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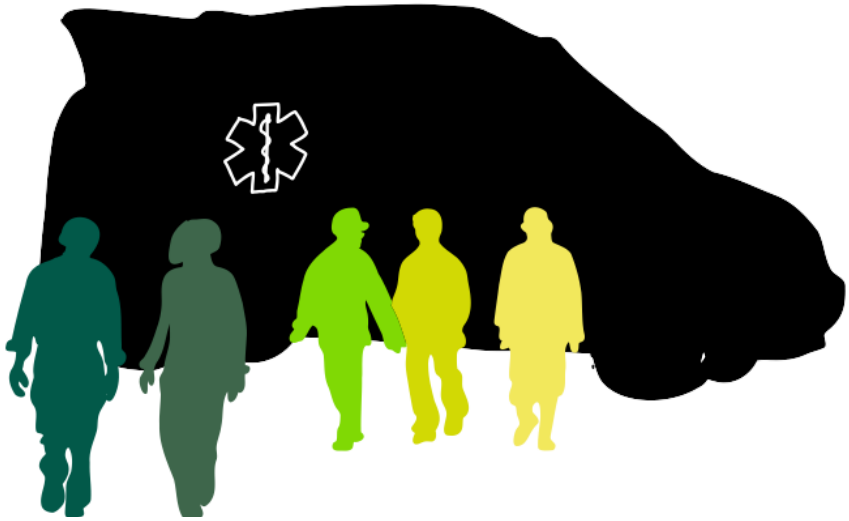

Improving ambulance mission progress tracking in Sweden

Developing a concept to increase the reliability of time registering during ambulance missions

Master's thesis in Industrial Design Engineering

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Masters thesis report

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All figures (illustrations and photos) are by the authors unless otherwise stated.

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Abstract

This master's thesis project aims to investigate present-day prehospital care, especially focusing on ambulance care in Sweden. This project targets the system that tracks progress during an ambulance mission. The system consists of six steps which have to be manually confirmed by the ambulance nurses at the press of a button. The interaction between the ambulance nurses and the system registers the time duration between the different steps of the mission. The goal was to map out unknowns in the system and propose a feasible solution to increase the tracking efficiency and minimise false time registration. During the project, three steps have been automated while two which are not yet tracked, have been added. Further, the project does not only touch technology but also the ambulance nurses' cognitive workload.

The project is executed in collaboration with PICTA – Prehospital Innovation Arena located at Lindholmen's Science Park in Gothenburg.

Keywords: prehospital ambulance care, human machine interaction, user research, co-design, system thinking

Sammanfattning

Detta masterprojekt syftar till att undersöka dagens prehospitalvård, med särskilt fokus på ambulanssjukvård i Sverige. Projektet riktar sig mot systemet som spårar framstegen som ska registreras under ett ambulansuppdrag. Systemet består av tio steg varav sex måste bekräftas manuellt av ambulanssjuksköterskorna genom att trycka på knappar på en i ambulanserna inbyggd färddator. Interaktionen mellan ambulanssjuksköterskorna och systemet genererar tidpunkter mellan de olika stegen i uppdraget. Resultatet av detta projekt är att undersöka systemet samt att föreslå en i dagsläget fungerande lösning för att öka noggranheten av de spårade tiderna och minimera felaktig tidsregistrering. Under projektet har tre av de sex manualla stegen automatiserats medan två som ännu inte spårats har lagts till. Kopplat till de tillagda och automatiserade stegen investigeras ambulanssjuksköterskornas kognitiva arbetsbelastning.

Projektet görs i samarbete med PICTA - Prehospital Innovation Arena vid Lindholmen Science Park i Göteborg.

Acknowledgements

During the project, we got meet and work with a variety of experts and academics. Some of those people could be reached whenever and were helping us to succeed with the project.

Firstly, we want to thank PICTA for letting us investigate and develop a meaningful area, where we felt we could make a difference. Andreas Dehre and other members of the board have been accommodating to us and would give us response on what we would like to do or had done.

Thanks to Pontus Frick, who has been incredibly helpful in regard to the technical implementation in ambulances in VGR and became our contact for the central ambulance station. Speaking about technology, we would like to thank Johan Nicander from Ericsson for his support in evaluating the feasibility of our final concept with us and for answering our less technically versed questions.

Alongside our research we got to be part of an ambulance mission shift, were the four ambulance nurses Johanna, Matilda, Jennie and Emelie took care of us and were kindly answering all our questions, which we are very glad about.

Last but not least, we want to express a huge thank you to our examiner and supervisor at Chalmers, Cecilia Berlin, for not only guiding us through the entire process and providing us with advice but also for listening to - according to her - "A new episode of Ahammer and Persson Palmqvist are bickering kindly, but firmly".

Marina Ahammer & Kasper Persson Palmqvist, 2024

Glossary

- **AmbuReg** *Svenska Ambulansregistret*
  Swedish ambulance registry
- **Ambulance** *Ambulans*
  Vehicle designed and equipped for ambulance healthcare and transportation of sick and injured individuals.
- **CPR** cardiopulmonary resuscitation (*HRL - hjärtlungräddning*)
  Abbreviation for a procedure in which an oxygen valve and rhythmic pressure over the rib cage is used to resuscitate patients.
- **ECG** Electrocardiography (*EKG - Elektrokardiografi*)
  An ECG machine tracks and measures the hearts frequency and can detect abnormalities in cardiovascular matters.
- **Emergency care** *Intensiv sjukvård*
  Healthcare and medical care provided by healthcare personnel in or in connection with an ambulance.
- **Emergency units** *Blåljusaktörer*
  Emergency units are public organisations that have the co-joined goal of helping people in crisis and emergency situations. The emergency units are for instance ambulance resources, police, fire brigades and other rescue services that help prevent or help in cases of public emergencies.
- **ER** Emergency room (*Akutmottagning*)
  Abbreviation for the emergency room at hospitals.
- **FLISA** *Föreningen för Ledningsansvariga Inom Svensk Ambulanssjukvård*
  The association for managers in Swedish Ambulance Care.
- **GPS**
  Abbreviation for *Global Positioning System*, is a system satellite-based position and navigation system use to determine geographic locations.
- **HMI** *Människa-maskin-interaktion*
  The abbreviation for HMI stands for human machine interaction and describes mainly the interaction of a human with a product or product interface.
- **HTA** *Hierarkisk uppgiftsanalys*
  Heuristic Task Analysis is a method in which a system goal is divided into different tasks to understand the system and its entities working together.

- **Paratus**
  Omda Paratus is a system providing emergency information for health care professionals digitally in various contexts.
- **Prehospital emergency care** *Prehospital akut sjukvård*
  Immediate medical action performed by healthcare professionals outside the hospital.
- **RAKEL** *Radio Kommunikation för Effektiv Ledning* Sweden's communication
  A network for actors within the emergency safety, rescue and healthcare.
- **PICTA** *Prehospital Innovations Arena*
  PICTA is short for Prehospital Innovation Arena and is an organisation working towards developing better prehospital care by collaborating with technology stakeholders and the health care sector.
- **SIS** *Svenska Institutet för Standarder*
  The Swedish Institute of Standards is an organisation publishing, revising and approving new standards within all kinds of scientific and non-scientic areas.
- **Socialstyrelsen**
  The Swedish National Board of Social Affairs and Health.
- **SOS Alarm**
  The national centre for emergency calling, where calls is being
  distributed to ambulances and their availability in the correct region
- **SvLC** *Sjukvårdens Larmcentral*
  The healthcare emergency contact centre.
  The organisation for emergency calling acting on a smaller scale in regions.
- **VGR** *Västra Götalandsregionen*
  A county in the southwest of Sweden, one of 21 counties in Sweden. And is the county in which Gothenburg is located.

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Introduction

In 2021 about 1 342 441 ambulance missions have been executed according to the Swedish centre for emergency calling *SOS Alarm* (SOS-Alarm, 2021. About 91% of missions were of the highest priority (priority 1) which means that *SOS Alarm* have determined that the patient is in an acute life-threatening condition. The remaining 9% are priority 2 missions which include the patient suffering from other symptoms that require medical attention yet are not of life-threatening nature. Closely related to these priorities for each mission are the time stamps which are continuously tracked for every ambulance. These time stamps vary depending on whether the ambulance accepts a priority 1 or a priority 2 undertaking. This being said the initial time from receiving a help call to arriving at the patient's destination for priority 1 is about 15.4 minutes while for priority 2 it is 32.8 minutes for arriving at the destination (Socialstyrelsen, 2023).

Since Western society demographics are trending towards people becoming increasingly older, this creates more demand for the health care sector. More resources such as health care personnel, hospitals, and medications need to be managed more efficiently. Moreover, the demand for prehospital care has risen simultaneously. Yet prehospital units - the ambulances - have to be distributed accordingly to the demand of the inhabitants of a specific area. That said this implies tracking various processes within prehospital care, where immediate medical action is performed by educated medical professionals outside of the hospital. Due to this, FLISA (*Förening för Ledningsansvariga Inom Svensk Ambulanssjukvård*, the Swedish organisation for management in prehospital care) has worked on a national standardised protocol for how documentation of an ambulance mission should be done. That standard explains how each type of mission, patient information, time stamps and more are handled (FLISA, 2020). This standardisation includes several steps of action for the ambulance nurses. To evaluate these steps according to the protocol, the times for each step are converted into a data point and saved into a database. The database then builds the foundation for managing the resources, such as ambulances, equipment and nurses, as well as supports decision-making for a sufficient distribution of prehospital units.

Besides the aim of FLISA to set up a standardisation for how an ambulance mission should be done, every county in Sweden operates under its own governance in regards to prehospital care. Even if decisions within prehospital care are made locally, *Socialstyrelsen* (The Swedish National Board of Social Affairs and Health) Socialstyrelsen, 2023 has a plan to ensure prehospital care's quality to minimise the gap between the counties' effort in this field.

1.1 Background

In February 2023 *Socialstyrelsen* (Socialstyrelsen, 2023) released a documentation explaining the current state of prehospital care in Sweden as well as an evaluation and outlook on its future. According to this document, every county in Sweden regulates prehospital care by themselves. In the 2009 paper *Socialstyrelsen* (Socialstyrelsen, 2009) defined the requirements on equipment when it comes to prehospital care. The paper discusses the profession of the ambulance nurse, their responsibilities, the equipment of the ambulances and their performance as well as some organisational issues.

For development and technical innovation in the area of prehospital care, the platform and knowledge centre PICTA – Prehospital Innovation Arena – has started up a variety of projects. PICTA is a program at Lindholmen Science Park and a non-profit arena providing collaboration between the industry, academia and healthcare system within the area of prehospital healthcare. One of the many projects conducted by PICTA investigates the technical solution space and automation of the time tracking system for each individual ambulance on a mission. The time stamps are a part of FLISAs standardised system for ambulance documentation FLISA, 2020. It is stated by *Socialstyrelsen* (Socialstyrelsen, 2023)that all actors in Sweden are encouraged to employ the FLISA model. The aim of the system is to gather data and gain insights into the ambulances' mission. The data collected is used to determine if the number of ambulances within a defined geographical area meets the requirements for emergency care. As mentioned briefly in the introduction, this can lead to a redistribution of ambulances from the hospitals as well as raise other question surrounding budgeting and resource management.

1.2 The emergency communication chain

In this section, a general emergency communication chain is presented (visualised in Figure 1.1). The chain consists of the logistics and communication from the caller until the ambulance arrives at the destination.

The person in distress calls the phone number for emergency help 112 (Riksrevisionen, 2012). An operator answers the call and conducts an inquisitive interview. If the person in distress calls from a county connected to SvLc (*Sjukvårdens Larmcentral*, healthcare emergency contact centre) they are at this stage forwarded to a nurse to examine the patient's need. Four out of 21 counties are connected to SvLc, for the other counties *SOS Alarm* is responsible for the evaluating the patient. After the need for emergency care is established an alarm is sent to an available ambulance in proximity of the patient using the RAKEL network (*Radiokommunikation för Effektiv Ledning*, communication network for emergency actors in Sweden).

The ambulance personnel are hailed on their portable RAKEL unit from *SOS Alarm* and the nurses accept the mission. This is the first step in the FLISA standard for the time tracking system. In total, the FLISA standard contains ten steps which measure the duration of each subtasks during an ambulance mission. Out of the ten steps, two are performed by *SOS Alarm* before the mission is assigned to a ambulance, while eight are performed by the ambulance personnel, presented in Figure 1.1. The ten steps cover a flow of events from calling *SOS Alarm* and registering the mission until the ambulance has left the patient and is ready for a new mission. However, in today's system the "Arrival

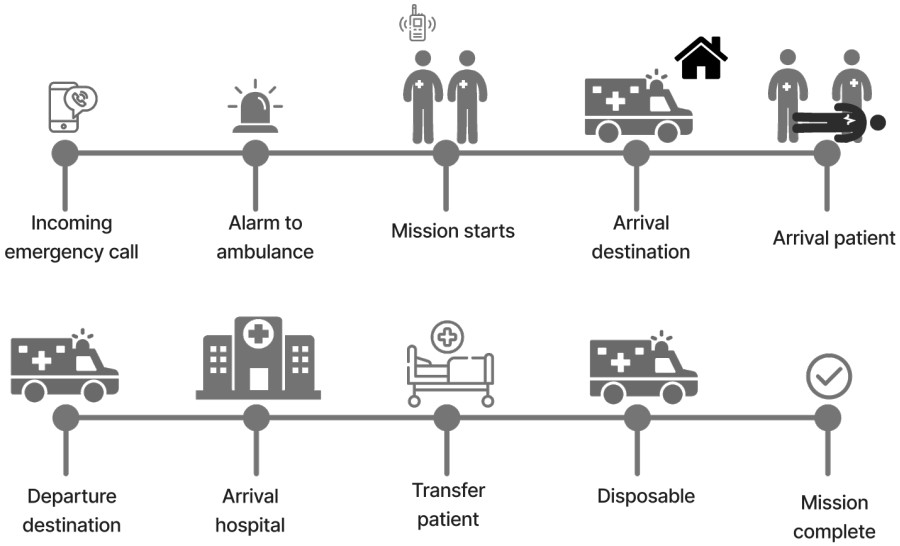

Figure 1.1: An illustration of the emergency communication chain

patient" (eTimes.07) along with "Transfer patient" (eTimes.12) have no possibility to be documented in real time and need to be added to the documentation retrospectively. This last step is crucial as the responsibility of care, which describes the liability the ambulance personnel has for the patient, needs to be noted to ensure patient security.

Number	Name	Responsible	Code
1	Answered emergency call	*SOS Alarm*	eTimes.02
2	Alarm to ambulance	*SOS Alarm*	eTimes.03
3	Mission starts	Ambulance	eTimes.05
4	Arrival destination	Ambulance	eTimes.06
5	Arrival patient	Ambulance	eTimes.07
6	Departure destination	Ambulance	eTimes.09
7	Arrival hospital	Ambulance	eTimes.11
8	Transfer patient	Ambulance	eTimes.12
9	Available	Ambulance	eTimes.13
10	Mission complete	Ambulance	eTimes.16

Table 1.1: The ten steps from the FLISA standard (FLISA, 2020)

1.3 Scope

The aim of this Master's thesis project is to investigate the time tracking system in the current ambulances and to analyse and improve the system from a human-machine-interaction perspective. Furthermore, the goal of the thesis is to propose a concept for improving the current system from the perspective of the user, the ambulance nurse, while also focusing on enhancing the consistency and quality of data collection. Moreover, the concept proposed shall target Sweden's prehospital care on a national level by collaborating with its 21 counties.

As a part of the goal to enhance the quality of the data collected the "Arrival patient"

(eTimes.07) and "Transfer patient" (eTimes.12) will be incorporated in the concept to enable a complete data set for each patient according to the FLISA model presented in 1.1. These two times are missing currently within the data set which makes the current data set incomplete leading to estimated times for the missing time stamps. Estimations and approximations though can have life-threatening consequences in prehospital care as time is the most crucial factor.

To pursue this goal and to provide a concept for the time tracking system of tomorrow for this thesis, the following research questions have been stated:

- Is it possible to increase the overall reliability of the time tracking system?
- How can a conceptual design proposal reduce the error probability caused by a system not accounting for external factors?

1.4 Demarcations

To ensure the best possible outcome in this project demarcations were made. These demarcations should avoid redundancies as well as keep the project on track. That being said the following demarcations were set in the beginning of the project and have been adapted throughout the project.

- Since the project aims to suggest a concept increasing the reliability for the time stamping system everything not related to that system such as staffing issues, budgeting, equipment and law changes are omitted. This avoids steering the focus away from the project's scope.
- Due to Chalmers University and PICTA being located in the county of Västra Götaland, qualitative research such as interviews and observations will exclusively be executed in that county with the possible exception of visiting the adjoining county of Halland.
- The thesis investigates the general road ambulance which is operating in everyday traffic requiring the driver to have a C-drivers license. These ambulances are currently operating the clear majority of the missions within Sweden.
- While the interface of the time tracking system plays an important role, it is not the aim to propose a completely new interface but rather extend and improve the existing functionalities which are, according to the studies conducted in this thesis, inadequate or insufficient for the needs of the personnel.
- The proposed solution of the thesis should be possible to implement in the coming generation of ambulances. The solution space will be limited to what the technical experts deem achievable within the next generation of ambulances. This demarcation aims to keep the work grounded and achievable within a reasonable future.
- Other areas of improvement may be found and stated during the time of the project. If new problem areas are identified, these will be described yet no suggestions for solutions will be given.

2

Methods

To investigate the problem areas and to propose a conceptual solution, the project will make use of various creative and analytical methods related to user-centred design and evaluation. To easier distinguish the used methods in every phase of the project, they are described for every phase and mapped out in Figure 2.1. The aim is to have active working phases followed by writing to consistently add content to the final thesis report.

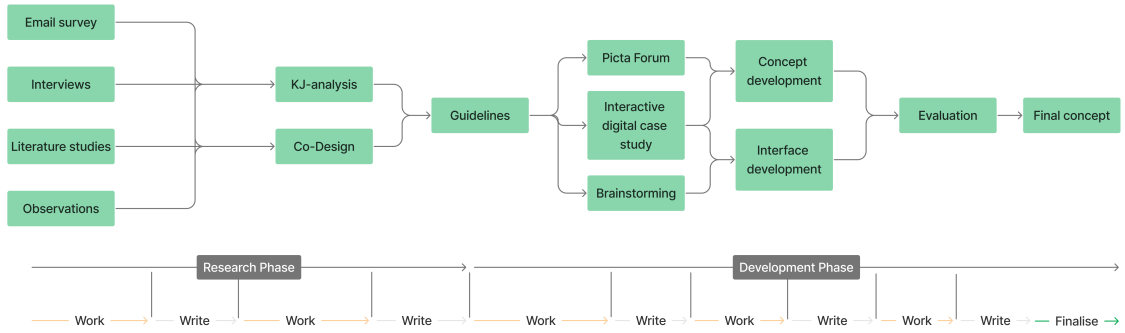

Figure 2.1: Overview of the working process

2.1 Research phase

The research phase included various methods for collecting qualitative data. This phase aimed to initiate the project, get acquainted with the terminology for the project as well as to build a foundation for the following development and evaluation phase.

2.1.1 Literature studies

In the initiation of the project, it was crucial to get familiar with the different terms and language surrounding prehospital care. Therefore literary studies and searching databases such as from *Socialstyrelsen* and other authorities dealing with public healthcare were searched through. Otherwise search engines, such as Google Scholar, Ecosia and the Chalmers library database, were used to obtain insights into other areas of interest such as getting accustomed to the current technical solutions in the ambulances. Searching prompts were for instance: prehospital care, ambulances, standards in prehospital care, laws and regulations regarding ambulance care (Swedish: prehospital sjukvård, ambu-

lanssjukvård, standarder inom sjukvården, lagar och regler kring prehospital sjukvård mm.).

2.1.2 System mapping

A system is described as multiple entities working together to reach a state of balance or homeostasis. Generally speaking, a system consists of inputs and outputs. Inputs are actions that are made both consciously and unconsciously by one of the entities in the system while the outputs are the reactions to the actions that the entity decided to make as described by Flood and Carson, 1993. Different systems interact differently with their surroundings and can be divided into open systems and closed systems. An open system allows the entities to interact with the outside world and external factors that cannot be influenced by anyone while closed systems do not allow for interactions with external factors. That said, it is crucial to define a system boundary to determine whether the system is closed or open and interactive with multiple subsystems or not (Flood and Carson, 1993). Systems usually provide feedback when the right inputs are given and expected accordingly by the entity in the system. Moreover, a system follows a clear system goal that defines the scope of the system and helps to find suitable system boundaries.

2.1.3 Hierarchical task analysis - HTA

Deeper insights into the ambulance nurses' tasks were gained after performing a hierarchical task analysis (HTA). The HTA was conducted on a best-case scenario of an ambulance mission and provided valuable understanding for the tasks within the entire system for the ambulance missions. In addition, the HTA helped to identify the cognitive demanding tasks.

2.1.4 Interviews

Another qualitative data collection method was conducting semi-structured interviews with experienced ambulance nurses, Sweden's counties and other professionals connected to the project. For the counties various responsibles such as prehospital unit chiefs, statistic and data supervisors as well as prehospital nurses were interviewed. These interviews were done to tackle collect views on the tasks, actions, organisational and technical demands of the system. The interviews were both held in person as well as digitally.

2.1.5 Mail survey

A short survey was created to broaden the horizon on how healthcare providers in other counties of Sweden work with the time stamping process of emergency ambulance missions. As the thesis focuses on Sweden it was important to establish the differences and similarities for the counties to understand the conditions and possibilities for the work at hand. If any deviations or development had happened in some counties these then can be used in the development for the final concept proposal to improve the efforts of standardising Sweden's prehospital care. An email with a few short questions was sent out to every counties' prehospital department using public email addresses found on each county's website.

2.1.6 Observations and contextual inquiry

As part of the methodology, insights into the prehospital workflow were obtained by observations. The observations can be categorised as participatory yet hidden observations as the ambulance nurses knew they were going to be observed throughout an entire workday yet they did not know what exactly was observed.

In combination with the observations, a contextual inquiry was used to get further acquainted with how the time tracking system works while being part of the context of an ambulance mission on call. A contextual inquiry is a method in which the person executing the inquiry is part of the context of its counterpart (Kip et al., 2018). The aim of the contextual inquiry is to better understand and outline the underlying problems the enquired counterpart is experiencing. According to Kip et. al. (2018), being in the context of the users enhance their sense of security and benefits their abilities to explain their environment. The inquiry was performed simultaneously with the observations at two different locations at the same time as each author got to join one ambulance nurse team. The contextual inquiry contributed to a better comprehension of the tasks connected to the systems the ambulance nurses are interacting with.

2.1.7 Analysing the interviews, survey, observations and contextual inquiry

The data collected was analysed with multiple KJ-analyses which was done in Figma. The analysis of the collected data helped to define target areas to ideate on later in the process of developing a concept. Besides the KJ-analyses, clustering information was used to further define the different areas of interest.

2.1.8 KJ-analysis

A KJ-analysis is a method developed by the Japanese ethnologist Jiro Kawakita (Scupin, 1997). The method's purpose is to collect and analyse data collected through various qualitative research methods by finding commonalities denominators in the data collected. The commons are then clustered together and assigned a key word which works as an umbrella term for the gathered data. The umbrella terms can then be used to further explore the identified areas of interest.

2.1.9 Graffiti walls

Graffiti walls is a method where a poster is placed in an environment where the users can directly comment in the context of use. The graffiti wall enabled the users to make anonymous comments about the environment, system or context by using coloured stickers and placing them in a graph, writing comments on post-its or drawings. The method was a way of gaining insight into the mind of the user combined with giving them the possibility to come up with new ideas.

2.2 Development and synthesis

After terminating the research phase, the development and synthesis phase was initiated. In this stage, a variety of creative methods were part of the concept development process and are described in more detail below.

2.2.1 Co-design: Interactive digital case study

The interactive digital case study - **IDCS** for short - takes inspiration from co-design and co-creation. Co-creation, according to Frow (Frow et al., 2015), is a way of exploring the possibilities to explored problem areas by the presence of users in the context explored. In traditional co-creation, a mediator, usually a designer, acts as a guide for the participants of the co-creation session while not being influential or biased. The aim is to create different solutions for the identified problems by letting the users collaborate with each other. The **IDCS** is a method developed by the authors of the report aiming towards involving other individuals to take part in the design process for the final concept.The study adds a gamification take to the classic method of co-designing by leading the participants step-wise through a imaginary case. The case study focuses on gaining detailed knowledge and encourages the participants to be creative. The idea is to utilise other professionals such as engineers, designers and people with industry experience knowledge to help come up with ideas during concept development. The method can be seen as "co-design on demand" with the main benefit over other more traditional methods being that the participants can do the study individually without supervision or a mediator while having time available. With the information being gradually presented in different parts the participant could change their focus and so provide more information on the different parts of the case. The case was presented step by step and asking the participants to be creative along the way. The information gathered was processed with another KJ-analysis.

2.2.2 Brainstorming

As a part of the creative process brainstorming was the main method used. For the first brainstorm, the idea was to ideate around specific stages for the time tracking system an ambulance mission goes through. The brainstorming was a dynamic discussion between the project members where everyone got the chance to state every idea that came to mind without filtering them or classing them as possible or impossible.

2.2.3 Concept development and design

With the research and initial brainstorming done, the development phase was initiated. This phase used creative design sprints as the main method (as described by Banfield et al., 2015). In the first sprint the information gathered was decoded and interviews, observations and co-design were all analysed together to find correlations and patterns. Along with the information gathered, a second brainstorm was completed, both using original ideas and building on previous ideas from the research phase. In the second sprint the entire concept was separated into smaller more digestible sub-concepts with focus on the different time stamps. Going through the ambulance mission and for each time stamp, a sub-concept was developed. For the third and final sprint, a complete

concept was assembled using the different sub-concepts in different combinations. The design was then completed and the parts that were visually presentable were mocked up using Figma.

2.2.4 Concept evaluation

To evaluate the concept, a mock-up was created in Figma to test the user interface. The tests were conducted on nurses at the central ambulance station of Gothenburg. The aim was to gather insights and thoughts on the concept from the professionals and see if there were any blind spots that were overlooked in the design.

3

Results - Research phase

In this chapter of the report the results from the research phase are presented according to the methods used and described in detail.

3.1 Literary research

The aim of the literary research was to obtain a better understanding for the topic and the development of prehospital care especially ambulance care in Sweden.

3.1.1 Prehospital care historically

The following section gives a brief introduction to ambulances in a historical context and is based on the paper *Ambulanssjukvårdens utveckling* which was published in collaboration with *Sveriges Kommuner och Regioner* (An organisation that facilitates joint work between counties and municipalities in Sweden) (Kight and Beda Andersson, 2023). According to the paper prehospital and ambulance care in Sweden goes as far back as to the early 1800s where horse wagons were used to deliver and transport patients from town due to them having contagious illnesses.

Stockholm 1910, the first motorised ambulance was introduced. Between the first and second world war the Red Cross took over with their motorised vehicles combining both sick transports and emergency transports. In the early 50's the lack of standardisation became apparent and the Swedish ambulance standard was evoked. From that time on prehospital care would be evolving further and further.

Figure 3.1: Ambulance station in the 1960s in Örebro county. From Örebro Stadsarkiv. (1960s). Ambulansutryckning från brandstationen [Photograph]. https://digitaltmuseum.se/0210111524056/ambulansutryckning-fran-brandstationen-1960-tal. CC BY 4.0

In 1964, a reformation was released stating that ambulance personnel is required to perform basic medical care. Until today the development has involved the working force, the organisations and counties in Sweden both on a local and national level, and technical advancements.

A ambulance from the era can be seen in Figure 3.1. In contrast, Figure 3.2 show one of the current ambulances within the fleet of the county of Halland that were taken into service in 2018.

Figure 3.2: Ambulance in the current fleet of Halland

The technological strides are huge, and so are the organisational and professional ones. To become a certified ambulance personnel, there are requirements to undergo a seven week long medical foundation training was established. The people driving the ambulances by that time were usually firemen or taxi drivers with the necessary first aid training. In the late 80's to early 90's, the introduction of new medical devices and work structures required the ambulance personnel to educate themselves further by receiving a 20 weeks training targeting prehospital first aid. In 1999 *Socialstyrelsen* proposed a law that by 2005 only nurses were allowed to prescribe and give medicine to patients which implied heightened educational requirements for ambulance personnel.

Present days ambulance and prehospital care is described in depth in the next chapter 3.1.2.

3.1.2 Socialstyrelsens documentation

According to *Socialstyrelsen*, 91% of all the ambulance missions are priority 1 missions while the rest are priority 2 missions. Depending on its priority the time from receiving the call from the emergency centre to arriving at the patient will take 15.4 minutes for primary missions while it takes about double the time, 32.8 minutes, for a secondary missions. Moreover, the documentation states that 15 out of the 20 counties asked do not share the same system for receiving data about patients connected to the ambulance missions. *Socialstyrelsen* presented five suggestions for development in prehospital care of which prompt one and five are tied to this project (Socialstyrelsen, 2023).

Prompt 1: Aiming to investigate and clarify the national guidance and knowledge within prehospital care.

Prompt 5: Aiming to follow through a pre-study on how information needs to be both exchanged and delivered between the different actors to increase digitisation.

These two prompts were indicators of how undefined the sector of prehospital care and ambulance services still are and showed the potential for a more joint development. It is worth mentioning that ambulance care has been the centre of attention only since a couple of years back but has gained immense importance as the ambulance nurses now can give care as good as the emergency room.

3.1.3 Current situational assessment

In Sweden the prehospital emergency care is made up of different types of vehicles with different properties and responsibilities. Depending on the mission and the circumstances a certain type of ambulance is sent out.

The following types of emergency care vehicles are in the Swedish prehospital fleet according to Socialstyrelsen, 2023.

- General ambulance (car)
- Speciality ambulance (car)
- Ambulance helicopter
- Ambulance plane
- Ambulance boat

For the most emergency missions a general ambulance is used, however in some cases a speciality ambulance is used if the condition of the patient is out of the ordinary. For an example this can be a medical car with a doctor if a patient is in critical condition and are in need of higher expertise than the ambulance nurses can offer. Another type of ambulance is the intensive care ambulance which is made to transport patients in critical conditions from one hospital to another. Furthermore, there are special ambulances for inaccessible terrain like helicopters and boats, yet they are rarely used for priority emergency missions according to Socialstyrelsen, 2023.

In the same report (Socialstyrelsen, 2023), the lack of standardisation for prehospital emergency care in Sweden is presented. The responsibilities lie on each county to offer adequate prehospital emergency care. However, it is *Socialstyrelsens* responsibility to follow up on that the counties achieving the quality and standards given in the report by Riksrevisionen, 2012 (The Swedish National Audit Office). In addition to this it is worth mentioning that the Swedish government does not provide any guidelines for the counties or *Socialstyrelsen* for improving prehospital emergency care.

Figure 3.3: A satirical take on budgeting in prehospital care. Tomas Överström/CFFC.se (2024-04-30). Cortegétåg [Photograph]. https://cffc.se/bilder/2024/cortegen/84289/ . Used with permission from the photographer.

That being said budgeting has become more difficult for the counties in the past years in the health care sector. Even if Figure 3.3 exaggerates the current debate of budget shortages, it illustrates how crucial it is to find a common ground to guarantee prehospital care's quality.

3.1.4 Standardisation for road ambulances

During the last reformation of the standard for road ambulances (*SIS-1789*, 2024) provided by SIS *Swedish Institute for Standards* for which equipment road ambulances need to have, the following devices have to be found in an ambulance.

- Medical devices such as CPR and ECG devices;
- Power-assisted or manual stretcher;
- Equipment for special emergencies such as fire helmets, suits, gloves and gas masks for chemical accidents;
- Oxygen flasks and suction equipment;
- Respiratory and pressure regulating equipment;
- and standard sanitising and medical equipment.

In Figure 3.4, a top view section of a road ambulance is shown. The dark green areas show equipment the ambulance nurses interact with during an ambulance mission and can be moved or carried around. The light green areas are other types of equipment that depending on the mission can be removed from their designated spots in the emergency care space and taken with. The emergency care space is the space in which the patient receives the necessary medical care usually while one of the ambulance nurses is driving to the closest hospital. The grey areas display the ambulance's mounted rigid seats. A

road ambulance has up to four built-in seats, one for the driver, one for the co-driver, and either one or two in the emergency care space depending on the ambulance model.

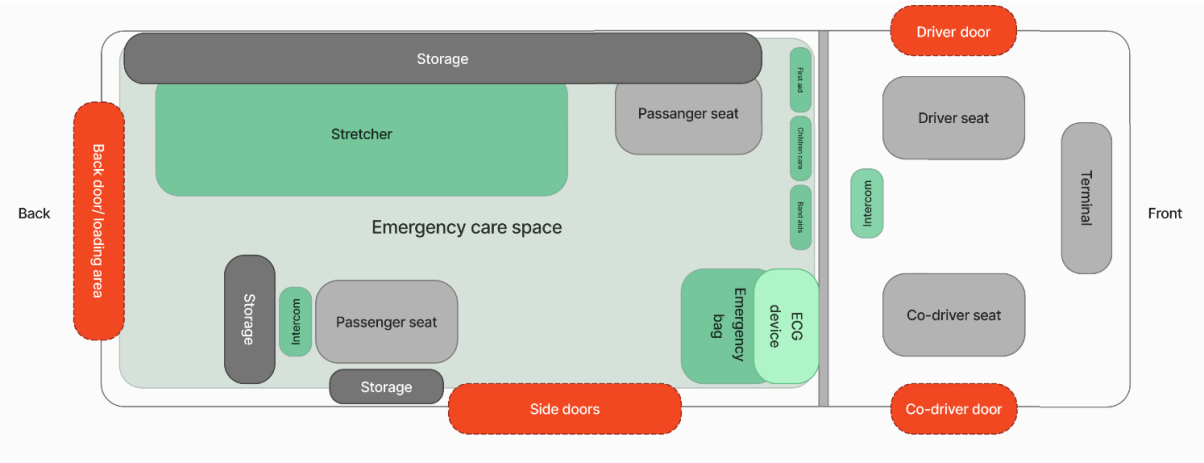

Figure 3.4: Illustration of an ambulance and its equipment

Moreover, every ambulance studied in this thesis is equipped with four doors. Two doors in the driver's cabin of the ambulance placed next to each seat respectively. The other two doors are found in the back of the ambulance. One big sliding door on the side of the ambulance making the emergency care space accessible sideways from where ever the parking location is. First and foremost, this door is the main entrance for the nurses to get to their tools from the emergency care space but also for entering or exiting when having to switch between activities while giving care. The back door is used for loading and unloading the stretcher and entering the ambulance when giving care to the patient. Besides these features there are numerous cupboards to store other devices or equipment in the ambulance.

Lastly, an ambulance's expected lifetime lies between 5-6 years when being used consecutively day and night every day of the year. In VGR (*Västra Götalandsregionen*, county in west Sweden), ambulances drive with fossil-free fuel since May 2023 to increase working towards a more sustainable environment (VGRegionen, 2023). However, an ambulance weighs about four tons which means it consumes more fuel due to the added weight and they are in general quite costly to replace.

3.1.5 National ambulance registry

In the absence of a national quality assurance, a system had to be introduced to guarantee that quality indicators are met throughout the entire country. *AmbuReg* was launched in 2016 and serves a national registry ensuring that the every Swedish county meets the requirements within the competences and medical care in prehospital care (Ambulansregistret, 2022). AmbuReg's aim is to provide a foundation for following up processes and supporting development on a regional and national level in ambulance care. The system has the following five general system goals:

1. Process documentation
2. Monitoring deviations and standards towards the target guidelines

3. Quality assessment regarding the care given to the patient and effects
4. The possibility to develop the professional competencies in the area of ambulance care aided by follow-ups
5. Evaluating assessment support which is used when an emergency call is made and prioritised

AmbuReg documents, monitors, saves and delivers data and wants to secure the quality of prehospital care yet it is difficult to manage of the data in the different counties. The data is handled and tracked diversely nationwide which makes following up on progress and development in prehospital care complicated.

3.2 Email survey

As previously mentioned, in 1.3 Scope, the work for this thesis was conducted with all 21 counties of Sweden in mind but due to geographic limitations and PICTAs established connections a preliminary focus will be on Västra Götaland and the healthcare provider VGR. However, to understand how other counties of Sweden operate a short email survey was composed and sent out to all counties of Sweden. This part of the report will focus on the other counties of Sweden, and not include VGR. Data gathering concerning VGR will be presented in 3.4 Semi-structured interviews and 3.5 Observations.

3.2.1 Goal of email survey

The goal of the email survey was to understand how the different counties work with the time stamp system today, what software they were currently using and if they had any interest in the development in the area. As the healthcare providers in the counties work as separate entities and are only connected to *Socialstyrelsen* in case of quality and administrative management (Socialstyrelsen, 2023). This means that different counties more often than not operates significantly different to each other when it comes to healthcare.

3.2.2 Questions asked

In the email sent out to the different healthcare providers, the context for the project was given along with questions for the respondent to understand the scope of the project. The following questions were asked (translated from Swedish to English):

1. Does the ambulance personnel need to manually act on the steps, or is anything automated?
2. Do you see a need to develop a simpler or more automated system?
3. Do you have any knowledge about whether any development has occurred in your county in this area?

3.2.3 Response

Out of the 20 counties contacted 13 responded, which is a response frequency of 65%. In most instances a manager working with ambulance care responded, while in some cases

the email was forwarded to someone with technical know-how. Out of the 13 responses submitted ten were positive or very positive to the development of an automated system for time stamping. Three respondents were more conservative and answered that the system today was sufficient or that there was no need to develop a new system. However, it was unclear if these respondents understood the scope of the project, due to its brief introduction, as some answers were ambiguous or vague. The data collected from the different emails was processed and coded using a KJ-analysis to categorise the different responses from the counties, presented in Figure 3.5.

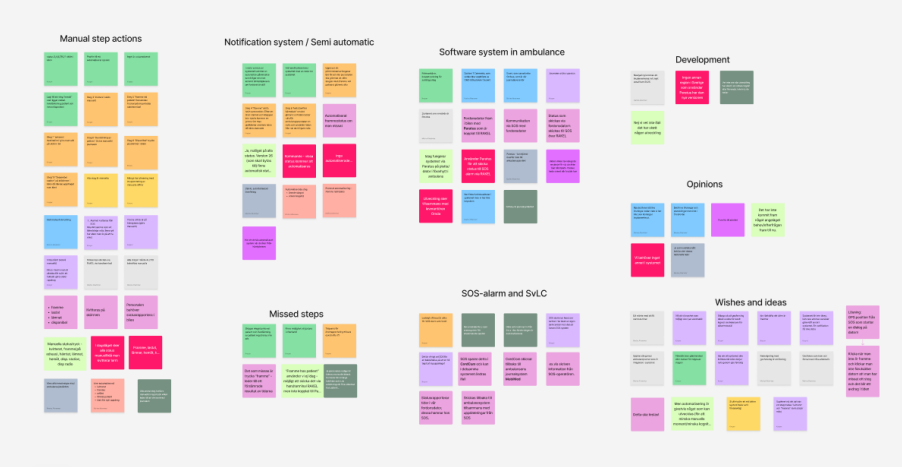

Figure 3.5: The KJ-analysis of the email response from the counties

3.2.4 Result of email survey

The result of the survey was that the clear majority of the responses encouraged the development of a more automated system. Some of the counties responded with a healthy amount of information, some even went out of their way to include more information and suggest ideas for possible solutions.

11 out of the 13 respondents used *Paratus*, a emergency care software provided by Omda, as their in ambulance terminal system for managing GPS navigation, mission information, time stamps and more. According to the respondents there are frequent system updates and that the system is tailored for each customer (or county) and that specific functionalities are locked and have to be paid for specifically. The time stamp process was in large a manual labour for the ambulance nurses across all of Sweden, however some counties have taken measures to make some steps "semi-automatic". Some of these were the "Arrival at the destination" and "Arrival at hospital" where a notification pop-up on the terminal's screen was used to nudge (Weinmann M., 2016) the nurses into pressing the confirmation button for the time stamp.

Arrival destination

Another time stamp that seems to be semi-automatic or under way to be semi-automatic is the "arrival destination" (eTimes.06) at destination. It seems to be that some counties get updates before others as two respondents said they had the update whilst two answered that the update is planned to come in the near future. This may be due to difference in policy agreement between the software provider and the different counties.

Arrival patient

Every county equally lacked the time stamp for "Arrival patient" (eTime.07). Due to the *Paratus* terminal being placed in the driver's cabin, the ambulance nurses cannot track the time from that terminal as it is not in their close proximity. None of the asked counties has solved this issue yet. The current options were either ignoring the time stamp or tracking it on the portable RAKEL unit. In theory there is always a possibility to use the portable RAKEL unit to send a time stamp to the AmbuReg and *SOS Alarm*, however, it does not hold up with present-day usability standards in Figure 3.6. Usability standards are standards regarding product semantics and their usage together to create a satisfactory experience for the user. These standards can be linked to different factors such as memorability, satisfaction, error probability, learnability and efficiency (Mazumder and Das, 2014). While one county used this as a method to register "Arrival patient" (eTimes.07), none of the other counties are. Moreover, giving necessary medical care to the patients is prioritised over registering the time through the RAKEL device according to 92% of the respondents probably due to the high learnability threshold as mentioned by Mazumder and Das, 2014.

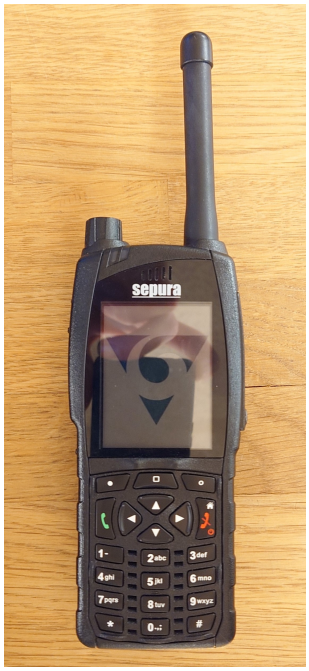

Figure 3.6: The portable RAKEL unit used by first responders

Departure destination

In some counties a notification system has been implemented. Here, the system notifies the nurses if they are departing from the destination (time stamp "Departure destination" eTimes.09) without having pressed the button for departure. The system notices if the ambulance is moving while departure has not yet been pressed on the ambulance terminal. This semi-automatic system does however not seem to be active in all counties as only 4 out of the 13 responses mentioned it.

Arrival hospital and Transfer patient

Another time stamp that seems to be some what troublesome is the "Arrival hospital" (eTimes.11) in combination with "Transfer patient" (eTimes.12). Some respondents mentioned that it was common for the ambulance nurses to be waiting for the ER personnel when transferring the patient. This may be due to the ER personnel not being able to immediately attend the ambulance nurses and their patient. As with today's system there is no way to measure the time to deliver a patient or if there are improvements to be made at the different hospitals.

Main takeaways

In a more general sense, there some strides of development have been made across the whole system as previously mentioned in this section. The semi-automatic steps seem to be appreciated by the personnel and is a step in the right direction to provide more accurate data and take some cognitive load off from the ambulance nurses. But this novel functionality does not seem to be active in all counties and it is uncertain weather all counties will be able to acquire this functionality.

The result from the survey is that "Arrival patient" along with the "Transfer patient" seemed to be the two areas lacking compliance with the FLISA standard. Whilst other parts of the time stamp process have had development the respondents were interested in further development.

3.3 Technology review

As part of the research phase and simultaneously to the email survey, an assessment of the current technology was made together with two counties of Sweden to gain a better understanding on how the different counties are working with the technology that is implemented already.

3.3.1 Technology in VGR

In VGR the ambulances use two systems. *Paratus* which is the time tracking system of the ambulance missions registering a time stamp upon the press of a button on the built in terminal in the ambulance cabin. The other system VGR uses, is a separate medical record system that the ambulance nurses use when arriving at the ER and after having handed over the patient to other health care professionals. Currently, VGR is tracking six times as shown in the image 3.7 and table 3.1 below.

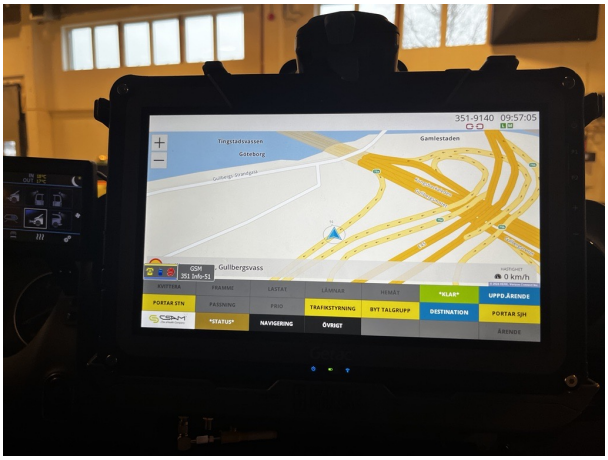

Figure 3.7: The Paratus system in VGR

Name	Responsible	Code
Mission starts (KVITTERA)	Ambulance	eTimes.05
Arrival destination (FRAMME)	Ambulance	eTimes.06
Departure destination (LASTAT)	Ambulance	eTimes.09
Arrival hospital (LÄMNAR)	Ambulance	eTimes.11
Available (HEMÅT)	Ambulance	eTimes.13
Mission complete (KLAR)	Ambulance	eTimes.16

Table 3.1: The time tracking system in the ambulances in VGR

The possibility of adding or removing buttons from the system exists yet adapting the system to ones liking can be costly and budgets are tight in the healthcare sector.

Functionality-wise the programme acts as both GPS system and confirmation system for tracking an ambulance mission times. The system has a function that recognises when the ambulance is moving and therefore reminds the ambulance nurses if they forgot to confirm some statuses.

3.3.2 Technology in Halland

Halland uses the same system for tracking the time stamps for an ambulance mission, namely *Paratus*. Besides Halland and VGR both using *Paratus* as a system for time stamping, these systems appeared related with each other but the interfaces were different.

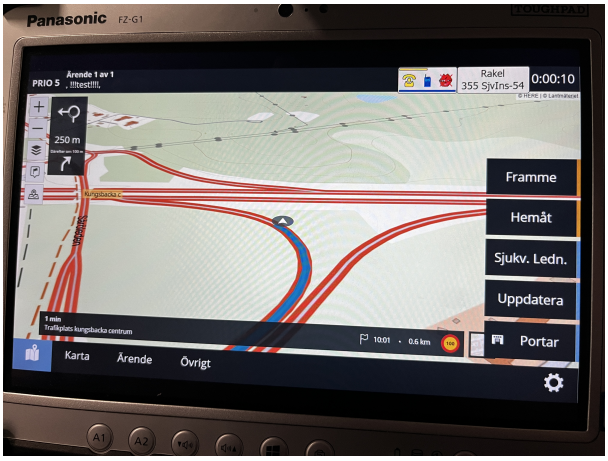

Figure 3.8: The Paratus system in Halland

One notable difference though was that the buttons would disappear after confirming a specific step during the mission. Further, Halland also used *Paratus* for writing the patient's record and reporting patient data over to the hospital. In present day, Halland has one person working with the registered times and has responsibility to check whether all the time stamps have been registered or not. On demand, they send out a request to the ambulance nurses to fill in the missing estimated times.

In the new version of *Paratus*, the system notices automatically when certain actions have been taken to avoid faulty time stamps. For instance, a GPS sensor should work as such that it recognises when the ambulance is not moving anymore. The system recognises that the car has come to standstill and will then account for the time passed by since the engine stopped by subtracting an unspecified amount of time.

3.4 Oral inquiries

As part of the research phase three semi-structured interviews were held with experts in the field. Less structured interviews were conducted with four nurses while taking part in the observations while the other four conversations were unstructured inquiries taking place between the missions. The nurses had different educational levels and years of working experience. This was beneficial for a diverse set of answers and to understand how experience and education play a role.

3.4.1 Semi-structured interviews

For those interviews a template (Appendix A) for each expert was created with the aim to get a deeper insight into the where the current technology is heading as well as to highlight certain areas of interest.

Technical officer from VGR

Interviewing the Technical officer, Pontus Frick, at the central ambulance station, led to a better understanding of the current time tracking system. He talked about the technical possibilities and the upcoming changes in the version of the system and presented the

current ambulance model with its belonging. The main takeaways from this interview was that the technological development progresses slowly while also tackling a tight one year budget for the ambulances.

Statistics officer from Halland

While talking to Kristoffer Wibring at the ambulance station in Kungsbacka, he brought up the fact that the same software used for time tracking could be used for documentation. For documenting the medical records and editing missed or false time stamps, the software from the first terminal is mirrored to the second terminal in the care space as described in 3.3.2. His work involved mostly to look into the deviations between the times to suggest and look for patterns to secure the missions efficiency.

Technical expert from Ericsson

For the technical feasibility an expert was needed which is why Johan Nicander from Ericsson was consulted. His role is to investigate and validate innovative ideas and determine whether these are realisable or not. His expertise came in handy when searching for specific knowledge about sensors, their data collection process and their connectivity in the existing ambulances. Throughout the project, he became the technical consultant for this project. Moreover, the understanding of what is managed by the system and how sensors are working together as well as what is needed for sensors the be implementable and working became more apparent after this interview.

3.4.2 Unstructured inquiry

Even if the inquiries were rather unstructured, the base for them was a set of predefined questions. Some key points and questions are stated in bold below.

Q: What is the best part of the job? The answers to this question were diverse. For some nurses it was the flexibility the job allowed for as well as the fact that they got to interact with and help a variety of people. Regarding their profession they found that they had a vast impact on the inhabitants in the city. Moreover, they stated that it was a versatile profession in which every day is different and brings new challenges.

Q: What is the best technical advancement? When bringing up the technical forward stride, the nurses stated that the invention of the automated stretcher is the biggest game changer. The stretcher was quite heavy by itself before but with the development of a mechanism for automatically lifting it into the ambulance reducing the physical ergonomic load on the ambulance nurses. Another technical advancement they mentioned was the internal ambulance communication system called *Pandora* 3.9.

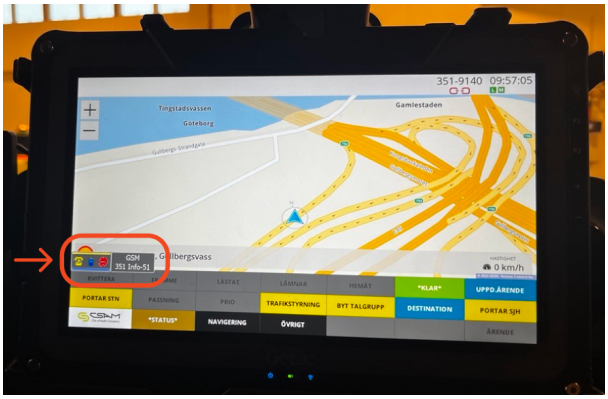

Figure 3.9: Pandora - internal communication system

Mostly, Pandora is used during the transport of the patient to the hospital as the nurses can talk to each other via the intercom in the car. Before they had to more or less scream through a little window between the driver space and the emergency care space.

They further mentioned the development of the automatic cardiopulmonary rescue (CPR) machine, the GPS and even the fact that they could talk to *SOS Alarm* through RAKEL at any time.

The asked ambulance nurses were open-minded about implementing new technology into their workday yet they felt that a better information flow as well as training would be desirable as they otherwise had to figure out the technical innovations on the go while being in a real emergency situation.

System- and organisational criticism

During the data collecting process it became evident that the major problems are organisational ones. These issues were mainly related to not having the right administrative tools, systems that were not working interactively but also the fact that there is no standardisation for prehospital care in Sweden as everything is managed on a municipal level. Once the ambulance nurses take the patient with them they are responsible, which means they are not allowed to leave the patient by themselves without having handed them over to another care unit, e.g. the ER at a hospital.

Furthermore, the ambulance nurses pointed out that they sometimes could get frustrated if they had to drive to patients that did not really need help due to *SOS Alarm* sending a mission request when help would not necessarily be required. This is sometimes, according to the nurses, due to *SOS Alarm* not having nurses answering the incoming emergency calls. The *SOS Alarm* personnel have only undergone some basic training and learnt how to work with *SOS Alarm* specific evaluation processes. While SvLc has nurses answering the emergency calls and so a more extensive medical analysis is giving to the caller, this could mitigate unnecessary ambulance missions by asking the right questions. That said the collaboration with *SOS Alarm* is going to be terminated by September 2024 (SOS-Alarm, 2021) leaving SvLc the only actor to take emergency calls.

Lastly, critique was directed towards VGR for working with one-year budgeting and funding within prehospital care. Short-sighted budgeting makes it difficult to plan ahead, creating a discrepancy when wanting to implement new technologies. The administrative

rigidity for implementing new technology, budgeting and too little input from the working people raises problems for the health care staff. Yet again these issues can only be resolved if tackled on the organisational level.

3.5 Observations

To better grasp the actual mental and physical workload put onto the ambulance nurses as well as to see the time tracking system operate in real time, the opportunity of a participatory observation was taken. The project team split up to join two teams of two ambulance nurses on call at two different stations in the county of Västra Götaland. One member joined the first team from *Mölndals brandstation*, while the other member joined another team at central ambulance station. Before the observations both prehospital care teams got to know that they were being observed throughout an entire workday but they did not know what exactly was being observed. The decision of not telling them what the observations were for was made to avoid changing their behaviour when confirming the time stamps. The guide used for what to look for and observe is presented in Appendix B.

Name	Responsible	Code
Mission starts (KVITTERA)	Ambulance	eTimes.05
Arrival destination (FRAMME)	Ambulance	eTimes.06
Departure destination (LASTAT)	Ambulance	eTimes.09
Arrival hospital (LÄMNAR)	Ambulance	eTimes.11
Available (HEMÅT)	Ambulance	eTimes.13
Mission complete (KLAR)	Ambulance	eTimes.16

Table 3.2: The time tracking system in the ambulances in VGR

According to FLISA and as shown in Table 1.1, ambulance nurses should be able to confirm six of ten time stamps manually by actively remembering to press a button. During the observations, it became clear that theory often differs from reality. Table 3.2 shows the actual time stamps documented by the ambulance nurses. Besides the first status - "Mission starts" (eTimes.05) - which was confirmed on the portable RAKEL unit to be able to receive a call from *SOS Alarm*, the other statuses were accepted on the cabin terminal.

The times for "Arrival patient" (eTimes.07) and "Transfer patient" (eTimes.12) are either not filled out or estimated according to a template which creates approximated time stamps for the missing status. While being part of the ambulance nurses work shift, seven separate observations were made. In advance to the observations a guide (Appendix B) had been created to ensure both project members would acknowledge and look at the same parameters. One of these parameters was for instance measuring the missing time stamps to better grasp to what extent the estimated times according to the template would deviate from reality. Those status and their belonging time stamps are presented in Table 3.3. The table displays the name of the time stamp which is saved in the system on the built-in computer, while M1 - M7 present the different ambulance missions.

Code	M1	M2	M3	M4	M5	M6	M7
eTimes.03	8.40*	10.18*	12.54*	7.55	10.58	12.08	13.51
eTimes.05	8.45	10.22	12.55	8.03	11.02	12.08	13.51
eTimes.06	9.11	10.43	13.13	8.13	11.13	12.37	13.58
eTimes.07	9.15*	10.46*	13.15*	8.15	11.17	12.54	14.01
eTimes.09	9.27	11.13	13.23	9.06*	11.32	13.40	14.20
eTimes.11	9.40	11.42	13.45	9.23	11.51	-	14.28
eTimes.12	9.43*	11.45*	13.15*	9.25*	11.54	-	14.50
eTimes.13	10	11.56	13.54	9.47	12.07	-	15.20*
eTimes.16	10.13	12.10	14.15	10.28	12.08	13.51	15.40*

Table 3.3: Timestamps according to the observations

The times marked with * were approximated rather than precisely measured. The decision to add the * was made for transparency.

3.5.1 Summarising thoughts

To summarise the observations, it was interesting to see that the pressing of the button and the manual confirmation did not seem to be an issue yet that the issue rather lies in that there is no time tracking for the times that are estimated, which creates a discrepancy when trying to provide the right number of ambulances within the counties.

Another significant takeaway was that the priority of the ambulance emergency did not seem to affect the ambulance nurses in how many misses or lapses were made while confirming the status. It goes without saying that the observations played a crucial part in this stage of the project as the topic felt vague and it was difficult to understand the context without actually having been in it.

Moreover, it was interesting to observe the nurses' body language rather than asking them how they felt when being on a mission. They never said that they were stressed or frustrated, yet their gestures showed that they experienced feelings of frustration when patients or other stakeholders in the emergency chain did not communicate as desired. This goes mainly for the communication between *SOS Alarm* and the ambulances. People employed by *SOS Alarm* just receive a basic training and work according to a template to evaluate the patient's status but these employees are usually not educated nurses which in some cases creates misunderstandings. These misunderstandings lead to ambulances taking on missions that they might not have had to take in the first place.

Having the opportunity to experience prehospital care first hand as a participatory observer provided valuable insights into how various events and sequences of actions affect the ambulance nurses abilities to press the buttons for time stamps. During the entire day of observations, three major deviations were noted where the nurses forgot to press the button to the time tracking system. Once after leaving the hospital during M1 where they forgot to press the button for being "Available" for a new mission. The second time where they did not confirm their arrival at the hospital to avoid *SOS-Alarm* checking on them as their mission was part of an external assessment which will not be explained further in this report. And, thirdly, when the nurses had a time delta of 20 minutes for

arriving at the destination due to the fact that the built-in navigating system led them the wrong way which led to the nurses pressing the button for having arrived prematurely.

A more detailed description of all missions can be found in Appendix C.

3.6 The system - An ambulance mission

After being introduced to the terminologies in prehospital care, the aim was to provide an overview of the system in order to identify the different main stakeholders connected to the project's problem description. Mapping out the system in the beginning of the project was beneficial for further creating interview and observation guides. Furthermore, the system map provided a rundown of the entities and their connections and displayed the system's limitations clearly.

The goal with this system map was to identify the scope and the boundaries of the system that is explored and to clarify the system goal. For the project, the system goal is a successful ambulance mission according to the status provided by FLISA.

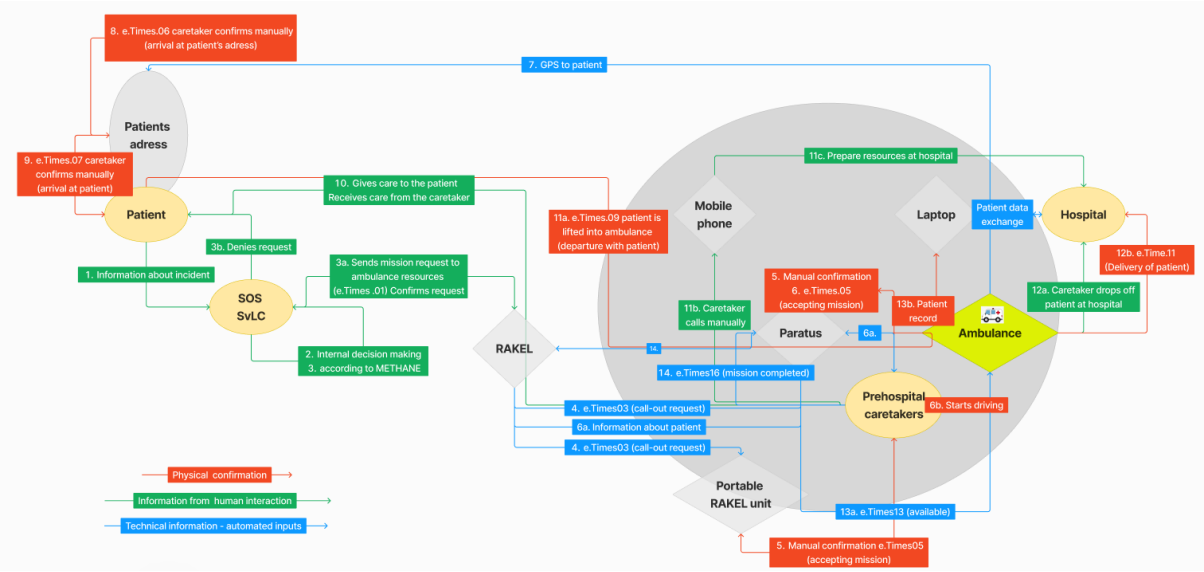

Figure 3.10: The system of an ambulance mission, see Appendix D for a more detailed view

The system shown in Figure 3.10 presents how an ambulance proceeds on a mission without any interference or deviations according to plan. Looking back to what the theory says about inputs and outputs into the system, an input to the system is a type of information. Informational inputs that entered the system were divided into three categories. These were physical information which implied manual inputs or confirmation from one of the entities in the system. These inputs are marked in red in the map. The second type of input is the technical information that is created often as a consequence of the physical input and is displayed in blue in the system image. Lastly, inputs provided by human interaction is displayed in green, and ought to better explain where human communication skills are needed instead of information provided through machine-written text such as checking the RAKEL status or the medical record system.

As the system for one ambulance mission is complex, it also consists of multiple smaller

subsystem. The subsystems are the *SOS Alarm* or SvLc as well as the ambulance itself. *SOS Alarm* and SvLc are treated as self-sufficient subsystems within the bigger picture and are not going to be looked into further besides their interactions with the other stakeholders in the system. The other subsystem is the ambulance. The ambulance on its own consists of several devices that are able to send and store information. The system goal is to track a successful ambulance mission characterised following the FLISA standard. The system is an open system as it can experience interference from external factors that are being omitted in this system map to keep it at a lower level of complexity. Furthermore, deviations from the ideal case are outside of the system's boundary. The stakeholders in the system for this specific system goal are:

- The person making the emergency call meaning it does not have to be the patient necessarily who is calling for help
- The patient, the person receiving prehospital care
- The alarm station, in this case *SOS Alarm* or SvLc
- The ambulance nurses
- The ambulance
- The hospital including the health care staff

In this system map, the centre answering the incoming emergency call is *SOS Alarm*. *SOS Alarm* answers the call and works internally according to their own evaluation strategy, METHANE, to assess whether it is necessary to send a request to an available ambulance or not. If *SOS Alarm* comes to the conclusion that the request should be answered positively than *SOS Alarm* send a request to an ambulance through the radio communication system RAKEL. The request will then pop up on either the ambulance nurses handheld device, such as the portable RAKEL unit or the in-car mounted computer. The screen, regardless if it is the handheld device's or mounted computer, displays the core information related to the ambulance mission. The system shows the current mission step (see Table 3.2). These time stamps are marked in red in the system map and represent the steps where the ambulance nurses have to put an active effort in remembering to press a button. Furthermore, every single red action in its turn creates a technical information exchange, shown in blue, between the different devices included in the system which in their turn are stored in *Paratus* and outside of the system's and the project's scope. The green actions are human to human interactions and are excluded from the system as well.

3.7 HTA - Hierarchical Task Analysis

In order to understand the system deeper a Hierarchical Task Analysis (HTA) was conducted to map the mission in a chronological order and to break down a bigger task in its constituents. The analysis is conveyed as a diagram with a hierarchy and chronological order to clearly show how tasks and subtasks relate and impact each other. The HTA is a credible method used by many human factors and ergonomics professionals to analyse the ergonomics of systems.

In the article *Hierarchical task analysis: Developments, applications, and extensions* (Stanton, 2006) the author highlights that the HTA method is highly adaptable for

many different practices and so, there is no definite method to conduct a HTA. Stanton does, however, present a generalised framework that describes the basic heuristics for conducting a generic HTA. For the HTA in this report that framework was used.

The purpose of the analysis is to gain greater insight into the task and subtasks of a ambulance nurse on a emergency mission. Making the HTA will prepare for later work in the development phase. Whilst the HTA covers from "Mission starts" to "Available" the main focus was be on the interaction between the nurses and the portable RAKEL unit or the ambulances stationary terminal. As a secondary focus the HTA shows how the nurses move around the ambulance to complete their tasks.

The boundary of the system is from the ambulances mission start by receiving a call "Mission starts") on the portable RAKEL unit from *SOS Alarm* (or SvLc) and heading to the ambulance until the mission finishes when the ambulance has restocked consumables and is marked available for a new mission ("Available"). The HTA also dissects various parts to different levels where some tasks and subtasks are not relevant for the development of the design concept.

To conduct the HTA different studies were made to gain the necessary knowledge in the area to be able to dissect the mission and divide it in to tasks and subtasks. According to Stanton, 2006 it is important to access a variety of sources to have a HTA with good accuracy. An interview with an ambulance nurse with technical expertise was conducted together with an observation and contextual inquiry.

The goal of the system is to successfully deliver a patient to the emergency room whilst also correctly time the mission with the eight compulsory time stamps (FLISA, 2020). The eight times the ambulance nurses have to interact with the timing system are providing the first subtasks of the system's task:

- Mission start
- Arrival destination
- Arrival patient
- Departure destination
- Arrival hospital
- Transfer patient
- Available
- Mission complete

Each subtask has a sub-goal, conditions and performance standards that are required to be carried out to achieve the sub-goal to move on to the next part of the system goal. As schematically shown in Figure 3.11, each subtask (marked in orange) of the HTA are shown in greater detail later in this chapter.

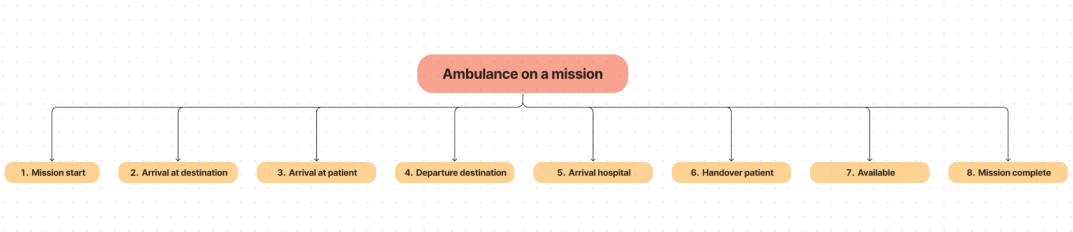

Figure 3.11: A schematic picture of the main subtasks of the HTA

3.7.1 Scope of the HTA

There are a few discrepancies between the HTA presented in this report and the real world scenarios observed in VGR. From the FLISA documentation (FLISA, 2020) every ambulance need to document the eight time stamps during any mission, however two of these times are estimated with a complementary time which does not correspond with the actual time. These times are "Arrival patient" (eTimes07) and "Transfer patient" (eTimes12). It is possible for the ambulance nurses to correctly add all the time stamps using their portable RAKEL unit, however they are not obliged to do so as it takes time and effort. Instead these times are automatically filled in by the system. This is the case in VGR and as presented in section 3.2.4. There are differences between the counties of Sweden. As VGR is just one out of 21 counties of Sweden a more general system is portrayed in this report. The presented HTA depicts a generalised scenario where the nurses fulfil all the criteria of the FLISA documentation standard.

3.7.2 HTA legend

The HTA is partly colour coded to convey various information types. Some tasks and subtasks has different colouring and markings to easier understand what the user is doing and who is doing it. The colouring is shown in Figure 3.12.

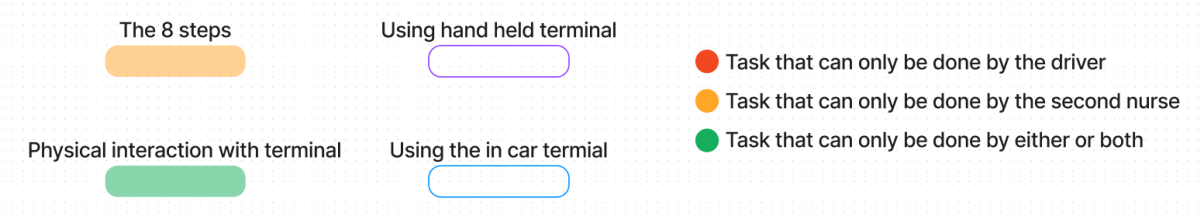

Figure 3.12: The colours of the HTA

3.7.3 Mission starts

For the HTA a generic scenario is portrayed and so the nurses and the ambulance start their mission at an ambulance central. As the mission starts, the two nurses receive a hail from *SOS Alarm* (or SvLc) to their portable RAKEL unit. The nurses accept the mission by pressing a button on the portable RAKEL unit and then heads to the ambulance. As the nurses begin driving to the destination they receive more information from *SOS Alarm* (or SvLc) on the terminal in the ambulance cabin about the condition of the patient, location and other circumstances. The first part of the HTA is presented in Figure 3.13.

Work distribution

- 1.1: Both
- 1.2: Both
- 1.3: Driver
  - 1.3.3 Both

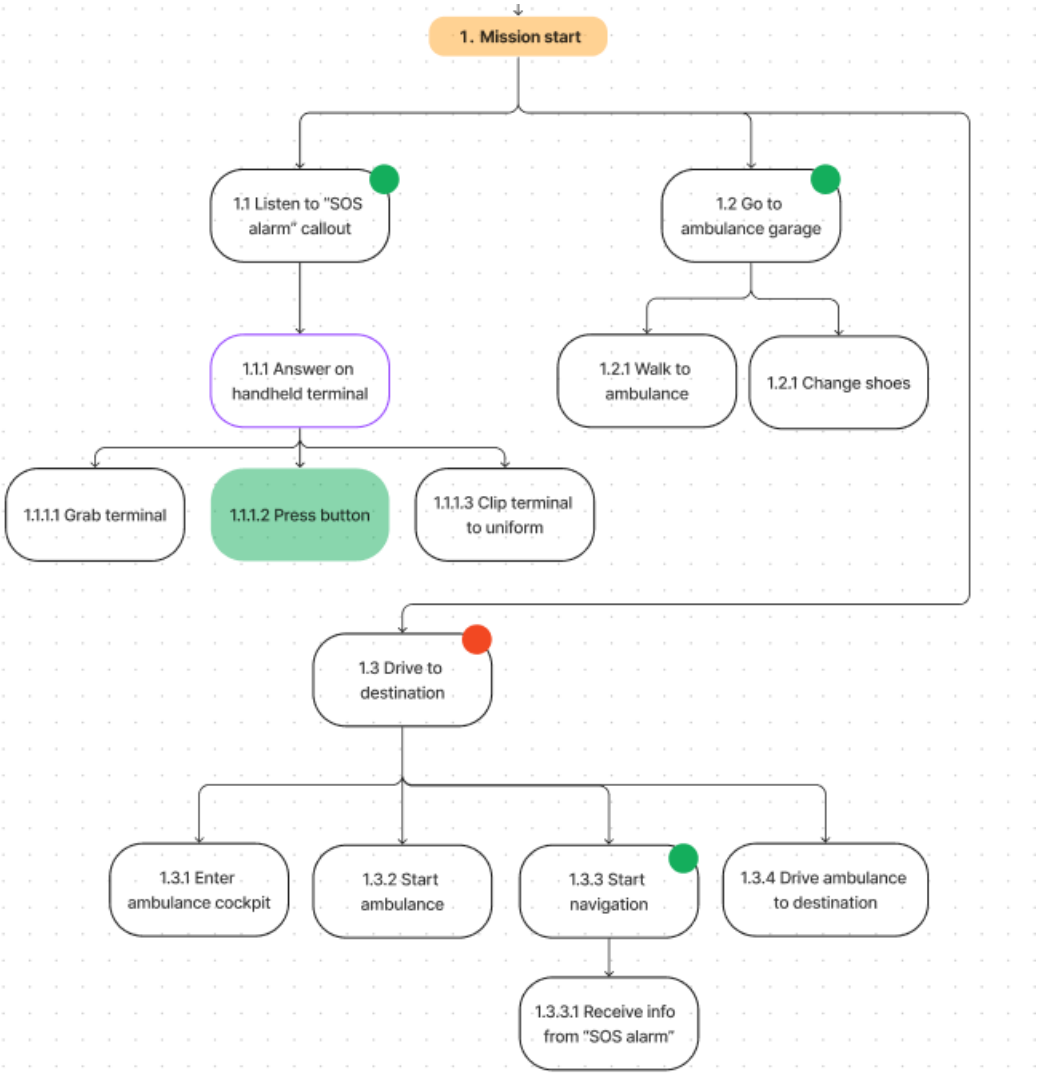

Figure 3.13: The first subtask of the HTA

3.7.4 Arrival destination

When the ambulance arrives at the destination, one of the nurses is required to press on the terminal in the ambulance cabin to register their arrival in the system. As the stress and pressure in this line of work is high, slips and lapses are possible. Depending on the situation they arrive to and the urgency there is a probability that this step is forgotten. The "Arrival destination" subtask contains a variety of conditions and requires the nurses to act swift. As the nurses attention span is limited the first priority is to attend the patient and give feedback on the situation to *SOS Alarm* (or SvLc) if the situation is more severe than previously estimated. In this phase of the mission it is also a possibility

to encounter hiccups and inconveniences such as the patient being located on the top floor without an elevator or that the wrong code for the keypad lock has been provided. Both of which can add to the pressure and stress on the nurses. The second part of the HTA is presented in Figure 3.14.

Work distribution

- 2.1: Driver
- 2.2: Both
- 2.3: Both

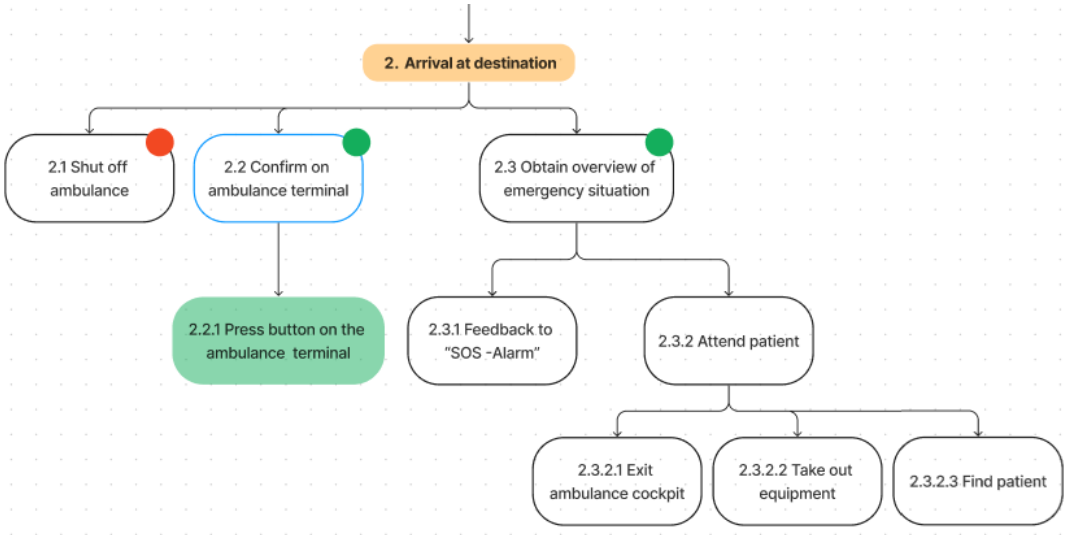

Figure 3.14: The second subtask of the HTA

3.7.5 Arrival patient

When the nurses arrive at the patients side one of the nurses should use their portable RAKEL unit to report that they have arrived at the patient. However, in reality, the compliance with this step is according to the sources asked very low or none-existent (discussed in the email survey section 3.2). This is mainly due to the intensity of the situation and the low priority of the reporting of time of arrival compared to attending a patient in a potential life threatening emergency. When the situation is assessed and an initial diagnosis is given, the nurses may need to fetch necessary equipment from the ambulance. The equipment can be a stretcher, a special medical bag for severe bleeding or a bag for childbirth. The third part of the HTA is presented in Figure 3.15.

Work distribution

- 3.1: Both
- 3.2: Both
- 3.3: Both

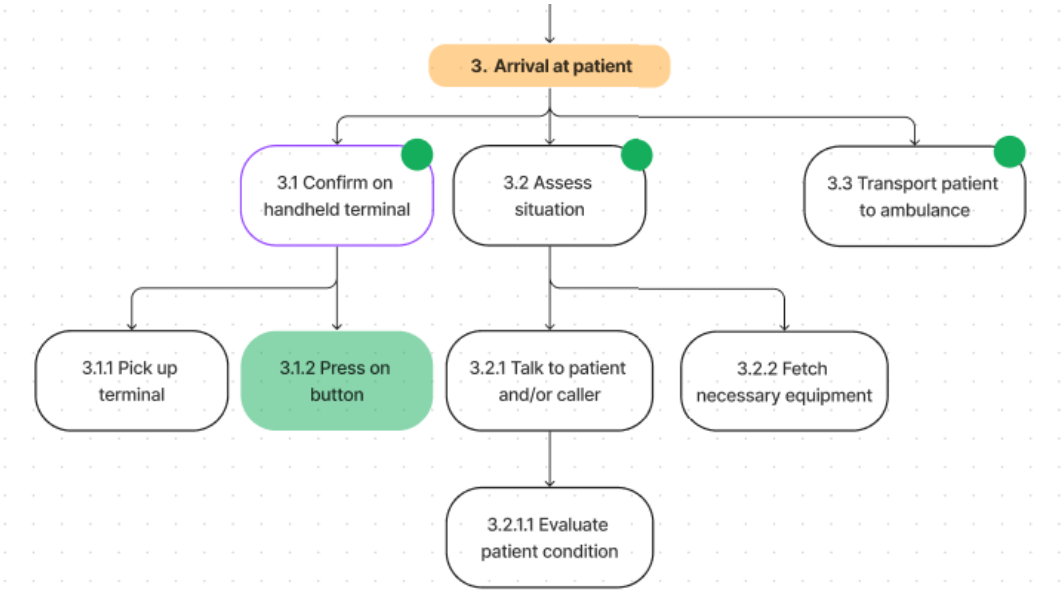

Figure 3.15: The third subtask of the HTA

3.7.6 Departure destination

The first step for the subtask is to load the patient into the ambulance, a stretcher is most often used. The second task is to start the ambulance and navigate to the closest available emergency room. As the ambulance leave the destination the driver needs to press on the ambulances terminal that they have successfully loaded the patient the driver needs to select the priority of the mission and the hospital. The mission gets an initial priority by *SOS Alarm* or *SvLc* but is always re-entered by the ambulance nurses as the state of the patient could have changed throughout receiving the necessary medical care by the ambulance nurses. Depending on the situation this can be a stressful task for the nurses, a scene with a lot of people or distractions may distract them from noting the time on the terminal. In this phase of the mission, the nurses are required to call the emergency room informing them about the patient and the necessary actions they need to take to be ready for the patient. The fourth part of the HTA is presented in Figure 3.16.

Work distribution

- 4.1: Both
- 4.2: Driver
- 4.3: Driver
- 4.4: Second nurse

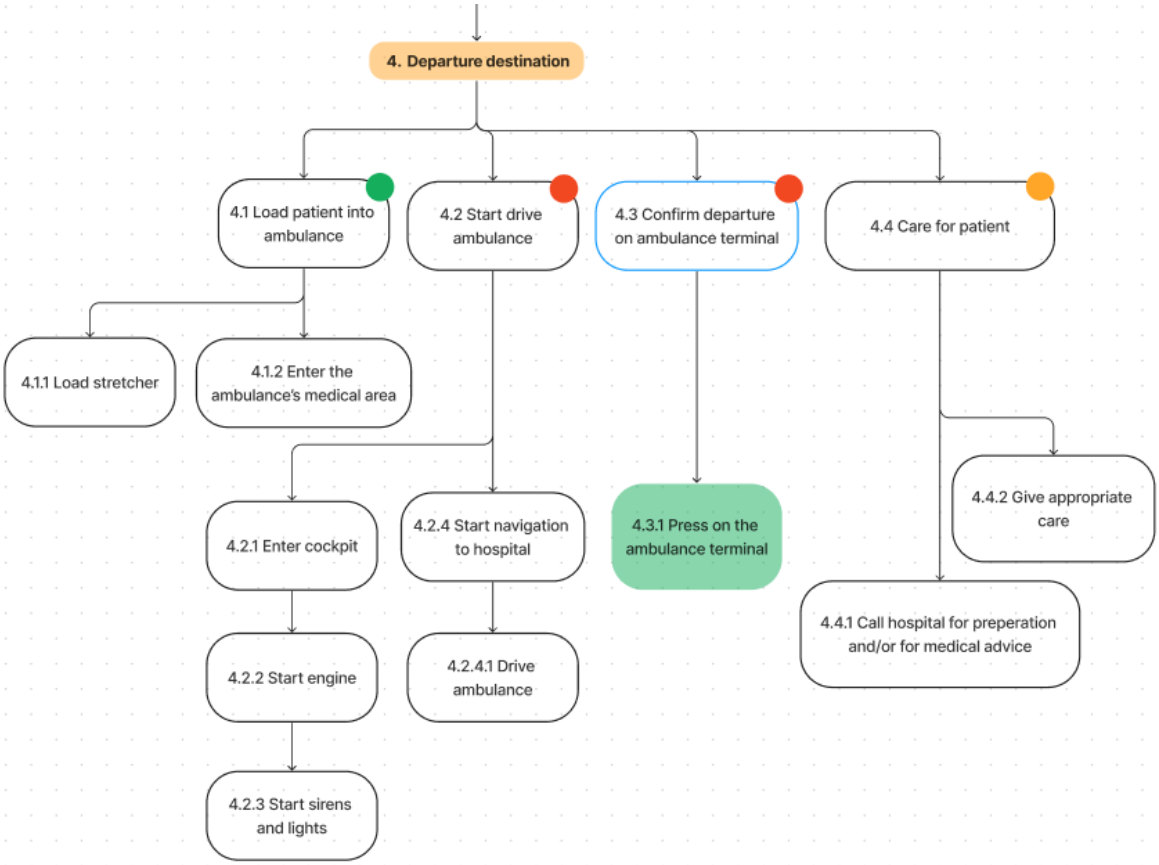

Figure 3.16: The fourth subtask of the HTA

3.7.7 Arrival hospital and transfer patient

When the ambulance arrives at the hospital the second to last step, the goal is to deliver the patient to the hospital. The driver needs to interact with the terminal in the ambulance cabin and mark the time of the arrival. Depending on the situation and the level of urgency this can be an easy or hard task to remember. As seen in 3.17. The fifth part of the HTA is presented in Figure 3.17.

Work distribution

- 5.1: Driver
- 5.2: Driver

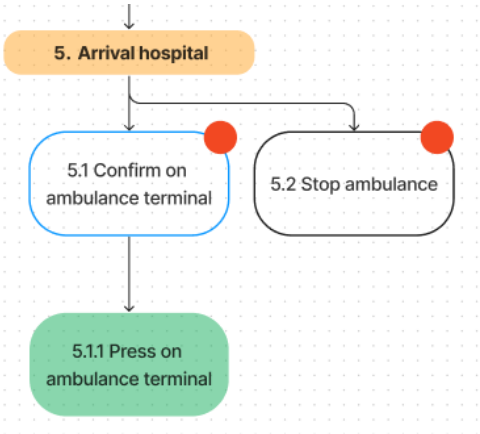

Figure 3.17: The fifth subtask of the HTA

The nurses proceed to unload and handover the patient to the hospital personnel. For this task, it is vital that the nurses and doctors at the hospital are able to receive the new patient. As the ambulance are not allowed to accept a new mission until they have passed on the responsibility of care to another medical professional at the hospital. After the transfer of the patient, the ambulance nurse who was giving care enters the necessary information in the patient's medical records on a separate computer in the garage. The second nurse proceeds to clean the ambulance and restock on equipment and consumables to ready it for the next mission. The sixth part of the HTA is presented in Figure 3.18.

Work distribution

- 6.1: Driver
- 6.2: Both
- 6.3: Second nurse
- 6.4: Driver

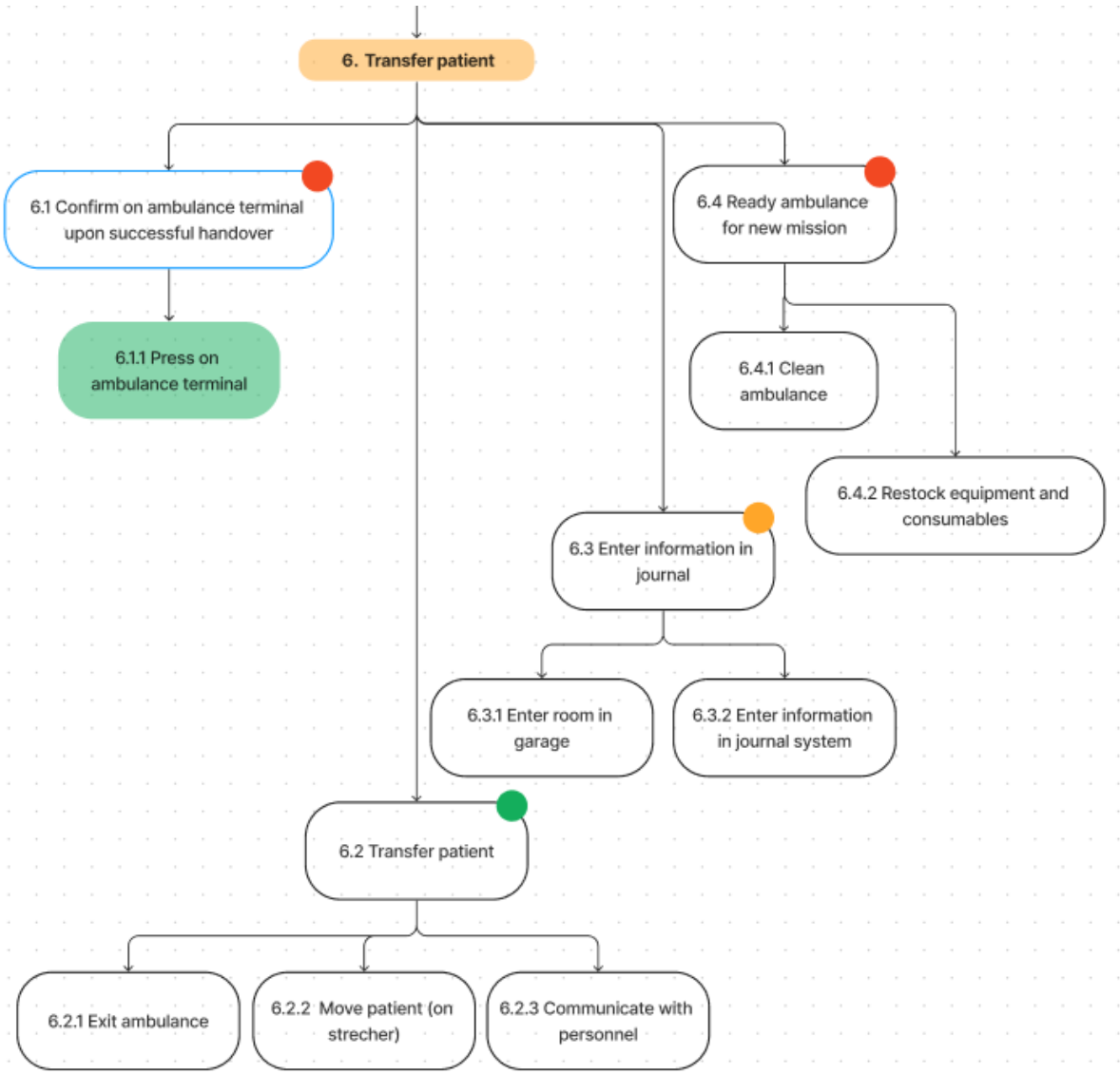

Figure 3.18: The sixth subtask of the HTA

3.7.8 Available and Mission complete

When the ambulance is ready the nurses enter the driver's cabin and mark the car as "Available" through the terminal and drive homewards. If they reach the ambulance station they can mark the mission as "Complete" manually, however there is a possibility of receiving a new mission before they are back at the station and if so the last mission will be marked as "Complete" in the instant they receive the new mission. The goal of successfully executing an ambulance mission is achieved. The seventh and eighth part of the HTA is presented in Figure 3.19.

Work distribution

- 7.1: Both
- 8.1: Both

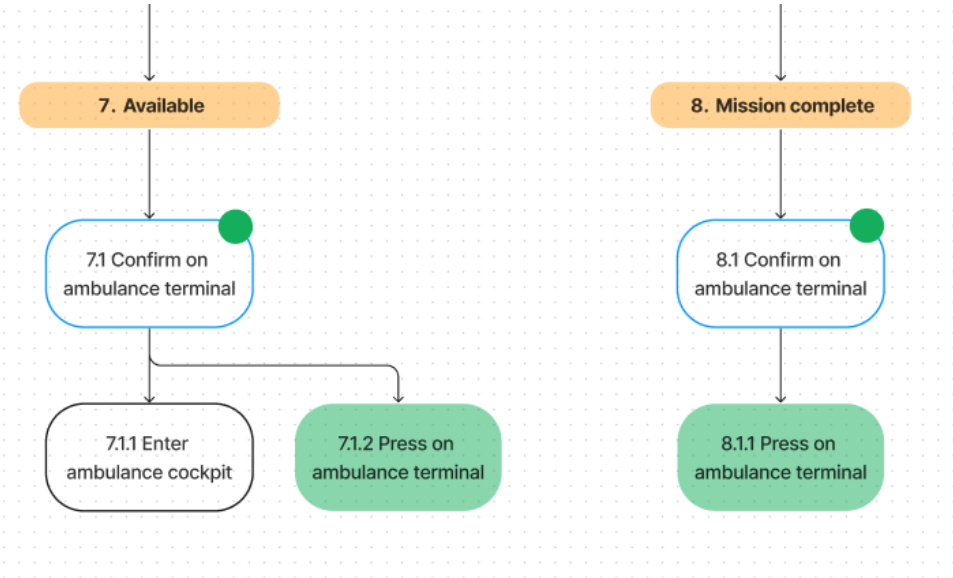

Figure 3.19: The seventh and eighth subtask of the HTA

3.7.9 Local deviations

There are some variances in the HTA depending on the local healthcare providers in the different counties, as presented in Scope of the HTA 3.7.1. Therefore, there are local deviations in the HTA compared to the general case described previously in the report. In this section of the report the discrepancies from different counties compared to the general case are presented. Only aspects deviating from the general case will be outlined. In the absence of specific information, it can be assumed that the general case is applicable to the local deviation. The county of VGR and Halland were the two counties that were possible to visit and further analysed.

VGR

As for VGR there are a few discrepancies and differences compared to the general case. These differences were noted during the conducted observation study presented in the section *Observations* 3.5. The first variation is in "task 3" (presented in Figure 3.20) where the ambulance nurses did not use the portable RAKEL unit to save the time stamp "Arrival patient" (eTimes.07) instead that time stamp is left blank. The decision to not use the portable RAKEL unit to check in is not requested nor advised from a organisational standpoint. The reason being that it is too strenuous and time consuming according to one of the interviews conducted. This matches the result from the email survey presented in 3.2.

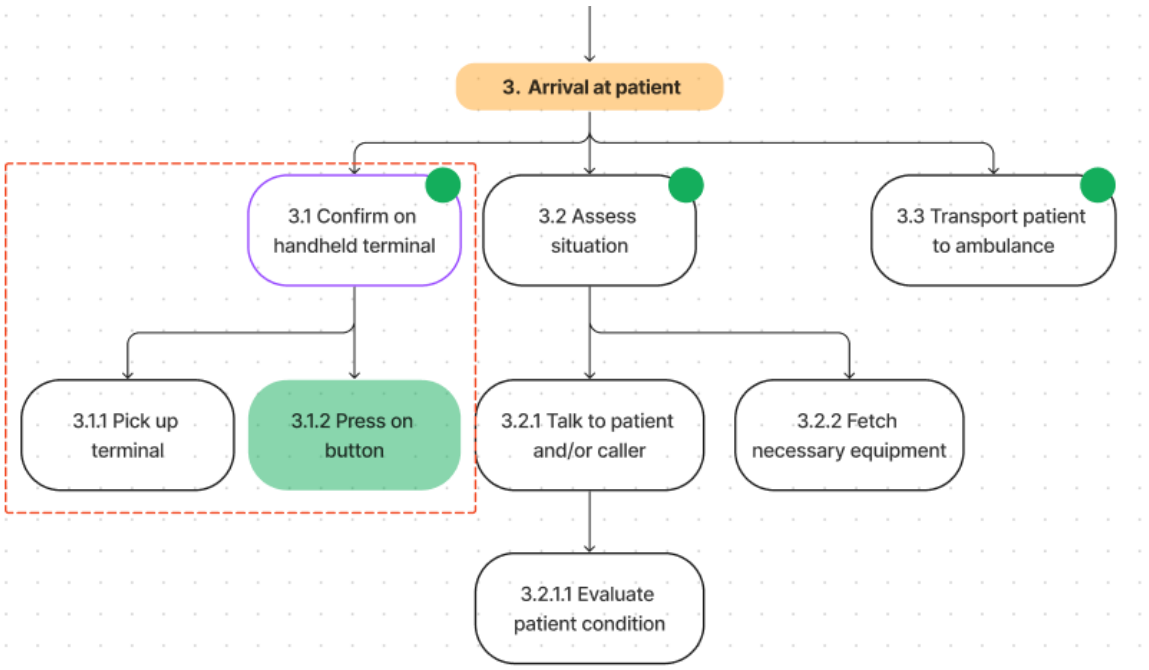

Figure 3.20: The VGR variation for Task 3

Lastly, the variation to the general HTA is the sixth task "Transfer patient" (eTimes.12), shown in Figure 3.21 where the ambulance personnel in VGR did not time stamp when handing over the patient to the medical personnel at the hospital. The reason being that there is no convenient method of reporting this from the emergency room inside the hospital. In theory, it could be done with the portable RAKEL unit, but as with "Arrival patient" this is too time consuming due to the interface of the unit not being intuitive and easy and is therefore not advised by each municipality's prehospital care responsible.

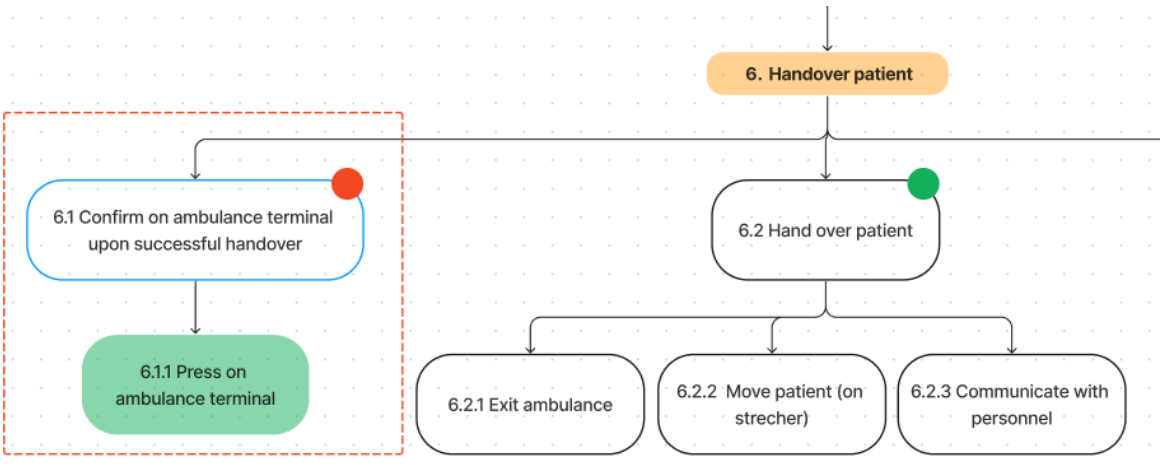

Figure 3.21: The VGR variation for Task 5

County of Halland

For the county of Halland, there is also some local deviations to the general HTA. The same deviations that applied to VGR also applied to Halland:

- Task 3: "Arrival patient" is not documented
- Task 6: "Transfer patient" is not documented

Beyond these, there are a few more deviations that relate to the combined hardware and software solution for the ambulances in Halland.The ambulance has two identical terminals, one permanently mounted in the drivers cabin and one portable terminal mounted in the care space. This makes it possible for the personnel to check info and edit the mission on the go, in addition the terminals are synced with the hospitals patient record system.

The first difference in the HTA is that the ambulance nurses need to take out their portable terminal along with the general equipment as the terminal is taken with to the patient. The portable terminal is mounted in front of the caregivers' seat that they are sitting in while attending the patient on the way to the hospital. The difference in the HTA diagram is shown in 3.22.

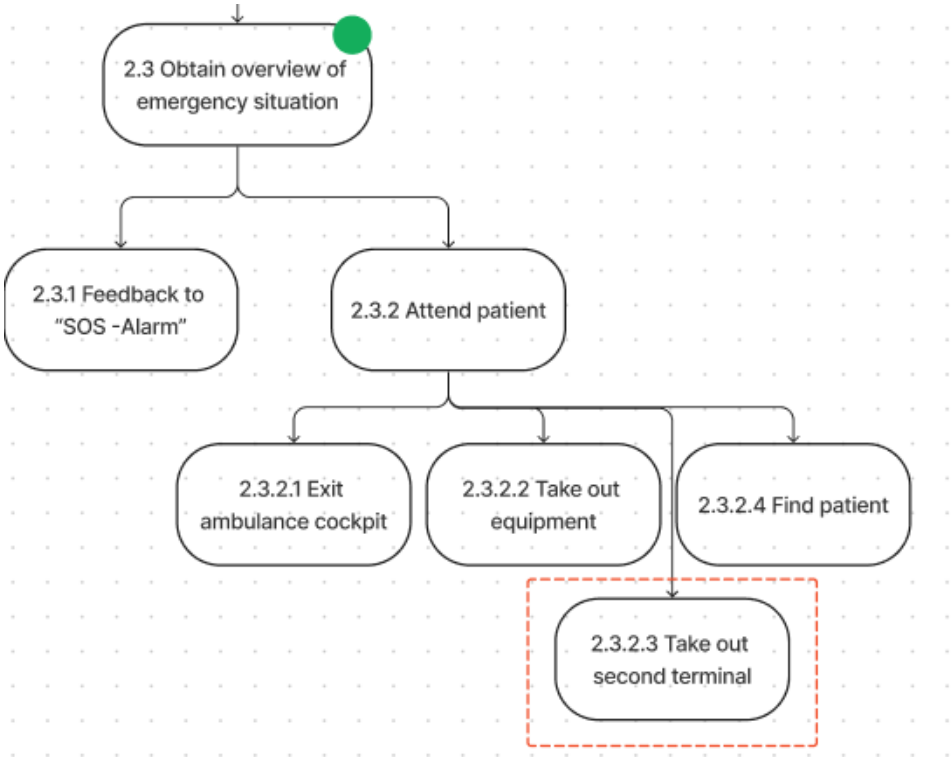

Figure 3.22: The county of Halland variation for Task 2

With the second terminal there is a possibility to check and edit the records on the way to the hospital. The records that the nurse edits (Figure 3.23)is directly linked to the hospital and so the medical staff at the hospital prepares for the patient's needs. As most of the edits to the medical records can be made on the fly before arriving at the hospital there is no need to enter information after the patient has been transferred at the hospital (as presented in the general HTA). See 6.3 in 3.18.

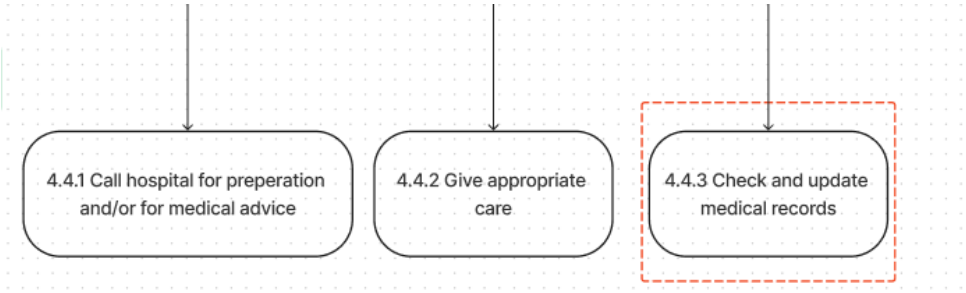

Figure 3.23: The county of Halland variation for Task 4

3.8 User involvement

To understand the end user perspective on the system and gather more data, user research was done. However, due to high pressure on the medical system it was a struggle to get time with the nurses and so alternative methods of gathering data were employed. The goal was to gather more data and opinions on a few key topics without taking up too much time from the nurses; for this the method Graffiti walls was a suitable option.

3.8.1 Graffiti walls

Graffiti walls is a method where a canvas is placed in the users' natural environment aiming to encourage the users to answer guiding questions while writing down thoughts as they perform the task (Martin and Hanington, 2012). The method was primarily chosen as it with minimal effort from the participants could gather valuable information whilst encouraging active participation from individuals in shaping their work environment. The method was considered suitable for the project. For the project a canvas (shown in Figure 3.24 with a mix of probing and creative questions were placed in the central ambulance station in VGR. The goal of the graffiti wall canvas was to gain insight into the thoughts of the ambulance nurses, and probe them on potential ideas.

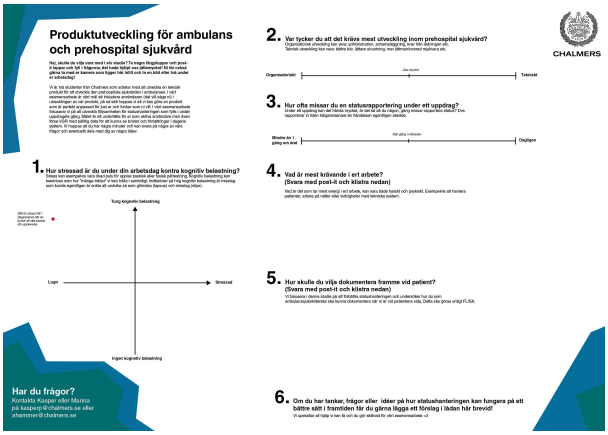

Figure 3.24: The canvas with questions and information

The canvas was printed on a A1 paper and mounted on a whiteboard in the break room at the central ambulance station, the material supplied were post-its, pens, small stickers and A4 papers as in Figure 3.25. The idea was for the users (ambulance nurses) to fill

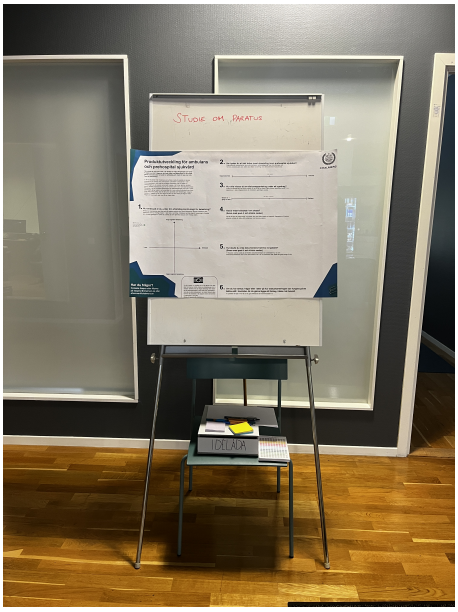

Figure 3.25: Setting up the graffiti wall

out the canvas during pauses or breaks in their work. The canvas was divided into six questions that tacked different parts of working as a ambulance nurse. The first three questions were "approximation questions" where the nurse were asked to take a small sticker and place it in a diagram.

The three questions were (translated from Swedish to English):

1. How stressed are you during your workday compared to cognitive load?
2. What aspect of prehospital care do you believe requires the most development?
3. How often do you miss changing the status (update the time stamp) during a mission?

Questions four-to-six on the canvas were more qualitative and asked the ambulance nurses to write down answers on post-its or sketching on paper. However, as question number six (Q6: If you have thoughts, questions, or ideas on how status management can work better in the future, please feel free to drop a suggestion in the box next to it!) did not generate any responses and will not be presented in this section. The goal of the study was to have a diverse set of questions probing - by asking how and why - the nurses about their day-to-day and their general opinions but also to let them be creative and suggest ideas for possible solutions or highlight problematic areas.

Q1: How stressed are you during your workday compared to cognitive load?

For the first question the nurse was asked to rank stress and cognitive load on a X-Y axis in a diagram, ranging from calm to stressed on the x-axis and low- to high cognitive load on the Y-axis. Together with the question presented a basic explanation of stress and what mistakes characterises high cognitive load (see exact question in the appendix E). The result is presented in Figure 3.26. In the diagram the result shows that the nurses have (what they consider) a normal stress level and act calmly. However, seven out of eight respondents think that they experience under considerable cognitive load. This

aligns with the previous observational study (section 3.5) where the ambulance nurses seemed focused on their work, but not stressed to a point where their mental well-being is impaired.

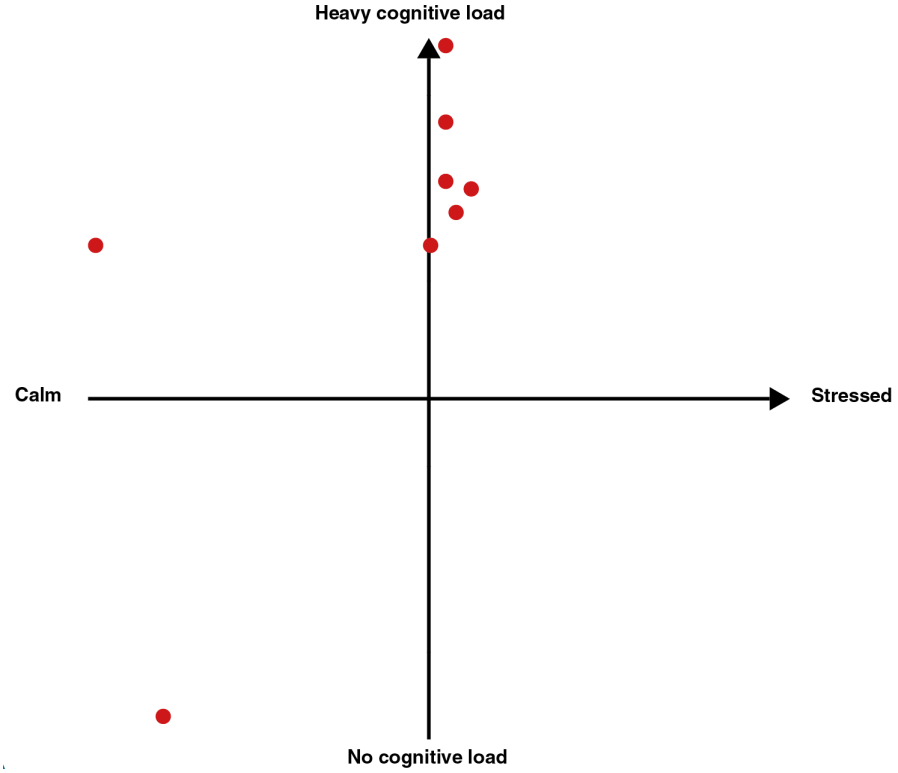

Figure 3.26: The response to the first question of the canvas; The vertical axis describes the cognitive load, while the horizontal axis describes the stress experienced

Q2: What aspect of prehospital care do you believe requires the most development?

From the observational study in section 3.5 it was clear that there were some problematic organisational structures that made life hard for the ambulance nurses. The question was formulated as a X-axis where the personnel could use a small sticker to mark their opinion. This questions goal was to understand if the nurses had any opinion on what was in most need of development, the technical- or the organisational aspect. However, in large the nurses answered that they considered the need for development to be equally important at this point in time (result shown in Figure 3.27). A couple of people had answered that they consider the organisational factor to be a bit more in need of development.

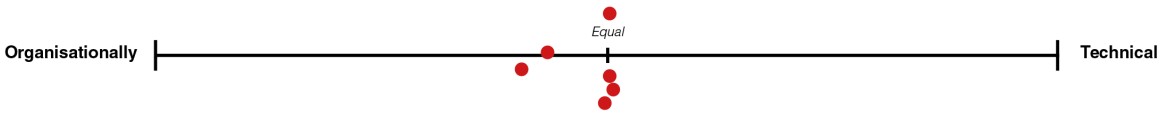

Figure 3.27: The response to the second question of the canvas. Showing Organisational to technical issues.

Q3: How often do you miss changing the status (updating the time stamp) during a mission?

To deliver more accurate data it is a must to understand how often there is an actual time stamp error and how often a data point is missed, delayed or entered prematurely. This inquiry answered the question whether the ambulance nurses actually missed time stamps or not. However, all of the stickers were placed at the far right and close to the "every day" mark, as shown in Figure 3.28. This shows that the nurses are aware of that there are errors made in the human-machine interaction and that they do miss logging data in the system.

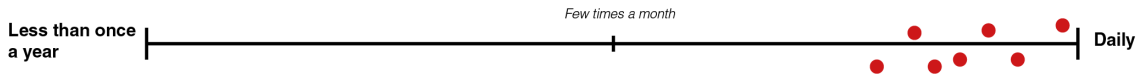

Figure 3.28: The response to the third question of the canvas. Showing the frequency of errors and miss clicks, from less than once a year to daily.

Q4: What is the most demanding in your line of work?

For question four the nurses were asked to write their answers on post-it notes and stick them on the canvas. The idea was to dig a bit deeper in to what they thought was the most difficult in their work. Here they were encouraged to elaborate and formulate an answer. The post-it notes were placed right under the question so other nurses could see answers and spin off each others answers and ideas. The result was highly focused on the technical aspect of the HMI (*Human Machine Interaction*) where the digital systems seemed to be undeveloped or not as user friendly as the nurses wished. Here are a few quotes from the canvas (translated from Swedish to English):

> *"Technical systems that do not synchronise with each other and that does not save to the cloud."*
>
> *"Sluggish apps, you need to keep so much information in your head."*

It is clear that the ambulance personnel wants to see development in how their digital tools both work and interact with each other but also how the personnel interacts with the system itself.

Q5: How would you like to document "Arrival patient"?

For the last question the nurses were asked how they wanted to document that they had arrived at the patient. This question, like the one prior, was of a qualitative nature and the nurses were asked to answer on post-its. The goal was to ask them if they had potential solutions to the problem. The question was a bit trickier than the previous ones and required the nurses to be a bit creative and think outside the box, therefore the questions only had two answers presented below (translated from Swedish to English):

> *Handle all information electronically, remove all paperwork.*
>
> *Connect Paratus to a tablet. And document everything on the tablet, documentation with paper is sub-optimal.*

The ambulance personnel may struggle with the systems of today, but they are not luddite. Moreover, the answers to this question show that they are confident in the potential of the implementation of technology in their workflow but they feel like the problem lies with implementation. The idea of using technology as an aid is therefore possible, and according to the answer to this question wished for. The second quote suggest using a portable terminal for documentation on the go and this is a solution both used by the county of Skåne and Halland today. The graffiti wall study was conducted at the central ambulance station in Gothenburg, mentioned in the introduction to the subsection. The answers to the question may therefore have differed depending on which county the study would have been conducted in.

3.9 Guidelines and requirements

To proceed in the project, some general guidelines had to be put into place. Initially there were eight steps identified which should be automatised or semi-automatised to relieve the cognitive load from the ambulance nurses yet after having collected data throughout the research phase, it was evident that there were five steps which should be either automatised or semi-automatised. The three steps and the reasoning for why they were excluded from the automation process are listed below.

- For accepting and confirming that the mission has started "Mission starts" (eTimes.05), the decision that this step needs to be accepted manually was made to ensure that the ambulance nurses consciously choose to take the mission as well as to guarantee patient safety.
- The status of "Available" (eTimes.13) should be actively chosen as well. The fact they the nurses cannot influence whether there is a queue at the hospital when handing over the patient as well as that refilling and re-organising the car could take up more time than planned for.
- The last step which the ambulance nurses have to think about registering manually is for ending the mission "Completed" (eTimes.16). The reason being is that the nurses have to know when they are finished with the mission entirely to be able to confirm a new one.

The guidelines aim to sum up the research phase and highlight the problem areas. Many of the stated guidelines have similar demands as they all concern the same system. The guidelines are categorised by either being necessary **N** or desirable **D** when looking at functionality or interaction.

3.9.1 Users affected by the guidelines

The primary target users of the conceptual design are the ambulance nurses who will interact with the concept. They are the ones using the time tracking system while pressing the confirmation buttons actively. The secondary target users are the counties of Sweden which would benefit from a more reliable time tracking system. Due to Sweden's counties regulating prehospital care autonomously, the concept should be adaptable for the counties' specific needs.

3.9.2 Understanding template times

Template times are the times or in this case time stamps that are approximated due to them not being tracked precisely. For the emergency in the time tracking system, major deviations between the template times and the actual times were found during the research phase which created the need for tracking the approximated times more thoroughly. There were two crucial time stamps "Arrival at patient" and "Transfer patient" that had major deviations according to the measured times during the observations (see section3.5) which will further be the focus of the project.

3.9.3 Guidelines - "Arrival destination" eTimes.06

Following problems when arriving at the patient's address were identified during the research phase:

- The probability of missing to confirm the arrival at the address is relatively low due to the fact that the ambulance needs to be parked and standing still. This could be concluded from the observations as well as the interviews. Yet the error margin is high as the ambulance may be parked in front of a gate first before driving the ambulance.
- The ambulance nurses are required to actively remember to press the button for creating the time stamp
- The cognitive work load is high according to the asked nurses (see section Graffiti walls 3.8.1).

The guidelines for the first mission times are summarised in Table 3.4.

Category	N/D	Description
Tracks the mission time	N	The missing time stamp is created. This is the main function of the system.
Works with current system	N	The time is tracked in *Paratus*' current version or later.
Increases working efficiency	N	The time stamp should enhance the efficiency and effectiveness of the system.
Operates automatic	D	The time stamp is registered without any or minimal human interaction.
Has to be implementable	D	The technology for implementing the changes to the registration system should be given.
Supports intuitive workflow	D	The time stamp is registered without any or minimal human interaction.

Table 3.4: List of guidelines for "Arrival destination" eTimes.06

In terms of interaction with the system, the new time stamp registration needs to be easy to follow for the ambulance nurses to not steer their concentration away from their actual work processes or the traffic situation.

3.9.4 Guidelines - "Arrival patient" eTimes.07

Aiming towards a better reliability to when the ambulance nurses arrive next to the patient, the following list of guidelines was set up and collected in Table 3.5. It makes a vast difference whether ambulance nurses are next to the patient two minutes or 14 minutes, and these minutes are not tracked accordingly. These guidelines include functional and technical aspects as well as design guidelines targeting the more intangible values of the project such as cognition, stress and satisfaction for the users.

Category	N/D	Description
Tracks the mission time	N	The missing time stamp is created. This is the main function of the system.
Works with current system	N	The time stamp should be tracked with the current version of the time tracking system *Paratus* version 25
Works with the future updates system	D	The time stamp should be able to be tracked with the updated versions of the time tracking system *Paratus* version 26 and further
Acts automatically	D	Time stamps are automatically created without manual confirmation such as pressing buttons by the ambulance personnel.
Allows for adjustment retrospectively	N	Time stamps created should be able to be changed and adapted accordingly to the missions if necessary.
Works on multiple devices	N	A time stamp may be created outside of the ambulance meaning that it has to be accessible to the ambulance nurses through all their devices.
Has to be intuitive	N	If the system is not automated the confirmation has to be executed intuitively for the ambulance nurses.
Increases working efficiency	N	The time stamp should enhance the efficiency and effectiveness of the system.
Supports manual registration	D	Registering the time stamp should be easy to remember and not require more mental capacity than necessary.
Allows for retrospective adaption	D	If a time stamp is registered faulty the option of editing the time should exist.

Table 3.5: List of guidelines for "Arrival patient" eTimes.07

3.9.5 Guidelines - Departure destination eTimes.09

In Table 3.6 the guidelines for the departure with the patient from the patient's location are described.

Category	N/D	Description
Tracks the mission time	N	The time stamp is registered.
Works with current system	N	The time is tracked with the current version of the time tracking system *Paratus* version 25.
Works with the future updates system	N	The time stamp should be able to be tracked with the updated versions of the time tracking system *Paratus* version 26 and further.
Registers automatically	D	A timestamp is automatically created any without manual or active decision making of the ambulance nurses.
Provides directions	N	Using correct GPS data to get to the hospital to support driving to the hospital.
Allows for adjustment retrospectively	D	Time stamps created should be able to be changed and adapted accordingly to the missions if necessary.
Registers semi-automatically	N	The ambulance nurses receive help to remember to track the time.
Supports manual registration	D	Registering the time should be easy to remember and not require more mental capacity than necessary.
Has to be intuitive	N	If the system is not automated the confirmation has to be executed intuitively for the ambulance nurses.
Increases working efficiency	N	The time stamp should enhance the efficiency and effectiveness of the system.

Table 3.6: Specific guidelines for "Departure destination" eTimes.09

In the present day's solution, the ambulance nurses press the button "Lastat" to confirm that they have transferred the patient from the pick-up location while also having to decide which hospital to go to in order to transfer the patient. The selection of the hospital is crucial for the next step "Arrival hospital" eTimes.11.

3.9.6 Guidelines - "Arrival hospital" eTimes.11

Upon arrival at the hospital, the ambulance nurses do not only have to take care of the patient even if they are operating in pairs where one nurse is the driver and the other is giving necessary medical care, but also open the garage doors, park and confirm the arrival. To reduce the chain of events and the mental work load, guidelines supporting this step of the mission were set up according to Table 3.7.

Category	N/D	Description
Tracks the mission time	N	The time stamp is registered.
Works with current system	N	The time is tracked with the current version of the time tracking system *Paratus* version 25.
Works with the future updates system	N	The time stamp should be able to be tracked with the updated versions of the time tracking system *Paratus* version 26 and further.
Registers automatically	D	A timestamp is automatically created any without manual or active decision making of the ambulance nurses.
Allows for adjustment retrospectively	D	Time stamps created should be able to be changed and adapted accordingly to the missions if necessary.
Opens the garage doors	N	The garage doors are opened upon a button press by the nurses.
Registers semi-automatically	N	The ambulance nurses receive help to remember to track the time.
Supports manual registration	D	Registering the time should be easy to remember and not require more mental capacity than necessary.
Has to be intuitive	N	If the system is not automated the confirmation has to be executed intuitively for the ambulance nurses.
Increases working efficiency	N	The time stamp should enhance the efficiency and effectiveness of the system.

Table 3.7: Guidelines for the missing time stamp "Arrival hospital" eTimes.11

3.9.7 Guidelines - Transfer patient eTimes.12

The second time stamp that is not tracked is the time were the patient is handed over by the ambulance nurses to other medical caretakers at the hospital. During the process of transferring the patient the ambulance nurses also hand over the responsibility of care

to the hospital staff which essentially marks the end of this step and is the cutting point where the time should be registered. Table 3.8 shows the guidelines for the time stamp "Transfer patient" (eTimes.12) which is currently missing in the existing data collection.

Category	N/D	Description
Tracks the mission time	N	The time stamp is registered.
Works with current system	N	The time is tracked with the current version of the time tracking system *Paratus* version 25.
Works with the future updates system	N	The time stamp should be able to be tracked with the updated versions of the time tracking system *Paratus* version 26 and further.
Registers automatically	D	A timestamp is automatically created any without manual or active decision making of the ambulance nurses.
Allows for adjustment retrospectively	D	Time stamps created should be able to be changed and adapted accordingly to the missions if necessary.
Registers semi-automatically	N	The ambulance nurses receive help to remember to track the time.
Supports manual registration	D	Registering the time stamp should be easy to remember and not require more mental capacity than necessary.
Has to be intuitive	N	If the system is not automated the confirmation has to be executed intuitively for the ambulance nurses.
Increases working efficiency	N	The time stamp should enhance the efficiency and effectiveness of the system.

Table 3.8: Guidelines for the time stamp "Transfer patient" eTimes.12

With these guidelines in mind the development phase was kick started.

4

Results - Development and synthesis

In the following chapter, the results deriving from the methods and research chapter are synthesised and presented. This section of the report focuses on the ideation phase and concept development.

4.1 Present day's development - PICTA Forum

To kick start the ideation phase of the project, the opportunity to take part at PICTA Forum was taken. PICTA Forum is a day which revolves around the development within the field of prehospital care and gives companies and organisations a platform to get together and discuss the latest developments. The forum is held twice a year and initiated by PICTA to start conversations and highlight the areas where adjustments have to be made. The entire day proved itself to be beneficial for the project as many relevant actors were either speakers or exhibitors.

Omda is a company which focuses on delivering software for health and emergency professionals with the aim to support their work with smarter technology (Omda, 2024). They are creating solutions to track and streamline the processes when on an ambulance mission by integrated their software seamlessly into the gadgets the ambulance nurses use. Omda has developed the time tracking system *Paratus* which can be adapted on demand of the customer. This means that *Paratus* can look differently in terms of functionalities and interfaces. Talking to the company and gaining a better insight into *Paratus* in terms of authorisation and how much the system is locked to specific conditions.

Besides the conversation with *Omda*, various projects in the field of prehospital care were presented and panel discussions were held.

4.2 User involvement inspired by co-design

To involve the users and use others expertise a co-design initiative was launched. Co-design is the activity of designing together for knowledge generation and identifying potential solutions to complex problems (Eriksson et al., 2021). As this thesis tackles a complicated and previously unexplored topic it was of high importance to incorporate the users and people in other engineering fields to acquire diverse insight and knowledge in the topic. The original plan was to do this by making a co-creation workshop with a diverse set of technical specialists, engineers and ambulance nurses. The goal of the co-design initiative was to diversify and to expand the solution space. However, scheduling is a complicated matter and there were no possibilities to assemble a diverse team on working

hours as the participants works for different companies. So, an alternative combination of methods was assembled to compensate for the absent workshop. As the main problem was time and scheduling the focus was on enabling co-design without the requirement of the participants needing to be in the same place at the same time.

4.3 Interactive digital case study

The interactive digital case study, short **IDCS**, ought to let individuals with and without prehospital backgrounds ideate freely without any guidance or interference. The digital case study presented an ambulance mission in smaller parts and gave the participants prompts to ideate. The participants were a mix of non-designers, two mechanical engineers, a innovation engineer as well as three industrial design engineers. The combination of the participants was deemed to be valuable to yield both feasibility and innovation among the ideas that were to be generated. The methods used to idea generate were brainstorming, six thinking hats and SCAMPER without using the terms of these methods but providing the right inputs for them. The result from the participants were clustered into to interactive case steps and the common denominators were highlighted as shown in Figure 4.1.

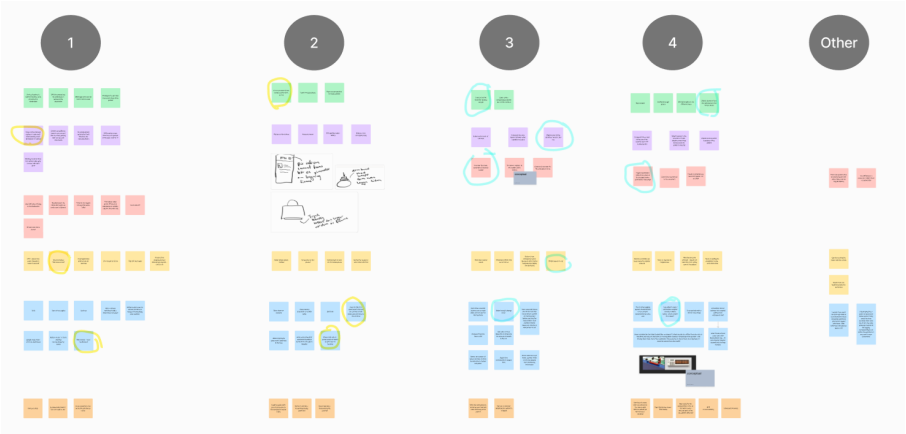

Figure 4.1: Schematic overview of the result of the IDCS

The schematic overview and clustering gave a deeper insight into how the co-designers would approach solving the identified focus areas. The entire case study was sent out and answered to in Swedish and can be found in the Appendix F. The results and the descriptions are summed up in English.

4.3.1 The start of the mission

In the first instance the participants got to use SCAMPER as a primary ideation method. SCAMPER's approach is to help creative thinkers develop and come up with new ideas trying to substitute, combine, adapt, magnify, use differently, eliminate or reverse different functions (Serrat, 2017). However, the participants did not know which brainstorming method they were using.

During the start of the case's ambulance mission the participants of the interactive study

got to follow along with two ambulance nurses. The nurses' day was based on the observations and interview answer from the research phase.

The participants of the interactive study received two prompts to ideate around (translated from Swedish to English):

1. Are there other possibilities for the system to know or track if they have arrived at the patient's address?
2. Can you add, remove, adapt or substitute any of the functions?

Figure 4.2: Ideas generated SCAMPER

During ten minutes, the six participants came up with multiple ideas as answers to the two questions that were asked. Using GPS for detection to where the ambulance is was a common idea that various participants had as well as using sensors in the doors of the ambulance determining that the car has stopped. The system would register this by itself without any human interaction which would eliminate the mental cognitive load. Interestingly, three participants mentioned voice detection or voice control as a potential feature to use for the ambulance nurses. This is shown by the red circles in the in Figure 4.2. The voice control should pick up and store easy commands such as "Arrival destination" which automatically saves the time stamp for "Arrival destination" (eTimes.06). Another innovative thought was to install cameras inside and outside of the ambulance and letting the ambulance system learn certain patterns of movements of the ambulance nurses near the car. This would require extensive testing before it would be ready for implementation yet with the current technological advancement it may be a potential solution in the future.

4.3.2 Arrival at the patient

The second activity of the interactive study was to ideate around "Arrival patient" (eTimes.07), namely registering the time at which the ambulance nurses arrive next to the patient. The time stamp for "Arrival patient" currently leaves a blank space in the system, as described in the section (3.9) Guidelines. In image 4.3, the ideas according to the given task *They are next to the patient now but there is a lack for registering the time in their records. Note down or sketch any ideas of possible solutions for registering the time stamp within the next five minutes!*, are displayed.

Figure 4.3: Ideas from using brainstorming as an ideation method

In this step no limitations were set in terms of the the ideas feasibility or technical solution space. Multiple ideas were tied to a handheld device, an extra terminal, or paper documentation. As there are technological advancements and reorganisations happening in the prehospital area, the documentation through a notepad seemed regressive in comparison to annotating everything on an electronic device. What stood out was that the participants thought a body (most commonly wrist) mounted activity tracker would be a good option to track the time of the mission. The activity tracker, some suggested smart watch, should allow the ambulance nurses to easily access the system and therefore create a time stamp at the press of one button. Both nurses shall in this case have an activity tracker and the first one to press the button would register the time stamp. Another idea was to use voice input for letting the system know that the nurses have arrived next to the patient. Essentially to be able to speak directly to the terminal to access functionalities or document in the medical records. The idea to use voice recognition is one that requires more in-depth and detailed research and testing. Whilst voice assistance has come a long way since the early beginnings, the medical setting is a highly dependable on functioning technology which is why this seems to not be included into ambulance care.

4.3.3 Departure destination and arrival hospital

In this step of the participatory case study, the participants got to come up with solutions for both "Departure destination" (eTimes.09) and "Arrival hospital" (eTimes.11). The question asked to the participants: *Are there any functions that can be added to the system to let the ambulance know that the patient is loaded into the ambulance?*

Figure 4.4: Ideas from using brainstorming as an ideation method

The ideas during this ideation sprint were quite scattered due to the fact that the participants had not received a specific ideation method or were limited on what to ideate around. The output is shown in Figure 4.4. Just like in the step before when the participants got to ideate on how to register the time of arrival next to patient, some ideas were similar to one another. Multiple mentioned, a sensor in the car that could detect the change in weight meaning that a time stamp is created for when the patient is lifted into the car. Further, the idea on video surveillance came up once again. Letting cameras track and detect when the patient is in the ambulance. For arriving at the hospital, people stated that the ambulance nurses could open doors with their activity trackers or that there should be coloured buttons to determine whether they had loaded the patient into the car or not.

4.3.4 Transfer patient

Using the ideation method of Six thinking hats which was developed by Edward de Bono (de Bono, 1967), the participants were asked to come up with suitable solutions for documenting the transfer of the patient to the hospital personnel. The participants then had five minutes to ideate around the following question: *How would you solve or try to solve this problem? Try to think through multiple ideas from a critical, innovative, positive, negative as well as emotional perspective!*

Figure 4.5: The participants inputs for "Transfer patient" (eTimes.12)

Looking at the ideas that the participants came up with some of them were more conceptual than others yet interesting from an user interaction point of view. One idea that stood out was using the same system as for keeping track of points during table football matches (or counting toy) where the users would move one "bead" from one side to another to register when they have handed over the responsibility of care. Other ideas to register the time of the arrival was similar to parcel tracking on a smartphone. When the patient is handed over the ambulance nurses would receive a notification to the ambulance nurses after a successful transfer. Radio-frequency identification tags were mentioned as well. This type of identification happens automatically where every tag is tied to one individual specifically. With the near field radio tracking the ambulance nurses would then have to check in with their tag at a tag-reader. A common denominator throughout all the ideas was using a digital signature for when the patient is handed over. More conventional ideas such as pen and paper were mentioned as well.

4.4 Brainstorming

Besides the PICTA innovation day and sending out the interactive digital case study as well as using graffiti walls described in section 3.8.1, a creative idea generation process was initiated.

With the results of the research phase in mind as well as the guidelines that were set up in section 3.9, focusing on the "Arrival destination", "Arrival patient", "Departure destination", "Arrival hospital" and "Transfer patient". Keeping the guidelines in mind to avoid generating solutions outside the scope of the project, the idea was to brainstorm within each stage during an ambulance mission. The output of the brainstorming session is shown in the Figure 4.6.

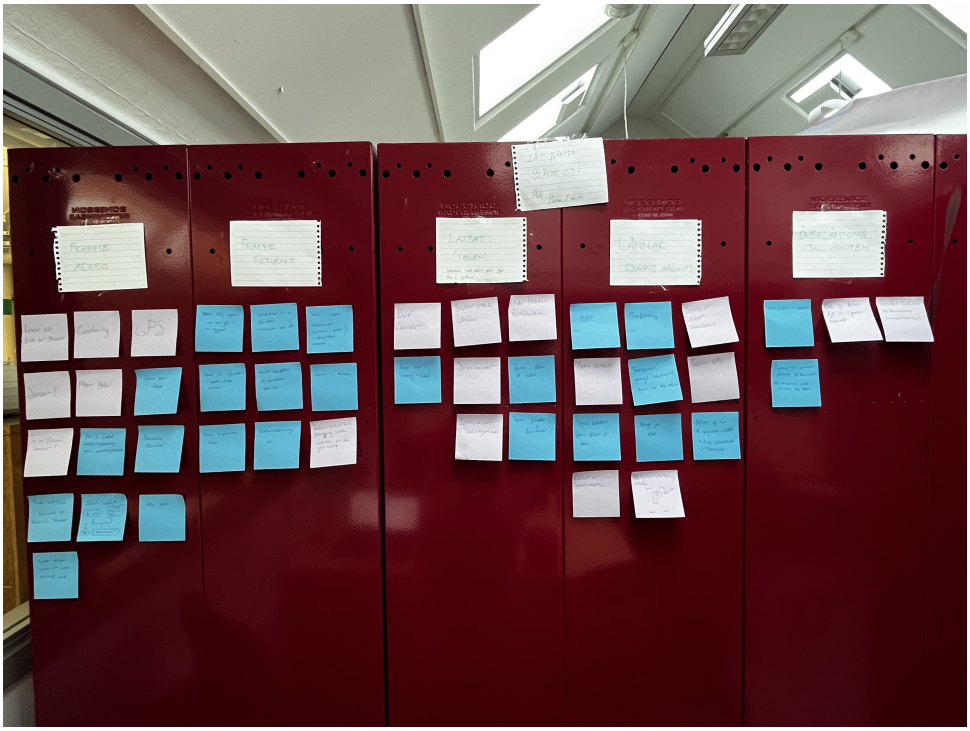

Figure 4.6: Brainstorming session's output

As shown in Figure 4.6 the ideas in this step went from easier ways of implementation to more innovative ideas. After getting to know that the *Paratus* system is not locked to any changes but rather can be accustomed to desire and liking by each county, the idea was to come up with suggestions that could be making an immediate impact. The ideas also derived from the flow of incidents and the described HTA tied to the equipment of the ambulance.

4.4.1 Arrival destination

Currently, this step requires an entirely manual confirmation from the ambulance nurses where they press the button "FRAMME" at the patient's destination or the address which the ambulance team received from *SOS Alarm*. To alleviate the pressure from the ambulance nurses and decrease the cognitive mental workload the idea was to automate this step as much as possible.

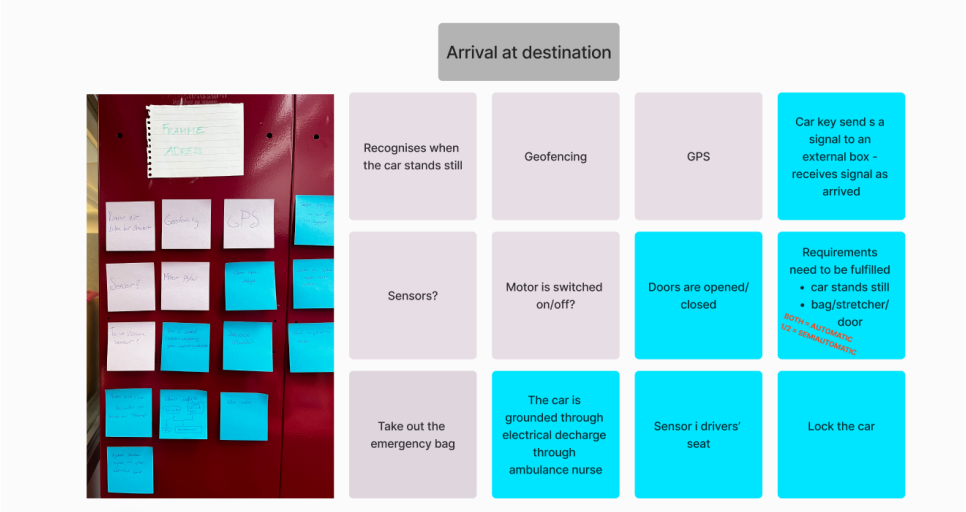

Figure 4.7: Ideas surrounding the arrival at the patient's address

When it comes to detecting whether the ambulance is at the desired destination - the patient's address - *SOS Alarm* uses a map with GPS in order to determine the location of the ambulance. This is done by displaying the ambulance within a predefined geographic area. When the ambulance enters the specific predefined area a notification is sent to *SOS Alarm*. This technique has potential in the arrival at the patient's address step as well due to that the technology is already implemented in some way in the process of patient delivery. The ideas brainstormed are presented in Figure 4.7.

Other ideas involved sensors built into the seats or seat belts as well as a possible solution using the car key when locking the car to create a time stamp or add a sensor into the medical bag as it is was one of the items that the ambulance nurses took with them on every mission.

4.4.2 Arrival patient

This step in the chain of steps for an ambulance mission is not tracked or monitored at all currently yet plays a crucial role in how the turnout of the prehospital care will be. Instead, a roughly approximated time according to a template is used (see section 3.9.2). If the approximated time is not used, this leaves an unknown blank space in the time tracking system which decreases its credibility.

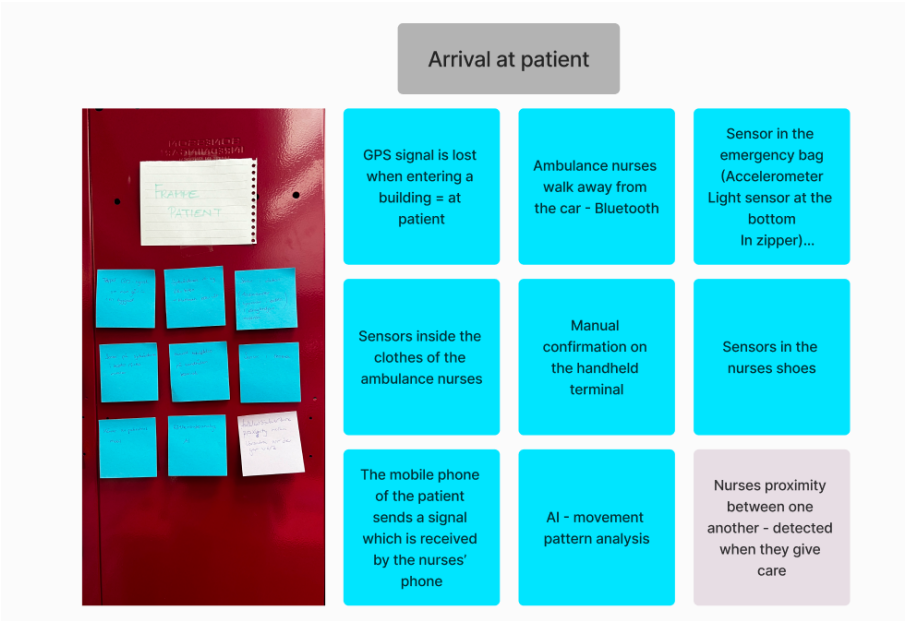

Figure 4.8: Brainstorm to the arrival at the patient

The alternative ideas are shown in Figure 4.8. Due to the fact that the ambulance nurses will enter a building in most cases the GPS signal from a phone or any other GPS device will be lost. One idea was that a time stamp is automatically created when the GPS signal is lost. While this would generate an automated solution for this missing time stamp the accuracy is low. Even if the signal is lost when the nurses enter the building that does not automatically imply that they have arrived next to the patient. Examples of this could be for instance, waiting for the elevator or climbing stairs. To avoid that this crucial time is tracked accordingly, the idea is to encourage the ambulance nurses to confirm the arrival next to the patient manually. Other options proposed in this step were sensors in the ambulance nurses clothing, zippers to bags and even an AI movement analysis that would allow to better understand the ambulance nurses movement patterns while giving care to the patient.

4.4.3 Departure destination

Departure from the destination marks the time when the patient is been placed into the ambulance on either the stretcher or onto the seats in the emergency care space. This step is currently tracked when the ambulance nurses are about to start the car's engine again and actively press on the front terminal that the patient is loaded and that they are departing. Coinciding with the confirmation that the ambulance is departing from the patient's address a choice for driving to a specific hospital needs to be made. Crucially the time stamp is generated **after** the patient is loaded into the ambulance which is why the ideas below 4.9 are discussed in this section.

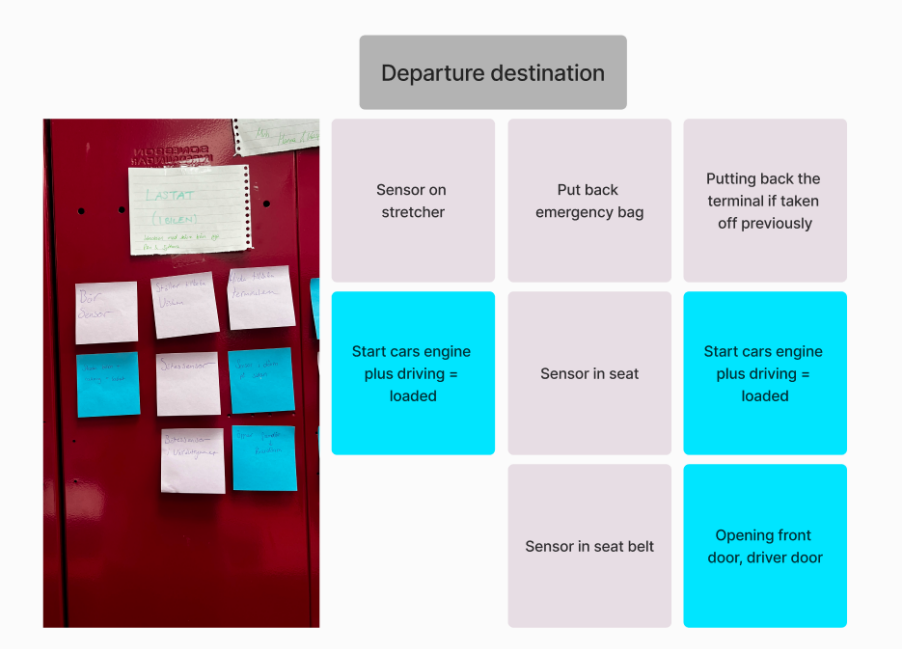

Figure 4.9: Ideas for the departing process

Similar to the arrival at the patient's destination, GPS and geofencing could be used to determine whether the ambulance has left the predefined geographic area. This though gives only an estimation of the actual time. A solution could be to build a weight sensors into the stretcher that detect the change in weight applied and therefore creates a time stamp in the time tracking system. Further solutions that were generated in this process were the usage of sensors in the drivers seat or the seat in the emergency care space in the ambulance, using the front or side doors to determine whether the nurses have loaded the patient into the ambulance or not and solutions like putting the terminal back into place which would automatically create a time stamp within the system. Lastly, the ambulance nurses have to select a hospital to drive to while being on a mission which could be used to confirm and register the time that they have picked up the patient. This would require minimal adaption to the system as well as the ambulance nurses.

4.4.4 Arrival at hospital

Hospitals are protected objects in Sweden (Götaland, 2024) which means that they are protected and "invisible" for some technology such as GPS when the ambulance is close enough. Presently, this step is confirmed manually by the driving ambulance nurse as well which means that they need to have to be actively thinking about pressing the button for their arrival at the hospital. Below in 4.10 the ideas surrounding this step are presented.

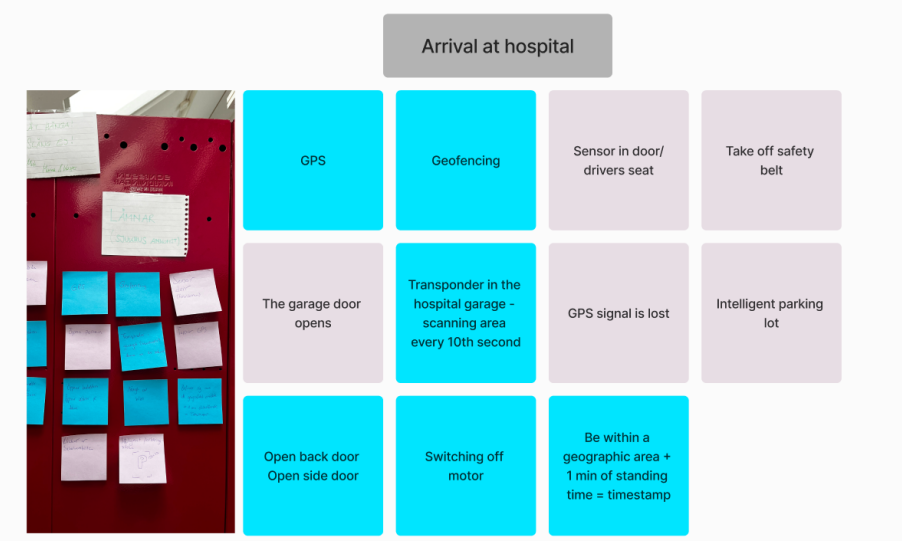

Figure 4.10: Brainstorm to the arrival at the hospital

When approaching the hospital, the disappearance from the GPS could be used to generate the time stamp automatically. Yet again, this creates an imprecision in the time that is tracked in the system as the car is not yet standing still but has entered the geographically protected area. To increase the precision of the time that is registered, an idea was to use the garage door opening button as an indicator for having arrived at the hospital. This would still require manual confirmation from the ambulance nurses as the doors do not open by themselves. Other suggestions were to install a transponder in the garage which scans the hospital's parking garage within reasonable intervals which then registers the newly arrived ambulances, having sensors in the safety belts that are taken off on arrival as well as sensors that are built into the doors.

4.4.5 Transfer patient

The final step in the brainstorming process was to find a solution for adding the time when transferring the patient. As mentioned in section 3.7.7, the responsibility of care has to be transferred to the emergency care personnel to be able to further proceed with making themselves available ("Available") for a new mission again. That time stamp is missing as for now and is either annotated automatically by a time approximation or not registered at all. This step proved itself to provide the most challenges and fostered less ideas than the other steps as shown in Figure 4.11.

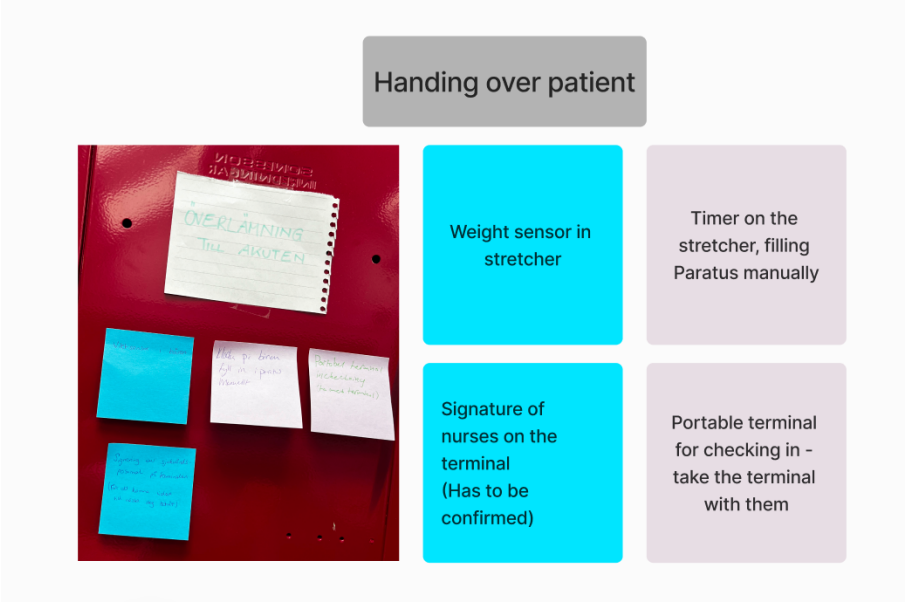

Figure 4.11: Brainstorm to the arrival at the patient

During the observation study (section 3.5) it became evident that the ambulance nurses were not carrying any additional items with them into the emergency room besides the stretcher (in case they had loaded the patient onto the stretcher). Installing a weight sensor on the stretcher could register the weight change and use this information as a way to determine the time where the patient is lifted from the ambulance stretcher to a hospital bed or similar. This does however not work if the patient is able to walk (that can be the case for emergency psychiatric missions). For all the cases were a stretcher is not used, the terminal could be used as a device for the hospital personnel to sign that the patient has left the ambulance nurses responsibility.

4.4.6 Idea elimination

As the ideas from the brainstorming process as well as the conducted **IDCS** were both realistic and innovative, it was worth going back to the initial goal set up in the beginning, namely proposing a concept which would be implementable in the near future. Here many ideas fell out of the scope of the project. The remaining ideas were clustered and combined in multiple ways, generating various working concepts. However, oftentimes the key to innovation lies in simplicity which is why the final concept design is described in the next section 4.5, Concept Design.

4.5 Concept design

The development of the concept design is an elimination process of ideas best fitting the goal of the project whilst also ticking all the boxes for the scope and demarcations. As the brainstorming phase came to a close, it was time to select and try different combinations and make a final concept. The concept is the result of all previous research and development work and is seen as the best solution to the problem described and to answer the research question:

Is it possible to increase the overall reliability of the time tracking system and how can a conceptual design proposal reduce the error probability caused by a system not accounting for external factors?

The concept can be divided into multiple parts where each part of the ten step process has different conditions and circumstances, as described in section 3.9 Guidelines. In the Figure 4.12 a timelines is presented with possible solutions to each part of the ambulance mission. Since two steps are handled by *SOS Alarm* (eTimes.02 and eTimes.03, see Table 4.1) they are not included on the presented timeline. The other eight time stamps are added to the timeline and were therefore included in the concept design.

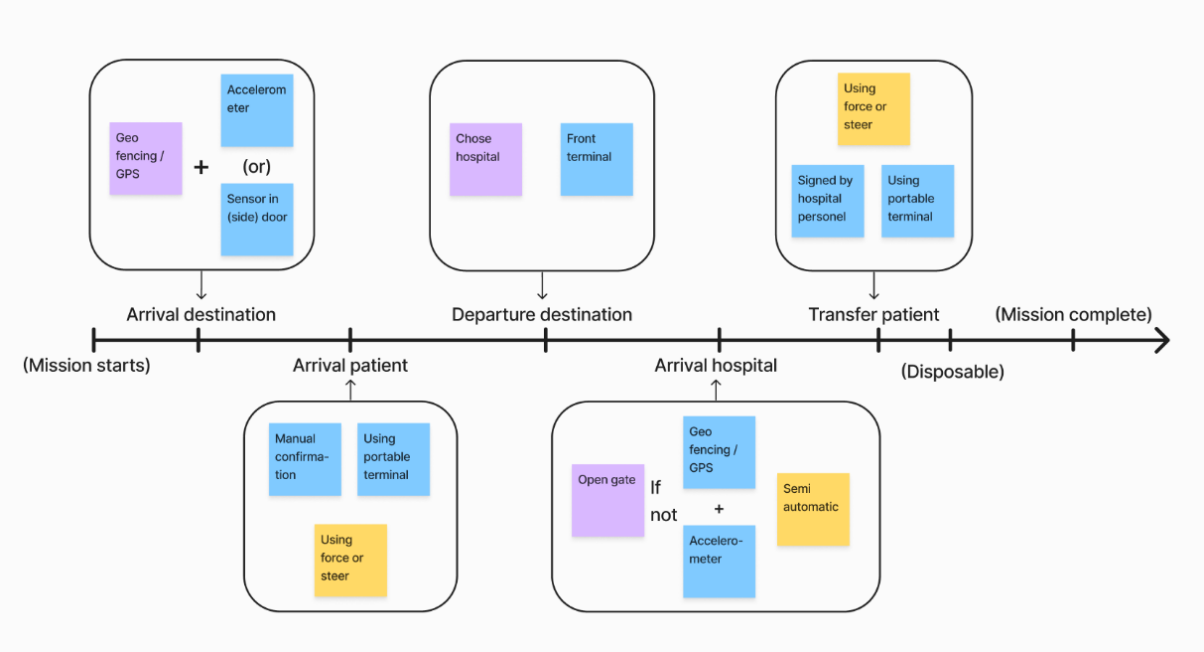

Figure 4.12: Map over the time line, with suggested solutions to each time stamp

Number	Name	Responsible	Code
1	Answered emergency call	*SOS Alarm*	eTimes.02
2	Alarm to ambulance	*SOS Alarm*	eTimes.03
3	Mission starts	Ambulance	eTimes.05
4	Arrival destination	Ambulance	eTimes.06
5	Arrival patient	Ambulance	eTimes.07
6	Departure destination	Ambulance	eTimes.09
7	Arrival hospital	Ambulance	eTimes.11
8	Transfer patient	Ambulance	eTimes.12
9	Available	Ambulance	eTimes.13
10	Mission complete	Ambulance	eTimes.16

Table 4.1: The 10 steps from the FLISA standard (FLISA, 2020)

The timeline consists of the eight steps, three of these are in parenthesise as they are deemed to not change compared to the current system (as described section 3.9 Guide-

lines). As the ambulance nurses need to be completely aware of the start of a mission it is necessary for the action to be manual. The ambulance nurses will therefore continue to manually accept their missions on the ambulance terminal (or portable RAKEL unit) in the proposed solution. The same goes for the "Available" (eTimes.13) and "Mission complete" (eTimes.16). The mission should only be concluded if the ambulance nurses manually confirm a termination as they mark themselves ready for a new mission. Therefore, there are only five instances that need to be adapted for concept development and design. A solution for each will be presented in this section of the report. The goal being to achieve either full automation, or design the solution so it eliminates errors in the HMI which will lead to more reliable time tracking system.

The five steps selected

- Arrival destination (eTimes.06)
- Arrival patient (eTimes.07)
- Departure destination (eTimes.09)
- Arrival hospital (eTimes.11)
- Transfer patient (eTimes.12)

For the description of the final concept, it was decided to include even the manual time stamps in the sections 4.5.1, 4.5.7 and 4.5.8 to increase the understanding due to the system's complexity.

4.5.1 Mission starts

The mission can start in a few different ways, either the nurses are at the station or in the ambulance. If they are at the station, they receive a call out from *SOS Alarm* to their portable RAKEL unit to then go to the ambulance. However, the nurses could possibly be out driving already, i.e., on their way back from the ER after dropping off a patient. What is displayed on the driver's cabin terminal is shown in Figure 4.13. If the nurses are out when the mission starts a prompt is sent to the driver's cabin terminal and a call out is made from *SOS Alarm* to the portable RAKEL units. A notification covering the whole screen (shown in 4.14) with only two options, to accept or deny the mission, pops up on the terminal. This demands the nurses to act consciously and be fully aware of their actions as it is of upmost importance that the nurses know that they have received a mission and accepted it. After the mission is accepted, GPS navigation is started on the terminal and the mission information is displayed (Figure 4.15).

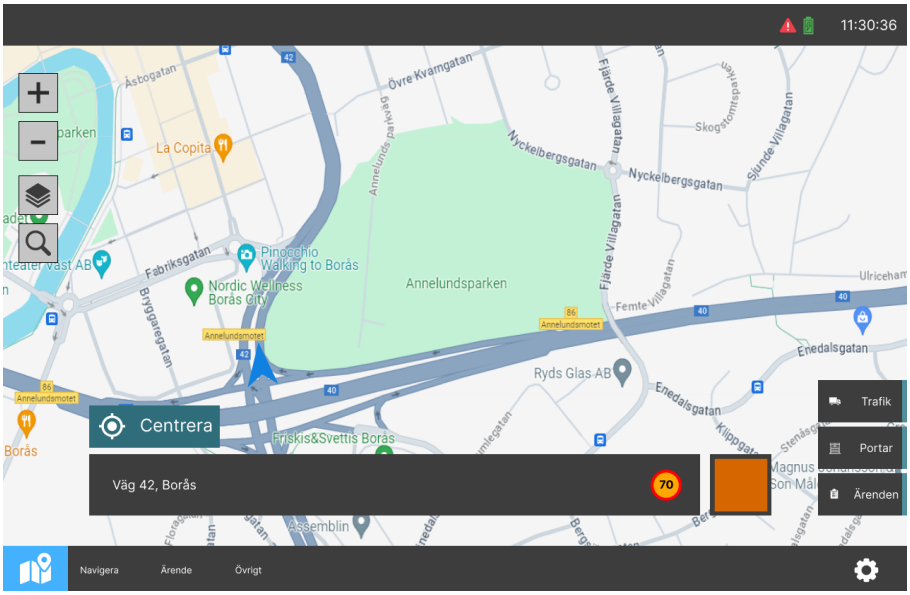

Figure 4.13: The screen as shown to the nurses when there is no mission in progress.

Figure 4.14: The screen shown to the nurses in the drivers cabin of the ambulance when a new mission is received from *SOS Alarm*.

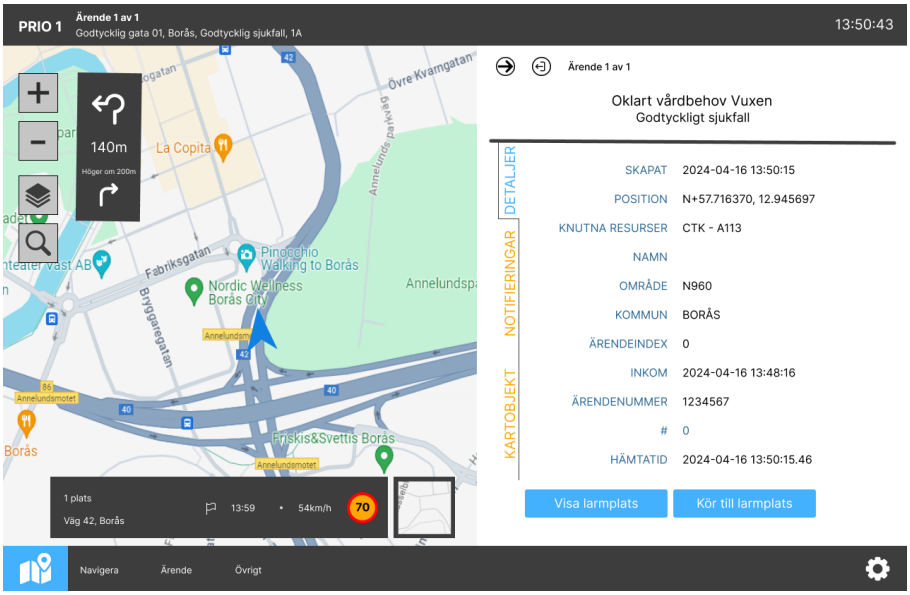

Figure 4.15: The screen showing navigation and mission information.

4.5.2 Arrival at destination

The goal for the "Arrival destination" subtask is for the system to automatically detect when the ambulance is in the vicinity of the destination and so automatically register a timestamp in the system. When the ambulance arrives at the location, or in the proximity of the address communicated to *SOS Alarm* by the caller, the system should be alerted to create a time stamp. The system therefore needs to know the relative position of the ambulance to the destination.

A solution that springs to mind is to use the GPS transponder in the ambulance to determine the location of the car. Yet, knowing the position of the ambulance is just half of the information needed to determine if the ambulance has arrived at the destination. The system also needs to know where the destination is. As *SOS Alarm* receives a call with a destination, the address and the coordinates are sent to the ambulance, which is all information needed to determine if "Arrival destination" is available. GPS has a high accuracy of <0.64 m 95% of the time (states government, 2022) and is so deemed to be accurate enough for this application. However, by only using the specific coordinates for the address the ambulance is required to park at the exact coordinates. Although the GPS positioning system is accurate enough, the ambulance may not always be able to park at the exact location of the address given. Therefore, the principal of geofencing is a suggested method to mitigate this issue. Geofencing is a location-based solution that uses, in this case, GPS to create a virtual boundary around a specific geographical area (Trafikverket, 2022). The boundary drawn around the address sent to the ambulance, creating a more general zone (example of a geofence in Figure 4.16). This way it is possible for the ambulance to park close to, but not directly, at the address. This is important since more often than not it will not be possible to park the ambulance in the exact coordinate of the address but only in close proximity.

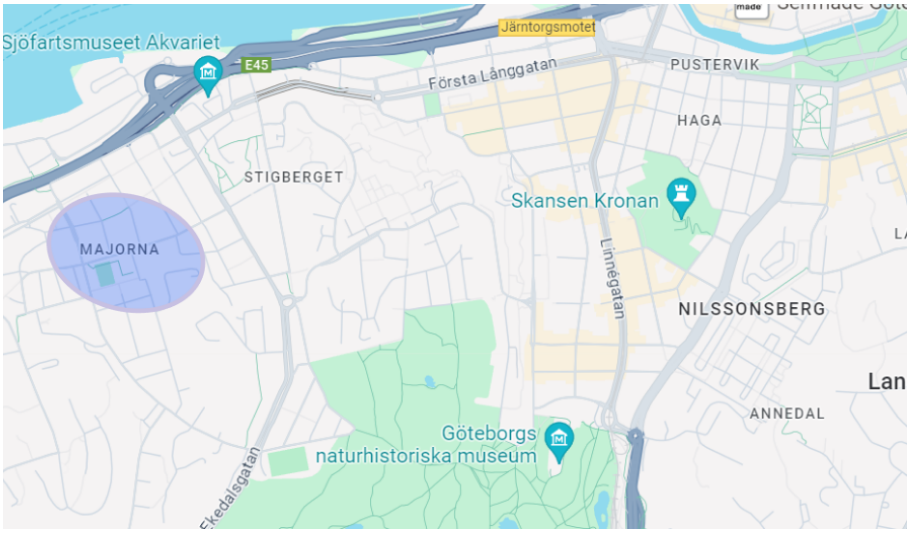

Figure 4.16: Illustration of a geofenced area with virtual boundaries

In addition to the GPS-geofencing system, the suggestion is a complement system to ensure reliability. The idea is to have a sensor in the ambulance that verifies that the ambulance actually has stopped and that the personnel is on their way to the person in need. This can be a crucial part in generating an accurate time stamp as the ambulance can be within the geofenced area but still needs to find a suitable parking or encountered other unforeseeable issues. A second sensor detects movement of the car or detect when the side door is opened to take out the medical bag, both of which have good potential to message the terminal and that the nurses have left the ambulance. How sensors could be mounted in the door is shown in Figure 4.17. The second sensor would help eliminating false positives and increase the quality of the data. When the arrival is registered a notification is sent to the cabin terminal (see Figure 4.18).

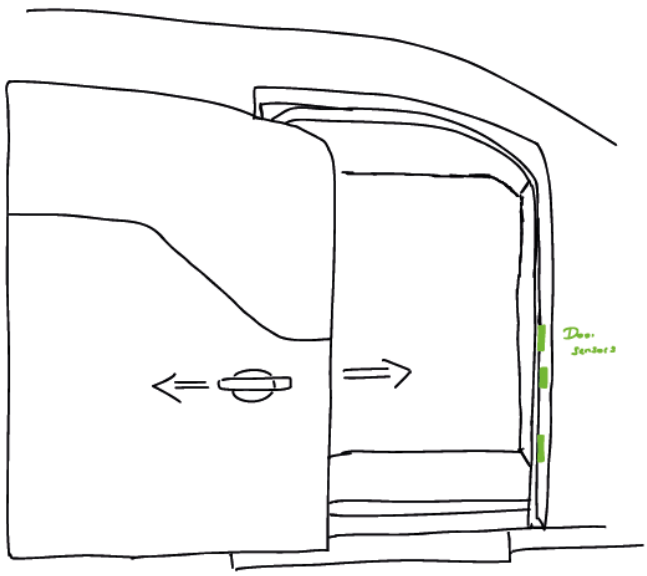

Figure 4.17: Schematic drawing showing the sensors placement (green)

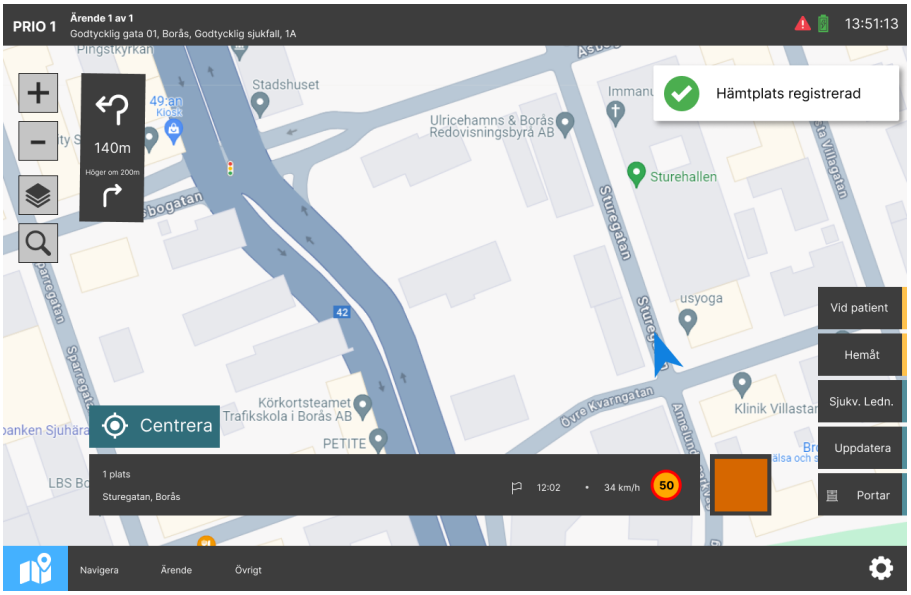

Figure 4.18: The notification shown on the driver's cabin terminal when the "Arrival patient" time stamp is registered

As shown in Table 4.2, and an accompanying equation, the sensor system is seen as an AND function. The function requires both the GPS to be '1' and the complimentary sensor to be '1' to send a signal to mark a time stamp for "Arrival destination". The Table shows that if just one of the sensors is '1' the ambulance is not standstill in the right area. This means that if not *both* the requirements are fulfilled the time stamp will not be entered in the database. The system thus eliminates false positives where the ambulance has entered the correct area but has not yet arrived at the address or if the ambulance stops in traffic.

$$GPS \cdot Sensor2 = output(F)$$

GPS	Sensor2	F
0	0	0
1	0	0
0	1	0
1	1	1

Table 4.2: Description of the output of the sensory system

For the secondary sensor there was a bit of uncertainty on what would be the most fitting way to determine that the ambulance nurses were on their way to the patient. And consulting with technical specialist, Johan Nicander from Ericsson, it seems that both types of sensors were reasonable to use. Nicander highlighted that both an accelerometer and a sensor for the door already are in place in the car that it is a question of implementation which would be the most fitting. Since one of the demarcations of this thesis is "limited technical implementation" tit was decided to leave it to the engineers with more technical background and expertise to determine the best solution for the second sensor.

In summary, the combination of a GPS and a secondary sensor will work together to determine if the ambulance has stopped in the correct geographical area eliminating false positives and providing qualitative data about the time of arrival to the destination. The time stamp is so completely automatised and the task of documenting arrival at the destination is eliminated from the list of tasks needed to manually be completed by the ambulance personnel. The cognitive load is thus reduced.

4.5.3 Arrival at patient

When the nurses have exited the ambulance, the aim is to get to the patient as quick as possible. In some cases the nurses have to call on the intercom at the patient's front door, in some cases they receive a code from *SOS Alarm* to open the door. In other cases getting to the patient may be more accessible. Once the nurses are next to the patient they start to assess the situation. The process of getting to the patient from the parked ambulance is very different from case to case making it difficult to account for all variations. In the observations (C), no significant problems were noted when making way from the ambulance to the patient. However, the problem arises when the nurses leave the ambulance where the main set of tools and set of sensors are left behind. This makes time stamping automatically challenging for "Arrival at patient".

The proposed solution for this time stamp is inspired by the technical and organisational advancements in the counties of Halland and Skåne where the nurses have a second terminal in the care space of the ambulance. The ambulance nurses take this terminal with them when examining the patient to see their medical record and document the case. According to the interview with Kristoffer Wibring working as a statistician for the county of Halland, this is currently the industry trend and that VGR would probably follow suit in adopting the second terminal idea. Due to this trend of implementing a second terminal, the proposed solution includes this as a part of the suggested solution for this time stamp. Even though ambulances in VGR do not currently have a second terminal was set as a goal for developing a concept and synthesis (1.3) that is in the forefront of technology today, but within reach of implementation in the next generation of ambulances, and further, be a solution applicable nationwide. Nevertheless, having a second screen seems to be the rule and not the exception even in present day.

The proposed solution for the "Arrival patient" time stamp is thus including a second screen mounted in the care space which is taken with when going to meet the patient. The idea is for the two terminals to synced with each other so that if a time stamp is documented on one of the terminals the other terminal should be aware and move on to the next time stamp. This is possible as the terminals are connected to the mobile network. The idea of the secondary terminal is to present the nurses with the patients medical records and information from the mission on the fly (Figure 4.19). When the nurses get to the patient the system steers the nurses to use the terminal to confirm their arrival at the patient in multiple ways. Firstly, a timer counting upwards is shown next to the information (shown to the middle right in Figure 4.19). The automatic time stamp for "Arrival destination" is registered and triggers the nurses to want to keep the count on the timer as low as possible. Secondly, the function to edit the record of a patient or take notes indicates that the nurses have arrived at the patient (since that is the only time they have a need to edit the records or take notes). Therefore a prompt is shown asking the nurse if they have arrived at the patient (Figure 4.20). When the "Arrival patient"

time stamp is confirmed the numbers showing the time turn green and the timer stops counting. The idea is to spur the user to press the button as soon as possible, or if they forget steer them into the right action. But the visual reminder of a timer ticking is a *just-in-time prompt* motivating the user to execute a certain task or give into a specific behaviour. Simple and familiar prompts encourage users to act as desired for the task at hand.

Figure 4.19: The default view of the second terminal that is taken with to the patient. Displaying the mission information, medical records, other connected resources and notes.

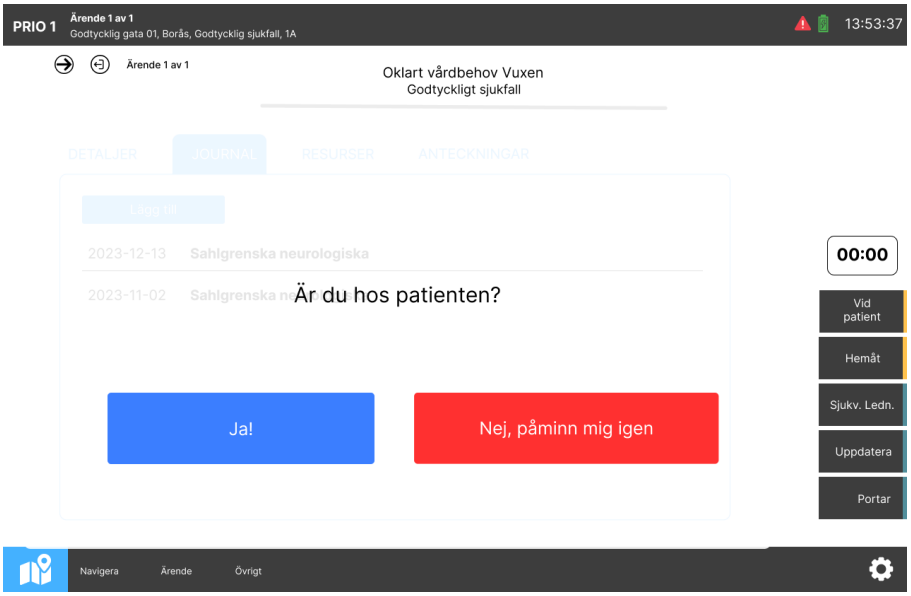

Figure 4.20: The promt shown on the secondary terminal when the nurse tries to edit the medical records or take notes without marked as arrived at the patient

On the cabin terminal (which is not supposed to be taken with to the patient), a notification (digital nudge) pops up to mitigate forgetting to register the time. The idea is

to mark the time stamp on the secondary terminal. However, in some cases this may be forgotten or the ambulance can drive straight to the patient and park right beside (which means that there is no need to bring out the second terminal). In these cases it is important to be able to mark the "Arrival patient" in the cabin terminal as well, and in addition a notification sent to the terminal. This notification is rather small yet should be effective enough to make the nurses aware that they have to remember to check in at the patient (Figure 4.21). Digital nudges provide the necessary guidance for the user in an interface without disturbing and shifting focus entirely away from the actual goal that should be achieved. After a set time interval a notification asking if the ambulance team is at the patient will appear on the home screen asking them to either confirm their arrival or get reminded later. If they press to get "remind later" once again a window asking the nurses whether they have arrived will show up a short period after. Here the time tracking database needs to be analysed to make an adequate guess about the pop-ups occurrence.

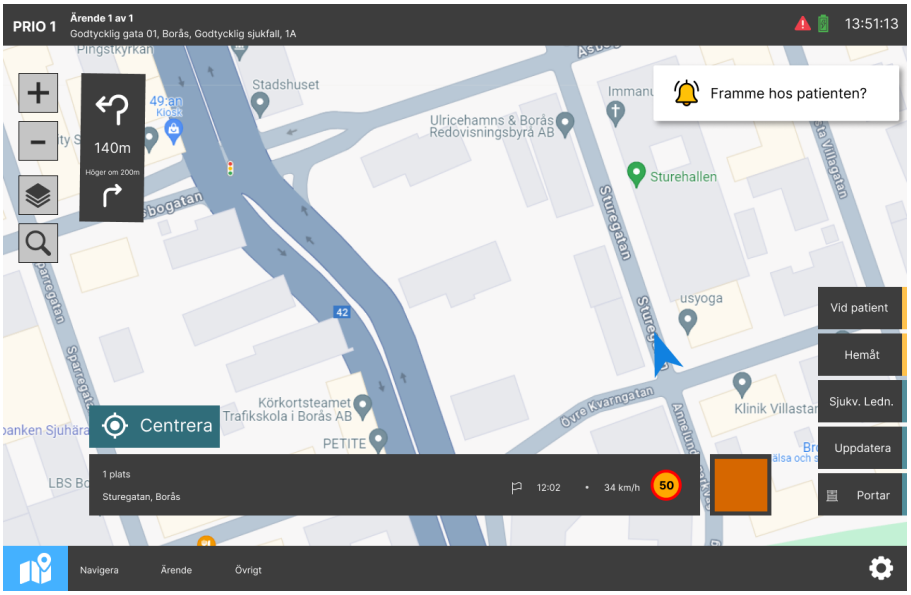

Figure 4.21: The notification shown on the cabin terminal

4.5.4 Departure destination

Up on departing from the patient's destination, the back doors are opened to load the patient on the stretcher into the emergency care space of the ambulance. One nurse is then attending the patient in the back of the ambulance while one nurse takes the responsibility of driving the ambulance. First, the priority of the case is chosen (Figure 4.22). Then, depending on where the patient is located the corresponding hospital is chosen as destination (Figure 4.23). This is selected by the driving nurse in the front terminal. In addition, the current system requires the nurse also has to press on the screen to mark the time stamp "Departure from destination". However, there is a notification reminder in the current system that detects if the ambulance starts moving without the time stamp being logged. So, the current solutions has made small strides to mitigate the problem of lapsus in this step. The goal for this project is to make this interaction completely automatic so the nurse can divert their attention to driving. In this section, a proposed solution will be presented to automate the "Departure destination" time stamp.

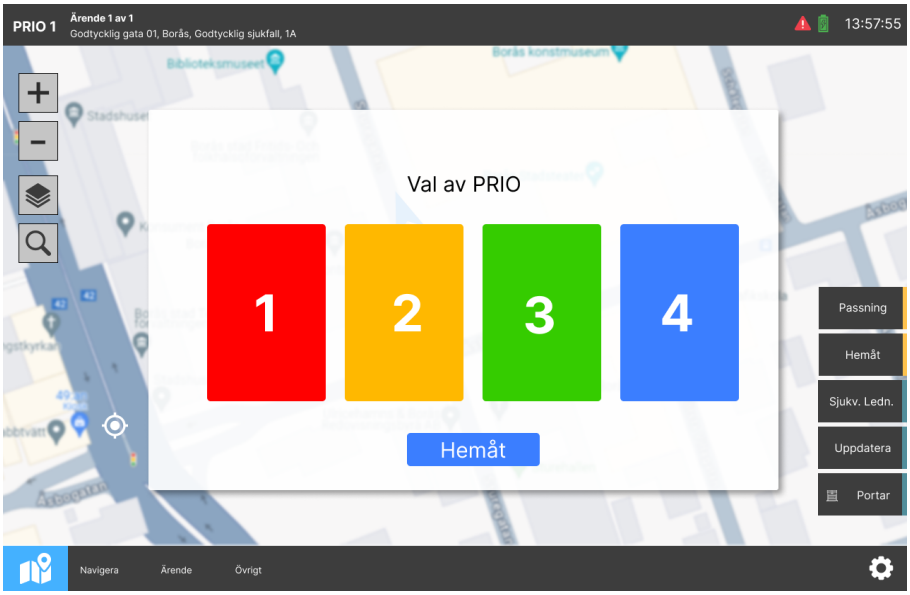

Figure 4.22: The front terminal as presented to the nurse when jumping in the drivers seat

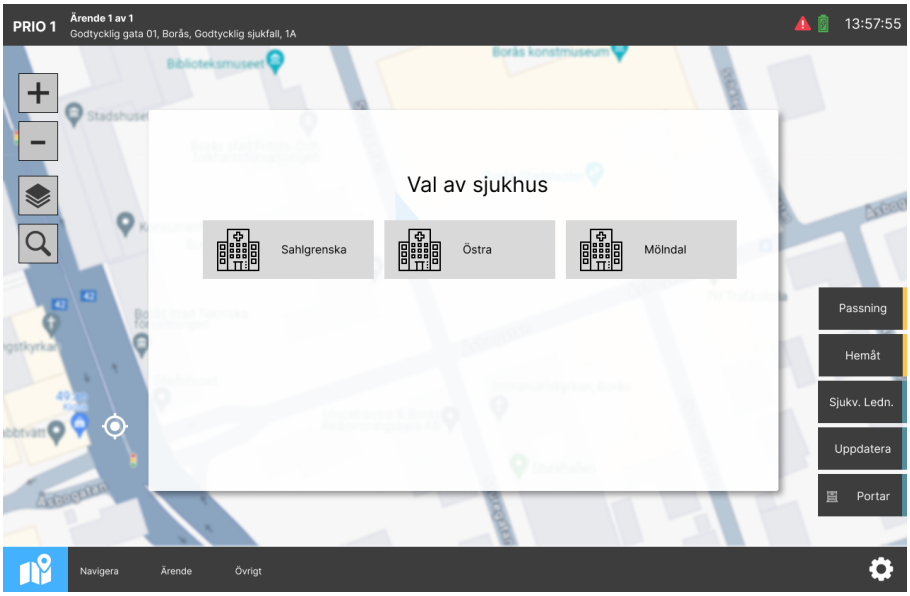

Figure 4.23: The screen showing the different hospitals that are available

As shown in Figure 4.12 the "Departure destination" uses a software to determine if the ambulance has left the destination. When the ambulance nurse enters the driver's seat he or she is presented with a view to chose priority of the case and which hospital to go to. The terminal in the drivers cabin is aware that the "Arrival patient" time stamp is documented on the secondary terminal and the choose priority screen is prepared in the ambulance as they make their way from the destination of the patient to the ambulance. Further, in order to receive the driving instructions the nurse has to select a priority and a hospital. This is forcing the user to act. And the only reason to select a hospital to drive to is because a patient is loaded and is in need of emergency care. Thus, when a hospital is selected this also means that the patient is loaded and this will be used as the timestamp for "Departure destination".

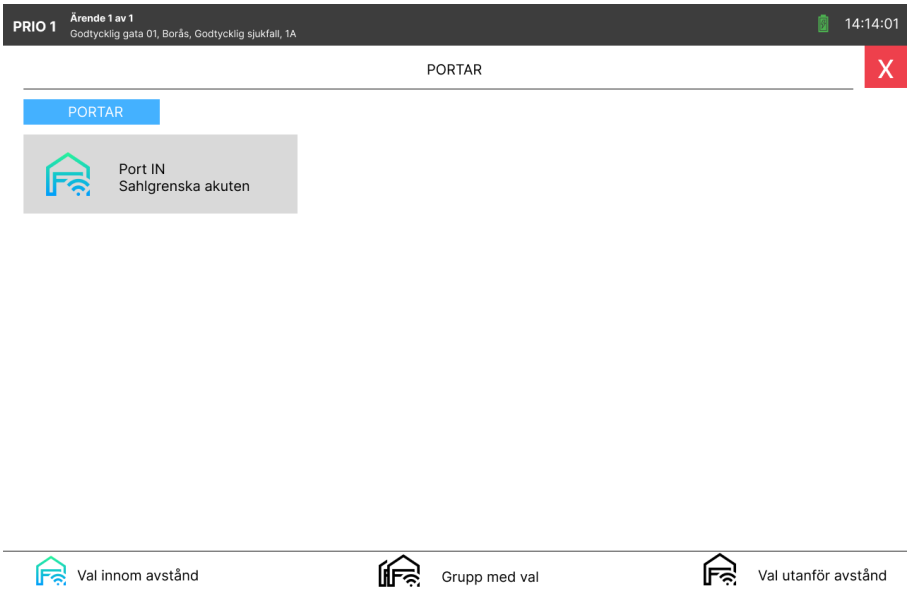

Figure 4.24: The screen shown in the cabin terminal when opening the garage doors

Depending on the case, the nurse may have to select different hospitals, as the capacities of each hospital differs, when pressing the button (as shown if Figure 4.23) on which hospital to drive to this marks the timestamp for "Departure destination". Since the system is "locked" until priority and destination is chosen the nurse is forced to act and so the "Departure destination" timestamp is marked off. The principal of influencing the behaviour of a user to act is described in the thesis *How to Design for Sustainable Behaviour?* (Lidman and Renström, 2011) where "forcing" is the highest influence over a users behaviour. By incorporating the time stamp in to the natural workflow slips and lapsus and to increase accuracy and dependability of the system.

4.5.5 Arrival hospital

When the ambulance has made its way to the hospital the driver presses on a button on the terminal (Figure 4.24) to open the door to the emergency room garage where the ambulance is then parked. In the garage there are often multiple spots to park, however depending on the load of the emergency room there can be multiple ambulances already there. The nurse driving finds an available spot, jumps out of the car and proceeds to unload the patient on the stretcher together with the second nurse. In the case of today the driving nurse needs to interact with the terminal and manually mark the time stamp "Arrival hospital" after parking and before exiting the cabin.

The solution to this subtask suggests a fully automated system, a combination of the suggested solutions for "Arrival destination" and "Departure destination" time stamp. The idea being a combination of terminal interaction, GPS and accelerometer. When the ambulance arrives at the hospital and the "open garage door" button is pressed (shown in Figure 4.24), it serves as a clear indicator that the ambulance has reached the hospital and is ready to deliver the patient. This will mark the "Arrival hospital" time stamp. However, in some cases there is no garage door and in other the door can possibly already be opened. This can be due to the emergency room being inundated with ambulances or a possible malfunction in the doors. Due to this it is important to have a backup system

that ensure that the time stamp is documented even when the garage door is not opened.

The idea of the secondary system is to use GPS to analyse if the ambulance is within the geofenced area of the selected hospital and a accelerometer to be able to see if the ambulance is standstill or not. If the ambulance has, for a shorter time, been in the geofenced hospital zone (without a garage door being activated) the terminal will check the accelerometer to see if the ambulance is standstill. If that is the case, the ambulance will automatically mark this as the "Arrival hospital" time stamp. A pop-up notification will be presented on the screen that the time stamp has been created and the nurse will have to press "Ok" to be able to continue to mark themselves as "Available" as shown in Figure 4.25. A notification pop-up is shown in the top right to keep the user in the loop of what is happening in the system and confirm that the time stamp has indeed been recorded (see Figure 4.26). This GPS and accelerator system will act as a backup to the primary system for the instances a garage door does not need to be opened.

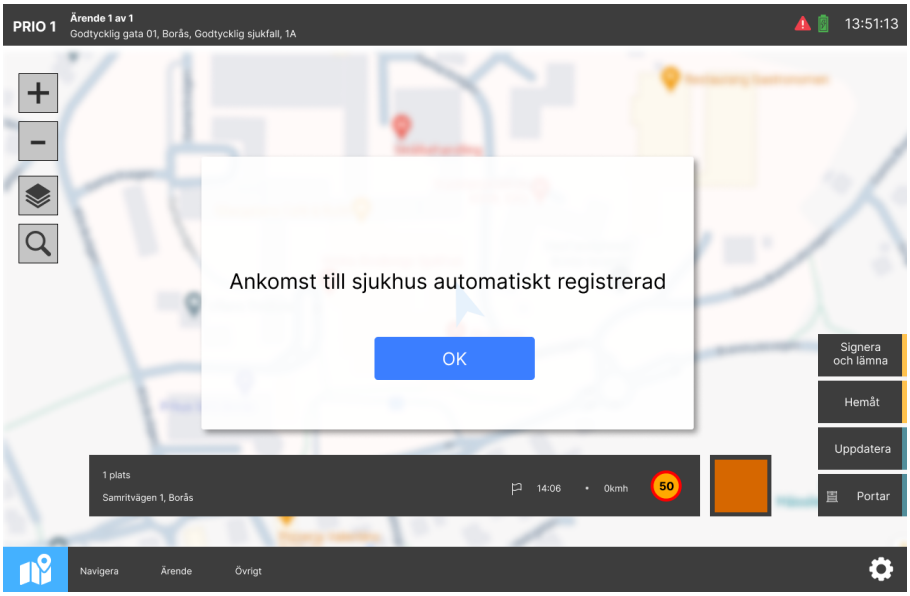

Figure 4.25: The prompt shown to the nurses as they arrive to the ambulance after delivering the patient to the ER

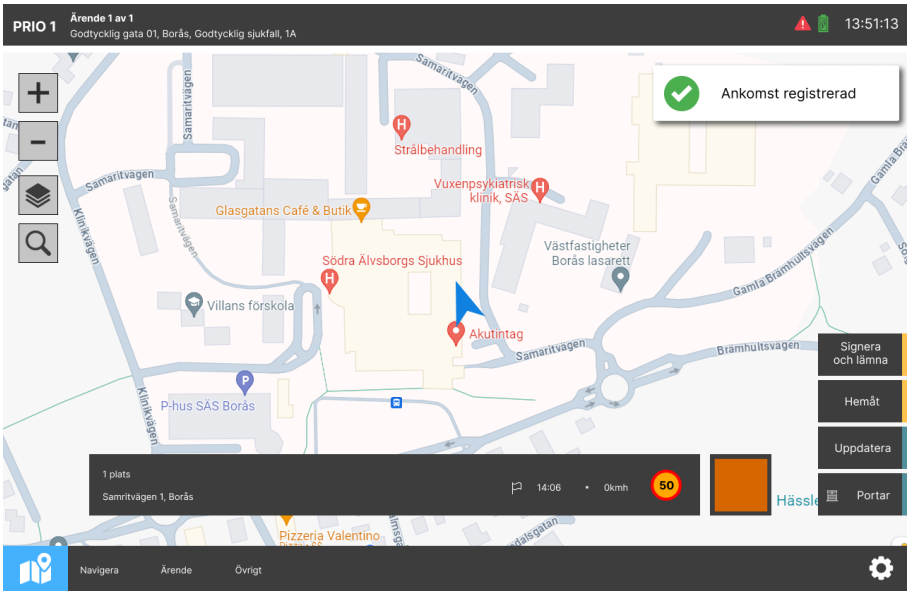

Figure 4.26: The confirmation notification that the arrival to the hospital has been registered

4.5.6 Transfer patient

The current system has no way of determining when a patient is handed over to the medical personnel at the hospital, and the time stamp is left blank. The ambulance nurses only document the prior step "Arrival hospital" but there can be a huge time difference between arriving at the hospital and the patient actually receiving medical attention. This was made clear in the response from the healthcare providers in the county of Skåne in the email survey. The interviewees even said that if the emergency room was operating at high capacity ambulance nurses could be standing waiting with the patient as all staff at the ER may be preoccupied with other patients. The reason for having a time stamp for "Transfer patient" is to map out the cases where the ER is unable handle the newly arrived patient in a reasonable time.

As the solution is based on the fact that there are two terminals in an ambulance it is once again the terminal in the back of the ambulance that needs to be taken into the emergency room as it displays the patients information and vitality parameters. The nurse that has been sitting with the patient in the back of the ambulance takes the terminal with them until they are met by hospital staff at the emergency room to hand over the patient. In the patient records, a function for transferring the patient *Signera och lämna* (English: sign and hand over) is shown in Figure 4.27. When pressing onto this tab, the nurse or doctor receiving the patient at the hospital is required to sign with their personal code as shown in Figure 4.28. The code is used for authorisation, by using the existing code we reduce the need to introduce new methods of verification that would otherwise increase the cognitive load on the personnel. After the hospital staff has signed, a notification will pop up next to the ambulance mission saying **LÄMNAD** (English: Transferred). Shown in Figure 4.29 in capital and red letters. With the digital signature, the responsibility of care has been officially transferred from the ambulance nurses to the hospital.

Figure 4.27: The default screen when the ambulance nurses make their way to the ER to meet a nurse or doctor.

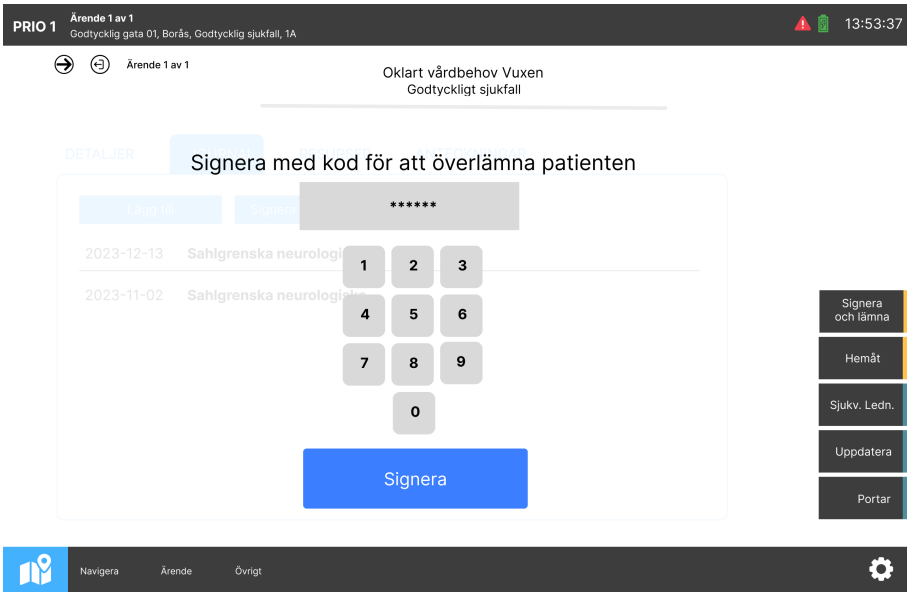

Figure 4.28: To be able to transfer the patient the receiving nurse or doctor has to sign with their personal code.

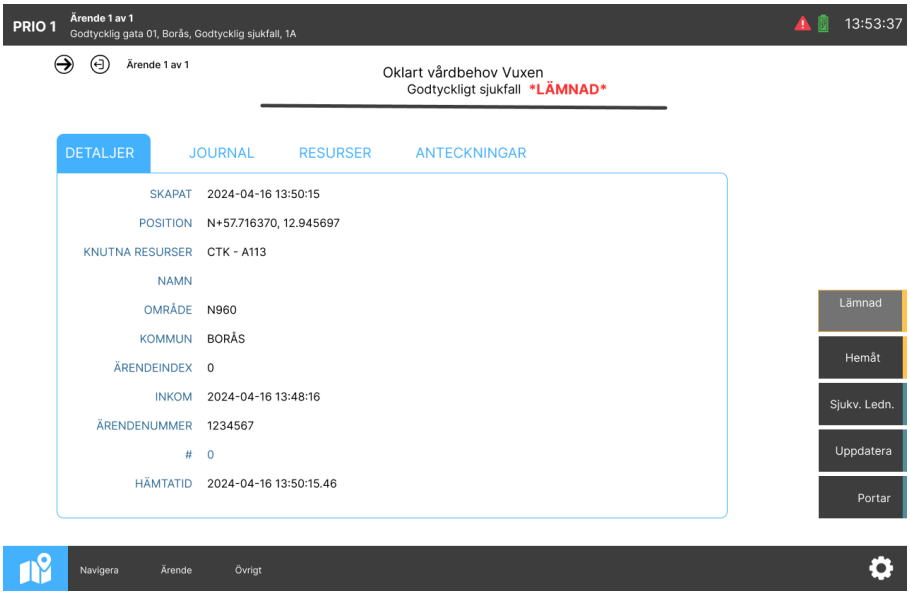

Figure 4.29: The screen shown when the patient has been handed over.

Simultaneously, the signature from the hospital personnel generates the time stamp for when the patient has been handed over to the hospital "Transfer patient". The ambulance nurses will be able to alter information in the patient's medical records and edit their notes after having handed over the patient. Since the nurses have two terminals available it is possible to fill in the records in the ambulance and so they are independent of the emergency room computers. This can be beneficial for when the emergency room is under high working capacity and the computers are occupied. This means that the nurses are able to faster return to the ambulance which in the end can make them available for a new mission faster. The ability to write the medical records in the ambulance could mean that there is no need for the computers for queuing and writing the patient's medical record at the emergency room, which in its turn could lead to reduce the number of computers used in the ER.

4.5.7 Available

When the nurses have refilled the consumables, cleaned the ambulance and filled out the medical records they both jump in the drivers cabin and mark them selves as "Available" on the terminal, Figure 4.30.

However, there is a catch in the system of today. Since there is no way to tell if the patient is delivered *SOS Alarm* presume that after 20 minutes after arrival at hospital the ambulance is available. However, the nurses can also mark themselves as "Available" (using the terminal in the cabin) prior to this if they are ready for a new mission. For the new solution the 20 minute rule is scrapped as there is a system in place to determine when a ambulance is available via the "Transfer patient" time stamp. The time stamp "Available" (eTimes.13) will however still be marked manually from the terminal in the cabin, the argument being that the nurses should always be aware that they are available for a new mission and therefore not be marked as available unknowingly.

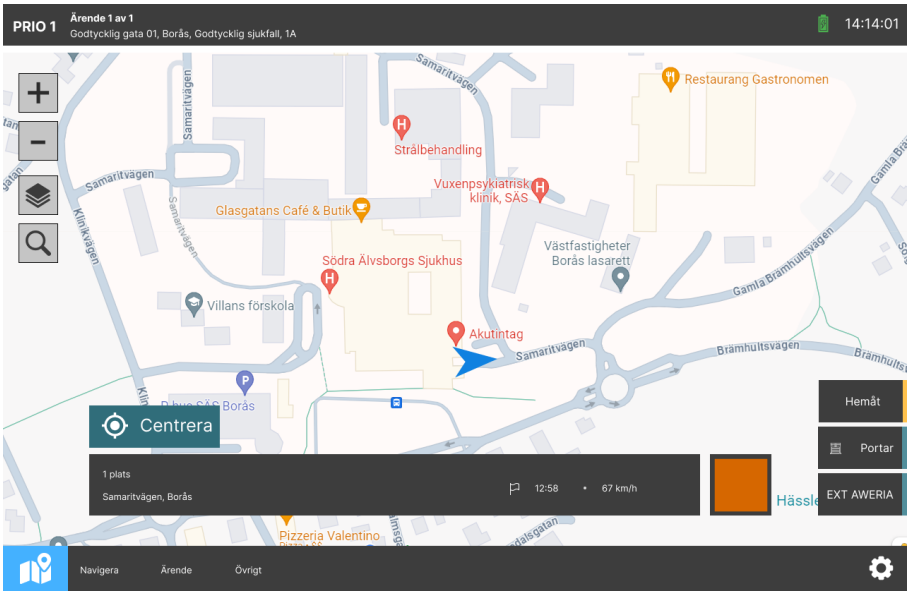

Figure 4.30: The view of the terminal when the nurses drive from the garage and select themselves as "Available" by pressing "Hemåt" (Eng: Homeward).

4.5.8 Mission complete

Mission complete is the last step in the ten step process and is logged only when the ambulance has arrived at the station. The timestamp is manually entered through the cabin terminal and as the nurses are under no cognitive load and is of low importance as the time stamp is mostly a formality.

4.6 Evaluation

To verify the concept design, an evaluation had to be made. The idea behind testing and evaluating the concept was to confirm whether the alterations made to *Paratus* would support the ambulance nurses work. The process was centred around the two added time stamps - "Arrival at patient" and "Transfer patient" - while also explaining the changes made to the existing time stamps. The user testing was mainly done to identify possible usability issues as well as to give possible recommendations if a problem was identified.

To start the procedure, one morning was spent at the central ambulance station in Gothenburg to walk the ambulance nurses through the system changes and collect their insights and thoughts. To support collecting their thoughts, an evaluation guide helped to ask relevant questions as well as guide the ambulance nurses while explaining the process for them walking them through the entire flow of the tracking system (Appendix G). The questions investigated the ambulance nurses feelings, thoughts and ideas rather than the technical or financial feasibility. In total, six nurses, both men and women in different age groups, agreed to part-take in the evaluation.

4.6.1 The automated steps

For the steps in the system that were automated according to the concept design, the ambulance nurses were asked the following questions below.

- Do you think it is good that the step is automated?
- Are you sure that the time has been registered? In either case, yes or no, why?
- Is it evident that you are at the desired destination?
- Do you feel in control over the system?

Upon being asked whether they liked that the system was automated or not, the ambulance nurses stated that:

"Everything, that adds functionality which does not cause more trouble and works seamlessly, is good".

That did not really answer the question which was why follow ups needed to be asked in terms of how and in what way it is good if it works. The ambulance nurses stated that they would appreciate if their work would be simpler in terms of not having to think about pressing a button. Despite, them pointing out inefficiencies with the current system, they had no concerns adopting the automated system. They would, if it worked in a real life scenario, trust the new system.

Regarding of how sure they were if the time was being registered or not, they felt that they knew the time was registered and said that they would acknowledge the pop-up on the first terminal when arriving at the hospital or any other destination that has an automated time stamp. Giving them some visual cues to distinguish whether the time is tracked or not seemed to be valuable to them and giving them the sense of control they need from the registering system.

"If it works it is great, one less thing to think about!"

However, one concern about the built-in navigation and GPS feature were mentioned by the ambulance nurses. The GPS-navigation through *Paratus* came up multiple times during the duration of the project. The navigation was oftentimes faulty when providing directions which was why the nurses relied on Google Maps. However, the project's aim was to look into correct delivery for the time tracking during an ambulance mission, so the GPS issues were deemed to lie outside of the scope for this project. Nevertheless, it should not be an issue integrating a navigation system receiving live updates on traffic situations. Nonetheless, the nurses were positive towards the changes made to the system.

4.6.2 The added steps

To make the ambulance nurses understand the new system steps, they were guided through a scenario in which they would have to take the second screen from the emergency care space from the car with them to track time when arriving at both the patient and the hospital. The questions asked in these steps are presented below.

- Is it clear for you whether the patient is handed over and that the time is registered?
- What do you think about taking the second screen with you to the emergency room?
- Do you feel you have control over the system?
- Do you think a system like this would simplify or complicate your work?

The aim was to make them understand that they would have to take the second screen with them. The nurses initial reaction when being presented with the idea to take a second screen with them was to decline the request.

"I don´t believe taking a screen with me to the patient just to track when I am at the patient is logical. I won´t use it if it is urgent."

While one nurse raised concerns about taking the terminal with them to the patient in terms forgetting the terminal when on an urgent mission, another nurse stated that they hardly ever have such extreme cases in which they would not be able to take the terminal with them and if so that there should be the option to change the time manually afterwards accordingly to register the arrival time. After having explained that the terminal is not only being used to track time, but should also act as a supportive tool for taking notes and writing the patient's medical records, the second screen suddenly became an appreciated change. The ambulance nurses liked the thought of the terminals in the car being one system, while not having to worry if the screens were connected to each other regarding the information and the process of tracking the time during the ambulance mission. Further, the nurses felt like this step would be a good complement in their work where they would be able to save time and also troublesome finishing work. They thought it was easy to understand and that the system was helping them in the process.

For the second manual step, the step of transferring the patient to the hospital staff, they seemed positive to take the second terminal with them as well to let an authorised person sign the request for handing over the responsibility of care. When explaining that the second screen would be used to effectively mark the end of their responsibilities they were more open to the idea of using the device. What stood out most though was that the ambulance nurses appreciated the fact that they could look up, add and edit information while being on the missions on the second screen instead of having to use pen and paper, further transfer their paper notes to the computer at the hospital which they described as inefficient and tedious. The idea of being able to write the medical records in the car was a welcomed change.

4.6.3 Main takeaways

All in all the nurses were positive but hesitant to the changes and felt like they could not entirely trust the system. This might be due to the fact that they are used to the current system in which the information needed is not updated consecutively as well as that they had to deal with a slow system. The nurses were a bit concerned as to whether they would miss registering the time for being at the patient or even if forgot to hand the patient over. Upon reflecting they said that they nevertheless would like to test the adapted system if possible to get a better feeling for its feasibility.

5

Discussion

In this chapter, we discuss certain parts of the project in terms of their realisation and execution from a more critical standpoint.

5.1 Co-Design and user research

In this thesis co-design and user research are used as methods to achieve a more user centred perspective in the design process. The methods used were *Graffiti Walls* and *Interactive Digital Case Study*. The goal was to incorporate designers, engineers, experts and system users to greater enhance the creative process. However co-design is a complicated matter and we deems a discussion on the matter is needed to keep the thesis transparent.

There are multiple levels of co-design and there is a fine line between user research and co-design. In a genuine co-design the facilitating designer relinquish the power to executive overrule what the user needs or wants in a design, system or product. With the goal of involvement and learning the user, designers, engineers and relevant stakeholders redistributes the power to facilitate mutual learning and reflection of the design process.

In this part of the thesis a discussion will be held on what extent co-design was achieved and if the result represents of the real world.

5.1.1 Graffiti walls

Firstly, the canvas implied questions regarding user research and not co-design (knowingly), trying to understand different matters regarding their well being and behaviour. The questions were answered by putting a small round sticker in a diagram where the nurse felt that it displayed his or her stance on the matter. However, this causes a big issue. Since everyone can see the previous answers this may cause the nurses to be (knowingly or unknowingly) influenced. The fact that responses are aggregated in clusters (see Figures 3.26, 3.27 and 3.28) implies that the answers to the questions may be influenced by each other and so, not true to the beliefs of the respondents. This could have been avoided with the use of an anonymous submission system, for an example digital survey. Still, if a digital survey would have been conducted some of the later creative questions (where building on each others ideas may be a positive) would suffer. Additionally, we considered it more intriguing for the nurses to answer questions on a big canvas more than scan a QR code and fill out a form, and thus generating more answers.

For the second part of the canvas the questions were more aimed to let the ambulance

nurses suggest ideas. And so, Whilst there were creative elements it is unclear if the *co-design goal*, namely ideating together with the user of this part of the study, was achieved. Therefore the Graffiti walls study as been characterised as "User research" through out the report, as we feel that it fell short of fulfilling the co-design criteria "involvement of the end user in generating design ideas" as described by Eriksson et al., 2021. The questions on the canvas were aiming to start an ideation phase and encouraged the ambulance nurses to be creative and to think like a designer and suggest possible solutions to the arrival-at-patient time stamp. The answers to the questions were scarce, for the fifth question *Q5: How would you like to document "Arrival Patient"?* two short answers were submitted. And for the sixth question *Q6: If you have thoughts, questions, or ideas on how status management can work better in the future, please feel free to drop a suggestion in the box next to it* there were no generated answers. This sparks the age old question, *can anyone be creative*? The answers collected from the graffiti walls canvas were scarce and may suggest not, unless having the right tools to be creative. However, from the perspective of the nurses it may be intimidating to suggest ideas, judging their ideas to be useless because the lack of training in design or engineering. Another alternative could be that the nurses lacked initiative to actually be creative, this may be due to organisational reasons or personal reasons. As there has been some criticism directed towards the organisation, particularly regarding the lack of being adaptable and flexibility, this may influence the nurses, initiative to participate in changing their working environment as they do not feel heard (as mentioned in 3.4.2 Criticism). As a result, they may not take the time or effort to answer the questions to the best of their abilities.

All in all the result from the graffiti wall study was a success in generating data confirming theories on the ambulance nurses, well being and pain points. However, the goal of incorporating the user in the creative design process, to achieve co-design and have a saying in the development was mostly unsuccessful due to the factors discussed. This may have lead to a less user-centred concept than intended.

5.1.2 Interactive digital case study

To start with, the purpose is to get different stakeholders within the same area of interest together to help come up with designs and ideas and in some cases low fidelity prototypes, while being supported by a designer or design engineer as a guide. However, due to the schedules of the different stakeholders and participants colliding, the original approach of a co-design workshop was remodelled into a digital format where the participants could follow a structured sequential case without any interference from a designer or other participants. The benefits of co-designing are to produce a wide-spread variety of solutions, integrating the users in the design and development stage and from the beginning let them express their concerns (Frow et al., 2015). The method, is to our knowledge, a new method that has not previously been used in the co-design field. Therefore, we have decided to name the method *Interactive digital case study*.

One could argue that remodelling a co-creation workshop into an interactive digital case study in which users do not get to interact with each other as well as the absence of designers who facilitate the ideation process is inefficient and not reliable. This could be due to the fact that the designer can mediate the process if the participants get stuck at any time. While it is true that the absence of a facilitator might have resulted in the participants losing motivation to exploit their full potential, it may have prevented a

push towards certain ideas that can occur unconsciously when acting as facilitators.

The digital interactive case study proved itself to be an effective way to get users and non-users to participate in the ideation process. What stood out was that the participants generated a good variety of different possible solutions. Some of the ideas were more conceptual such as adding a gamification aspect when having to press a button and confirming that the ambulance nurses have executed a certain step. Introducing the digital case to participants with multidisciplinary backgrounds opened the solution space more and brought other ideas to life that an ambulance nurses or designer may not have thought of. Moreover, due to the **IDCS**' flexibility the incorporation of different people from various professional areas could be easily included by sending the case to them through mail for instance. The general thought of presenting the case for people from different backgrounds is one to keep in mind for the upcoming research and development projects.

Another problem with the interactive case study was translating the design and thinking methodologies so that non-design engineers could understand and use them without using their terminology. Especially methods such as *SCAMPER* and *Six Thinking Hats* can feel overwhelming when used for the first time. These methods can be learned though yet this requires training, effort and time. This may also be a reason for why the participants came up with few ideas, as it can be difficult to interpret the instructions correctly. Here the presence of a design engineer to facilitate the process would have been beneficial.

Summarising the above, the interactive digital case study was beneficial during the ideation process to obtain a broader perspective of what may or may not be possible. However, the method provided a base for more conceptual and futuristic ideas that may be of interest in the future but are not feasible just yet. Moreover, the timing of the study was slightly off. By the time the participants took part and took time to work with the digital workshop, our own brainstorming process had already produced the majority of the ideas the study's participants came up with. In hindsight, the study should have been sent out with a clear set date and time to not only reduced the amount of post-processing but also the delay of other tasks to proceed further in the project.

5.1.3 Brainstorming - sensors

Some conclusive thoughts regarding the brainstorm are described in the following paragraphs.

Sensors can be implemented fairly fast if they are not already present in the current ambulances. Yet even if there are numerous combinations of sensors available it does not mean that they are solving the problems this project has tackled. Sensors are detecting and responding to some type of input from the environment, yet a sensor has to be connected to a source where the data can be stored or uploaded to a cloud service. The data transformation is the crucial part in this case as the times registered should be used to further determine whether more ambulances are needed in the county or not.

In contrary to VGR, at least two counties in Sweden have two terminals in the ambulance, of which one is mounted in the front between the driver and co-driver seat and the other is located in the emergency care space. In the case of two terminals, the one in the emergency care space is used to note down patient information. The terminal in the back of the ambulance is the terminal which allows the nurses to take notes and editing the

patient's medical record while being seated in the emergency care space. This terminal works with the same software and is an equivalent to the terminal that is placed in the front of the ambulance in terms of workflow, yet just operates the note taking function and signing functions and is not meant to be an exact reflection of the first terminal.

5.2 Evaluation

In section 4.6 a nurse acknowledged *"Everything, that adds functionality which does not cause more trouble and works seamlessly, is good"*, proved to be a double-edged sword. This was mainly due to the nurses' attitude towards the thesis. On one hand they were open- and positive-minded, on the other hand sceptical and unwilling to cooperate. While the quote above confirms the new system's feasibility as well as a willingness to adopt the system by the nurses was shown, this quote was not really the answer we had hoped for. In general, the ambulance nurses' willingness to answer to questions asked was quite low. This made the evaluation process rather difficult as the nurses seemed rather uninterested in the development of the system even though it could help them with their everyday work tasks. Upon reflection and the answers collected, we came up with the following explanations for the nurses, disinterest in taking part in the evaluation process.

Firstly, the GPS system which is currently used in *Paratus*' time tracking system, does not update itself in real time. There is according to the nurses a few minutes, frequency on the GPS live updates, for instance the current traffic situation. This can be a problem especially in the occurrence of traffic jams or temporary construction sites, making it tedious to drive to the destination. This was a surprising fact as every GPS driven system updates itself in a given time interval chosen by the provider of the GPS service device and can differ by as little as one minute to up to an hour. Nevertheless, the fact that the map does not account for external changing factors created a major pain point for the ambulance nurses. When asked how they are tackling the insufficient GPS system, the answer was that they used their work mobile phones to pull up Google maps which both displays more updated routes to different addresses, sends suggestions on how to get to destinations faster, and receives news on the current traffic situations.

Secondly, the nurses were generally open and positive minded towards the alterations made to the time tracking system, yet they saw a discrepancy between the implementation and the health care budget in VGR specifically. The idea of adding a second screen in the car's emergency care space received a resounding yes, due to the fact that this enables the nurses to fill in the medical record of the patient independently from the computers that are currently provided at the emergency rooms. Further, the screen would make the current solution of writing down the arrival time at the patient with pen and paper obsolete, and collect all the medical information necessary in one place rather then having various different systems scattered throughout the emergency chain. Scepticism arose regarding the second screen as the screen and the corresponding access to the medical records as well as a note-taking function, seemed costly to the ambulance nurses. The budgeting for health care, especially prehospital care, is tightly calculated already which was why the nurses were rather unconvinced about seeing the development happen.

Lastly, it is worth mentioning that some of the nurses clearly signalled that the concept was more wishful thinking than being actually possible to implement. During the entire project, we discovered, that there is a certain rigidity of how work tasks are delegated but

also executed. This may cause the ambulance nurses to adopt a sense of resignation and hopelessness towards change. The fact that the organisational level within the health care sector is highly administrated and therefore slow makes it difficult to implement new work routines, but even harder to justify buying new equipment for ambulances as the budget is tightly measured. Nevertheless, the trend of having two screens in the ambulance of which one serves the purpose of writing in medical records and to register the missing times, seems to be the norm and not the exception.

5.3 Edge cases

During the project numerous scenarios had to be outlined to ensure the system would work in practice. Some of these scenarios were so called edge cases meaning cases that deviated greatly from the norm. The edge cases were by our own choice excluded from the project's scope to avoid scope creep.

5.3.1 Emergencies in open spaces

When having to give medical care on the streets, in parks or any other open spaces and environments, the ambulance nurses may just jump out of the ambulance and start giving necessary care immediately. In this case, the second terminal will not be removed from the emergency care space and therefore no arrival at patient may be registered, as "Arrival destination" and "Arrival patient" are essentially the same. The probability for this happening seems low though as the most missions are connected to people being at home and not being outside. If this occurs, the time will be left blank until the ambulance personal has picked up the patient, loaded them into the ambulance, gives care and chooses which priority and which hospital to drive to. Here the time for departing from the pick-up location and the time for arrival at the patient will be the same.

Double time stamping could be avoided by implementing a search function for those who manage the data and statistics of the time tracking system. How this search function could work is outside of the scope for this project but seems like a feasible solution. Moreover, outdoor emergencies, such as traffic accidents or emergencies in other public places, i.e. parks, public pools etc., are not as common as picking up the patient in their own home or in other indoor places.

5.3.2 Threats and safety

When interviewing the ambulance nurses it became clear that some special cases require the ambulance nurses to wait further away from the actual arrival destination due to safety measures. This happens when an ambulance is called to a public emergency or public threat while having to work together with other emergency units such as the police and rescue services. For example, the 7th of April 2017 Stockholm was shaken by a terror attack (Krisinformation, 2017) demanding several emergency units to work together. The *Swedish Security Service* and the Swedish police had to collaborate to neutralise the situation and make sure it was safe for other units such as ambulance resources to examine multiple injured people. Clearly, this case is an extraordinary event which should be the exception but these cases can occur to a less extreme extent.

In these scenarios, the police informs the ambulance in terms of where they are allowed to park to stay safe. Here the ambulance may be parked within the correct geographic area already but they might have to wait for clearance of the police to drive closer to the incident. To avoid false tracking the new system checks that two conditions are fulfilled to be able to register a time.

5.3.3 Double time tracking

Some cases are more diffuse than others and sometimes a patient requires specific care depending on the resources a hospital provides. An example of this could be that a patient is in need of care that the closest hospital is not capable of giving. So the ambulance has to drive to another hospital to get the patient handed over. While this does not seem significant, it creates a flaw within the new adapted system.

The new system recognises by itself whether the ambulance is at the hospital destination through opening the garage doors. The ambulance's time is now registered as having arrived at the hospital. The nurses proceed with their usual workflow of delivering the patient to the emergency room waiting for a doctor or nurse to take over the responsibility of care. However, if the hospital staff decides that the patient does not have to be taken into the hospital as an emergency case and should therefore be transferred to another hospital. To transfer the patient to a different hospital creates a time stamp registering discrepancy.

Now that the nurses have to drive to another hospital the time that has been registered before is incorrect. Upon arrival at the new hospital and opening the garage to their ambulance parking, another time stamp would be created but for the same purpose. However, this could be mitigated by allowing the time tracking system to override the first time stamp but only if an authorised hospital member at the second hospital is signing for taking over the responsibility of care. In this case, the time between the departure from the patient's pick up location and the final arrival at the hospital will be significantly longer which could create the impression that this mission has taken far too much time and effort. That said this would create data distorting the actual mission times which can lead to a inconclusive ambulance resource distribution, if scaled up.

5.4 Other considerations: Environmental, economic and social sustainability

The sustainability aspect of this project is something not yet discussed. There are three main aspects of sustainability; social, economic and environmental. Social sustainability focus on societal well-being as in focusing on the nation and its population, whilst environmental sustainability seeks to describe the impact on the ecosystem and the well-being of nature. The third aspect of economic sustainability touches on the resource distribution within prehospital care.

For social sustainability the project is beneficial on multiple levels, both short and long-term. For the short term aspects, the nurses can benefit from the reduced cognitive workload, and so focus on the patient and give appropriate care. By giving attention to the patient instead of complicated technical system the patient can receive the best

care possible. However, it is unlikely that the system will have a direct impact on the critical number of lives that can be saved. Long term, the system changes and adaptions aim to increase the reliability and the quality of the data that is delivered. In doing so bottlenecks and other problems may be found in the prehospital care organisation. By having a accurate and reliable time tracking system problems regarding both ambulance missions and ER handovers can be detected and so also be corrected in time. Offering a more secure emergency care system, and by doing so saving lives.

Environmental sustainability is something that unfortunately has not been touched upon in this project. As the thesis focus on system development for social sustainability the goal of environmental sustainability has been disregarded almost completely. The ambulance as a concept is not very environmentally friendly as the car weighs about 4000 kg, kitted with advanced technology devices and drives with combustion engine. And on top of all that they are driven around almost 24/7 and so have an life expectancy of about 5-6 years due to this harsh treatment. With that being said, life threatening emergencies are (and should be) prioritised over long term environmental impact.

Throughout the entire work, the shortsightedness when planning the budget for prehospital care became apparent. While it is true that the final concept will add an extra cost for buying new equipment it may be a minor inconvenience compared to the relief of the ambulance personnel. This extra cost may, however, be justifiable due to it increasing the nurses work efficiency. Furthermore on an organisational level, it might be worth thinking about re-budgeting to accommodate the addition of a second terminal as this may increase the counties' thoroughness of the tracked times which in its turn may lead to a better resource distribution.

The development of the system (and introduction of a second terminal) are regarded as having negligible environmental impact. In addition, there are many other industries that should be regarded as much more present matters when it comes to development of environmental sustainability before limiting the ambulance and prehospital care.

5.5 General discussion points

Many factors in this project depended on the execution and the planning set up in the beginning and could be influenced and steered while others could not be influenced, i.e. the terminology throughout the emergency chain and the Swedish counties' inconsistency in organising prehospital care. Many steps in prehospital patient care have multiple names for the same action.Further, these steps could be executed significantly Moreover, the lack of proper English terms became apparent when working during this project.

For using the system for time tracking system, four stakeholders working closely with the system have different names for the times created during a mission. Lead times (*ledtider*), response times(*responstider*), status time (*statustider*), status handling (*statushanteringar*), time stamp (*tidsstämplar*) as well as process times (*processtider*) are six different terms which are used by the different stakeholders. This inconsistency may foster misunderstandings when multiple stakeholders come together wanting to discuss the time tracking system. We believe that this could have caused issues if we had not been very clear during the research and development phase that these terms are interchangeable. With that said, a consistent and standardised terminology is strongly recommended to

avoid confusion and misunderstandings. This proposal may seem insignificant compared to other advancements yet will make a vast impact in further discussions.

Further, we propose that the ambulance nurses shall take the second terminal with them when on arrival at the patient. One argument for the second screen is that it makes registering the time easier and more efficient while maintaining a consistency throughout system's interface. The familiarity of the interface shall lower the threshold for the ambulance nurses to embrace the new system without creating new usability issues. The system ought to work in the ambulance nurses favour, guide them through small nudges and steer them into the right direction when using it. Due to the high grade of automation in three of the five steps focused on, the ambulance nurses further needed confirmation that even the automated time stamps made their way into the time registry without leading their attention away from their actual goal which is provided good prehospital care for the patient and should not be mixed up with the system's goal of delivering as reliable check in times as possible during the process of taking care of the patient.

During the thesis work, the observations proved themselves to be one of the most valuable tools throughout the project work. This was mainly the case due to gaining a better understanding if lapses are common while registering the time or if it is a rather made-up problem. When looking at the data of the registered time stamps that we have collected and compiled after the participatory observations, it became clear that the time deviations are vast in some cases. Further, time registry was missed twice during the observations as well as once the time was consciously not registered as the ambulance nurses would have had to deal with questions from *SOS Alarm* regarding their whereabouts. Three misses or lapses may seem few, however, when having part taken in seven observations those three deviations create a 43% probability for misses, lapses or other reasons as to why the time is not properly registered. If this number was to be up-scaled, the initial question to why this project was started becomes more apparent. When discussing this with PICTA it became clear that there is no way to verify the times in the current system and the insight gained from the observations conducted were unique and that there had been no such insight previously.

Regarding the technical advancements it is worth mentioning though that a reformation and testing process was initiated in which voice recognition and voice detection is used by authorised medical staff. These tools have been part of health care since a few years back but first and foremost to help patients that do not speak Swedish or English to make themselves understood and to guarantee that they receive the correct treatment. With artificial intelligence advancing rapidly, it seems like the implementation of voice control is not too far away in the near future. This discussion point is mainly tied to the digital case study results in which multiple participants suggested AI voice tools to support the ambulance nurses' work tasks. Nevertheless, due to that the concept should be implementable in the near future, these ideas were discarded. Overall, AI will eventually play a role in health care.

Lastly, it is important to touch on the aspect of cognitive ergonomics. Throughout the research and development phase, the target users, namely, the ambulance nurses have been asked consistently to whether, how and in which grade they are feeling stressed or pressured during their work. Further, they have been describe their perceived cognitive ergonomic work load throughout their work shift to be quite low, however they were irritated if the systems they are interacting with are working slowly or not at all. This

was noted to be the major cause for frustration and some cases hopelessness to change their work situation, and was taken into consideration when designing a solution for them. All in all, the use of cognitive ergonomic methods was lower than expected in the beginning of the project which is why the focus lies more towards developing a feasible concept.

6

Conclusion

Circling to the initial research question set up in the beginning of the project - *"Is it possible to increase the overall reliability of the time tracking system and how can a conceptual design proposal reduce the error probability caused by a system not accounting for external factors?"*, the following conclusions can be made.

To start with, it is possible to increase the overall reliability of the time tracking system. Present days technology is advanced as of so far, that measures to improve the existing *Paratus*system can be made. By implementing a two step verification safety system for the times that should be registered automatically, actions have been taking to prevent false time tracking. This increases the reliability of the system while also reducing the cause of errors and removing the active cognitive workload from the ambulance nurses. Further, a second terminal as a solution for active manual time registering by the ambulance nurses, was proposed. This adds the two missing times that should desirably saved to AmbuReg in the end. This will leave no empty time stamps if handled correctly.

To summarise the project, evidently, budgeting is tight in the medical area. Everything relies on a better distribution of both human and equipment resources which is why flawless data is crucial. Nationwide, Sweden's counties and organisations such as PICTA are making a co-joined effort to raise awareness on the deficiencies and possibilities. This gives hope for a better future of prehospital care in the future.

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Appendices

A

Appendix 1 - Interview Guide

General

- How long have you worked as an ambulance caregiver (or nurse)?
- What motivated you to work in an ambulance instead of, for example, regular nursing or the emergency room?
- Describe a typical workday.
- What would you say is the best part of your job?
- What would you say is the most challenging part of your job?

Work distribution

- What does the division of responsibilities look like among those who work? Do you have a dedicated driver? Or do you switch?
- Do you have many different colleagues or do you usually work with the same people for longer periods?
- What does the shift schedule look like?
- Which shifts are the toughest?
- Do you find yourself making more mistakes during certain specific shifts? Or specific times during a shift?

General feeling about missions

- Can you tell me about a time when your work did not go as planned?
- How much do the different missions vary?
- In terms of stress, physical demand, time-wise
- How do you feel when a mission does not go as smoothly due to external factors? (Weather, seasons, traffic, etc.)

Technology and equipment

- Are there any tools/systems in the ambulance that facilitate your work? Why do they facilitate your work?
- Is there anything you miss in the ambulance (physical/technical product)

- How do you find out about updates and changes happening in the system or equipment?
- Do you have an example of when a system or technical product has been updated or replaced?
- Have you ever forgotten to press the button for the next step in the process?
- How often would you say you miss pressing it?
- Which of the steps is easier to forget? Why?

Opportunity to influence

- How do you perceive the opportunity to have influence on how the ambulance - is equipped? Operates?
- How would you proceed if something does not work as it should? (technically or mission-wise)?

Future

- How do you see the role of ambulance caregiver/nurse developing in the next 10 years?
- How do you think it will look like in 50 years?

B

Appendix 2 - Observation Guide

Personal background questions

1. How long have you worked as ambulance nurses?
2. What education do you have?
3. What is the best part of your work?
4. What is the best technological development that has occurred since you started working?
5. What is the responsibility division like among those who work?
6. What is the responsibility division like among those who work?
7. Dedicated driver? Or do you switch?
8. Do you have many different colleagues or do you usually work with the same people for longer periods?

Shifts

1. What do the shifts look like?
2. Which shifts are the toughest?
3. Do you feel that there is a greater chance of risks on certain specific shifts?
4. Or specific times during a shift?

How do external factors affect the work?

- Weather
- Road conditions
- Traffic
- Emergency room

How much do the different missions vary?

- Stress-wise (when is it most stressful)
- Physically demanding (carrying, stairs, etc.)
- Time-wise (takes different amounts of time)

What improvements in technology would you like to see in your operations?

- Do you have an example of when a system or technical product has been updated or replaced?
- Were there any difficulties?
- How should new technical equipment be implemented (training, warning, etc.)?

Check-in questions

- Are there any specific cases where it is likely that you forget to check in?
- Stressful mission
- Stressful mission
- Long time on the job
- Any particular stamp that is extra difficult?
- Their view of the timestamp system, is it an obstacle etc.?
- Can you tell me about a time you forgot to use the check-in?
- Which step is hardest to remember?
- How often would you say you forget to press?

Observations

- What affects them?
- Technology (phone, Paratus, RAKEL etc.)
- The work itself (someone dies or something, etc.)
- External factors (weather, traffic etc.)
- Work structure (schedule, management, SOS alarm etc.)
- How do they get affected? (Stress, aggressiveness, fatigue etc.)

How much does the time stamping actually affect the ambulance personnel's work?

- Do they always bring the emergency bag or other items?
- Interaction with the Paratus system?
- Do they express frustration? (physically or verbally)
- When do they use the portable RAKEL terminal?
- How do they divide up the tasks in the car?
- Look for patterns in who presses the screen etc. (same person regardless of role, or always for example the driver and that they switch)
- Are there compensations in their behavior that they themselves are not aware of because the technology fails? (For example, they know something doesn't work but have developed a habit of working around it without thinking about it)
- How do they divide up the interaction with the 8 steps among themselves?

- How much error is there in the time they report? Measure themselves?

C

Appendix 3 - Observation Summary

C.1 Mission 1 - Priority 2

The first mission started as expected with an alarm call from SOS to the handheld device of the ambulance nurses. Both ambulance nurses in a team have a walkie-talkie which allows them to accept the mission. If one confirms to take the mission the other automatically also has accepted the mission. One of them was the driver for the mission while the other one was the primary caregiver at the emergency scene. The drive pressed the status button for arrival at destination at the exact time after having reached a parking position closest possible to the patient's address. They grabbed the necessary equipment from the ambulance's care space, in this case the emergency care bag and another bag with extra material. From reaching parking position to reaching the patient the estimated template time is approximately two minutes. Due to the lack of an elevator and having to climb four floors the arrival time was double what would have been expected. They put down the emergency gear and started to evaluate the patient's situation and determined whether to take them with them or not. After the patient had received necessary care, the nurses took had to take them down the four floors that they had climbed previously, help the patient into the ambulance and then manually press the button for having loaded the patient into the ambulance. Then they drove off to the closest hospital. On the on-board monitor there was no option to confirm the time of arrival at the hospital, as proposed by FLISA's standardisation. On arrival at the hospital, one nurse handed over the patient to the emergency nurses and proceeded to write down information in the patient's journal, while the driver refilled the materials that had been used during the mission. Having written the journal and refilled the car with the necessary material the driver and the care-giving nurse swapped places, resulting in the care-giving nurse becoming the driver. When leaving the hospital the driver forgot to confirm that they now were available to receive another emergency call. The monitor then displayed a reminder asking whether they were moving towards the station again. Due to the reminder the driver confirmed that they are on their way to the station. This lapse created a deviation from by approximately three minutes. The ambulance was parked at the station, and the status button for the completed mission was pressed.

C.2 Mission 2 - Priority 1

Approximately ten minutes after they had returned back to the station another emergency call was received. They confirmed to take the mission in the car this time as the priority was higher than on the mission before. One of the nurses was allowed to drive the

ambulance with blue light and/or audible warning signals. At arrival at the destination the driver had to drive into a narrow parking lot, drive backwards and park, yet they pressed the button for having arrived at the destination before reaching the final parking position. This meant that the time for arrival saved in the system was before the actual arrival of at the destination. They then gathered the emergency bag and the ECG-device and arrived beside the patient within one minute as the entrance was at the ground floor. They took an ECG, and gave the patient the necessary primary care before getting the stretcher from the ambulance as they decided to take the patient to the closest hospital. Both ambulance nurses helped the patient to get onto the stretcher, packed up the emergency bag and mounted the ECG onto the stretcher before loading the patient into the ambulance. They made sure not to leave anything behind, then they swapped driver as they now did not have to drive with warning signals as the patient's condition had stabilised. The driver pressed the button and drove off. The other nurse sat next to the patient in the back of the ambulance retaking some of the prior measurements and making sure that the emergency unit at the closest hospital was prepared. Due to shakiness in the car the ECG-machine created obscure measurements which meant that the hospital called and demanded a re-measurement. They stopped the ambulance 150 meters in front of the hospital to take a new ECG which was why the ambulance lost time while delivering the patient. The hospital decided to take the patient in, the driver pressed arrival at hospital and they handed over the patient. This time they both filled up the materials while writing the patient's journal as well. Afterwards they pressed the button for available and drove back to the station and pressed mission completed.

C.3 Mission 3 - Priority 1

At around 12.50 a new emergency call came in which was a priority 2 mission. The ambulance nurses packed up their belongings systematically. Then communication system towards SOS rang once more. SOS had overridden the priority 2 mission with another priority 1 mission. This happened at 12.55 leading to the nurses immediately taking the call and confirming the mission. Due to the priority they drove as fast as possible to the patient's destination as well as with both light and sound warning signals. The ambulance arrived at the destination where the driver confirmed the status for having arrived. After that, one of them grabbed the emergency bag and other equipment to examine the patient. This time it took approximately two minutes from arrival at the destination to arrival next to the patient. Due to the emergency being at a public place one of the nurses got the stretcher to remove the patient from the stressful environment and the eyes of other people. The actual time they loaded the patient into the ambulance space and the time of confirming the status differed greatly here due to the nurses provided primary care in the ambulance. The driver pressed the button for confirming that they had left the destination, drove off, dropped the patient off at the hospital while confirming that they are available again after dropping the patient off. In this case, the entire mission went incredible fast due to the severity as well as the location of the emergency.

C.4 Mission 4 - Priority 1

This call was accepted immediately due to it being priority 1. The ambulance nurses were acting calmly and controlled even though they had to drive with sirens and light signals.

They pressed the button for arrival at the destination accordingly and arrived at the patient approximately after two minutes. Both ambulance nurses helped with the initial prehospital care as the patient required an intravenous drip as well as taking different tests. As a precautionary measure, the nurses had taken the stretcher with them to the patient from the beginning, likewise the emergency bag to give the best possible care at the patient's location. They loaded the patient into the ambulance and pressed the status to confirm driving to the closest hospital. On the way to the hospital the co-driver called the hospital to ensure they knew what to prepare for the patient. At arrival at the hospital the driver confirmed the patient's delivery at the hospital where one of them followed the patient to the emergency care while the other one refilled the used material. Both ambulance nurses had communicated with each other to determine what they had used up and what needs to be replaced. They pressed the availability status and the mission completed status without any issue.

C.5 Mission 5 - Priority 3

30 minutes after they had terminated the first mission they received another call which was categorised as a priority 1 emergency. They confirmed the mission and drove to the health centre which had sent the request for an ambulance. On arrival they pressed the button that they had arrived at the destination, four minuted later they arrived at next to the patient together with a portable ECG-machine and the emergency bag. At the health centre, the nurses seemed confused and frustrated by the fact that the personnel there misread their own ECG as it looked fine. Nevertheless, the ambulance nurses took the patient with them to the hospital while changing the mission's priority from an life-threatening emergency to a medical transport. The driver confirmed the status for having taking the patient with them as well as the status for the arrival at the hospital. They handed over the patient, cleaned the ambulance and wrote in the patient's journal and then pressed the button for being available again. Exactly at the time of being available again they received another call, which created both a mission completed and a new mission accepted time stamp.

C.6 Mission 6 - Priority 2

The ambulance nurses confirmed the new mission. In this case they were at the ambulance already which made it easier for them to drive to the patient's destination. It took some time for them to arrive at their destination due to the GPS leading them the wrong way. The frustration the prehospital caretakers experienced could be observed by ho they reacted about the GPS. When thinking that they had arrived at the correct address, they confirmed the status for the arrival at the destination. In reality, this time should have been 16 minutes later due to them not reaching the patient's address at the first try due to the GPS misguiding them. They arrived at the patient about a minute later and assessed the situation. After 40 minutes at the patient's address SOS contacted the ambulance nurses again to check why they had not moved yet meaning why the status of the mission were not updated. The nurses ten minutes after the check-in call of SOS leaving the patient in their apartment as they did not require special medical care. Therefore they never pressed the status button for departure from patient, arrival at hospital or available yet they just pressed mission completed instead. In this case, it

became clear that the time stamps do not account or allow for flexibility in the system.

C.7 Mission 7 - Priority 1

Whilst having pressed mission completed, the ambulance nurse team received another help call of priority 1, which they confirmed on the handheld RAKEL device which created yet again two time stamps at the exact same time. This is due to them confirming on taking the mission as well as they started the mission the same time. They took themselves as fast as possible to the patient, where they confirmed that they had arrived at the patient's address. Approximately three minutes later the nurses arrived at the patient. Due to a relative being stressed over the situation, the nurses wanted minimise the stress for both the patient and themselves which was why one got the stretcher. The nurses called the neurologist and the emergency care chain started. This was done ensure that the patient would receive the necessary care immediately at the right hospital. They pressed the button for departure destination and took the patient to the closest emergency room. They did not press the button at arrival at the hospital due as the status would have been changed automatically by SOS to being available again after 20 minutes. Therefore, the ambulance nurses called SOS to inform them that they needed more time for the mission. After the entire mission, on their way back to the station SOS calls to inform them that they had missed to update their status, so SOS confirmed that the mission was completed.

D

Appendix 4 - The system of an ambulance mission

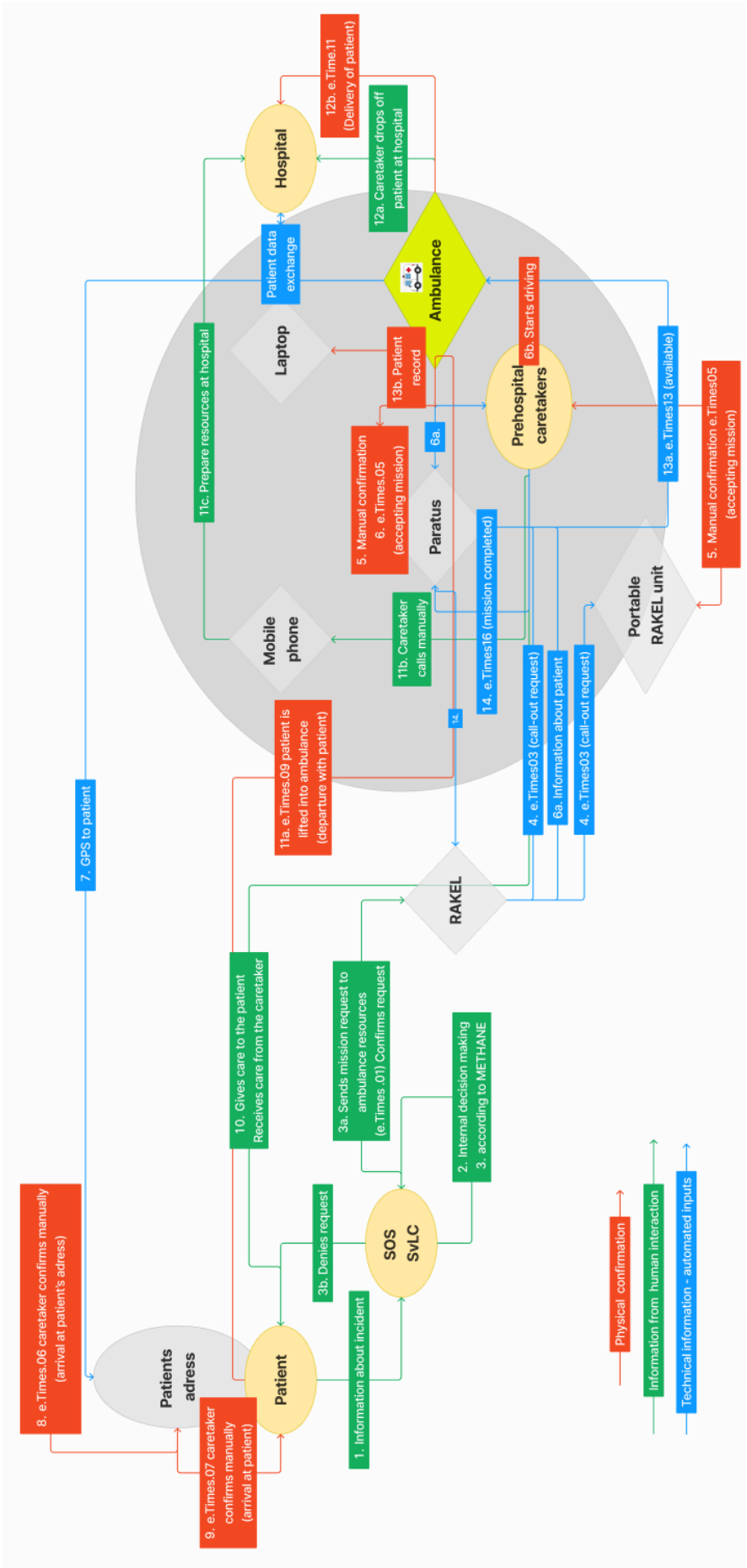

Figure D.1: The system of an ambulance mission

E

Appendix 5 Graffiti Walls

1. How stressed are you during your workday compared to cognitive load?

2. What aspect of prehospital care do you believe requires the most development?

3. How often do you miss changing the status (update the time stamp) during a mission?

4. What is the most demanding in your line of work?

5. How would you like to document "arrival patient"?

6.If you have thoughts, questions, or ideas on how status management can work better in the future, please feel free to drop a suggestion in the box next to it!

F

Appendix 6 - Interactive Digital Case Study

Hej!

Varmt välkommen till vår interaktiva digitala fallstudie!
I denna studie ska du få hjälpa oss att utveckla produkter för en ambulanssjuksköterskas arbetsflöde.

Fallstudien görs i syfte för att hjälpa oss i vår idégenereringsprocess där vi kommer guida er igenom en kreativ idégeneringsprocess. Det kommer gå till så att ni kommer få en introduktion till ett case som ni får spåna på idéer till några valda problemområden. Vi kommer även ge förslag på tid för de olika momenten som vi skulle vilja att ni håller er till. Om vi vill att ni använder en specifik metod för att idégenerera kommer vi instruera dig på bästa sätt.

Ha penna och papper till hands och behåll pappren tills du har gått igenom hela workshopen. Skriv och rita gärna så vi kan läsa och tolka det (gör pilar och förklarar med text) samt vilket steg du är på (1 -4) på pappret så vi vet vart ni befann er i processen. Tiden för varje delmoment är angiven med ett timglas och siffra.
Sist men inte minst – det finns inget rätt eller fel, alla idéer höga och låga är viktiga och relevanta. Lycka till 😊

Kasper & Marina

Fortsätt

Figure F.1: Welcome to the project

Bakgrund till arbetet

Ambulanspersonalen i Sverige använder sig av olika hjälpmedel under sin arbetsdag. De bär bland annat en portabel “walkie-talkie” som är kopplat till ett nationellt nätverk och är till för kommunikation mellan blåljuspersonal och SOS-alarm. I ambulansen finns en monterad skärm för att kunna hantera uppdrag.

Under ett uppdrag behöver ambulanspersonalen använda den monterade skärmen för att dokumentera hur lång tid olika steg i uttryckningen tar. Detta kan vara exempelvis när de startar uppdraget, kommer till sjukhuset etc. Totalt är det 8 tillfällen som personalen ska manuellt dokumentera tiden genom terminalen. Det är viktigt att ha rätt data för att kunna analysera eventuella brister i den prehospitala akutsjukvården.

I detta arbete försöker vi just utveckla ett nytt system för att dokumentera tiden. Målet är att minimera belastningen på personalen samtidigt som systemet levererar mer exakt data till beslutsfattarna.

Terminalen i hytten samt den portabla “walkie-talkien”

Tillbaka Fortsätt

Figure F.2: Introduction to the project

Case bakgrund

Lena har varit ambulanssjuksköterska sedan 5 år tillbaka. Hon upplever att arbetet är mycket händelserikt och spännande samtidigt som det är utmanande ibland, hon känner sig meningsfull i rollen. På fritiden gillar hon att vara ute i naturen med sin hund och röja i odlingslotten framför sitt lägenhetskomplex. Hon är inte särskilt tekniskt intresserat men jobbet medför att hon handskas med en hel del olika tekniska prylar – en färddator, en handhållen walkie-talkie och en dator samt diverse knappar i själva ambulansen och den utrustningen hon behöver hålla koll på. Just färddatorn tycker hon kan vara lite jobbigt ibland och att det kan vara svårt att komma ihåg att bekräfta olika delmoment i sitt arbete när arbetet blir stressigt. Tur att hon kan förlita sig på sin kollega Ludwig.

Tillbaka Fortsätt

Figure F.3: Introduction to case

Steg 1 - Uppdrag start

Lena och Ludwig får ett anrop i walkie-talkien från SOS-alarm för att åka med ambulansen till en patient. Lena trycker på en knapp på walkie-talkien för att acceptera uppdraget. De ska nu ta sig från stationen - belägen nära Centralstationen i Göteborg– till Kviberg. Uppdraget är inte livshotande men allvarligt vilket gör att de i raskt tempo tar sig till ambulansen och kör mot patienten. Idag är det Ludwig som tar plats i förarsätet. Han öppnar garageporten, sätter på blåljuset och påbörja körningen. Efter 10 minuters körning parkerar bilen framför en bom vid den angivna adressen de tidigare har fått när uppdraget påbörjades. Ludwig bekräftar detta med ett knapptryck. De plockar med sig akutväskan och walkie-talkien.

OBS: Målet är att terminalen får veta den exakta tidpunkten där de var framme på hämtplatsen.

Tänk utanför boxen nu!
Finns det andra möjligheter för systemet att veta att de anlänt vid hämtplatsen?
Kan man lägga till funktionalitet, anpassa eller plocka bort något?

10 min.

Tillbaka Fortsätt

Figure F.4: The mission stars

Steg 2 - Framme vid patient

De går förbi bommen framför vilken de parkerade och söker efter rätt entrédörr. De ringer på ringklockan, ingen svarar så Lena försöker ringa en gång till medan Ludwig kollar ifall det fanns en portkod i larmets information. “Men se där!” brister han ut när han har hittat portkoden. De tar sig in i huset, gå upp två våningar och anländer framför patientens lägenhetsdörr. De blir insläppta av en orolig anhörig som är väldigt stressad över situationen. Enligt den informationen ambulanssjukvårdarna har fått vid utlarmning har patienten haft kraftig buksmärta tidigt under morgonen. Frun hade ringt SOS med en gång när hon hade hittat sin man på soffan på morgonen. Ludwig placerar akutväskan på golvet och börjar med att undersöka den 67-årige mannens hälsotillstånd medan Lena försöker lugna frun.

De är framme hos patienten, men har inte registrerat det i tidsjounralen i terminalen. Vilket ska göras.
Skriv eller skissa upp så många olika möjligheter för tidsregistrering du kommer på!

5 min.

Tillbaka Fortsätt

Figure F.5: Arrival at the patient

Steg 3 - Lasta patienten

"Jag spelade badminton med några bekanta igår, det var trevligt. Bra med motion när man närmar sig 70 år..." säger mannen. Buksmärta är inget ovanligt tänker Ludwig som har jobbat med ambulansen i 3 år. Men det finns en risk för att patienten skulle kunnat ha överansträngt sig eller att det är tidiga tecken på något ännu mer allvarligt. För säkerhetens skull bestämmer ambulanssjukvårdarna sig för att ta med patienten till sjukhuset. De packar ihop och hjälpa mannen ner till ambulansen, där de lägger honom på båren och kontrollerar hjärtfrekvensen. Ludwig stannar i vårdutrymmet med patienten, Lena tar plats i förarsätet. Hon trycker på lastat knappen i terminalen och börjar köra.

Finns det någon funktion som kan läggas till för att systemet ska kunna veta när patienten är i ambulansen?

5 min.

Tillbaka Fortsätt

Figure F.6: Loading patient into the ambulance

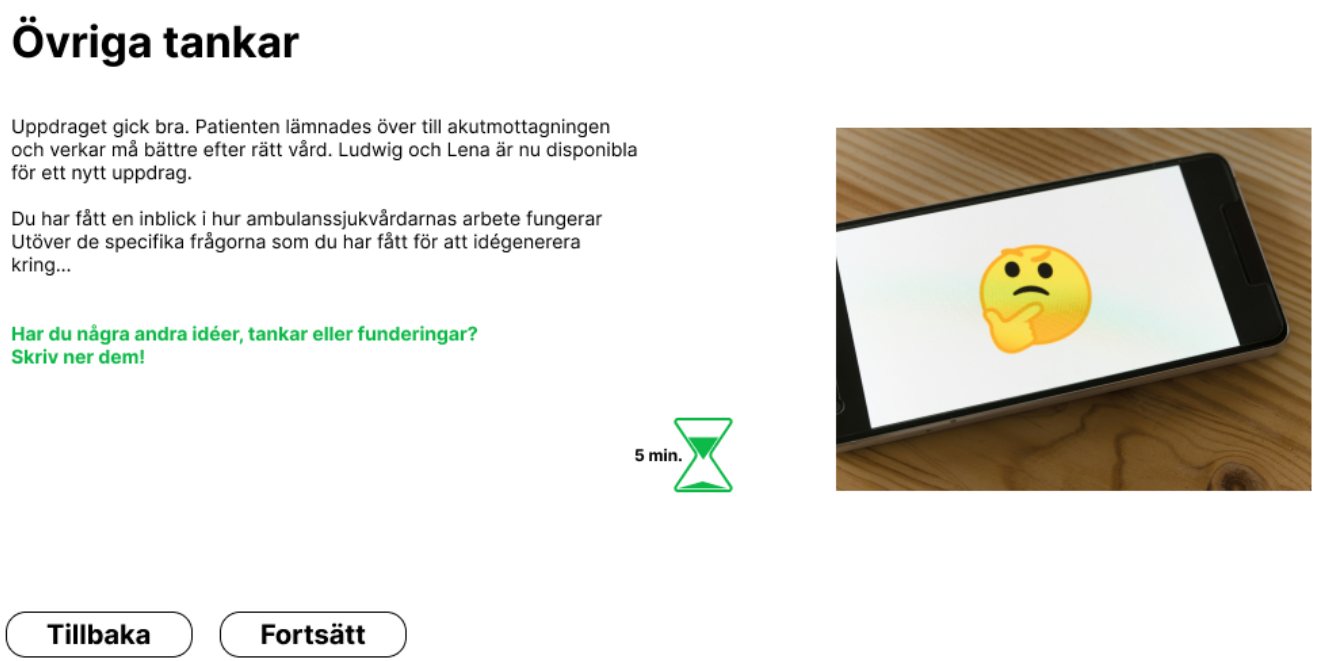

Figure F.8: Other thoughts surrounding the process

Avslutning

Avslutningsvis vill vi be dig att fota eller skanna in dina idéer du har skissat på. Se gärna till att vi kan läsa det som skrivits eller kan tolka vad som har ritats.
Skicka samtliga inskannade papper till Marina via ahammer@student.chalmers.se.

Tack att du tog dig tiden att delta i vår interaktiva digitala fallstudie! Vi uppskattar det verkligen otroligt mycket.

Ha en bra dag!
Kasper & Marina

Tillbaka Klart!

Figure F.9: Summary

G

Appendix 6 - Evaluation Guide

In our thesis project, we have examined the Paratus system and how time stamps are managed and recorded. Our goal has been to develop and facilitate you collaborating with the system and introduce our new concept to you.

Arrival destination – Pickup location arrival

In our solution, this step has been automated. Arrival is now registered by driving into a geofenced area with the condition that the door opens when exiting the ambulance. If only one condition is met, the time is not registered.

- Do you think it's good that this step is automated?
- Do you feel confident that the time has been recorded? If yes, why? If no, why not?
- Do you clearly see that you have reached the pickup location?

Arrival patient– Patient arrival

In this step, you will need to bring the Paratus terminal located in the medical compartment. The patient's record and information from SOS can be accessed when approaching the patient. You open the side door of the ambulance and take along the emergency bag and the second screen located in the back of the vehicle. The screen displays the medical case and other information such as door codes, floors and medical history. You are to register your arrival with the patient but also have the opportunity to write record notes.

- How do you proceed? Do you know how to record the time?
- Does it feel intuitive to register the arrival? If yes, why? If no, why not?
- What do you think about bringing the screen to the patient?
- Do you feel that the additional available information would have helped you in your work? (on-site and later during annotating)
- If it's inconvenient to bring along, what could be done to improve it?
- How do you perceive the time registration process in this step? (Smooth/awkward, easy/difficult to understand, informative/non-informative)
- How likely do you think it is that you would forget to press arrival at the patient?
- Do you feel that you have control over the system?

Loaded – Patient departure

You have picked up the patient and loaded them into the vehicle and are now heading to the nearest hospital. Since you registered in the previous step that you had arrived at the patient, the system knows that the next step is to leave the patient at the hospital. The front screen displays priority choices. After the choice is made, the hospital you are going to is indicated. By choosing the priority, you have already confirmed that you have loaded the patient.

- Do you think it's good that this step is automated?
- Is it clear to you when the time has been recorded? If yes, why? If no, why not?
- Do you feel confident that the times have been recorded?
- If you were on a mission, would you feel that it would have facilitated your work?
- Do you feel that you have control over the system?

Arrival hospital - Arrival at the hospital

You are now heading towards the hospital and need to open the gate upon arrival. By opening the garage door and driving into the hospital garage, you confirm that you are at the hospital.

- Do you think it's good that this step is automated?
- Do you feel confident that the times have been recorded? If yes, why? If why, no?
- Is it clear to you when the time has been recorded?
- If you were on a mission, would you feel that it would have facilitated your work?
- Do you feel that you have control over the system?

Hand over patient

You have arrived at the hospital and begin to unload the patient. One of you removes the rear screen again to bring it to the patient handover. You arrive at the emergency room and wait until hospital staff receives your patient. A nurse will take over the patient. One of you presents the screen you brought along, and the nurse signs at the handover using a personal code. Please observe the screen.

- Do you find it clear when the time has been recorded and the patient has been handed over?
- What do you think about bringing the screen into the reception?
- If it's inconvenient, what could be done to improve it?
- Do you feel that you have control over the system?
- Do you think this step would have made your work easier or more difficult?
- Do you think it's advantageous to find out when the patient is handed over in a broader perspective?

Closing questions

- Compared to how the system is today, would you feel less stressed/experience reduced cognitive load?

- Do you perceive an improvement due to our work from a technical/organisational perspective?
- How reliable does the system feel to you?