button however was kept as it was before.

The steps of the checklist was fairly modified. When the user unpack the possible goods from the drone it also needs to be scanned, to register in the system that it has arrived. Same procedure was applied with the blood samples, the user need to scan them before packing it into the drone. Scanning will be done by using the build in camera on the telephone.

6

Results

This project has had a exploratory character where designing for drone take-off and landing has been examined thoroughly, in the context of the project "Drönare i Skärgården" initiated and driven by Västra Götalands Regionen. The aim has been to identify key factors for when designing drone take-off and landing for nurses. By performing an in depth data collection, defining the target group, brainstorming for the specific problem, designing a prototype and evaluating said prototype, eight key factors could be identified. The key factors will assist designers in creating intuitive user interfaces for drone take-off and landing.

This chapter describes the result, an in depth walk through of the key factors together with an illustration of a future scenario describing how the nurses could interact with the drones. In this chapter the research question are answered by presenting the key factors in depth. The research question are stated below.

What are important factors for designing the interface controlling drone take-off and landing to optimise the User Experience for medical personnel during drone deliveries?

6.1 The Concept and the Prototype

The concept consist of an interface to support the personnel handling the human-drone interaction taking place when transporting blood samples from the islands outside of Gothenburg to the mainland. The interface is adapted for a mobile device and could be considered as a guide when unpacking and packing the drone. In the Figure 6.11, a scenario of the ideal outcome is illustrated to show the process of handling a drone transport. The aesthetics of the design is made coherent to match the color theme for VGR. The scenario also illustrated two additional components that are critical for this prototype to be implemented, a corral where the drone can land and a key to lock the fenced area. To represent this we used a low fidelity prototype made of an Easter egg, as seen in Figure 5.5.

Additional Components

The drone need a dedicated area where it can land without any external disturbances. To enter the fenced area a key will be utilized by the users and stored inside the

health center, to prevent intrusion. Our prototype requires the existence of these components since they are crucial for the service to function.

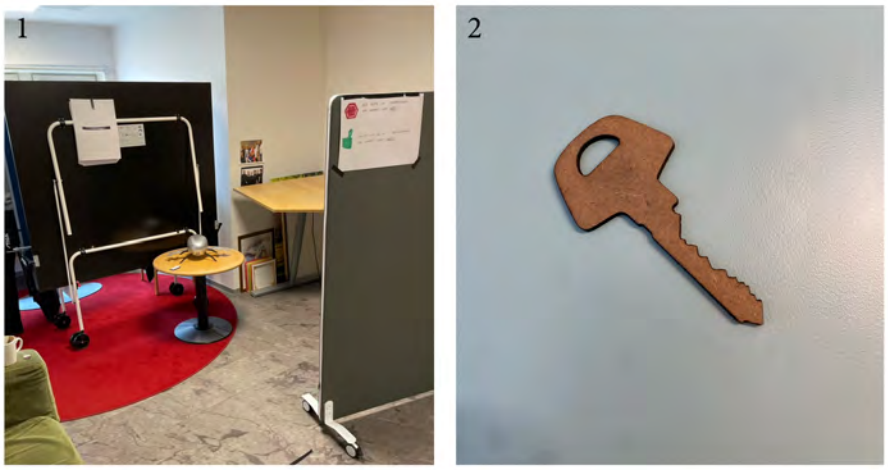

Figure 6.1: Picture 1 to the left shows what the corral looked like during the user tests and the picture on the right shows the key the nurses had to use to unlock the corral.

Figure 6.1 shows how we represented these two components during the user tests, as they are a critical factor for the security for the public as well as for the nurses.

6.2 Looking at the bigger picture

To receive a fair perception of the result, one should initially take a step back and examine the drone service from a more general perspective, where all the various components are visible and represented. Looking at the bigger picture has resulted in a more critical point of view. Further, the result does not answer if the implementation of the drone service would be a more efficient solution than the current transportation system.

Furthermore, it remains unclear whether this will be economically beneficial or more time efficient. The results of this master's thesis do not evaluate the feasibility of the overall project or its potential economic benefits or time efficiency and, therefore, cannot provide definitive answers regarding possible implementation. When it comes to the flexibility of the drone service, the results clearly shows that the nurses wished for a high degree of flexibility, potentially exceeding the solution's capacity.

Functionality

The main functionality of the interface is to support the users handling the packing of the drones. Therefore the focus lies on having an intuitive step by step guide how to conduct a drone delivery safely. There is additional functionality such as ordering a new drone delivery, receiving statistics from old drone deliveries, cancelling a delivery, managing your profile and adding new users.

Figure 6.2: These three images illustrate the three main pages in the application.

The application has three main pages; home page, archive and profile, which can be seen in Figure 6.2. This figure illustrates how the nurses can navigate through the application and use its main functionalities.

Figure 6.3: The home page shows the nurses the daily transports, but can also be filtered to view all the coming transports. By tapping on the plus icon the nurses can add new transports if needed.

The Figure 6.3 illustrates the home page where the nurses can see both the upcoming transports for the day and all the upcoming transports, see item 1 in the figure.

They can also see more information about the transport by tapping on the arrow, see item 2. Nurses may also need to book additional transports, which they can do by pressing the plus icon, see item 3.

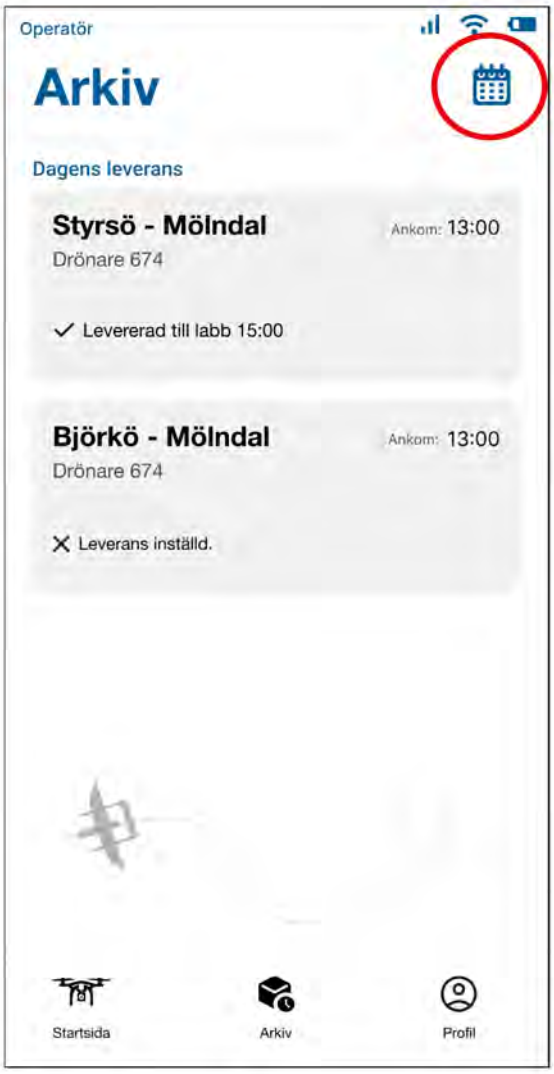

Figure 6.4: On the archive page, the nurses can view the history of transports. It is also possible to filter by day or period by tapping on the calendar icon up to the right.

By navigating to the archive page, nurses can view their transport history, see Figure 6.4. If the nurses need to see a particular day in the history, they can filter day or time span by tapping on the calendar at the top right, see red ring in the image.

Figure 6.5: On the profile page, it is possible to tap into "Utbildning" which is an educational page the nurses can read about how to interact with the drone. They can also receive support if something goes wrong. By tapping on the "Logga ut" button they log out from the system

On the profile page, nurses can view their profile, see Figure 6.5, where they can take a tutorial to learn or refresh their knowledge of how to use the drone, see item 1. If there are any problems during the flight or once the drone has landed, they can call the pilot or other support, see item 2. When the nurses are finished using the application, they log out from the application by pressing the log out button, see item 3.

However, it is unclear how much flexibility will be possible to implement. As shown in the quotations, the nurses would prefer a high degree of flexibility for the drone.

6.3 Key Factors for Designing Interfaces for Handling Drone Take-Off and Landing

This section describes eight identified key factors for how to design interfaces for controlling drone take-off and landing to optimise the user experience for the nurses. The key factors are created from the insights gained throughout the process, from the early stage data collection, down to the very last evaluation. A few of the key factors are directly connected to the interface and some are related to the overall experience of the drone service. The interface is the focus of this master thesis, however the interface is strongly connected to the overall drone service and will therefore be discussed briefly.

A short summary of the key factors are presented in Table 6.1, followed by an in depth description of each key factor.

Table 6.1: Summary of the Key factors.

KF	Name	Short Description
1	Minimal mental effort	Keep the mental effort to a minimum for the nurses conducting the drone deliveries.
2	Interacting close to the exposed drone blades	Make sure the interface support the safety of the nurses when interacting closely to the exposed drone blades.
3	Challenging climate conditions	Make sure the drone solution, including the interface is well equipped to handle various climates as faced with in the archipelago of Gothenburg.
4	Trusting the interaction between human and drone	Aim for a secure interface and make sure the nurses feel a high level of trust for the interface when interacting with the drone.

Continuation of Table 6.1		
KF	Name	Short Description
5	Considering different stakeholder needs and attitude	It is of high importance to consider the attitudes towards drones when working with commercially used drones, since the attitudes influence the experience of interacting with the interface.
6	Information balance	Display necessary information very accessible in the interface, all information needed to conduct a drone delivery. Secondary information should be accessible through a specific action. Ensure a balance between these two.
7	Clarity and simplicity of the interface	Support the nurses with a clear and simple structure for handling the drone deliveries, especially when going through the process of packing and unpacking a drone.
8	Flexibility when managing a drone delivery	Provide some degree of flexibility for the users since the situation demands for the drone deliveries to be flexible because of the various complex situations.

KF1 Minimal Mental Effort

This is directly related to the drone service overall, how the nurses experience the situation of handling the drone. The current situation faced by nurses demand minimal to no mental effort. They pack the blood samples into a designated container and position it at a specified location within the health center. The nurses do not need to worry about the blood samples at all, since they know someone will pick it up at the health center same time every day. The rest of the process is taken care of by the transport personnel, delivering the box to the correct location. The process is described by the nurses as being very simple, foolproof and secure.

"It is a very secure system." (N4)

By implementing a new process with drones, could potentially create additional mental effort. Instead of knowing exactly when the driver arrives they need to worry about the drone and if it will arrive at all since the transport is highly dependent on the weather conditions. When it comes to the driver, the existing interaction is minimal. Furthermore, he walks into the health center, picks up the box and leaves. No interaction is needed. By implementing the drone service, the interaction changes from being minimal to almost zero to becoming one of the most important factors.

During the user tests, there were concerns about the patients and what to do if there is a cancelled drone flight and new blood samples need to be taken. Since it is a fairly unique climate on the islands, some patients have a hard time travelling to the health centres. This can potentially also create extra mental effort for the nurses worrying for the patients. It was clear that the nurses prioritize their patients above all other things. Especially having stability and care for their patients. The organisational manager highlighted the need for a backup plan, if there is something happening causing the drone to not fly. Then this process need to be well structured and also contain minimal mental effort for the nurses.

> *"... that you don't need to use plan B, which, of course, must be in place in case this drone doesn't start and we don't have a drone for a while, so we need to have a plan B."* (OM)

Furthermore, it is highly important to keep the minimal mental effort when implementing the drone service and adding routines to there daily work. Meaning that the designed interface need to have a foolproof design where it is impossible to make mistakes. As previously mentioned, according to Harrison, Flood and Duce [26] one way of decreasing the unnecessary mental effort is to minimize the number of steps to complete a task and to aim for faster navigation. Both of these factors were applied on the finalised prototype of the interface. By having a very simple and clean interface, the navigation is basic and recognized from other similar interfaces.

KF2 Interacting Close to the Exposed Drone Blades

This key factor addresses the need to support safe interaction between humans and drones, related to the design of the interface. In order to do this, the interface should be able to support all the safety requirements for dealing with commercial drones designed to carry cargo. As the drones are relatively large, the propeller blades need to be adequately sized to carry the weight. The interface needs to give clear instructions to the user when it is safe to interact near the blades and when it is not. According to the principle of non-maleficence by Cawthorne and Wynsberghe [37]. The design should focus on minimizing the harm and risks of the users. It is clear from one of the interviews that there were a concern about safety when interacting with the drone.

> *"...the next step there would probably be that, well, that it's safe, that it's as safe as it is now...."* (OM)

Figure 6.6: This figure shows how one of the animated illustrations look like in the checklist.

One of the interviewees pointed out that their current routines are very safe and that this new implementation needs to maintain the same high standard. The exposed blades of the drone are the main concern. However, this interface will act as an additional safety feature, independent of the drone's design, to guide the user on how to handle the drone without getting hurt. It is therefore very important to have clear instructions on when it is safe to touch the drone and when it is not. Both by providing instructions directly in the interface and by providing additional feedback such as visual and audio feedback. These steps are highlighted with colour and moving images to illustrate the instructions which can be seen in Figure 6.6.

> *"... it's a good safety thing to have, just with checking the drone blades and being able to confirm that everything was okay when I sent it off."*
> (Nurse from user-tests)

Something else to consider is that it would be a significant change in terms of safety for the nurses. Today's transport does not require any safety considerations beyond how the nurses pack the blood samples safely, whereas using the drone for transport would require the nurses to consider not touching the blades of the drone in case the propeller starts to move.

KF3 Challenging Climate Conditions

It is important that the overall design solution and interface is adapted to the tough climate of the Swedish archipelago. Landing and take-off will be placed inside a fenced area outside of the health centre, which indicates that all the interaction will be held in a very varying climate. Facing low temperatures and strong winds, further challenging the landing and take-off for the drone.

> *"But my concern is that we live where we live, and it's very windy here quite often. So, I can also see a concern that it might be a bit foggy and such.* (N4)

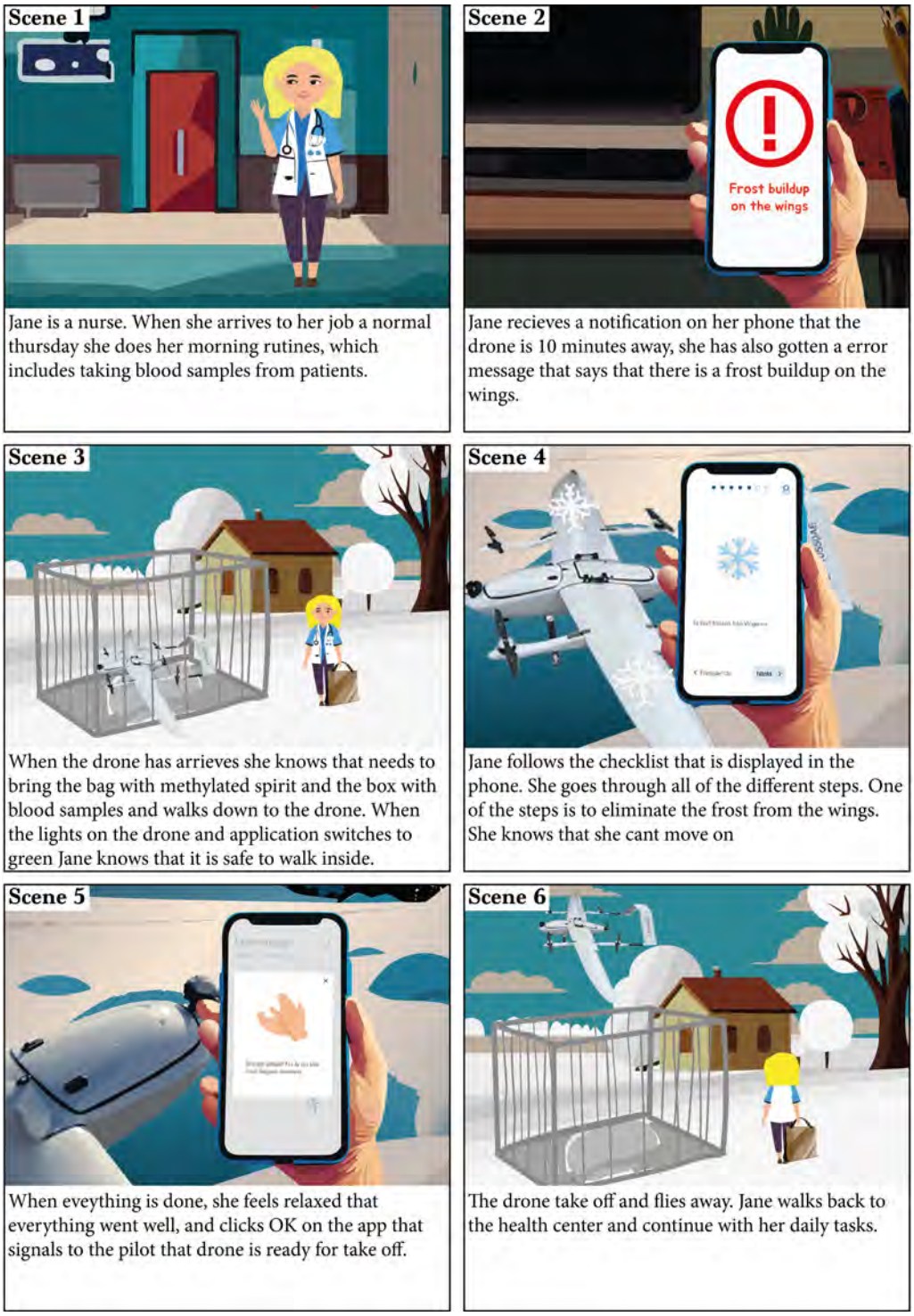

Figure 6.7: Frost build-up scenario. In this scenario, Jane arrives at work as usual and receives a message on her work phone that there is frost build-up on the wings. When this happens, she knows that she also needs to bring a bag with methylated spirit to the corral with the drone. She follows the checklist on the application that is connected to the drone. When all of her tasks are done she can walk into the health centre and continue to work.

During the winter, there is a good chance that frost will build up on the wings of the drone, which will need to be removed before it can take off again. A scenario where the nurses need to remove frost build-up from the wings is visualised and can be seen in Figure 6.7. The low temperatures can also hinder interaction by making it more difficult to operate a telephone with mittens or gloves on. During the user tests, participants raised the issue of standing outside in the cold and fiddling with gloves on.

> *"Yes, then it's cold out there too, standing around with gloves and fiddling."* (Nurse from user tests)

Figure 6.8: In the application the user can view the history from previous flights.

With this in mind, the interface need to obtain a simple interface with as low number of interactions as possible. The interface is designed to be very simple and no extra functionality, as seen in Figure 6.8. Similar problem are faced with the summer season, the sun creates sun glare on the screen of the telephone, making it difficult

to see and read instructions, which is why it is important that the text-size is readable.

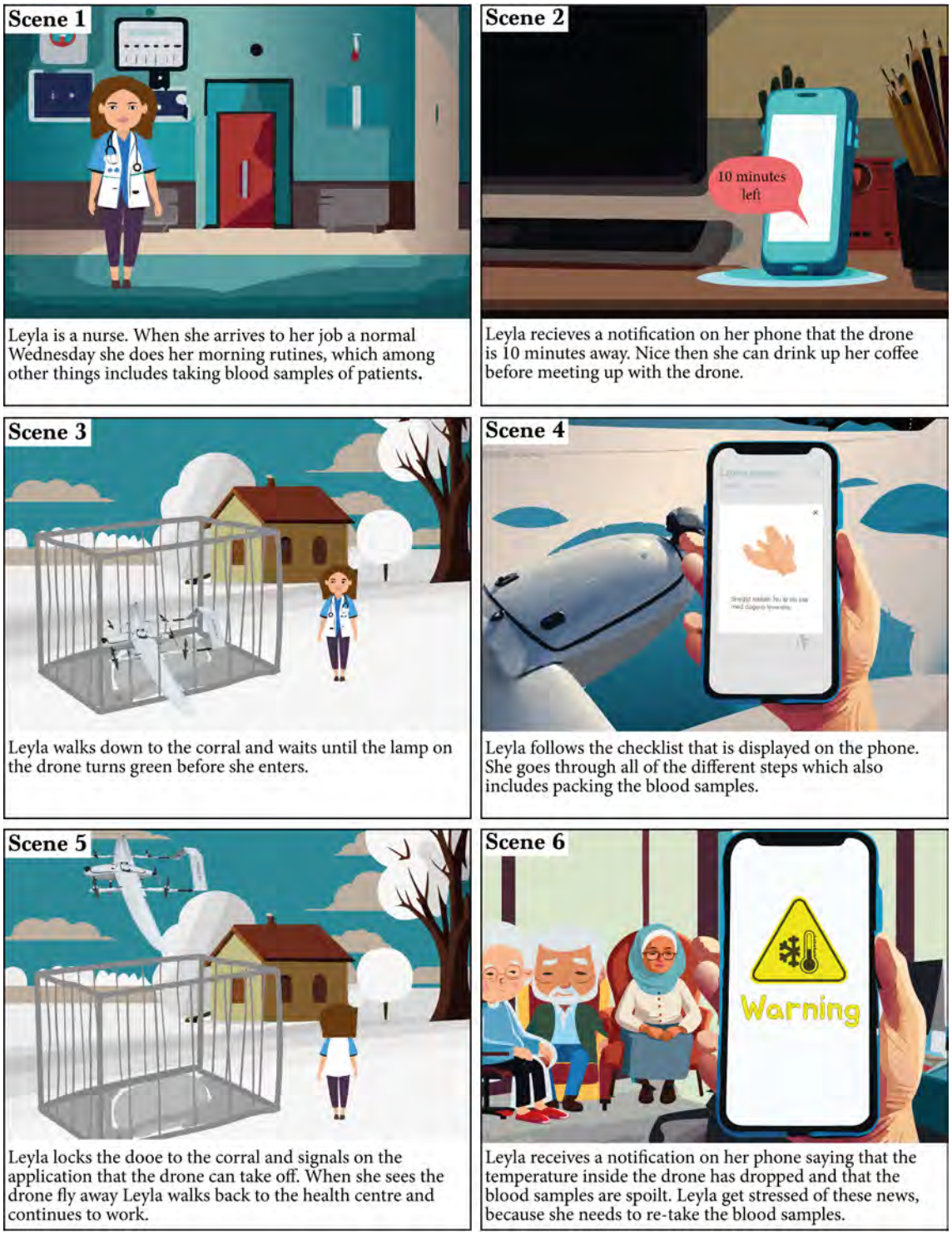

Figure 6.9: In this scenario, nurse Leyla packs the blood samples as usual, but then receives an error message that the temperature inside the drone has dropped and the blood samples have been spoilt. This means that she has to take new blood samples, which makes her feel stressed.

Unlike other countries, Sweden has a climate that varies in temperature depending on the season. It is therefore important for the drone to be able to maintain a temperature of 4-6 Celsius, regardless of whether it is hot or cold outside [74]. During test flights in early January 2024, the ability of the drone to maintain its temperature was tested, and it was found that the drone was failing to isolate the cold outside [10]. This problem is illustrated in Figure 6.9 and is something that needs to be taken into account.

As mentioned several of the interviewed nurses expressed concern regarding the tough climate of the archipelago. Both regarding the wind, fog and ice formation. The quote below explains their concerns of having to put on warm clothes and getting out in the cold and walk to the drone. Therefore they highlighted the need to have a good spot to place the fenced area in to make it accessible from the health centers. Especially if there is difficult weather to walk in, for example ice on the walking paths.

> *"It's good that it's placed in a good location. It's easily accessible to get out to the drone, which I think is important. You shouldn't have to navigate icy paths and climb stairs and things when you need to get out. So that's important."* (N3)

After the conducted test flights, the interview participants were asked what they were thinking about during the tests and also if there were something that surprised them. Several participants that attended the tests were a bit concerned about the drones limitations when it comes to strong winds and fog.

> *"And then I didn't think it would be so weather-dependent. But it's also because I didn't have a clear understanding of the current limitations, with all the permits that aren't finalized yet. And that also meant that you couldn't operate in just any weather because it's not permitted."* (N2)

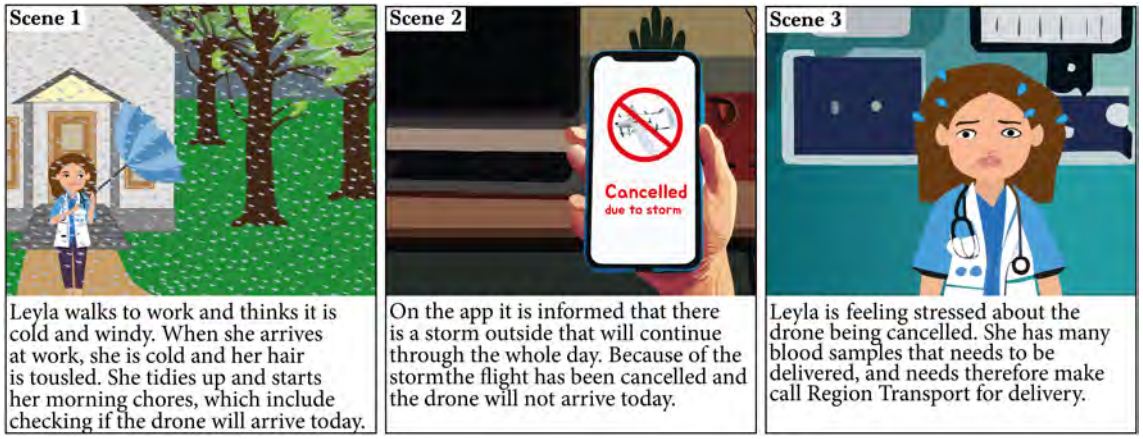

Figure 6.10: Drone flight cancelled. Leyla walks to work during a storm. When she arrives at work, she does her daily rounds and later receives a notification from the application that the drone has been cancelled. Leyla feels stressed that the drone has been cancelled and because it has been cancelled she has to contact the Regional Transport to pick up the blood samples instead.

During the test flights conducted by VGR and Aviant earlier this year, there were twenty flights scheduled and only nine of them were completed. Two factors were crucial, fog and the cloud base. Wind were also a bit problematic, since the drone had a limitation of flying at a maximum of 14 m/s, some flights were cancelled since the wind was measured to be closer to 20 m/s. For this test flights there were a specific permission, with specific limitations for cloud base and sight. Furthermore flights were cancelled to due a low cloud base and to much fog deteriorates the sight [10]. As wind has such a large impact on whether the drone can fly or not, a scenario has been visualised to show the problems that can arise during implementation and is therefore an important aspect to consider, see Figure 6.10.

KF4 Trusting the Interaction Between Human and Drone

This key factor relates to the goal of having a trustworthy interface, and it is important that the interface can provide high reliability, as it will be used on a daily basis and should act as an additional guide for the nurses interacting with the drones. In what can be a complex situation, it is important that nurses feel that they can trust the interface and that it will support them.

Since the interface is connected to a drone it is also of high importance that the nurses feel safe while interacting with it. Research conducted in 2018 [75] shows that many people associates drones with military. To change people's perception of the drone can be done by designing the drone to look more friendly. It was also evident from the interviews that many associated drones with warfare, this is also closely linked to the attitude of users, but nevertheless an important point for users to feel that they can trust the drone.

> *"... what other experience do we have of drones? Well, it is more the kind of thing you have heard on TV now with warfare and things like that that they use a lot of drones."* (Nurse 1)

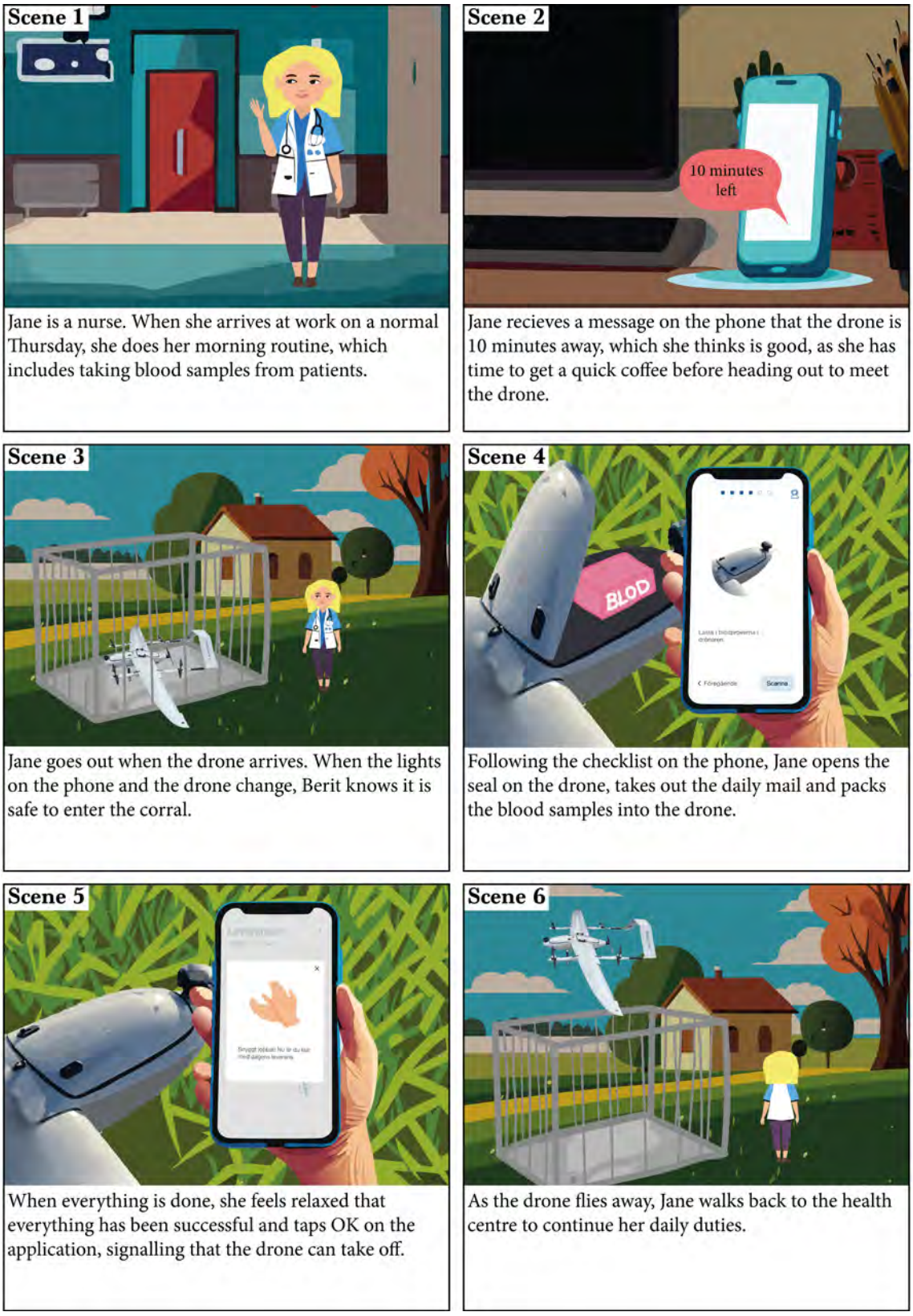

Figure 6.11: Optimal scenario for sending blood samples. The scenario shows what a normal day might look like for nurse Jane, who is updated via the app when the drone has arrived and is ready to be packed. She can then complete her tasks by following the checklist.

Ease of use and usability have been considered and implemented in the design to ensure that the interface is reliable. In particular, the interface aims to provide the right information at the right time, letting the user know when there are deviations, such as a cancelled drone flight, leading to a sense of trust from the nurse. For example, the interface tells the nurse when it is safe to interact with the drone and when it is not. This is visualised in Figure 6.11 in Scene 3.

KF5 Considering different stakeholder needs and attitudes

One of the key factors that need to be considered when designing is peoples attitudes, related to the general drone service. Depending on what attitude the user has, it will change the way of feeling and interaction with technology [76]. A successful implementation of new technology depends on users adopting and using it effectively. In some cases, users do not accept the new technology, which can lead to a failed implementation, wasted resources and missed opportunities. Lack of user acceptance of technology can also hinder future initiatives and organisational agility [77].

In general, drones are accepted by the public when they are used for public safety and rescue missions [78]. However, many still associate drones with the military and warfare. It also shows that privacy and security are important factors in people's perceptions of drones. The public's attitude towards drones may vary depending on the purpose of the drone use, for example, participants in the Netherlands were curious about the reasons for the use of drones in certain situations and showed a more neutral or positive attitude [78]. From the interviews it was also shown that the nurses have a fairly neutral attitude toward the use of drones in the health care.

> *"Yes, it feels all right, I suppose. No, but I guess it is whatever. No, there's nothing strange about it being a drone. I don't think I would have any problems with that."* - Nurse 2

It was also clear from the interviews that there is a degree of uncertainty and anxiety about drones flying in residential areas.

> *"It feels a bit unsettling if you know there are large vessels flying above your head."* (Nurse 1)

KF6 Information balance

It is important to maintain a sufficient level of information displayed in the interface. There should be a well thought through balance between simple information and complex information. Necessary information needed to conduct a drone delivery should be very accessible in the interface. Furthermore, secondary information should be accessible through a specific action. As shown in the quote below, the organisation manager for one of the health centers specifically highlighted the need for a high information level, and that this is of high importance in the beginning of implementing the drones.

> *"...it feels like it's somewhat in space, where one needs to have a slightly higher level of information so that the sender also sees that it's okay for*

it to take-off and also receives this message back." (OM)

During the interviews a questions was asked regarding what kind of information were necessary to have access to. According to the interviews information that was sufficient was; when the drone will arrive, live updates of the position of the drone, notification when it is a few minutes until arrival and some kind of signal when the nurse is done packing the drone. This clearly symbolizes some of the specific information need for the nurses.

> *"... is it available in real-time or where is it located? A live broadcast, so to speak. And perhaps there could be a signal when there's a certain number of minutes left before it lands or before it arrives at its destination...but then, of course, there must be some way for me to send a signal or some clear indication that I'm ready. That I've left the area."* (N2)

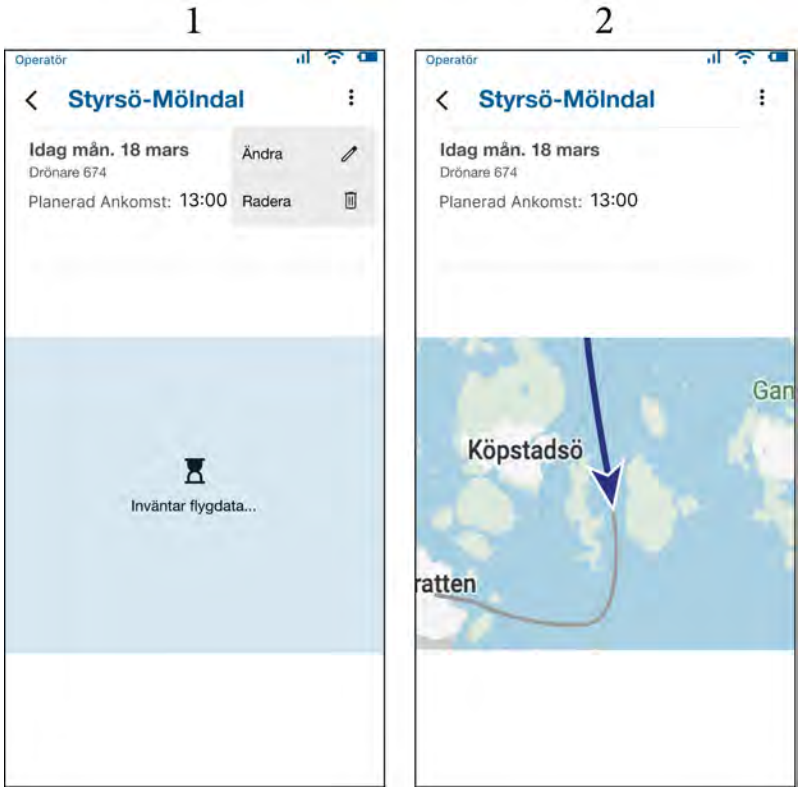

Figure 6.12: On the first screen, see picture 1, the drone has not yet started its flight and is waiting for more information about the flight. As the drone has not started its flight, the user can modify or cancel the flight. On the second screen, see picture 2, the user can view when and where the drone will fly, the estimated time of arrival as well as a real-time update of the drone on the map.

When it comes to the more secondary information, it should be accessible but only by choice. Meaning that it could be placed in a different screen, visible only when the user actively requires to see that information. As shown in the Figure 6.12, see picture 1, the user has the possibility to modify or cancel the flight, as long as the

drone has not yet started to fly towards its destination. Once the drone is packed at the drone hangar, the nurses can see a real-time update on the map, as well as the estimated time of arrival, see Figure 6.12, see picture 2.

It is also important that correct information are displayed at the right time. Especially when the drone is being packed since it is the most critical situation, being stressful and potentially dangerous. If there are to much information shown in the interface, uncertainties arise very quickly and the risk of information overload is high.

KF7 Clarity and Simplicity of the Interface

According to research conducted in 2015 [79], the use of simplicity in an interface can influence usability and also contribute to a higher user experience. Therefore, it is important that the interface has a clear and simple structure. This means that the letters should be large enough to be read by anyone in a unique environment, such as outdoors in a potentially harsh climate. The same approach can be applied to all headings, they should be simple, easy to understand and read outdoors. In Figure 6.13, the text is larger as it is important for the nurses to be able to take in the information that is given to them when they are packing the drone. As several of the nurses pointed out the problem of having too small text during the tests.

Figure 6.13: These two frames are from when the drone has landed on its platform and the nurse has started the checklist. Within the checklist there is a step-by-step animated illustration of the task that must be completed before moving on to the next.

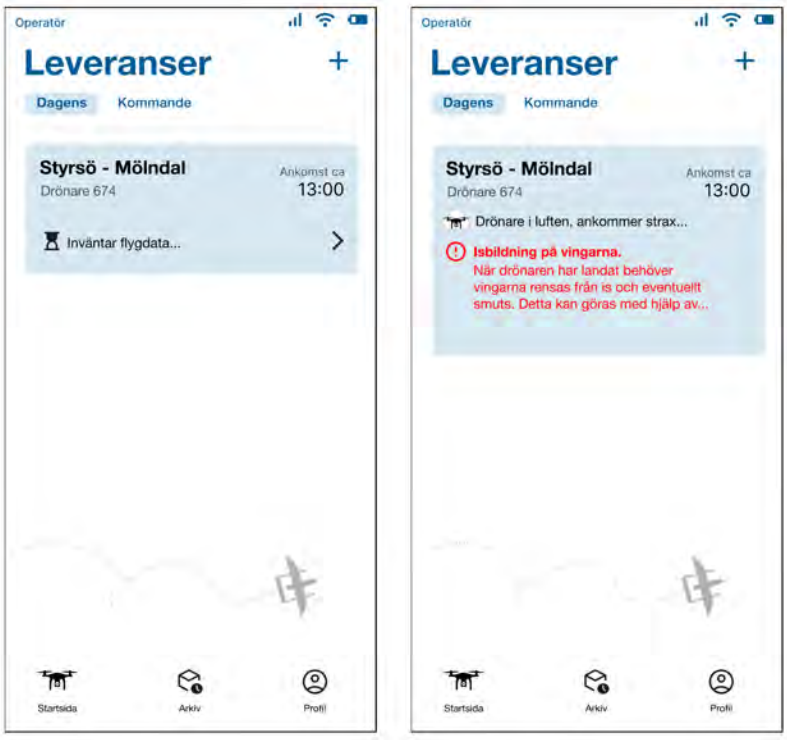

Figure 6.14: These two screens illustrate what it might look like to receive an error message. In this case, the application is informing the user that there is frost on the wings of the drone, as can be seen in the image on the right.

When it comes to the overall experience of the drone interaction it should maintain a clear and simple structure. This should also be the case if a problem occurs during or after the flight. In Figure 6.14, the nurses are notified that frost has formed on the wings, and this is also displayed in the application. This unique situation is already very stressful and vulnerable, and putting too much complexity into the interface can potentially have negative influence on the mental effort. Same goes for the experience in general. The different steps to go through need to be well structured and the users needs to be informed when to do what. It should be feasible for everyone regardless of prior experience of technology or drone interaction. The quotation shows that one of the participants wished for stability, as well established routine and specifically emphasized that it should be simple to execute.

> *"...it's probably linked to stability, you know, having an established routine that works... and then, of course, that the actual handling on-site becomes both simple and, you know, feels safe or secure for the person managing it."* (OM)

While stability and simplicity are essential, it is also important to raise questions about information overload. Too much information can lead to negative outcomes such as increased stress, decreased productivity and reduced job satisfaction among users. It is therefore important to consider design principles that provide clear and easy access to important information and avoid overwhelming users with excessive data[80].

> *"... it's good not to have too much information. That might make things difficult.... "* (Nurse from user-tests)

KF8 Flexibility When Managing a Drone Delivery

One if the most important key factors deals with the need for flexibility for the personnel handling the drones, regarding both the drone service and the interface. This connects to the hectic environment at health centers where there are big variation in duties from day to day. The number of patients one day is hard to anticipate, therefore the drone interface need to be flexible in the sense that unexpected urgent patients can be dealt with before taking care of the packing of the drone. Meaning that the drone might have to stand still at the health center until someone is available.

> *"That it's stable, that it works, that it becomes routine, that it's not like you have to cancel it, that you don't have to use plan B, which of course must be available in case this drone starts and we don't have a drone for a while, so we need to have a plan B.* (Nurse from user-tests)

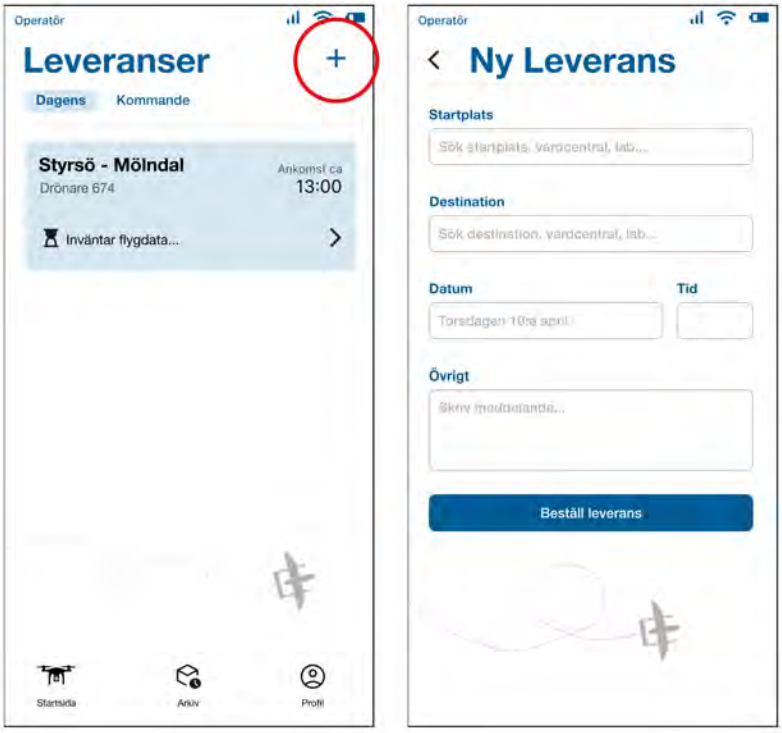

Figure 6.15: This illustration of the application shows how the nurses can book a new delivery through the application. This is done by tapping on the "plus" sign on the picture to the left. The user is then navigated to a new page where they can make the booking.

When it comes to the interface, the flexibility should be high. It should be possible to schedule new deliveries, if there is a need to send more blood samples. Figure 6.15 displays the functionality for ordering an extra drone delivery. To allow some

degree of flexibility there also need to be a secondary process if something stops the drone from flying. Therefore, scheduled deliveries should be possible to reschedule for another day or later that day. If something happens with the drone, stopping it from flying, there also need to be a backup way of delivering the blood samples. This was also brought up during one of the testings on Island B that they wished for the ability to contact the regional transport for an alternative transport through the application.

> *"If you could contact the regional transport through the application, the driver will know that he needs to come..."* (Nurse from user-tests)

However, during the user tests, the nurses wanted to be able to send drones between the islands more freely if they had forgotten something or needed additional supplies.

> *"We want a drone that we can fly between the Health Center and the other islands. So we can leave items there if we have forgotten to bring them because we are at other locations among the small clinics."* (Nurse from user-tests)

However, this kind of flexibility is not implemented in the drone solution and the interface, since it is difficult to have such high degree of flexibility.

7

Discussion

This chapter presents a discussion about this master thesis beginning with the process, continuing with a reflective discussion about the results. The chapter ends with a short discussion about future work.

7.1 Analysis of Results

This section presents a analysis of the result followed by a discussion related to the key factors.

7.1.1 Improvement for Whom?

One of the problems with implementing drones is keeping the mental effort involved in the drone service to a minimum. As described in the findings, the existing process for packaging blood samples is very simple and does not require much effort from the nurses, as they only have to pack the blood samples and wait for Regiontransport to pick them up [10]. The introduction of the drone service is likely to increase the overall workload for nurses as they will be required to manage the take-off and landing of the drones. There are also concerns about the possibility of the drones being cancelled due to climatic conditions and how to deal with such a situation, which creates uncertainty for the nurses. A driver will probably need to be contacted to deliver the blood samples by car and boat.

During the test flights and user tests, the nurses were very positive about using drones to deliver blood samples. However, there is no guarantee that it will maintain the same simplicity as their current process, most likely it will not. Therefore, it is extremely important to try and keep the drone service and interface as simple and straightforward as possible. During the interviews and user tests, nurses were very satisfied with the usability of the interface. However, the user tests did not include all the elements they would face in the real scenario, which could have led to a different outcome.

7.1.2 Tough climate conditions

As described above, the climate in the Swedish archipelago is variable and in places very harsh, with low temperatures, fog and strong winds. This places high demands

on robustness on the overall transport solution, including the interface. Firstly, the temperature inside the drones must be kept between 2řC and 6řC[38], but was measured to be lower than the accepted temperature for medical products. As seen in the previous chapters, the interface is adapted to interact with the outside, with large letters and headings. In addition, the situation requires the nurses to be able to use the mobile outdoors, with gloves in winter and sun glare in summer. The number of interactions required is also kept to a minimum to avoid the need for nurses to click multiple buttons when standing outside.

However, temperature is an important factor for nurses to consider when managing take-off and landing. In a realistic scenario, they would need to ensure that a drone delivery has not deviated from the accepted temperature. They would most likely do this in the interface, as all interaction is handled in the application. However, there may be other issues that need to be considered. The temperature would need to be visualised somehow in an easy to understand and clear way without any risk of misinterpretation. Nurses then need to know how to read the information and what to do with it. For example, if there is a drone delivery that has dropped below the accepted temperature, they need to know how to read the information, which may be visualised in some kind of temperature graph. They also need to know what to do with that information, who to contact. If they need to repeat the blood samples, they also need to have a procedure for doing that. After discussing this, we decided not to include the temperature in the interface at all, with the motivation that it would only lead to more questions.

Another issue related to the harsh climate is frost build-up on the drone, which is related to the drone service. This also needs to be communicated to the nurses as it is not always easy to see. There is a warning in the interface if frost build-up is detected during a flight. So the nurses need to know what to do when that happens. There may be some kind of liquid they need to bring to the drone to get rid of the ice. During the user tests, the nurses were not worried about this at all, quite the opposite. They suggested that there could be some sort of bag to store the fluids and take them to the fenced area when needed.

7.1.3 Safety of the nurses

As [34] bring up in their study, drone blades can be a major concern for the user interacting with drones. Therefore, the interface has been designed to increase the safety of the nurses while interacting with the exposed drone blades, while being economically viable. This is consistent with Cawthorne and Wynsberghe's [37] principle of non-maleficence, minimizing the risks associated with transporting blood samples. By implementing more advanced technology such as sensors and cameras in the corral, safety would be enhanced by linking the interface to the real-time location of the phone. The interface would then react if the phone was outside the corral, making it safer for the nurse. However, implementing the sensors and cameras would most likely increase the cost significantly, especially given the number of potential landing sites for the drone.

It is also a question of how much workload you want to put on the nurses, so having

the confirmation button in the interface before moving on to the next step takes some of the workload off them by not having to memorise the steps. If there is no confirmation before moving on to the next step, there is a relatively high risk of errors. For example, stress may affect the ability to work and steps may be skipped if the interface allows the user to move on without confirming that the previous step has been completed. If steps are skipped, nurses are likely to be less safe and the risk of accidents will increase.

7.1.4 The Need for a Plan B

Today, a blood sample delivery is almost never cancelled. With the introduction of drones, there would need to be an alternative process for handling a delivery if the drones are not operational. For example, there are several reasons why drones might not complete a flight. First and foremost, the drone has limitations in terms of weather, such as wind and low cloud base, which can prevent the drone from flying, and this was also reported in the VGR report [10]. Then there needs to be a well-established alternative procedure. We do not know exactly how this will be done, but preferably a car can be called in to transport the samples for the day, or they will be sent on the next scheduled drone delivery the next day, depending on the type of samples and how urgent it is. In some cases, blood samples may need to be collected again. Then the patients may have to travel back to the health centres, and in some cases they may have travelled quite a long way. During the user tests, the nurses emphasised that they were very concerned about their patients and their well-being.

In addition, hiring a truck is expensive and, depending on how often drone deliveries are cancelled, may not be economically beneficial at all. There also needs to be an alternative process to deal with the fact that the drones may crash or be disrupted by external factors, such as attempted robbery, resulting in the destruction of the cargo, or because the weather is too harsh. There is also the risk of being stressful and mentally exhausting for the nurses, who already have a busy schedule. Both a physical process of what to do when a flight is cancelled and a solution in the interface to handle this situation need to be implemented.

7.1.5 Repetitive Process

Our design consists of a graphical interface for a telephone, designed to assist nurses in handling the take-off and landing of the drone. In the interface there is a defined process for ticking off all the steps in packing the drone for take-off, as shown in Figure 6.13. Before proceeding to the next step, there is a button to click to confirm that you are proceeding to the next step in the process. Waiting for the nurses to confirm their intention to proceed to the next step ensures a safer process and minimises errors. After a few iterations, this process can become overly repetitive and redundant, but we have chosen to design for a high level of safety, as there are some safety issues with interacting with the drone [34]. The manual confirmation to proceed to the next step ensures that the previous step has been completed. During user testing, nurses were not concerned about the interface being repetitive, but

we will not know for sure until an actual implementation has been made and the interface has been used for some time.

However, one possible solution to the feeling of repetition is to divide the workload between several different nurses. You could have two different modes in the interfaces with two different user groups, one for beginners and one for advanced users. Also, nurses who are more used to using the drones can switch on the advanced design. New nurses can then be given an interface that is designed to be intuitive and educational. It is also important to consider the possibility of a higher safety risk if less experienced nurses are allowed to handle deliveries. Therefore, the beginner mode needs to have a higher level of safety.

7.2 Uncertainties in the Project

During this project there were a number of uncertainties that we had to take into account in the design, which meant that we had to make a number of assumptions in order to design the interface. Most of these were related to the drone service in general, which indirectly affected the design of the interface.

Firstly, the design of the drones had not yet been decided. This leads to uncertainty about how the box containing the samples will be loaded onto the drone. On one hand, it could be placed inside the body of the drone, and on the other hand, it could be attached to the bottom part of the drone, which is placed on the outside of the drone. Depending on how the box is attached, the interaction could be slightly different. We chose to design the interface where the drone has the blood samples placed inside the body of the drone, as this was the case during the test flights earlier this year2.1.

There is also uncertainty about the fencing around the drone. The design idea of the corral has not yet been finalised. However, the corral will be used to protect the public from the drone and to prevent trespassing. We have made some assumptions about the corral and how it will work, but we do not know for sure. When it comes to the locking mechanism on the door, it could be electrical, connected to the interface, or it could be manual with a physical key. We have designed for a physical key to make it as economical as possible. When it comes to the safety of the nurses, having the door electrically connected to the interface would increase the overall safety. In addition, connecting the interface to the door would ensure that nurses could not enter when the drones were switched on, as the real-time location of the phone would sense when nurses were trying to enter when the drones were switched on. Whether or not the door is connected to the interface has a lot to do with economics. Having more sensors picking up signals about where the phone is would most likely increase nurse safety.

Today, the mail is delivered to the islands along with the car that delivers the blood samples, and is an important part of the process. So they want to integrate the mail into the drone deliveries. This adds complexity to the situation in terms of whether it would be integrated into the interface and, if so, how it would appear.

In the design, there is a specific process that is designed to be used when the nurses pack and unpack the drone. These steps are based on the information given by the drone pilot during the interview, along with some assumptions we made to test the interface. However, we do not know for sure exactly what information is needed in this process. This is partly because the design of the drone has not yet been decided and this will directly influence the steps in the process. We also tested the process during our user tests and iterated it afterwards. The feedback was positive, especially regarding the few steps and the simplicity of the instructions. When it comes to the more technical aspects, it may need to be adapted to the specific drone used.

7.3 The Project Process

Throughout this project, great emphasis has been placed on evaluating and testing the design of the interface. According to Cooper et al.[81], usability testing is an excellent way of identifying key issues relating to interaction, buttons and labels. During the project several user tests were conducted to iterate the design and ensure a satisfactory outcome.

In terms of data collection, our target group was very specific: nurses working in the health centres in the archipelago outside Gothenburg, preferably with experience of the project led by VGR. Most of the nurses interviewed had prior knowledge of the project and had been present during the test flights. However, they had neither seen the drone in person nor tested its packing. In addition, due to the geographical distance to the target group, the interviews were conducted digitally. This may have had a negative impact on the results and made it more difficult to connect with the interviewees and read their body language during the interviews. In addition, the group interview was conducted digitally, which further complicated the situation. One computer was used for seven participants, which made it harder for us to pick up on different responses. If we were to repeat the interviews, we would probably get better results by conducting them in person and limiting the group interview to three participants.

We also conducted a co-design workshop with the project leaders at VGR. In order to properly follow the guidelines for conducting co-design workshops, the target group and stakeholders should be represented during the workshop. Due to the geographical distance, we only conducted the workshop with the project leaders from VGR. However, they had a strong understanding of the topic and could take part in the workshop activities. Although, including nurses in the workshop would probably have improved the outcome.

All our user tests were carried out on the health centres at Island B and Island C with the nurses on site. Not all the nurses were familiar with the VGR project and had to be informed before the tests started. This may have influenced their actions and thoughts about our prototype. In addition, some of the nurses were also present during the test flights, which meant that they had a prior understanding of the drone and how it worked.

Due to the difficulties of using a real drone for the user tests, we had to create a smaller drone to enhance the feeling of carrying out the process of packing the drone. This also meant that the measurements were much smaller than the real drone, leading to a possible distorted perspective, as several of the important factors are related to the size and components of the drone. For example, the drone's wings were made of wood and did not actually work. This meant that the nurses did not get the realistic feeling of being close to the dangerous exposed drone blades.

Also, our concern that it might feel repetitive could not be tested. Nurses were allowed to try the process of packing the drone once, and in some cases twice. However, one of the discussion questions afterwards was related to this. They did not perceive the process as repetitive, but rather as positive and safe. In order to fully investigate this, the drone service would need to be implemented and new tests carried out after a period of time to obtain a credible result.

7.3.1 The role of Service Design

A service design process was implemented in this project and is useful for designing a sustainable solution for customers in a unique context, based on the stakeholders, location and other factors unique to the project [43]. This project really has a unique context, as it is located in the Swedish archipelago and focuses on nurses working in the health centres on the islands. Therefore, the service design approach helped us to gain a good understanding of the organisational structure as well as the specific needs of the users, i.e. the nurses. As user-centred design is one of the key elements of the framework, understanding the daily context of the user is essential.

In addition, the delineation of the different phases within the process seemed somewhat unclear, so we created our own phases of the process based on the activities and guidelines from the Service Design Framework. We did this to facilitate our work and to have a clearer process with well-defined steps to follow.

7.4 Future work

From a broader perspective, there are still several rules and regulations that need to be developed legally in Sweden to facilitate transport between the mainland and the archipelago. Regarding this project and the test flights in January, there was a temporary permission to facilitate the drones. A more permanent solution needs to be considered. In terms of the more technical aspects of the project, research would need to be carried out into the optimal design of the drone and where to place the container with the blood samples. The fenced area would also need to be studied in order to optimise the design.

The user tests and evaluations during this study were conducted using a low-fidelity drone made from Easter egg and wood. In order to increase the validity of the research, testing needs to be carried out with a real drone to ensure that the interface is sufficient to support the nurses in handling the take-off and landing of the drone.

At present, there is no clear plan on how to handle a potential accident or an

attempted robbery. Furthermore, this will need to be figured out before an implementation where to happen, since it is highly important to have a solid routine for how to manage it.

As mentioned previously, incorporating sensors and cameras into the fenced area for the drone would likely increase safety by ensuring that nurses are outside the area before the drone is activated. This setup would also allow the pilot to monitor the drone via the cameras within the fenced area. In addition, the process of packing and unpacking the drone requires further discussion with a drone pilot to determine the relevant components. Our design is based on an interview with a drone pilot, but we had to make some assumptions. In a realistic implementation scenario, this will need to be explored in more detail.

7.5 Ethical Considerations

During this project, the General Data Protection Regulation (GDPR) was applied. It is important to ensure that the data collection complies with the GDPR regulations, and to obtain the necessary permissions. We followed the guidelines provided by Chalmers School of Technology. In addition, a research information form was handed out before the start of each data collection, both interviews and user tests, together with an informed consent form. This gave them the opportunity to know how their data would be stored and how it would be handled, while also informing them of their right to withdraw at any time without their data being stored.

All interviewees were treated confidentially in this thesis in order to maintain the integrity of the participants and to ensure that they felt comfortable sharing their honest opinions.

7.6 Limitations

Due to the exploratory and futuristic nature of the project, there were a number of limitations that had to be taken into account. There were some uncertainties regarding the physical implementation of the drone service. As mentioned above, these uncertainties have led us to make some assumptions about certain components. For example, the functionality of the corral and the design of the drone were two components we had to make assumptions about, since there is no formal decision made about these things yet.

8

Conclusion

This project was initiated to investigate a possible design for drone take-off and landing to optimise the user experience for nurses interacting with the drones. The transport of blood samples with drones is new in Sweden, but there has been research in this area nationally. The Master's thesis aims to provide key factors for designing this type of user interface in a future scenario, and the focus has been on designing a digital user interface. Therefore the following research question was formulated

What are important factors to take into consideration, when designing the interface controlling drone take-off and landing to optimise the User Experience for medical personnel during drone deliveries?

To answer this research question, a service design process was applied to correctly identify the key factors. Firstly, the focus was on building an in-depth knowledge and understanding of the specific research area. This was done by collecting data from stakeholders and the target audience. A lot of effort was also put into understanding the target group and the organisational structure. Several different models were visualised along with a thematic analysis to analyse the data collected from the interviews. A co-design workshop was held with VGR to start the ideation phase. The low fidelity prototype was tested with the target group and iterated to move to a more developed high fidelity prototype. Evaluations were conducted with nurses at the health centres and project leaders at VGR.

By evaluating our prototype and gaining insight throughout this project, we were able to identify eight key factors to assist designers in developing interfaces for handling drone take-off and landing, with nurses as the target audience. These key factors are listed below.

KF1 **Minimal mental effort**

KF2 **Interacting close to the exposed drone blades**

KF3 **Challenging climate conditions**

KF4 **Trusting the interaction between human and drone**

KF5 **Attitudes towards commercially used drones**

KF6 **Information Balance**

KF7 **Clarity and simplicity of the interface**

KF8 **Flexibility when managing a drone delivery**

Firstly, the current process for nurses requires minimal mental effort, and there is no guarantee that the new drone service will maintain this low level of mental effort. In addition, the challenging climate of the Swedish archipelago places significant demands on the drone service, forcing it to adapt to the conditions. The interface must also support the nurses when they interact near the exposed drone wings. The interface should be clear, well structured, provide an appropriate amount of information and allow for flexibility. Finally, it is important to consider the different attitudes of the stakeholders in the design process.

In conclusion, the aim of this project was to identify critical factors in the design of interfaces for managing drone take-off and landing operations, resulting in a list of eight identified key factors. In addition, when considering the broader context, there remain significant uncertainties regarding the feasibility of implementing this type of drone service in Sweden, primarily due to the lack of rules and regulations governing the use of drones. Furthermore, with regard to the specific circumstances of nurses, it remains unclear whether the implementation of this technology will be an improvement on their existing conditions.

Bibliography

[1] M. Ayamga, S. Akaba, and A. A. Nyaaba, *Multifaceted applicability of drones: A review*, Jun. 2021. DOI: 10.1016/j.techfore.2021.120677.

[2] S. Wulfovich, H. Rivas, and P. Matabuena, "Drones in Healthcare," pp. 159–168, 2018, ISSN: 2197-3741. DOI: 10.1007/978-3-319-61446-5{_}11. [Online]. Available: https://link.springer.com/chapter/10.1007/978-3-319-61446-5_11.

[3] *Nu tillåts drönare här är galna användningsområden | SvD*. [Online]. Available: https://www.svd.se/a/g9q19/nu-tillats-dronare-har-ar-galna-anvandningsomraden.

[4] J. M. Lundgaard, "Reassembling operative policing: The introduction of drones in the Norwegian police," *https://doi.org/10.1177/14613557231184693*, vol. 25, no. 3, pp. 313–323, Sep. 2023, ISSN: 14781603. DOI: 10.1177/14613557231184693. [Online]. Available: https://journals.sagepub.com/doi/full/10.1177/14613557231184693.

[5] "A Home That Floats," Tech. Rep. [Online]. Available: http://spectrum.ieee.org/medicaldrones0118.

[6] R. Luppicini and A. So, "A technoethical review of commercial drone use in the context of governance, ethics, and privacy," *Technology in Society*, vol. 46, pp. 109–119, Aug. 2016, ISSN: 0160-791X. DOI: 10.1016/J.TECHSOC.2016.03.003.

[7] "International Civil Aviation O International Civil Aviation Organization," Tech. Rep.

[8] Easa, "AVIATION SAFETY," 2020, ISSN: 2020-2024.

[9] A. Otto, N. Agatz, J. Campbell, B. Golden, and E. Pesch, "Optimization approaches for civil applications of unmanned aerial vehicles (UAVs) or aerial drones: A survey," *Networks*, vol. 72, no. 4, pp. 411–458, Dec. 2018, ISSN: 1097-0037. DOI: 10.1002/NET.21818. [Online]. Available: https://onlinelibrary.wiley.com/doi/full/10.1002/net.21818%20https://onlinelibrary.wiley.com/doi/abs/10.1002/net.21818%20https://onlinelibrary.wiley.com/doi/10.1002/net.21818.

[10] A.-L. Alvekrans and M. Svensson, "Slutrapport Delprojekt 1-Drönare i skärgården," Västra Götalands Regionen, Gothemburg, Tech. Rep., 2024.

[11] A.-L. Alvekrans and M. Svensson, *Interview with VGR*, Feb. 2024.

[12] "Avancerade drönartjänster i Västra Götalandsregionen - strategi för luftrumshantering," Tech. Rep., 2024.

[13] *About Aviant*. [Online]. Available: https://www.aviant.no/about.

[14] *Flyga drönare i luftrummet - Transportstyrelsen*. [Online]. Available: https://www.transportstyrelsen.se/sv/luftfart/luftfartyg-och-luftvardighet/dronare/flyga-dronare-i-luftrummet/.

[15] *Ett år med nya drönarregler - Transportstyrelsen*. [Online]. Available: https://www.transportstyrelsen.se/sv/om-transportstyrelsen/pressrum/nyhetsarkiv/2021/ett-ar-med-nya-dronarregler/.

[16] *Utrustning mot drönare på väg till flera förband - Försvarsmakten*. [Online]. Available: https://www.forsvarsmakten.se/sv/aktuellt/2022/12/utrustning-mot-dronare-pa-vag-till-flera-forband/.

[17] *Registrering av operatör - Transportstyrelsen*. [Online]. Available: https://www.transportstyrelsen.se/sv/luftfart/luftfartyg-och-luftvardighet/dronare/registrering-av-operator/.

[18] *This is LFV*. [Online]. Available: https://www.lfv.se/en/about-us/this-is-lfv.

[19] *Geografiska UAS-zoner - Transportstyrelsen*. [Online]. Available: https://www.transportstyrelsen.se/sv/luftfart/luftfartyg-och-luftvardighet/dronare/flyga-dronare-i-luftrummet/geografiska-uas-zoner/.

[20] *Håll koll på vad som gäller i luftrummet luftrumsrestriktioner | Droneinfo*, Apr. 2023. [Online]. Available: https://www.droneinfo.fi/sv/studiematerial/hall-koll-pa-vad-som-galler-i-luftrummet-luftrumsrestriktioner?toggle=Tj%C3%A4nster%20som%20ger%20viktig%20information%20om%20luftrummet%20.

[21] *Drönare*. [Online]. Available: https://www.sjoraddning.se/forskning-och-utveckling/dronare.

[22] S. Schierbeck, J. Hollenberg, A. Nord, *et al.*, "Automated external defibrillators delivered by drones to patients with suspected out-of-hospital cardiac arrest," *European Heart Journal*, vol. 43, no. 15, pp. 1478–1487, Apr. 2022, ISSN: 0195-668X. DOI: 10.1093/EURHEARTJ/EHAB498. [Online]. Available: https://dx.doi.org/10.1093/eurheartj/ehab498.

[23] *Implementeringen av U-space för en säker och effektiv tillgång till luftrummet för drönare - Transportstyrelsen*. [Online]. Available: https://www.transportstyrelsen.se/sv/luftfart/flygplatser-flygtrafiktjanst-och-luftrum/Luftrum/implementeringen-av-u-space/.

[24] H. Sharp, J. Preece, and Y. Rogers, *Interaction design: Beyond humancomputer interaction*. Springer, May 2004, vol. 3, pp. 289–289, ISBN: 0471492787. DOI: 10.1007/S10209-004-0102-1. [Online]. Available: https://link.springer.com/article/10.1007/s10209-004-0102-1.

[25] J. D. Gould, "How to design usable systems," in *Readings in HumanComputer Interaction*, ser. Interactive Technologies, R. M. BAECKER, J. GRUDIN, W. A. S. BUXTON, and S. GREENBERG, Eds., Morgan Kaufmann, 1995, pp. 93–121, ISBN: 978-0-08-051574-8. DOI: https://doi.org/10.1016/B978-0-08-051574-8.50014-5. [Online]. Available: https://www.sciencedirect.com/science/article/pii/B9780080515748500145.

[26] R. Harrison, D. Flood, and D. Duce, "Usability of mobile applications: literature review and rationale for a new usability model," *Journal of Interaction*

Science, vol. 1, pp. 1–16, 2013. [Online]. Available: http://www.journalofinteractionscience.com/content/1/1/1.

[27] W. Hwang and G. Salvendy, "Number of people required for usability evaluation: The 10ś2 rule," *Communications of the ACM*, vol. 53, no. 5, pp. 130–133, May 2010, ISSN: 00010782. DOI: 10.1145/1735223.1735255.

[28] P. Desmet and P. Hekkert, "Framework of Product Experience Human-Product Interaction," *International journal of design*, vol. 1, no. 1, pp. 13–23, 2007. [Online]. Available: www.ijdesign.org.

[29] S. Oviatt, "Human-Centered Design Meets Cognitive Load Theory: Designing Interfaces that Help People Think," in *Proceedings of the 14th ACM international conference on Multimedia*, 2006, pp. 871–880, ISBN: 1595934472.

[30] T. Treeratanaporn, T. Torat, and T. Kongtaworn, "Usability Evaluation of Touch Screen Interface with Various User Groups," in *ICSEC 2021 - 25th International Computer Science and Engineering Conference*, Institute of Electrical and Electronics Engineers Inc., 2021, pp. 149–154, ISBN: 9781665411974. DOI: 10.1109/ICSEC53205.2021.9684661.

[31] H. A. Yanco, J. L. Drury, and J. Scholtz, "Beyond Usability Evaluation: Analysis of Human-Robot Interaction at a Major Robotics Competition," vol. 19, no. 2, pp. 117–149, 2004, ISSN: 0737-0024. DOI: 10.1080/07370024.2004.9667342. [Online]. Available: https://doi.org/10.1080/07370024.2004.9667342.

[32] G. Albeaino, M. Gheisari, R. R. A. Issa, G. Albeaino, ů. M. Gheisari, and ů. R. R. A. Issa, "Human-Drone Interaction (HDI): Opportunities and Considerations in Construction," *Automation and Robotics in the Architecture, Engineering, and Construction Industry*, pp. 111–142, 2022. DOI: 10.1007/978-3-030-77163-8{_}6. [Online]. Available: https://link.springer.com/chapter/10.1007/978-3-030-77163-8_6.

[33] J. R. Cauchard, A. Tamkin, C. Y. Wang, *et al.*, "Drone.io: A Gestural and Visual Interface for Human-Drone Interaction," *ACM/IEEE International Conference on Human-Robot Interaction*, vol. 2019-March, pp. 153–162, Mar. 2019, ISSN: 21672148. DOI: 10.1109/HRI.2019.8673011.

[34] G. Iannace, G. Ciaburro, and A. Trematerra, "Fault Diagnosis for UAV Blades Using Artificial Neural Network," *Robotics 2019, Vol. 8, Page 59*, vol. 8, no. 3, p. 59, Jul. 2019, ISSN: 2218-6581. DOI: 10.3390/ROBOTICS8030059. [Online]. Available: https://www.mdpi.com/2218-6581/8/3/59/htm%20https://www.mdpi.com/2218-6581/8/3/59.

[35] P. Abtahi, D. Y. Zhao, J. L. E., and J. A. Landay, "Drone Near Me," *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies*, vol. 1, no. 3, pp. 1–8, Sep. 2017. DOI: 10.1145/3130899.

[36] A. Strömsöe, S. Afzelius, C. Axelsson, *et al.*, "Improvements in logistics could increase survival after out-of-hospital cardiac arrest in Sweden," *Journal of internal medicine*, vol. 273, no. 6, pp. 622–627, Jun. 2013, ISSN: 1365-2796. DOI: 10.1111/JOIM.12041. [Online]. Available: https://pubmed.ncbi.nlm.nih.gov/23360556/.

[37] D. Cawthorne and A. R. V. Wynsberghe, "From HealthDrone to FrugalDrone: Value-Sensitive Design of a Blood Sample Transportation Drone," *Interna-*

tional Symposium on Technology and Society, Proceedings, vol. 2019-November, Nov. 2019. DOI: 10.1109/ISTAS48451.2019.8938019.

[38] F. Yakushiji, K. Yakushiji, M. Murata, N. Hiroi, K. Takeda, and H. Fujita, "The quality of blood is not affected by drone transport: An evidential study of the unmanned aerial vehicle conveyance of transfusion material in Japan," *Drones*, vol. 4, no. 1, pp. 1–7, Mar. 2020, ISSN: 2504446X. DOI: 10.3390/drones4010004.

[39] C. Sandbrook, "The social implications of using drones for biodiversity conservation," *Ambio*, vol. 44, pp. 636–647, Nov. 2015, ISSN: 16547209. DOI: 10.1007/s13280-015-0714-0.

[40] N. Wang, M. Christen, and M. Hunt, "Ethical Considerations Associated with Humanitarian Drones: A Scoping Literature Review," *Science and Engineering Ethics*, vol. 27, no. 4, Aug. 2021, ISSN: 14715546. DOI: 10.1007/s11948-021-00327-4.

[41] M. Mulero-Pázmány, S. Jenni-Eiermann, N. Strebel, T. Sattler, J. J. Negro, and Z. Tablado, "Unmanned aircraft systems as a new source of disturbance for wildlife: A systematic review," *PLOS ONE*, vol. 12, no. 6, e0178448, Jun. 2017, ISSN: 1932-6203. DOI: 10.1371/JOURNAL.PONE.0178448. [Online]. Available: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0178448.

[42] R. Patel and B. Davidson, *Forskningsmetodikens Grunder: Att planera, genomföra och rapportera en undersökning*, 5th ed. Lund: Studentlitteratur, 2019, ISBN: 9789144126050.

[43] *What is Service Design?* 2024. [Online]. Available: https://www.interaction-design.org/literature/topics/service-design.

[44] M. Sticdorn, M. E. Hormess, A. Lawerence, and J. Schneider, *This Is Service Design Doing*, 1st. Sebastopol: O'Reilly Media, Inc., 2018, ISBN: 9781491927182. [Online]. Available: https://books.google.se/books?hl=sv&lr=&id=aqRGDwAAQBAJ&oi=fnd&pg=PP1&dq=Service+Design+Methodology&ots=FG7GXAcZT1&sig=odfiCGG2JACHXo7jElBwx5Dl6w4&redir_esc=y#v=onepage&q&f=true.

[45] J. G. Teixeira, L. Patrício, K.-H. Huang, R. P. Fisk, L. Nó Brega, and L. Constantine, "The MINDS Method: Integrating Management and Interaction Design Perspectives for Service Design," DOI: 10.1177/1094670516680033.

[46] J. Bell and S. Waters, *Introduktion till forskningsmetodik*, 5th ed. Lund: Studentlitteratur, 2017, ISBN: 9789144110622.

[47] W. Tellis, "Introduction to Case Study," Tech. Rep., Jul. 1997. DOI: 10.46743/2160-3715/1997.2024.

[48] O. A. Adeoye-Olatunde and N. L. Olenik, "A Companion to QUALITATIVE RESEARCH," 2021, ISSN: 25749870. DOI: 10.1002/jac5.1441.

[49] T. Miaskiewicz and K. A. Kozar, "Personas and user-centered design: How can personas benefit product design processes?" *Design Studies*, vol. 32, no. 5, pp. 417–430, Sep. 2011, ISSN: 0142694X. DOI: 10.1016/j.destud.2011.03.003.

[50] A. Williams, "Proceedings of the 27th ACM international conference on Design of communication.," ACM, 2009, pp. 1–8.

[51] K. Goodwin, "Designing for the digital age : how to create human-centered products and services," p. 739, 2009.

[52] L. Nielsen, "Human-Computer Interaction Series Personas-User Focused Design," Tech. Rep. [Online]. Available: http://www.springer.com/series/6033.

[53] T. Matthews, T. K. Judge, and S. Whittaker, "How do designers and user experience professionals actually perceive and use personas?" In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 2012, pp. 1219–1228. DOI: 10.1145/2207676.2208573.

[54] *User Journey Maps | Usability & Web Accessibility*. [Online]. Available: https://usability.yale.edu/understanding-your-user/user-journey-maps.

[55] *What is Service Blueprints?* 2024. [Online]. Available: https://www.interaction-design.org/literature/topics/service-blueprint.

[56] M. Tomisch, M. Borthwick, C. Wrighley, *et al.*, *Design. Think. Make. Break. Repeat. A Handbook of Methods*. Amsterdam: Bis Publishers, 2018, pp. 7–223, ISBN: 9789063694791.

[57] S. N. Cox, P. T. Wedlock, S. W. Pallas, *et al.*, "A systems map of the economic considerations for vaccination: Application to hard-to-reach populations," *Vaccine*, vol. 39, no. 46, pp. 6796–6804, Nov. 2021, ISSN: 18732518. DOI: 10.1016/j.vaccine.2021.05.033.

[58] P. Jankowski, N. Andrienko, and G. Andrienko, "Map-centred exploratory approach to multiple criteria spatial decision making," *International Journal of Geographical Information Science*, vol. 15, no. 2, pp. 101–127, 2001, ISSN: 13658816. DOI: 10.1080/13658810010005525.

[59] A. Kiekensid, B. Dierckx De Casterlé, and A.-M. Vandammeid, "Qualitative systems mapping for complex public health problems: A practical guide," 2022. DOI: 10.1371/journal.pone.0264463. [Online]. Available: https://doi.org/10.1371/journal.pone.0264463.g001.

[60] V. Braun and V. Clarke, "Using thematic analysis in psychology," *Qualitative Research in Psychology*, vol. 3, no. 2, pp. 77–101, 2006, ISSN: 14780887. DOI: 10.1191/1478088706qp063oa.

[61] *What is Ideation?* 2024. [Online]. Available: https://www.interaction-design.org/literature/topics/ideation.

[62] R. Van Der Lugt, "How sketching can affect the idea generation process in design group meetings," *Design Studies*, vol. 26, no. 2, pp. 101–112, Mar. 2005, ISSN: 0142694X. DOI: 10.1016/j.destud.2004.08.003.

[63] K. Forbus, J. Usher, A. Lovett, K. Lockwood, and J. Wetzel, "CogSketch: Sketch understanding for cognitive science research and for education," *Topics in Cognitive Science*, vol. 3, no. 4, pp. 648–666, Oct. 2011, ISSN: 17568757. DOI: 10.1111/j.1756-8765.2011.01149.x.

[64] I. M. Verstijnen, C. an Leeuwen, G. Goldschmidt, R. Hamel, and J. Hennessey, "Sketching and creative discovery," *Design studies*, vol. 19, no. 4, pp. 519–546, 1998.

[65] *Share and engage with the Design Sprint Community*. [Online]. Available: https://designsprintkit.withgoogle.com/methodology/phase3-sketch/crazy-8s.

[66] E. Sanders and P. J. Stappers, "Co-creation and the new landscapes of design," *Co-Design*, pp. 799–809, Feb. 2008, ISSN: 1745-3755. DOI: 10.1080/15710880701875068. [Online]. Available: https://www.tandfonline.com/doi/abs/10.1080/15710880701875068.

[67] *What is Co-Design?* 2024. [Online]. Available: https://www.interaction-design.org/literature/topics/co-design.

[68] R. Sefelin, M. Tscheligi, and V. Giller, "Paper prototyping - What is it good for? A comparison of paper- and computer-based low-fidelity prototyping," *Conference on Human Factors in Computing Systems - Proceedings*, pp. 778–779, 2003. DOI: 10.1145/765891.765986. [Online]. Available: https://dl.acm.org/doi/10.1145/765891.765986.

[69] J. Rudd, K. Stern, and S. Isensee, "Low vs. high-fidelity prototyping debate," *Interactions*, vol. 3, no. 1, pp. 76–85, 1996. [Online]. Available: http://home.aol.com/Isensee.

[70] R. A. Virzi, "What can you learn from a low-fidelity prototype?" *Sage CA: Los Angeles, CA: SAGE Publications.*, vol. 33, no. 4, pp. 224–228, 1989, ISSN: 0163-5182. DOI: 10.1177/154193128903300405.

[71] *The Wizard of Oz Method in UX*. [Online]. Available: https://www.nngroup.com/articles/wizard-of-oz/.

[72] U. Flick, *An introduction to qualitative research*, 4th ed. London: SAGE, 2009, ISBN: 9781847873248.

[73] S. Bell and S. Morse, "How People Use Rich Pictures to Help Them Think and Act," *Systemic Practice and Action Research*, vol. 26, no. 4, pp. 331–348, Aug. 2013, ISSN: 1094429X. DOI: 10.1007/S11213-012-9236-X/TABLES/2. [Online]. Available: https://link.springer.com/article/10.1007/s11213-012-9236-x.

[74] W. Health Organization and R. Office for Europe, "Surveillance Guidelines for Measles, Rubella and Congenital Rubella Syndrome in the WHO European Region," Tech. Rep., 2012. [Online]. Available: http://www.euro.who.int/pubrequest..

[75] H. Tan, J. Lee, and G. Gao, "Human-drone interaction: Drone delivery & services for social events," in *DIS 2018 - Companion Publication of the 2018 Designing Interactive Systems Conference*, Association for Computing Machinery, Inc, May 2018, pp. 183–187, ISBN: 9781450356312. DOI: 10.1145/3197391.3205433.

[76] F. D. Davis, R. P. Bagozzi, and P. R. Warshaw, "USER ACCEPTANCE OF COMPUTER TECHNOLOGY: A COMPARISON OF TWO THEORETICAL MODELS*," Tech. Rep. 8, 1989.

[77] H. Taherdoost, "A review of technology acceptance and adoption models and theories," in *Procedia Manufacturing*, vol. 22, Elsevier B.V., 2018, pp. 960–967. DOI: 10.1016/j.promfg.2018.03.137.

[78] M. Miron, D. Whetham, M. Auzanneau, and A. Hill, "Public Drone Perception," *Technology in Society*, vol. 73, May 2023, ISSN: 0160791X. DOI: 10.1016/j.techsoc.2023.102246.

[79] D. Lee, J. Moon, Y. J. Kim, and M. Y. Yi, "Antecedents and consequences of mobile phone usability: Linking simplicity and interactivity to satisfaction,

trust, and brand loyalty," *Information and Management*, vol. 52, no. 3, pp. 295–304, 2015, ISSN: 03787206. DOI: 10.1016/j.im.2014.12.001.

[80] M. Arnold, M. Goldschmitt, and T. Rigotti, *Dealing with information overload: a comprehensive review*, 2023. DOI: 10.3389/fpsyg.2023.1122200.

[81] A. Cooper, R. Reimann, D. Cronin, and C. Noessel, "About face : the essentials of interaction design,"

[82] M. Denscombe, *Forskningshandboken; För småskaliga forskningsprojekt inom samhällsvetenskapen*, 4th ed. Lund: Studentlitteratur, 2018, ISBN: 9789144122885.

A

Planning & Schedule

The time plan will be constructed with the utilizing of a Gantt scheme, to be able to keep track of different task and when to do them. Roughly, the time plan will be divided as the following; February data collection and analysis, march designing the interface and April will be dedicated to compiling the results and writing the discussion and conclusion of the essay. As a complimentary tool, to-do-list will be applied on a daily basis.

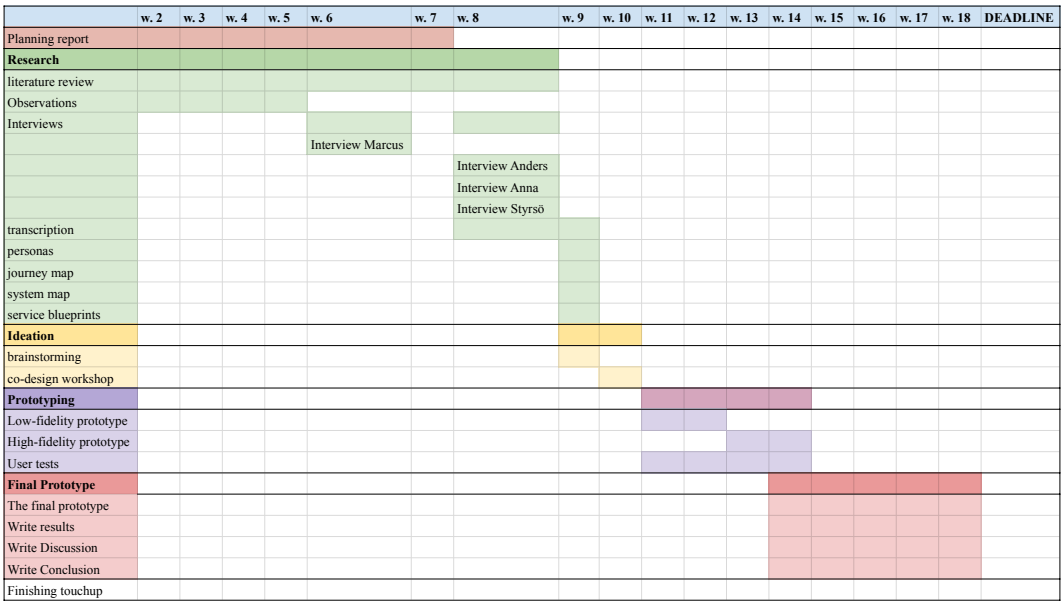

Figure A.1: Gantt Schedule of the planing

As this study can focus on identifying crucial factors in the design of human-drone interaction, and explore the key elements that enhance the user experience for medical personnel during drone delivery, *qualitative research* will be used as a methodology.

The first phase include research for this project and will start with a literature review

to gather knowledge and insights in the field of human-drone interaction. Google Scholar together with the Chalmers library database will be used to find articles. Once the literature review is done, interviews will be conducted. As Chalmers already has contact with VGR through their project *Drones in Organisation and Society*, the people who will be contacted for interviews are already part of and aware of their project. Through VGR's contacts, connections will be made with the appropriate people for the project. In total, five interviews are planned. Three will be nurses and one will be a doctor, one of the nurses and the doctor from the care centre in Björkö and the other two nurses from Styrsö. One interview will be with the project leaders from VGR. Three interviews have already been conducted with the drone pilot from Aviant who flew the drones during the test flights and the the others with medical staff connected to this project. The forthcoming interviews will focus on people who seem relevant to the research project. Relevant sampling methods are convenience sampling, snowball sampling and subjective sampling. For this project, the interviewees will be selected by *subjective selection*, which means that the selected group will be hand-picked based on their relevance and knowledge they possess for the intended study. This project aims to target people who are relevant and knowledgeable about the topic under study [82]. As the chosen area of study is limited to the interaction of healthcare professionals with drones, the choice of interviewees will be limited to those working in the specific area of study and the drone manufacturers. To complement the interviews, observations will also be made based on how the pilot and nurses interacted when packing the drone from the test flights carried out in January. The observations will also be analysed and used in further methods. The observations in this project will be based on subjective selection. [82]. Many of those who will be interviewed will also participate in the observations during the test flights. Another method that has been in mind is questionnaires, but will not be used since this study will focus on more "soft" data. Mainly because the study focuses on a narrow target group and the people who have been involved in the test flights are the ones who have been selected.

With the gathered information personas will be created to get a good perspective of the users' needs. The personas will be based on the interviews and observations that will take place. By understanding the users it will be possible to deliver a result based on their area of use and knowledge that will contribute to a better user experience [51]. The personas will be created for this project and used for the purpose of journey mapping to provide the user's point of view. A scenario of the journey that the user will take will be based on the personas, which are based on assumptions about user behaviour. The journey phases are then described with high level stages of the user journey. The user's behaviour will be encountered throughout the journey stages. The insights gained from the journey mapping results will allow the team to identify important design aspects [54]. Two system maps will also be created during this phase, one visualising the current delivery process and the other a futuristic system map to understand what factors would need to be considered when implementing drone deliveries. Service blueprints, which is an extension of a customer journey map will be created. As service blueprints go into more detail about the customer's interaction with the product and help to understand an experience in the early stages of design, this method will be used for this project [56].

The second phase is an ideation brainwriting, which will be used as a brainstorming method. Since brainwriting is often referred to as 6-3-5, where six people participate, and the team for this project consists of only two members, this method will be referred to as 2-3-5. This phase will also include one co-design workshops that will involve the project leaders at the innovation platform at VGR. This workshop will aim to harness the collective knowledge and expertise of all stakeholders to further innovate and develop the service [67]. During the workshop will paper sketching be used as a tool.

The third phase is prototyping where low fidelity prototypes will be developed using paper sketching as a tool as it easily generates quick and simple prototypes. Once the low fidelity prototypes have been created, user testing will be carried out using think aloud and cognitive walkthrough with some of the medical staff who were also involved in the interviews. Think aloud user testing will be used in conjunction with the low fidelity prototypes. After the user testing of the low-fidelity prototypes, high-fidelity prototypes will be developed. During this iteration, software such as Adobe XD will be used to create the high fidelity prototype. Once the high fidelity is complete, user testing will be carried out using think aloud and cognitive walk through with the medical staff involved. A heuristic evaluation will also be carried out with the project leaders from VGR, as they have knowledge and experience in the organisation.

The final and fourth phase consists of the final prototype. During this phase will the final prototype be developed based on the user tests and the previous prototypes.

B

Interview Questions

Interview with Pilot

Bakgrund:

- Utbildning?
- Hur är din relation till detta projekt?
- Hur många piloter är utbildade för att styra detta gränssnitt?

Allmäna frågor

- tidigare erfarenhet adrönare?
- tidigare utbilding?
- fick du ngåon utbildning via jobbet? Aviant, hur såg den ut?

Öppen fråga, hur skulle du beskriva din interaktion med drönaren? bekväm, osäker?

om du applicerar detta på en sjuksköterska som ska interagera/ hantera en drönare, vad är viktigt?

vad tror du är viktigt för någon som inte är vad att hantera en drönare att tänka på?

Hur tror du att interaktionen mellan dig och drönare och drönaren och en sjuksköterska hade skilt sig?

Hur upplever du din interaktion med drönaren? Om du skulle beskriva den lite mer ingående?

Vad tycker du är bra/vad är mindre bra?

Finns det någon lathund för hur drönaren behöver packas?

Förberedelse-Processen

Hur tänker du kring säkerheten vid packning/förberedelse av drönaren? Behöver sjukhuspersonalen göra balans-checken, hur ser säkerheten ut isf kring propellrarna?

Kan du beskriva vad du gör från att du börjar förbereda drönare till att du skickar iväg den!

Beskriv process

Är det någon av stegen i förberedelsen som kan göras på distans?

Vilka steg är extra kritiska?

Finns de steg som är onödiga?

I förberedelsen, vad tror du kommer ligga på sjuksköterskan och vad ligger på piloten att sköta remote? Finns det grejer som måste göras på plats?

Vill du förklara skillnaden mellan restricted areas, UAS zoner, U-space förordningen? Notam?

Vad för typ av regler och regulationer gäller för eran flygning?

Vilken kategori, öppen etc? Vilken c-klassificering tillhör drönaren?

Kan du introducera Avaiant lite kort? (Har vi fått svar på denna??)

Vad ni gör?

Vem startar drönaren?

Finns det någon grej som piloten behöver kolla säkerhetsmässigt innan den flyger eller räcker det med att sjuksköterskan säger att det är ok?

Feedback från drönare, vad ger den för typ av feedback? Hur känns det, litar du mer på den med feedback?

Hur ser det ut i miljöaspekt med drönare?

Interview with Organisation Managager

Allmänt

- Kan du berätta lite om dig själv, vilken bakgrund har du?
- Vad är din roll/ arbetsuppgifter?
- Hur ser ditt dagliga arbete ut? vill du beskriva vad du gör en normal dag?

Inställning

- Vad är din inställning till drönare?
- Har du tidigare erfarenheter av drönare?
- Om ja, i vilket sammanhang? vill du berätta mer om det?
- Hur skulle du känna om det var ditt blod som skulle transporteras med en drönare?
- Organisationen/verksamheten

Nuvarande transportprocess

- hur många är de som är anställda?

- hur ofta tas blodprover?
- hur ser rutinerna ut gällande blodprover?
- Hur ser blodtransporten ut idag? Vad tycker du om den? fungerar det bra/dåligt?
- Vad tycker du är viktigt mer organisatoriskt med att implementera drönare i eran verksamhet? ur ett helhetsperspektiv ? om man tänker mer på hur det ser ut idag med biltransport och då om man skulle implementera drönare istället
- Svårigheter organisatoriskt sett?
- är de något specifikt du täbkte på under testflygningarna?
- Vad har du för förväntningar på detta projekt?

Interfacet

- Ofta är det ju så att man har en bild i huvudet hur ett sådant här system hade kunnat sett ut. Vill du beskriva hur din bild av systemet skulle se ut?
- Har du några tankar på saker som du tror är viktiga i systemet? information? färger? teman? smått som stort?
- Vilka kommer använda systemet? Sjuksköterskor? läkare? andra? utifrån den verksamheten du arbetar i?
- vad behöver användaren veta? informationsmässigt?

Interview with Nurses

Group Interview

Allmänt

- Hur länge har ni arbetat som sjuksköterskor?
- Vilken bakgrund har ni?
- Vill ni lite kort berätta om eran arbetsroll och hur länge ni har arbetat?
- Vad är era roller/ arbetsuppgifter?
- Hur ser ditt dagliga arbete ut? vill du beskriva vad du gör en normal dag?

Inställning

- Vad är eran inställning till drönare?
- Har ni tidigare erfarenheter av drönare?
- Om ja, i vilket sammanhang? vill ni berätta mer om det?
- Hur skulle ni känna om det var ert blod som skulle transporteras med en drönare?

Drönar-interaktion

- Hur bekväm känner ni dig med att röra en drönare? Är det någon del av drönaren som känns mer bekväm att röra än andra?
- Är det någon skillnad om drönaren är avstängd?
- Hur känns det när drönaren är på?

Stress

- Hur ser arbetsbördan ut? Är du ofta väldigt stressad på ditt jobb?
- Tror du att en drönare hade påverkat din stressnivå? På vilket sätt?
- Hade ni känt att det blivit ett extra moment att fokusera på i jämförelse med de som finns i dagsläget?

Feedback kopplat till trustworthyness / safety

- Litar du på drönaren? Varför, varför inte?
- Vad skulle göra att du litar mer på den?
- Det som kan vara farligt på en drönare, eller mest farligt är ju egentligen propellrarna.
- Propeller-skyddet? litar du mer på den då om det finns ett skydd?

Nurse 1

Allmänt

- Hur länge har du arbetat som sjuksköterska/läkare?
- Kan du berätta lite om dig själv, vilken bakgrund har du?
- Vill ni lite kort berätta om eran arbetsroll och hur länge ni har arbetat?
- Vad är din roll/ arbetsuppgifter?
- Hur ser ditt dagliga arbete ut? vill du beskriva vad du gör en normal dag?

Inställning

- Vad är din/eran inställning till drönare?
- Har du/ni tidigare erfarenheter av drönare?
- Om ja, i vilket sammanhang? vill du berätta mer om det?

Organisationsmässigt

- Vad tror du är viktigt för att drönare ska kunna fungera med er verksamhet?
- Vad finns det för utmaningar?

Stress

- Hur ser arbetsbördan ut? Är du ofta väldigt stressad på ditt jobb?

- Tror du att en drönare hade påverkat din stressnivå? På vilket sätt?
- Hade ni känt att det blivit ett extra moment att fokusera på i jämförelse med de som finns i dagsläget?

Gränssnitt

- Finns det något som du upptäckt som varit extra smidigt i något annat transportsystem eller app som du tycker om lite extra, smått som stort?
- Vilken information tror du är viktig att inkludera i detta gränssnitt? smått som stort

Nurse 2

Allmänt

- Hur länge har du arbetat som sjuksköterska/läkare?
- Kan du berätta lite om dig själv, vilken bakgrund har du?
- Vill ni lite kort berätta om eran arbetsroll och hur länge ni har arbetat?
- Vad är din roll/ arbetsuppgifter?
- Hur ser ditt dagliga arbete ut? vill du beskriva vad du gör en normal dag?
- Hur ser blodtransporten ut idag? Vad tycker du om den? fungerar det bra/dåligt?

Provflygningingarna

- Du va ju med på prov flygningarna ett par ggr, så du har ju sett hur drönaren ser ut och beter sig. Och hur hela processen med att starta en drönare ser ut.
- Vad var dina förväntningar innan provflygningingarna?
- Ser den uppfattning/förväntning annorlunda ut efteråt?
- Hur kändes det att vara med?
- Du fick ju packa drönaren, hur kändes det?
- Vad gäller säkerheten, hur kändes det kring den?
- Hur tänker du till säkerheten om man skulle implementera det här med drönaren?
- Hur kändes det att röra drönaren?
- Kände du att du kunde lita på drönaren?
- Var det något som du tänkte på specifikt efter att du varit med? Kanske något som du inte hade funderat över tidigare?

Inställning

- Vad är din/eran inställning till drönare?
- Har du/ni tidigare erfarenheter av drönare?

- Om ja, i vilket sammanhang? vill du berätta mer om det?

Organisationsmässigt

- Vad tror du är viktigt för att drönare ska kunna fungera med er verksamhet?
- Vad finns det för utmaningar?

Stress

- Hur ser arbetsbördan ut? Är du ofta väldigt stressad på ditt jobb?
- Tror du att en drönare hade påverkat din stressnivå? På vilket sätt?
- Hade ni känt att det blivit ett extra moment att fokusera på i jämförelse med de som finns i dagsläget?

Gränssnitt

- Finns det något som du upptäckt som varit extra smidigt i något annat transportsystem eller app som du tycker om lite extra, smått som stort?
- Vilken information tror du är viktig att inkludera i detta gränssnitt? smått som stort

C

Process Model

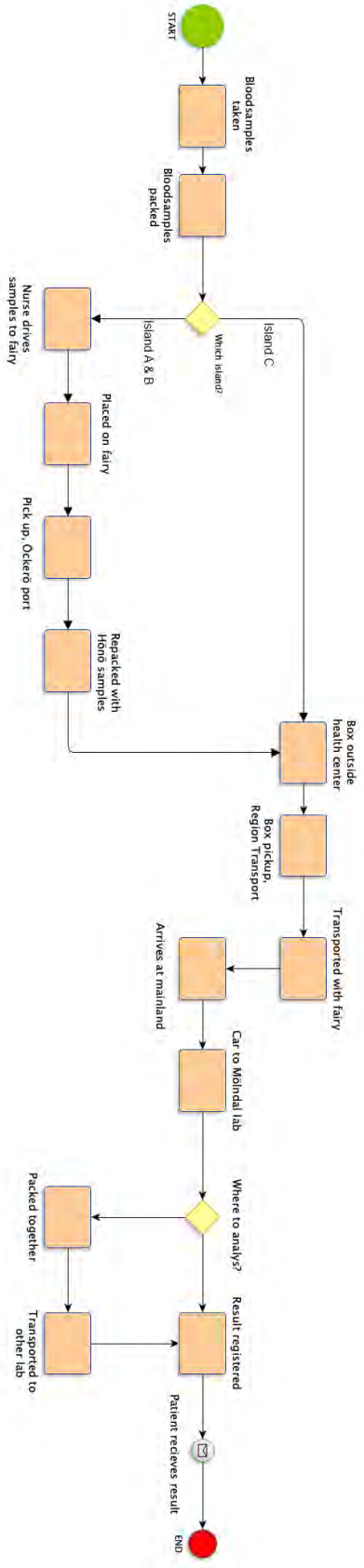

Figure C.1: Process Model

D

Service Blueprints

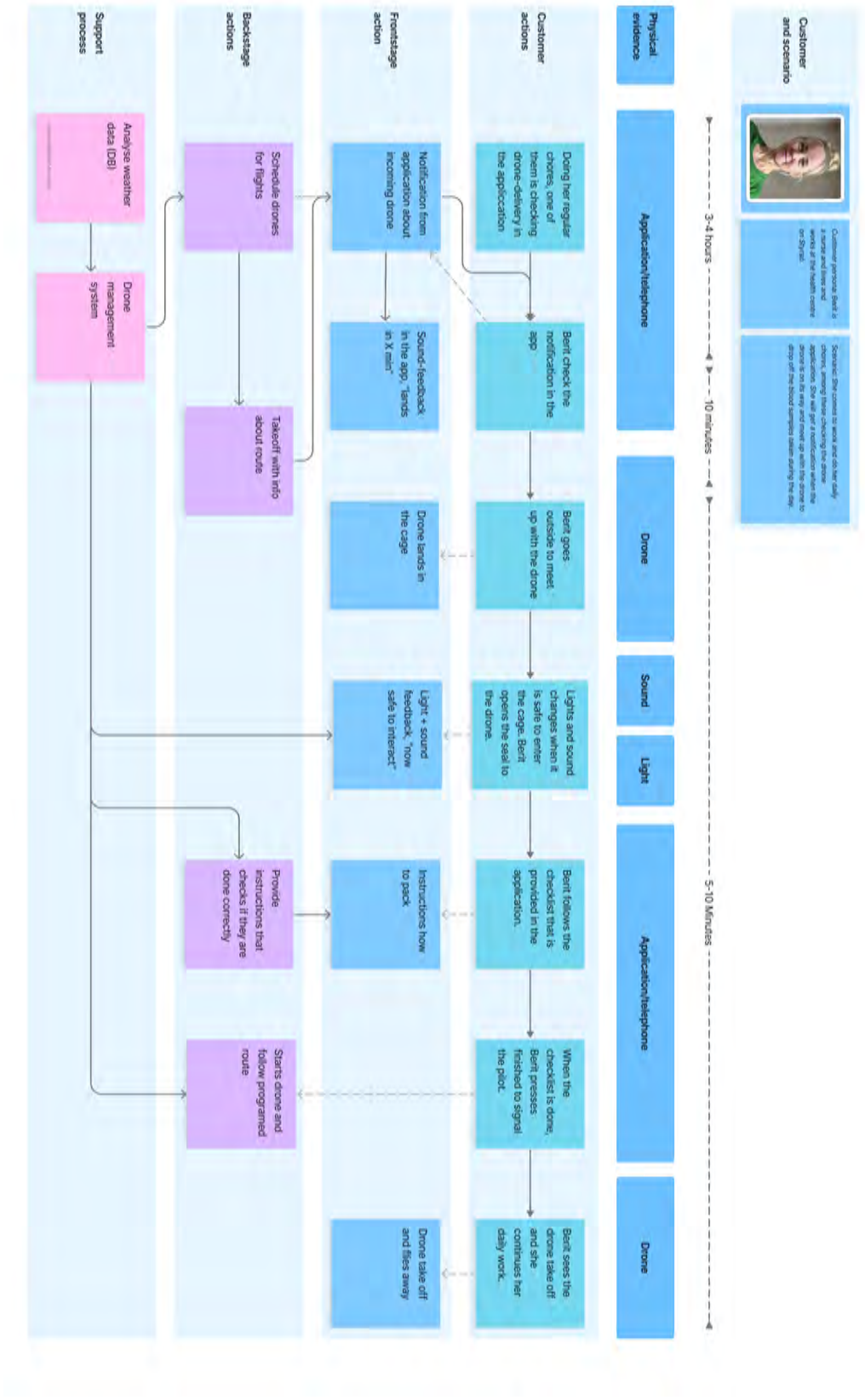

Figure D.1: Service Blueprint