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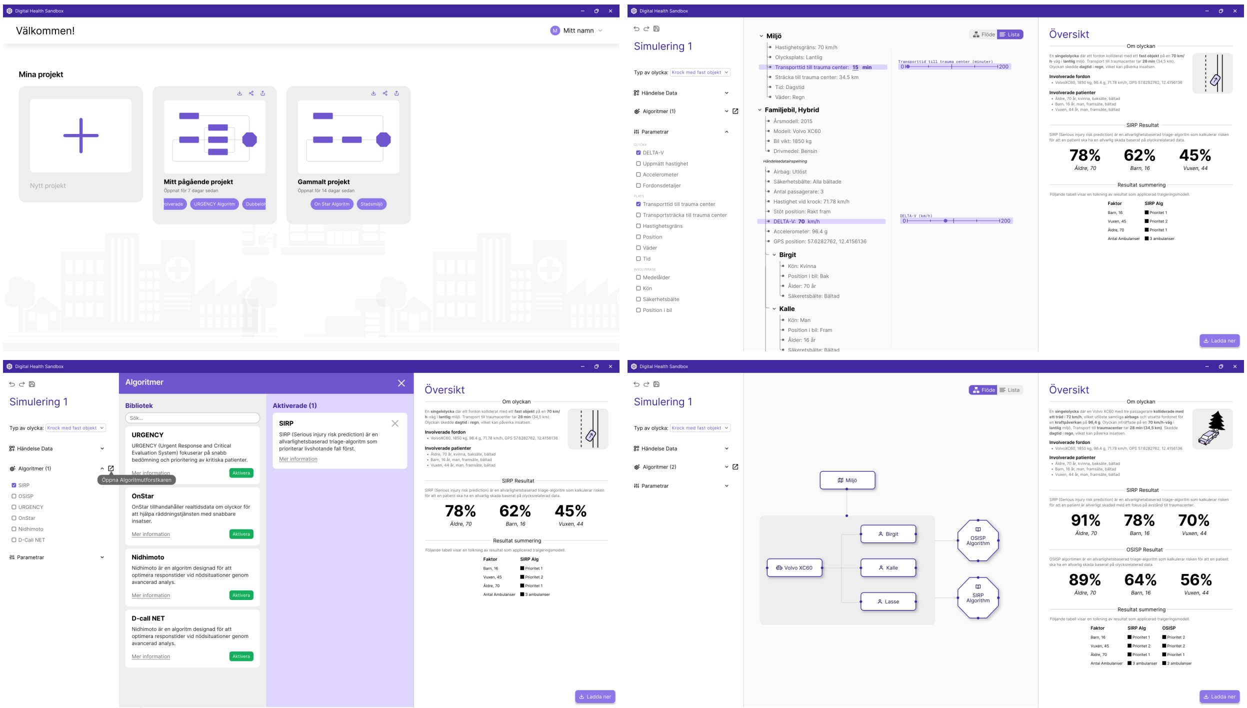

Designing a Sandbox for Smarter Health Solutions

Creating a Usability-Centered GUI Sandbox for Innovators Within Healthcare to Simulate Traffic Events and Validate Digital Health Algorithms

Master's Thesis in Interaction Design and Technologies

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

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Cover: A collage of key frames within the user interface design of the Digital Health Sandbox.

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Abstract

Efficient and accurate decision making is of high importance in emergency healthcare, particularly in the triage of traffic related incidents. However, current systems face challenges such as overtriage and limited use of available data. As a result, the Care@Distance team at Chalmers has developed the ASAP framework, which includes the development of a Digital Health Sandbox (DHS). This thesis centers on the creation of the DHS, a simulated environment designed to allow healthcare developers to test and explore triage related algorithms using synthetic data. It further explores how user-centered and visualization-focused design affect the usability of a digital interface aimed at improving healthcare planning and evaluation.

Through an iterative design process grounded in User-Centered Visualization Design (UCVD), a high-fidelity prototype was developed and evaluated with input from end users. The prototype enables simulation visualizations of healthcare scenarios, with a focus on traffic accidents.

The results suggest that user involvement and visualization techniques can improve the usability and clarity of digital tools intended for healthcare development. While the DHS remains a prototype, it offers insights into how design methodologies can help bridge the gap between technical solutions and user needs, contributing to the ongoing development of more effective and user adapted digital health tools.

Keywords: Sandbox, User-Centered Design, User-Centered Visualization Design, Usability, Information Visualization, Health Algorithms, Digital Health, Triage, Emergency Healthcare, Traffic Accidents.

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Wilma Bergman & Susanne On Huang, Gothenburg, June 2025

List of Acronyms

Below is the list of acronyms that have been used throughout this thesis listed in alphabetical order:

AACN	Advanced Automatic Collision Notification
AI	Artificial Intelligence
ASAP	Acute Support Assessment and Prioritizing
DHS	Digital Health Sandbox
EMS	Emergency Medical Services
GENRWD	GEmelligeNerator - Real World Data
GUI	Graphical User Interface
MVP	Minimal Viable Product
ML	Machine Learning
OSISP	On-Scene Injury Severity Prediction
ORE	Overall Relative Efficiency
SIRP	Serious Injury Risk Prediction
SEQ	Single Ease Question
SUS	System Usability Scale
TBE	Time-Based Efficiency
UCD	User-Centered design
UCVD	User-Centered Visualization Design
UI	User Interface
VGR	Västra Götalandsregionen
WP	Wicked Problems

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1 Introduction

Each year, around 200 people die and approximately 3600 are severely injured in traffic accidents in Sweden [1], [2]. These numbers highlight the urgent need for improved triage systems and more efficient use of medical resources [3]. Timely and accurate decision-making in healthcare emergencies is essential, but in practice, it can sometimes be inconsistent or delayed. In Sweden, traffic accident triage frequently suffers from misclassifications, with many incidents being prioritized as more severe than they are. According to statistics from Västra Götalandsregionen (VGR)[3], 95% of traffic accident alarms were initially assigned the highest priority. However, only 13% were later confirmed to be that urgent upon arrival of emergency personnel. This mismatch can lead to necessary healthcare being unevenly distributed and result in people not receiving the help needed. Modern vehicles generate extensive data [4]. Although this data could support emergency decisions, much of this information remains underutilized in Sweden's healthcare sector. The integration of digital health technologies offers a promising solution to this inefficiency.

Digital health technology refers to technology that encompasses information, communication, recording, analysis, and more, in the health sector [5]. It involves a broad range of innovations, such as Artificial Intelligence (AI), Machine Learning (ML), cloud computing, tele-health, and mobile health apps, that can change how care is delivered [6]. These tools do not only enable earlier diagnoses and better patient outcomes, but also enhance collaboration between patients, caregivers, and researchers'. One emerging area of interest is the application of algorithms in healthcare-related decision-making processes, such as decision support systems in emergency healthcare [7], [8].

The focus of this Master's Thesis project is on the development of a Digital Health Sandbox (DHS); a simulated environment for testing, validating, and refining new technologies before they are deployed in real-world healthcare systems. It will further explore how to visualize the inclusion of digital health algorithms in emergency triage workflows, specifically within the context of traffic accidents.

The DHS initiative is part of the broader work being conducted by the Care@Distance research group at Chalmers University of Technology. Their research aims to address the complexities of remote and pre-hospital healthcare through tools such as the ASAP framework (Acute Support Assessment & Prioritizing), which focuses on the aggregation of data from heterogeneous data sources [3]. The DHS is designed to extend this work by offering a safe, exploratory space for stakeholders to assess the practical fit of different solutions in a range of healthcare scenarios.

The Graphical User Interface (GUI) design for the DHS is the central task of this thesis. As the project can be categorized as a wicked problem [9], the challenges of it are not fully known at the outset. Hence, they will emerge and evolve throughout the process. The idea for this project emerged from the TEAPaN project (Traffic Event Assessment Prioritizing and Notification), which involved stakeholders from healthcare, the automotive industry, and academia to improve safety and response strategies in traffic-related incidents [3]. This context serves as the foundation for designing a visualization tool which supports better triage, data understanding, and ultimately, smarter healthcare decision making.

1.1 Target group

The project's target group of this study is business analysts within healthcare looking for possible improvements or new implementations, which are the majority of the participants. Specifically, they are interested in simulating healthcare scenarios and digital health technology utilization. In this project, the business analysts involved were people working at various healthcare-related organizations (such as hospitals and alarm centers) within VGR in Sweden.

1.2 Research Aim and Area

This interaction design project explored the application of user-centered visualization design on a technically challenging concept which works to combine several parameters, heterogeneous data sources, and modeling tests. It entailed developing a GUI that strives to achieve usability by focusing on the involvement of its users as well as usability principles. It examined the challenges that emerged when these approaches were combined and explored the potential they provide. By implementing the chosen design methodologies, their ability to manage the product's complexity while, at the same time, still delivering on their assurance of a strong user focus was assessed.

1.2.1 Research Goals

This thesis works with the following research goals:

- Applying the User-Centered Design Visualization methodology to visualize heterogeneous data sources.
- Involve target groups during development to create a usability-focused interface in line with users' needs.
- Design the user flow of the interface in one simulation scenario of one traffic accident.
- Create a high-fidelity prototype for the DHS.

1.2.2 Research Question

This master thesis project works to answer the research question:

Can the process User-Centered Visualization Design be used to achieve usability when creating an interface for visualizing information from heterogeneous data sources?

1.3 Limitations

The potential application of the DHS is large, with many different users. However, this thesis is a starting point specifically dealing with healthcare processes related to traffic accidents. The target users are business analysts with varying experience within healthcare organizations, and the interviewees in this project all work within the Västra Götaland region. The project will produce a high-fidelity graphical prototype, and no back-end will be constructed. This means that the final product will not be functional. The language of the final prototype will be in Swedish due to participants' preferences. Finally, the prototype will contain a single traffic accident scenario, and legislation aspects are not included. This raises scalability concerns, which will have to be managed in future development.

1.4 The Digital Health Sandbox Architecture

The development of the design is based on the initial architectural framework provided by the Care@Distance team, where the DHS was divided into four main components [10]. The components are: *Data providers, Services, Consumers*, and *Scenario Engine*. See Figure 1.1 for a model of the user flow, and Figure 1.2 for how the architecture specifically manages this project. The framework was used a guide to understand and develop the concept.

The *Data Providers* supplies the simulation with data. They can be real sensor data or synthetically created for each scenario, but can also be manual input. They provide data from different sources such as car sensors, smart watches, and phones. The user can add the data sources of interest as input for the simulation.

The data can then be used as input to the simulation's operational component (*Services*). It processes the information and can be a type of digital health tool using data for its input, for example, algorithms, machine learning models, or artificial intelligence models. The user can then use the DHS to simulate a run, generating an output of the algorithm.

The *Consumers* visualize information to users in terms of the processes performed by Services and Data Providers. In this project, Consumers is the Sandbox GUI, which contains information regarding the simulation parameters as well as the results from the algorithm calculations. Consumers function as a decision support when exploring development and new processes in healthcare with digital solutions.

The *Scenario Engine* represents how the user can control and configure the elements within the DHS. In this project, the *Scenario Engine* refers to the DHS interface concept, where the user can manage and control the simulation they conduct.

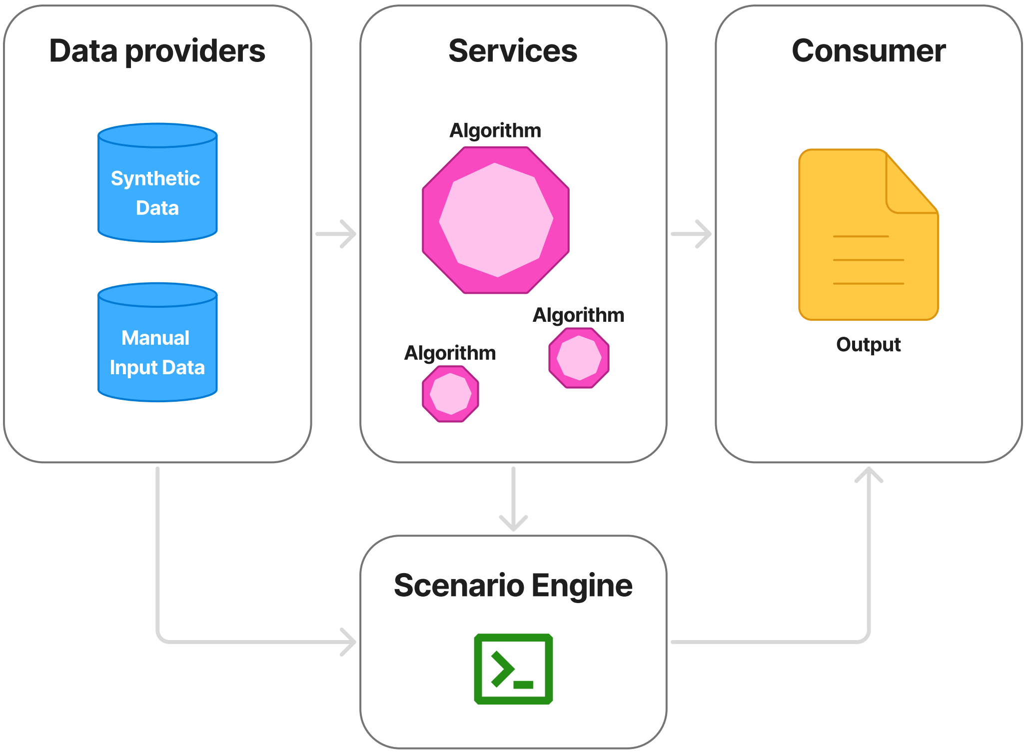

Figure 1.1: The building blocks of the DHS architecture.

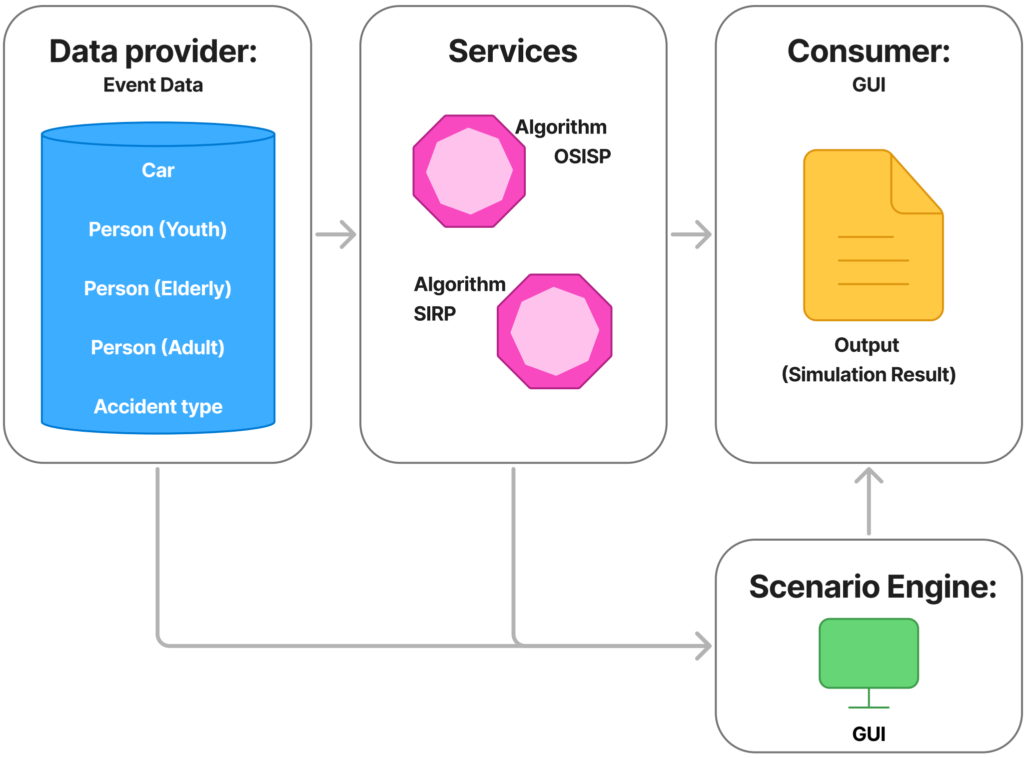

Figure 1.2: The DHS architecture specifically in relation to this design project.

1.5 Ethical Considerations

To reduce the risk of participant identification in our data collection, ethical standards were upheld throughout the interviews and evaluations conducted with participants. Informed consent aligning with GDPR's data collection policies specified by Integritetsskyddsmyndigheten (The Swedish Authority for Privacy Protection's) was collected [11]. See Appendix A for the consent form. The participants were informed about their voluntary participation and anonymized answers. Interview transcriptions were only be accessible to the authors. No personal identifiers were included in the analysis. Participants were further informed about the possibility of withdrawal from the study at any time without providing a reason, and removal of data from the analysis upon request. To minimize any discomfort, interview questions were limited to professional tasks, tool use, and user experience, with no collection of sensitive personal information.

A challenge which concerns maintaining anonymity in a limited participant pool was of concern. In specialized fields like healthcare, roles and affiliations may be recognizable despite anonymization. The risks of this was mitigated by avoiding detailed role descriptions in reporting and aggregating findings where possible. Another challenge within this project is the power dynamics in institutional contexts. Some participants may feel obligated to contribute based on professional roles or relationships, despite participation being voluntary. This will be addressed by clearly emphasizing the voluntary nature of participation and offering the option to opt out at any time without consequence.

Additionally, interpreting qualitative feedback involves a degree of subjectivity, which raises concerns about faithfully representing participants' perspectives. To address this, thematic analysis was done collaboratively and design iterations were shared with participants to confirm alignment with their expectations. Finally, the prototype developed in this study is based entirely on synthetic data, which avoids ethical concerns related to real patient data.

Further ethical implications of the system and its broader impact are discussed in Chapter 10. This finalizes the introduction to this project. The following chapter will present the background of this project.

2

Background

This chapter describes the technical aspects relevant to this project. It explains digital sandboxes and present their strengths, weaknesses, and usage areas. It also addresses simulations and synthetic data specifically related to healthcare scenarios. Related works regarding other digital health sandboxes similar to the project are presented. Finally, it reports on triaging systems and usability in healthcare software.

2.1 Digital Sandboxes

A sandbox provides a safe environment, physical or digital, for developing and testing new processes, methods, or products without disrupting existing operations [12], [13]. It allows organizations to evaluate compliance with current procedures before implementation [13]. Digital sandboxes within healthcare are used to safely test new forms of assessment and technologies like AI and advanced medicinal products before real-world implementation, suitable for working with products and methods that can have a significant impact on people's lives, such as patients. Sandbox utilization is not limited to improving patients' experiences, it extends to healthcare providers, commissioners, and regulators, inter alia.

One of the essential attributes identified by Leckenby et al. [13] for the successful use of a sandbox is the ability of stakeholders to collaborate effectively. This is a key element to keep in mind when developing the DHS fort this project as new innovative products and practices in the healthcare sector often are met with skepticism by both healthcare providers and patients. This underlines the importance of taking both patients and the public into account to ensure uptake and implementation. Including all stakeholders allows for an iterative process for innovative development. Other success factors include clear mission statements, targeted deliverables and time-frames, work streams defined by involved participants, and expected milestones [13].

The main benefit reported from the use of sandboxes in general is reduced implementation time of new products and processes [13]. It was further recorded that financing for projects is more easily accessed as the innovations can be tested in their early stages, which increases the innovations' trustworthiness. Additionally, improved collaboration between organizations, regulators, and innovators is recorded as well.

2.1.1 Simulations

Computer simulations allow users to explore real-world scenarios and test strategies without direct experimentation [14]. They offer insights into system behavior, predict outcomes from strategy changes [15], and help clarify theoretical arguments when empirical data is lacking [16]. Simulations also let stakeholders adjust parameters to better understand system functions [14]. Katsaliaki and Mustafee [14] informs about the insights that simulations allow:

> As a result, decision-makers, and stakeholders can gain a new perspective on the relationships between the given parameters, the level of systems' performance, the cost-effectiveness and its quality, or risk association [14, p. 1431].

Healthcare involves complex and uncertain parameters, making evidence based decision making challenging [15]. Simulations are well suited to address these complexities by illustrating system interconnections and predicting outcomes. As both a primary and supportive method in healthcare research, simulations help test improvements in large, costly systems [14], [16]. They are valuable for evaluating care processes and broader health issues, complementing expert knowledge where empirical evidence is limited.

2.1.2 Synthetic Data

One of the main concerns in health related simulation research is regarding the patient-specific data necessary for accurate results [17]. Ensuring data privacy and compliance with ethical regulations often makes the use and access of patient data challenging. Additionally, clinical research frequently relies on data that represents only a smaller sample size [16]. Although these samples aim to represent the whole population, they will produce differences in population means and the data sample rather becomes observations of specific group characteristics [18]. Simulations enable the analysis of larger and more randomized datasets, leading to more accurate representations of the overall population. A way to work around these challenges is to utilize synthetic data. Synthetic data can be defined as:

> Micro-data records created by statistically modeling original data and then using those models to generate new data values that reproduce the original data's statistical properties [18, p. 3].

Synthetic data is created from known distributions of data, simulations, or generated datasets that are used for the simulation to mimic the real world closely as possible [16]. It can be categorized into three main types; *fully synthetic, partially synthetic, and hybrid* [18]. An example of synthetic data in healthcare is an electronic health record dataset in which sensitive, identifiable patient information is either replaced with artificially generated data points or the entire record is fully synthetically generated. Fully synthetic data was decided to be used in the ASAP DHS project to work around the ethical issues of collecting real health-based data.

2.2 Related Works

The GEmelligeNerator - Real World Data (GENRWD) Sandbox developed by Gottardelli et al. [17] is a distributed analysis platform that works as a research playground for medical research. The stakeholders include programmers, clinical researchers, policymakers, and pharmacists. The sandbox allows the users to analyze clinical data through distributed analytics without data transfer. The sandbox works by allowing users to submit research requests which processes on local hopsital data. The results are then sent back to the users. This makes the raw data secure as through the processed data it is impossible to trace patient-specific original data. Gottardelli et al. raise important questions through their product regarding how to ensure data security when working with experimental sandboxes. Their work highlights how to effectively improve the process of data anonymity both in terms of time sufficiency and security. Their interface also works to be adaptive to its user's previous knowledge, which allows for a wide range of usability for their stakeholders.

Another project Elvidge et al. [12] examines how sandboxes can be used to minimize decision errors in healthcare development. Health Technology Assessment (HTA) organizations work to evaluate and assess new specific policy or decision inquiries about health technology, specifically regarding its evidence base. They continuously evaluate innovative health treatments and need to understand their complexity and evolvement. This introduces the risk of decision errors by HTA organizations, where effective innovations may be delayed in approval, or ineffective ones may be mistakenly accepted. An example of ineffective innovation is when the solution fails to be cost-effective. This is significant as it can lead to the misallocation of limited healthcare resources, ultimately being suboptimal for both patients and healthcare professionals. A sandbox developed by Elvidge et al. [12] specifically for HTA organizations work followed three main principles that had been identified based on previous applications and uses of sandboxes. The following principles for their sandbox development were used:

1. Create a "safe space" environment that is isolated from ongoing business-as-usual activities, in which participants can develop or test new approaches.
2. Create a neutral environment that fosters collaborative working with a broad range of relevant stakeholders.
3. Establish a clear scope to ensure participants understand the issue being addressed by the sandbox and the intended output [12, p. 2].

2.3 Triaging in Healthcare

Today, triaging has become a deeply integrated aspect of modern healthcare and can be defined as:

> Triage is utilized in the healthcare community to categorize patients based on the severity of their injuries and, by extension, the order in which

multiple patients require care and monitoring [19, Definition/Introduction section].

Triage takes place at three key stages of patient care: before hospital arrival, at the scene of the incident, and upon entry into the emergency department [19]. The goal in each phase is to provide effective care and optimize resources and time. Numerous triage methods and guidelines exist worldwide, but they all share a common goal. These can be referred to as triaging algorithms and include both manual and digital triage systems. For example, a common starting point is assessing whether the patient is breathing normally or not. After determining this state, there are follow-up questions that further direct the patient's prioritization level, such as if there is concern for inadequate oxygenation. Hjälte et al. [20] analyzed ambulance dispatches in Sweden and found that emergency medical dispatch operators often assign higher priority levels to accidents than warranted, a practice known as overtriage, which creates a built-in safety margin. Ambulance staff generally support this priority system despite their lack of on-scene information.

The Swedish National Board of Social Affairs and Health (Socialstyrelsen) has examined and outlined opportunities and obstacles for innovation in healthcare in Sweden. One of their findings states that there is a "Need for test environments with rapid evaluation capabilities based on data and current evidence and support regarding the use of e-health and welfare technology" [21, p. 7]. The need for an improvement in triage systems, along with growing interest in innovation-driven testing environments, establishes a foundation for the future development of healthcare-oriented testing platforms. One potential way to do this is by utilizing digital test environments such as a DHS.

This project will examine how to design a digital testing sandbox environment that works to evaluate and compare triage algorithms' results. To do this, two car crash-focused triaging algorithms were used as a guide to derive parameters of interest and results in the prototype scenario. See Section 6.3.1 for how these algorithms were used. The first algorithm is the on-scene injury severity prediction (OSISP) algorithm [8]. OSISP uses only accident characteristics that are possible to acquire at the scene of the accident. The model works to assess the probability of a car occupant being severely injured after a crash. The second one is the serious injury risk prediction (SIRP) algorithm, which is a vehicle occupant injury prediction algorithm that calculates the risk of serious injury for vehicle occupants in a road crash [22]. This algorithm was developed as a result of finding that many robust injury prediction algorithms do not include time to treatment in their patient predictions. Injury prediction algorithms are used in Advanced Automatic Collision Notification (AACN) systems, which are designed to reduce traffic fatalities by signaling the need for medical intervention. The developers believed that a crucial parameter was the inclusion of time to treatment in algorithms to increase their accuracy. Similar to OSISP, the algorithm identified key parameters that influence risk prediction in car crashes, with transport time being a significant factor. By incorporating transport time into a basic injury prediction algorithm, an AACN system can estimate the risk of death or serious injury resulting from delayed treatment.

2.4 Usability in Digital Healthcare Systems

Today, healthcare professionals need to work with excessively complex computer systems that raise usability challenges [23]. This includes, but is not limited to, triage algorithms and AI [24], [25]. Poor usability in electronic healthcare systems is a significant barrier to the successful implementation of new technologies in healthcare [23]. Additionally, research suggests that data visualization software in healthcare is not as advanced as applications in other fields [26]. With the introduction of digital systems, replacing traditional paperwork, the quality of care has only slightly improved, and in some cases, it has even resulted in a decline [27]. Despite having a positive effect on patient safety within healthcare, the implementation of electronic healthcare systems risks technology-induced user errors, which can negatively affect patient care. Moreover, updating and replacing inadequate systems adds a cost to the already strained healthcare sector [23]. Systems fail due to steep learning curves and reduced productivity [28]. Safe and effective healthcare applications need to be designed with high usability to avoid human error and its consequences [29].

Information visualization in the healthcare sector plays a critical role in overcoming the usability challenges presented and raising the quality of care for patients [28]. Users tend to prefer systems with high usability, and suggestions to enhance usability in healthcare systems include interface customization, integration of information visualization with decision elements, and the use of adaptable templates. These suggestions are important because the end product will be used by a diverse group of practitioners who differ in technical proficiency, preferences, and levels of required support.

Shneiderman et al. [30] states that development in visualization and visual analytics can make significant contributions to developing reliable, effective, and safe systems that support personal health, clinical care, and public health policymaking. They present a set of challenges that they believe require further development to significantly enhance current healthcare systems. One of the challenges is called *Evaluation*, which emphasizes that interface designers must deepen their understanding of healthcare and medical contexts to create designs that effectively meet user needs [30]. Furthermore, they believe that more thorough usability testing is required both before and after the implementation of new systems. This is because the stakes in healthcare are significantly higher, and usability issues can have serious consequences for both practitioners and patients.

Usability in systems also affects the acceptance and effectiveness of the systems from the user's perspective [31]. To tackle the disconnect between developers and healthcare providers, there is a need for a user experience focus throughout development, implementation, and future usage [32]. When appropriate data visualization is implemented, findings indicate improved usability for practitioners and quality of care for patients [26]. Improved data visualization further raises assurance for the used systems. Khan et als. [26] findings indicate that healthcare systems incorporating visualization techniques perform better than those without, and users feel more comfortable using systems with well-designed GUIs.

This chapter has summarized the key background elements that are essential to understand when exploring the DHS concept, such as its challenges, possibilities, and similar solutions. The next chapter will introduce the theoretical framework that will be applied to explore the research questions and GUI design.

3
Theoretical Framework

Following chapter presents the design theory that this project is based on. Firstly, it presents wicked problems and how to handle them. Following is user-centered design and user-centered visualization design. As an addition to these frameworks, information visualization principles and their importance are then provided. Then, usability and usability-focused design principles are provided.

3.1 Wicked Problems

Wicked problems (WP) are ever-changing complex challenges that lack clear problem statements [9]. These problems are usually described as not having a clear solution or linear path to the solution [33]. The wickedness of problems can be measured in two dimensions [34]. First, in terms of complexity, low complexity means that both the problem and the solution are known, and high complexity means that neither the problem nor the solution are known. Secondly in terms of diversity, where low diversity means that only one party is involved and it has the same opinions or goals, and high diversity entails that multiple parties are involved and they have conflicting interests or values.

Furthermore, the problem statements can be sorted into tame problems, messy problems, and WP's [33]. Tame problems are simple to define and solve. Messes are at the middle level of complexity; they cannot be solved without considering other problems, but can still come to a consensus. True WP's are at the end of the complex spectrum, so complex that diving deeper into them yields more divergent opinions about the problem and solutions. In WP's, not only is the arrival to a solution non-linear, but the problem is also hard to define. The definition and solution go hand in hand and might need to be redefined during the process to fit with the context. A WP should thus be tackled with a holistic approach, and flexibility and involve as many people as possible (the stakeholders).

Many challenges in healthcare can be defined as WP's [35]. The diversity of the problems is often high, as many stakeholders are involved. The complexity and interconnectedness of problems are often hard to measure and understand. Petrie et al. [35] suggest that one way to work with WP's in healthcare sectors is to accept the complexity and try to work with it.

The DHS concept at large has a wicked nature where neither the problem or the solution is known, and many stakeholders are involved who have different needs for the solution.

3.2 User-Centered Design

User-Centered Design (UCD) is a multidisciplinary approach that emphasizes understanding and actively involving users throughout the design process [36]. Its primary goal is to meet users' needs [37] and it's suitable for creating designs which concentrate on usability and usefulness [36]. Compared to other design processes, such as systems-centered design approaches which can have limited user understanding, it often succeeds in achieving usability and meeting users' needs. [38]. Mao et al. define UCD as "The active involvement of users for a clear understanding of user and task requirements, iterative design and evaluation, and a multi-disciplinary approach" [38, p. 106]. In this report, the same definition is adopted when discussing this process. The approach involves users throughout the entire user experience and emphasizes broad and active user participation [39]. In UCD, the design evaluation is a key aspect, and refinements must continue after long-term use. Mao et al. [38] performed a study on expert UCD designers and their opinions and beliefs regarding the approach in their work organization. They found that the designers believed that the UCD methods most important in practice were field studies, including contextual inquiry, and user requirements analysis.

UCD is an iterative design process that typically revolves around four phases [39], which are repeated through each iteration of the design process until the result is satisfactory. Satisfactory results are determined by the designers themselves. Generally, it means that the product has achieved a high usability score and low user error. The iterative process uses a set of investigative and generative methods and tools to achieve an understanding of users' needs for the design. The four phases included in the approach are Understand Context of Use, Specify User Needs, Design Solutions, and Evaluate Against Requirements, see Figure 3.1 for their connections.

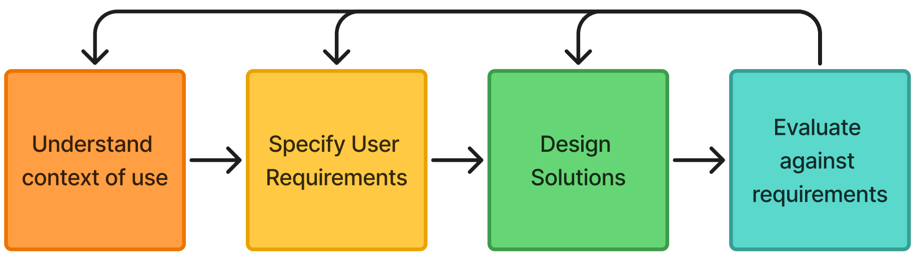

Figure 3.1: The four phases of UCD and their connectivity.

The *Understand Context of Use* phase works to provide the researchers with insights into the users and their needs [39]. This can be done through different data-gathering techniques, such as interviews or field studies. *Specify User Needs* works to analyze the data and insights collected in the first phase. This will highlight patterns of use and user habits that will be advantageous when developing the concept or product. The *Design Solutions* phase is focused on ideation techniques and prototyping to create a design of the concept based on the user requirements. Finally, the *Evaluate Against Requirements* phase assesses the design solution through user evaluations and testing. The test results can then be used to understand the quality of the design solution. The most common ways to evaluate UCD are through User testing, Surveys/Questionnaires, Interviews, Usability metrics, and Heuristic Evaluation [37].

It has been proven that in early iterations, low-fidelity prototyping, often paper prototypes, is beneficial for UCD [40]. This is because the lower fidelity allows the designers to better evaluate the user's requirements in the design. If a higher fidelity prototype is made right away, it is more common for designers and users to get stuck on design details rather than the concept functionality and faults as a whole.

3.3 User-Centered Visualization Design

Wassink et al. [41] state that human perceptual abilities tend to be underestimated in visualization designs, yet they could be utilized to make informed design decisions. They present the design methodology User-Centered Visualization Design (UCVD) as a method particularly used to achieve good interactive visualization design. Interactive visualization design can be defined as "a system that not only provides different views on data (objects, structures, processes), but also enables dialogues to explore and to modify the data" [41, p. 2].

The center of UCVD maintains the same focus as UCD, of continuous user involvement [41]. Additionally, UCVD emphasizes the importance of analyzing the users and the task they wish to perform with the visualization. One way to achieve good usability with a user group of varying characteristics is to design for both the novice and expert user. When including both ends, unique design solutions can be found. Wassink et al. [41] believe that novice users are important for establishing a user profile, while expert users can provide information about expert workflows. Furthermore, different user profiles imply that users have different tasks they want to perform. This indicates that they have different needs that the visualization systems have to fulfill.

Visualizations can be perceived differently by different users [41], meaning that a visualization can be great for one user but not successful at all for another. The perceptual differences can be attributed to users experiencing varying *Worldview Gaps* and having different *Mental Models*. Worldview gaps is a term referred to as "the gap between what is being shown and what actually needs to be shown to draw a straightforward representational conclusion for making a decision." [42, p. 2]. Mental models are cognitive models people have of external objects and what they think they know about an artifact [43]. A mental model is a belief held by users, and not necessarily a fact. Each mental model is unique and affected by the user's previous knowledge and experience. When a system does not align with a user's mental model of that product, confusion or user error can occur. The reason for perceptual differences in visualization often stems from whether the user is an expert or novice, whether they are domain knowledgeable or not, earlier experiences, and mental visualizations [41]. Thus, it is important to involve users throughout the entire visualization design process. In a scenario where people of different backgrounds result in varying levels of domain knowledge and skill, a challenge is how to help the collaboration between them. In Wassink et al.'s [41] UCVD case study, the expert users expressed that visualization is important in research in which multiple disciplines collaborate. This is to help with the discussion of experiment design and results, but is often underutilized. One way to form the interface is to keep in mind the differences of users and how to satisfy both use cases, for example, by ensuring there is help for new users, and shortcuts for experienced users. The *Training Wheels Approach* is one way to make user-friendly interfaces for novices. It is designed to make sure that novices can perform essential yet safe actions, and when they become more experienced, advanced functionality becomes successively available to them. This way, advanced users can get satisfactory functionality while the interface preserves user-friendliness.

UCVD process revolves around some central questions that should be answered [41]. These are regarding users and their characteristics, the task they want to perform, objects and processes for visualization, and what kind of insights the visualization should support. The process is iterative, user-centered, and each iteration is divided into three phases, which in turn consist of activities, see Figure 3.2 for an illustration of the process. The following are the three phases and the activities:

Phases

- *Early envisioning phase*: Analyzing the current user situation and context. Form user-profiles and requirements.
- *Global specification phase* and *Detailed specification phase*: Proposal and presentation of solutions to stakeholders.

Activities

- *Analysis*: Getting to know the context and users, finding requirements.
- *Design*: Solutions are developed.
- *Evaluation*: The solutions are evaluated.

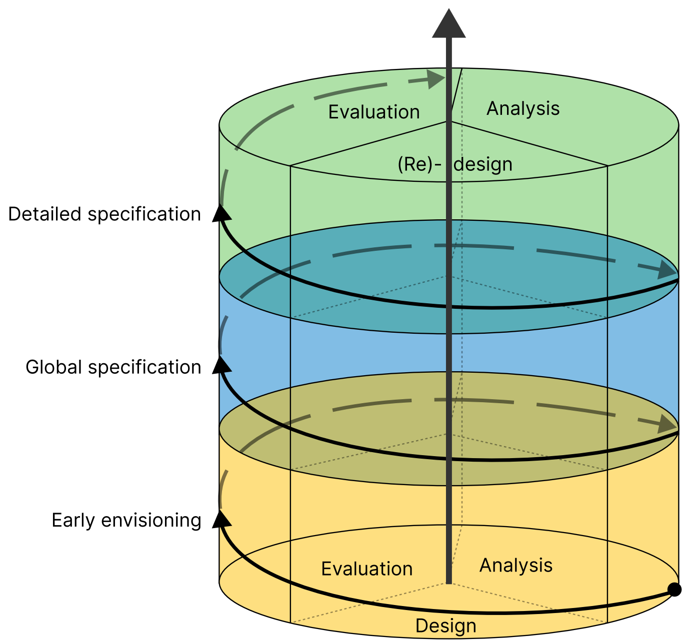

Figure 3.2: The iterative UCVD process.

Each activity can be executed in different depths of execution depending on where in the process timeline the project is residing [41]. This cycle is repeated until some requirement or constraint is reached, which can be, for instance, the client deadline, project budget, or design criteria. Working in this way helps with discovering problems in the early stages, where changes are not as costly to make compared to changes in later project stages. This project will combine UCD and UCVD as their base methodology is very similar, yet the project will have more focus on visualization. UCVD is suitable for this project as it encompasses a range of stakeholders with different previous knowledge and requires visualization of complex information and heterogeneous data. It is also more focused on facilitating collaboration between users, which other design methodologies can lack.

3.4 Infomation Visualization

Information Visualization is a research field dedicated to transforming abstract data into interactive visual representations [44]. The process aims to aid users in exploring, understanding, and analyzing complex datasets. Information visualization provides users with the possibility of creating mental models of data, information, and knowledge. The process of visualizing information consists of five main phases according to Liu et al. [44]: data transformation and analysis, filtering, mapping, rendering, and UI controls.

The first phase is focused on creating structured data from a dataset [44]. Once this is done, filtering can be applied that only extracts the data of interest to the user. The filtered data can then be mapped to geometric primitives and attributes. This means that each value, for example, should be represented by a dot or a line, and this could then also achieve an attribute such as a color or a size. The render phase then transforms the mapped data into an image, such as a graph. To finalize the information visualization, users can interact with the rendered image to understand the data it represents. The mapping, rendering, and UI control phases of information visualization are where the visual design decisions take place. To achieve good information visualization, a key aspect is that the mappings between the dataset and the visual used to convey it are understood by the user [45]. This means that users should be able to interpret the visualization in reverse, inferring the underlying data characteristics from the visual representation. Design decisions involve selecting from various visualization structures, each best suited to specific types of data. For instance, bar graphs may not always provide the most effective representation; some data sets require alternative visualization techniques to achieve accurate and meaningful insights. Using visual representations of data benefits users in the following ways [26]:

1. **Expand Working Memory:** Visual aids help reduce cognitive load and expand working memory.
2. **Reduce Search:** Large amounts of data can be visualized space-efficiently to make it easier to grasp.
3. **Identifying Patterns:** Visually explicit representations of data make it easier to identify patterns that arise within the dataset.

4. **Monitoring of Large Data:** Aggregated views of data are easier to monitor when datasets are large.

Research suggests that when appropriate data visualization techniques are deployed, usability and assurance of systems are improved [26]. Thus, working with these techniques can both benefit users' understanding of data, as well as the usability of the UI controls used to manage that data.

3.5 Usability

Usability is a term used within design to describe both development and product characteristics as well as a measurement of the product quality [46]. It can be viewed as an interactive property that is decided by the system context, that is, the user situation, which occurs depending on the user, context, assignment, and product. Usability is a quality characteristic of a product, similar to functionality and efficiency [47].

To understand usability, it is essential to comprehend how a human interacts with a product and its interface [48]. By examining the interface, the user can search for clues that provide information about possible actions or the potential outcomes of those actions, that is, the goals. After selecting and performing an action, the user looks for feedback to evaluate the result of the action. This process is referred to as exploratory learning by Lewis and Polson [48]. Problems in the interaction typically arise when the gap between the human and the interface becomes too large. This can result in difficulty performing actions, where the user does not understand which action is required to achieve the goal. It can also lead to challenges in evaluating the outcome of an action [46].

ISO defines usability as the extent to which a specified user can use a system, product, or service to achieve specific goals with effectiveness, efficiency, and satisfaction in a specified context of use [49]. Effectiveness refers to the accuracy and completeness with which the goal can be achieved, while efficiency encompasses the effort or resources required to achieve the goal. Satisfaction measures how the user's cognitive, physical, and emotional responses align with their expectations and needs. In addition to the three categories in the definition, Nielsen has defined five attributes of usability [50]. The attributes are: Learnability, Efficiency, Memorability, Error tolerance and prevention, and Satisfaction. If a system has high usability, it should achieve all of the attributes, though different designs require different distributions of the attributes. Achieved learnability implies that the user can quickly start working in the system, and that it's easy to learn. Achieving efficiency means that the user should be able to use the system and achieve a high level of productivity. Achieved memorability entails that casual users should be able to return to the system without having to learn everything all over again. Achieving error tolerance and prevention means that the user can navigate the system without making plenty of errors to achieve their task, and if they do, it is possible to recover from them. Finally, achieved satisfaction indicates that the users are subjectively satisfied with the system.

3.5.1 Five Components of Usability Framework

As a complement to ISO's definition, keeping focus on effectiveness, efficiency, and satisfaction, Jordan [51] has formulated the five components of usability framework. This framework can be used to describe the usability characteristics a design has achieved. The framework breaks down usability into five different components.

- **Guessability**: The effectiveness, efficiency, and satisfaction with which specified users can complete specified tasks with a particular product for the first time.
- **Learnability**: The effectiveness, efficiency, and satisfaction with which specified users can achieve a competent level of performance on specified tasks with a product, having already completed those tasks once previously.
- **Experienced User Performance**: The effectiveness, efficiency, and satisfaction with which specified experienced users can achieve specified tasks with a particular product.
- **System Potential**: The optimum level of effectiveness, efficiency, and satisfaction with which it would be possible to complete specified tasks with a product.
- **Re-usability**: The effectiveness, efficiency, and satisfaction with which specified users can achieve specified tasks with a particular product after a comparatively long period away from these tasks.

3.5.2 The Psychology of Artifacts

The guidelines followed in the design of user interfaces in this report are primarily based on Norman and Jordan's usability principles [52]. Norman discusses the psychology of artifacts and suggests that a user interface should be designed according to the following principles. Following these principles can work as a guide to achieve more usable design and smoother interactions.

- **Mental Models** – Everyone has mental models of things in their surroundings. These are shaped by experiences and training and influence how individuals interpret and interact with a product.
- **Affordance** – Describes the relationship between the user's capabilities and the properties of an artifact, which determines how an object can be used.
- **Signifiers** – Features of an artifact that provide clues about how a product can be used.
- **Constraints** – Features of an artifact that limit the possibilities for actions.
- **Mapping** – The relationship between the design of an artifact, how it is manipulated, and how it affects the external environment.
- **Knowledge in the World** – Knowledge about how to use a product is embedded in the world, meaning it is found in the product or its environment. This facilitates first-time use and increases the product's guessability. This concept includes affordances, signifiers, constraints, and mapping.
- **Knowledge in the Head** – Knowledge about how to use a product is within the user, meaning it is learned. With increased use of an interface, the user's

knowledge in the head increases, reducing the need for knowledge in the world. This is primarily linked to the user's mental model.

3.5.3 Ten Principles of Usable Design

Jordan has, additionally, developed the following 10 guidelines for usable design [46]. These principles aim to provide the design characteristics associated with usability, and when followed, they can increase a product's usability:

- **Consistency**: The interface has internal consistency, meaning similar tasks are performed in similar ways throughout the interface.
- **Compatibility**: The interface is adapted to external consistency, meaning tasks are performed in a way that resembles similar tasks in the surrounding world.
- **Consideration of User Resources** : The interface is designed with consideration for the user's cognitive and physical resources.
- **Feedback**: The interface provides feedback to help the user understand that an action has been registered and its outcome.
- **Error Prevention and Recovery**: The product prevents user errors and allows for quick and easy recovery from them.
- **User Control**: The interface gives the user maximum perceived control over their actions.
- **Visual Clarity**: Information in the interface is clear and easy for the user to interpret without causing confusion.
- **Prioritization of Functionality and Information**: The interface is structured so that important functions and information are easily accessible to the user.
- **Appropriate Transfer of Technology**: Suitable technology is applied in the interface to enhance the product's usability.
- **Explicitness**: The interface includes clear cues or signifiers that indicate what can be achieved and how.

This chapter has presented the framework used to explore this project's research question. The following chapter will discuss design methodologies applied to it.

4 Methodological Framework

This chapter addresses the theory of the methodology used throughout the project, specifically focusing on design methodologies. It details data collection, analysis, prototyping, ideation, and user evaluation. Furthermore, it discusses the ethical considerations relevant to this project. To finalize, it presents the iterative project plan developed for this project and contents of each iteration and phase. The following chapters will thereafter detail how the methods were executed within the project.

4.1 Interviews

An interview is a type of empirical research used to gain a deeper understanding of the respondent's thoughts and experiences [53]. Interviews can be designed differently depending on the purpose, but are typically categorized as unstructured, structured, or semi-structured. Unstructured interviews are conducted without a predefined set of questions to follow. Structured interviews, on the other hand, use an interview guide with specific questions to be answered. If quantitative data are needed, it is advantageous to use a structured form of interview, while an unstructured interview is preferable when qualitative data are sought. Semi-structured interviews combine the flexibility of unstructured interviews with the guidance of a structured format [41]. This approach enables open conversations and exploration while using the predetermined questions as a guide and maintaining some level of consistency across interviews [54]. When creating interview questions for structured interviews, it is important to have an idea of what information is desired to be extracted from the question. Questions should be clear and comprehensible not to come across as leading or trick questions that nudge the participants to a specific answer. Well-defined questions are important when you want to interview more than one person to obtain comparable data. Iterative or open-ended questioning can arise when the researchers learn about the data in real-time and may need to add more questions between or during interviews [55].

When it comes to selecting participants in qualitative research, it is guided by the nature of the research question and the need for in-depth, context-rich data [54]. Several non-probability sampling strategies are commonly employed to identify suitable participants, each with its own strengths and limitations. Sampling is done to select participants from the population. These are participants with fitting profiles for data gathering in the study. Different sampling principles can be utilized when selecting participants for interviews [56]. These include statistically convenience-, snowball-, purposive- and, theoretical sampling.

Convenience sampling involves selecting participants who are readily available and willing to take part in the study, often referred to as volunteer sampling [56]. This approach is easy to implement, time-efficient, and cost-effective, making it a practical choice in many situations. However, it may lead to the inclusion of individuals who are not best suited to provide meaningful or relevant data, potentially limiting the depth and applicability of the findings.

Snowball sampling, also known as chain sampling, relies on referrals from initial participants to recruit additional participants [56]. This method can be particularly useful when studying hard-to-reach or niche populations, as it facilitates trust through personal recommendations. It is generally efficient in terms of both time and resources and often leads to the inclusion of participants who are appropriate for the study. Nevertheless, the quality and diversity of referrals may be limited, and there is a risk of sampling bias if recommendations come from a narrow social network.

Purposive sampling - sometimes called purposeful, judgmental, or selective sampling - involves the deliberate selection of individuals who are especially knowledgeable or experienced with the phenomenon under investigation [56]. This approach includes several strategies such as maximum variation sampling, homogeneous sampling, typical case sampling, extreme (deviant) case sampling, and critical case sampling. The strength of purposive sampling lies in its ability to target participants who are most likely to contribute valuable insights. However, finding these information-rich individuals can be time-consuming and may require prior knowledge of the population.

Theoretical sampling is primarily used within the Grounded Theory methodology and was developed by Glaser and Strauss [56]. In this approach, participant selection is guided by the evolving theory being developed during the research process. Rather than selecting all participants at the outset, the researcher iteratively chooses new cases to explore concepts that emerge from the data. The goal is to refine and build theory by choosing cases that can help elaborate on or test theoretical constructs. Theoretical sampling is essential in studies where theory generation is the primary aim, but it also requires careful interpretation and flexibility as the study evolves.

4.2 Thematic Analysis

Thematic analysis is a method used to analyze and synthesize collected data from interviews [57], [58]. It is useful for systematically identifying patterns, themes and insights that emerge from qualitative data, allowing for a deeper understanding of participants' experiences, perceptions, and challenges. The process begins with reviewing the interview material to extract quotes or statements that are relevant to the study's research question. These quotes are then grouped based on similarity in content or context. By organizing the data in this way, recurring issues, relationships, or tensions that were raised during the interviews can be detected. Hidden connections can be uncovered and the findings can be structured into coherent thematic areas. The organized architecture not only brings clarity to complex data and unstructured material but also supports the identification of key user needs, behavioral patterns, pain points or design implications. These insights can then inform the design process, support problem framing, and guide decision-making in subsequent stages of development. Ultimately, thematic analysis is an effective and flexible tool for transforming raw interview data into actionable knowledge that aligns with the goals of the project.

4.3 Idea and Concept Generation Techniques

In order to generate ideas and concepts that meet the needs of the target group, a range of different methods was used in this project.

Brainstorming is an idea generation method well-suited for developing many ideas [59]. The session is guided by a theme or problem statement, with a facilitator who supervises and moderates the process. All participants write down their ideas and thoughts on post-it notes or sketch them on paper. There should be an emphasis on being free from judgment and critiques to let creativity flow freely. After a short period, when ideas begin to slow down, the brainstorming session concludes. The ideas generated are then discussed and categorized, determining which can be developed, which need further refinement, and which should be discarded. The remaining viable ideas are then further developed.

Another method is Brainwriting 6-3-5, which allows participants to help each other collaboratively create innovative concepts [59]. The numbers in the name represent six participants, three ideas, and five minutes. In a similar fashion to brainstorming, it is important not to let judgment or critiques disrupt creative flow. A facilitator moderates the process and keeps the session structured. A question is formulated, and three sheets of paper are distributed to each participant. Each participant writes down three ideas, one per sheet. After a predetermined time, participants exchange papers and continue developing each other's ideas. By the end of the session, a large number of ideas have been generated. These are then categorized by theme and discussed, after which some ideas are selected for further development.

Finally, the brain-drawing method is similar to brainwriting, but differs in execution by drawing instead of writing to further stimulate creativity [59]. It has the same principle in that the sessions are based on some theme or related question, and the participants get a set amount of time to generate ideas.

4.4 Prototyping

In the design process, sketching and prototyping are essential early steps, often featured in methodologies like Google's design sprint [60]. They serve as tools for idea generation and exploration. While following a methodology is helpful, adapting the process to each unique project context of importance. In this project, the main focus will be on sketching and prototyping to create a functional prototype.

To explore various ideas effectively, it is helpful to concretize them. Sketching, as per design models Google's design sprint, aids in diverging the project [60]. To warm up, a suggestion is to write down ideas before transitioning to sketching. This approach presents a dual perspective. Some can get stuck on the initial ideas, while others view it as a method of clearing their minds to generate new concepts. While words are defined in a way, they can still be open to interpretation. Images have a unique ability to convey nuanced details that words might miss. Sketching, therefore, is a powerful tool that allows for more precise communication and capturing ideas more accurately by visualizing them. Finally, sketching is a cost-effective tool in the early design stages, allowing exploration without relatively high commitments, unlike constructing prototypes [61]. It encourages the exploration of ideas and options, and if used effectively, prevents fixation on a single concept.

Related to sketching, there is the prototyping activity. High-fidelity digital prototypes can be created in software such as Figma. which is a tool for creating digital prototypes and interfaces. Prototyping is an essential tool for interaction designers [62]. In this project, prototyping will allow us to explore concepts, use it as a mediator in evaluation, and assess feasibility. This not only aids exploration but also helps with idea comprehension and design evaluation since a more concrete form of the concept makes it more graspable.

4.5 Usability and Concept Evaluation

The definition of usability, alongside its subcategories, makes it possible to measure and improve the usability of designs [50], [54]. The practice of measuring usability is often referred to as user testing or usability evaluations. The advantage of conducting user tests lies in the ability to obtain comparable, empirical data that can highlight areas for improvement, providing a stronger foundation for design decisions than relying solely on subjective judgment. To effectively evaluate usability, it is appropriate to conduct usability tests with the users from the target group of the design [63]. This is important, as the primary objective of usability testing is to uncover usability challenges and gain insight into users' perceptions of the interface [54]. There are different ways to evaluate a product, most prominently used in this report is through controlled settings directly involving users [54]. This means that users' activities with the product are controlled to test, measure, and observe behavior. This often entails usability testing or experiments.

User tests are often designed to measure if the typical user can perform the typical tasks the design is intended for [54]. The tasks are often predefined, and the user and their actions are then recorded to collect task data. When designing the usability test itself, other than defining the tasks themselves, it is important to ensure measurability in terms of *effectiveness, efficiency,* and *satisfaction* [49]. Each category of usability is associated with its own set of usability metrics that are beneficial to understand that category in better detail. The following are each of the categories presented alongside their associated usability metrics.

Effectiveness is defined as "accuracy and completeness with which users achieve specified goals" [49, Sec. 3.1.12]. It is commonly measured through *completion rates* of user-performed predefined tasks [64]. It is calculated by assigning the value 1 to users who successfully complete the task and 0 to users who do not. Furthermore, completion rate is easy to understand and provides a good baseline for success [65]. If a user cannot complete a task, the rest of the usability experience does not matter. Based on a study by Sauro, a benchmark of 78 percent is the average completion rate across a database of 1200 tasks [66]. Additionally, measuring *users' errors* is a useful metric to understand effectiveness. It can clarify which task users find difficult, and where their mistakes occur [67], [64], providing data on where to focus improvement. Measuring errors could include counting clicks, slips, movement etc. It can also be useful to add a severity rank of the error and, ideally, the errors should be mapped to UI problems. Meaning that the error measurement is mapped to a description of the problems that users encountered during testing. According to Sauro, usability problems affect 37 percent of users, and the average number of errors per task is 0.7 [68], [69]. Where only 10 percent of tasks were error-free. These statistics both uncover that error is common, and that most frequent usability problems will be uncovered from small sample sizes.

Efficiency is defined as "resources used in relation to the results achieved" [49, Sec. 3.1.13]. Efficiency measures provide insight into how well a task is performed compared to the resources required to do it [70]. Resources include time, mental or physical effort, and money. It can also refer to equipment and materials used or training needed to complete tasks. These measures often center around measurements of *task time* [64]. This measures the duration for the user to complete or give up on a task. It is calculated through: Task Time = End Time − Start Time. If a user fails at completing a task, then time is measured until the user cancels that task, i.e. gives up.

As an addition to task time, the complementary metrics *Time-Based Efficiency* (TBE) or *Overall Relative Efficiency* (ORE) can be calculated [71][64]. TBE calculates an average measurement of task completion by time, following the equation:

$$\text{Time Based Efficiency} = \frac{\sum_{j=1}^{R}\sum_{i=1}^{N}\frac{n_{ij}}{t_{ij}}}{NR} \tag{4.1}$$

Where

- N = The total number of tasks
- R = The number of users
- nij = The effectiveness of task i by user j (0 = uncompleted task, 1 = completed task)
- tij = The time spent by user j to complete task i

ORE compares the time taken by users who successfully complete a task to the total time spent by all users, including those who didn't finish [64]. It calculates a ratio for the efficiency of successful tasks to unsuccessful. ORE is calculated by following the equation (using the same variable names as TBE):

$$\text{Overall Relative Efficiency} = \frac{\sum_{j=1}^{R}\sum_{i=1}^{N} n_{ij}t_{ij}}{\sum_{j=1}^{R}\sum_{i=1}^{N} t_{ij}} \times 100\% \tag{4.2}$$

Satisfaction is defined as "the extent to which the user's physical, cognitive, and emotional responses that result from the use of a system, product, or service meet the user's needs and expectations" [49, Sec. 3.1.14]. Where "Satisfaction includes the extent to which the user experience that results from actual use meets the user's needs and expectations" and "Anticipated use can influence satisfaction with actual use" [49, 3.10 Satisfaction section]. Satisfaction is commonly measured by involving standardized satisfaction questionnaires after each task is completed, or after the whole test has been completed, or a combination of both [64]. The purpose of the standardized questionnaires is to gain insight into users' experience of the design. Measuring *task-level satisfaction* means asking a specific question/questions after each task is completed. This is done to understand how difficult the user thought that particular task was. The question is often rated on a Likert scale. A common standardized task level question is the *Single Ease Question* (SEQ), where the user is asked "Overall, how difficult or easy was it to perform this task?" and asked to rate it on a scale from Very Difficult to Very Easy [72]. The *test-level* satisfaction measures the users' overall impression of the design [64]. To measure this, longer form questionnaires are typically used, one common example is the System Usability Scale (SUS), which consists of ten statements that the users have to take a stance towards on a scale from Strongly Agree to Strongly Disagree [73]. The SUS questions are the following:

1. I think that I would like to use this system frequently.
2. I found the system unnecessarily complex.
3. I thought the system was easy to use.
4. I think that I would need the support of a technical person to be able to use this system.
5. I found the various functions in this system were well integrated.
6. I thought there was too much inconsistency in this system.
7. I would imagine that most people would learn to use this system very quickly.
8. I found the system very cumbersome to use.
9. I felt very confident using the system.
10. I needed to learn a lot of things before I could get going with this system.

Another useful technique in user testing is the think-aloud method, where users are encouraged to verbalize their thoughts while carrying out a task [74]. This can provide valuable data on users' expectations of the design and their experience. Think-aloud can be difficult to perform, but when successful, it offers valuable insights into the reasoning behind users' actions.

When evaluating concepts, there are mainly two approaches, namely, formative and summative tests [63]. Formative testing involves evaluating a concept with the goal of identifying areas for improvement based on user feedback. These tests focus on identifying areas for improvement by collecting user feedback to address the issues. Summative testing, by contrast, provides an overall assessment to determine whether the concept meets the established expectations and objectives. Formative testing can vary in scope and purpose, often categorized into tactical and strategic studies. Tactical studies focus on identifying and resolving immediate usability concerns through quick adjustments, while strategic studies take a broader view, aiming to shape the long-term development of the product. The scope of the study influences how many participants are needed. Tactical studies typically require fewer users, whereas strategic studies benefit from a larger sample for more robust insights.

As a guideline for the amount of participants in the tests and data collection in this report, we followed Berry's [75] recommendations for user interviews, moderated usability tests, and early concept validation. The suggested amount is according to the following table (See Table 4.1).

	Tactical Study	Strategic Study
User interviews	3-5	10-20
Moderated usability test	5	6-10
Early prototype concept validation	2-5	5-10

Table 4.1: Suggested number of participants for different type of user evaluations.

4.6 Project Process

This study applies both qualitative and quantitative methods to answer the research question and is thus a hybrid study. By using triangulation of data, a nuanced result can be achieved. This project further used UCD and UCVD as methodology frameworks. UCD methodology is a framework used to work towards creating usable designs. It focuses on the overarching processes of design work and typically involves four iterative phases, each encompassing specific methods aimed at acquiring the user knowledge necessary to develop the product concept. UCVD is similar, but rather aims for three iterations that in turn has three phases.

By applying these methods in the context of this project, the approach also served as a structured way to engage with the complexity of healthcare as a wicked problem. Through iterative exploration and active user involvement, the project sought to reduce ambiguity, uncover needs, and develop more grounded, context-aware design outcomes.

To start the project, the iterations and phases were defined, as well as each of the methods that would be used throughout the iterations. However, as the project evolved, it became necessary to adapt the initial plan to better accommodate emerging insights and design needs, resulting in adjustments between iterations. The original structure of UCD and UCVD proved too rigid and time-consuming for our context, leading us to develop our own model inspired by their phases. This resulted in a more agile, three-phase model: *Collect, Analyze,* and *Design.* This approach remained grounded in the core principles of UCVD and UCD, which emphasizes continuous user involvement and a deeper understanding of both the users and the specific tasks they aim to perform with a visualization.

Our adapted process reflects this combined perspective. *Collect* draws from both UCD's "Understand context of use" and "Evaluate against requirements" phases, as well as UCVD's early envisioning phase, and involves all user-facing activities such as interviews, evaluations, and usability tests. *Analyze* corresponds to UCD's

"Specify user requirements" and UCVD's analysis activity, broadening its scope to include data synthesis from all collected materials. *Design* integrates the UCD phase "Design solutions" and UCVD's emphasis on tailoring visual and interactive elements to different user profiles. The iterative nature of the process means that once the design is completed, a new cycle of collection and evaluation begins. See Figure 4.1 for a visual representation of the interaction between the phases.

Figure 4.1: The phases of our own iterative process inspired by UCD and UCVD.

The final design process consisted of four iterations following the *collect, analyze*, and *design* phases. See Figure 4.2 for the stacked iterations along what each phase contained for separate iterations. Following is a walkthrough of each iteration, detailing how the design developed and changed over time. In Figure 4.2, the third iteration does not include an analysis phase, this is because the data was quickly summarized to give design suggestions, and no formal analysis was performed. See Chapter 7 for details.

This finalizes the methodological framework, and the following chapters will now work to apply the presented methodologies within our iterative design process.

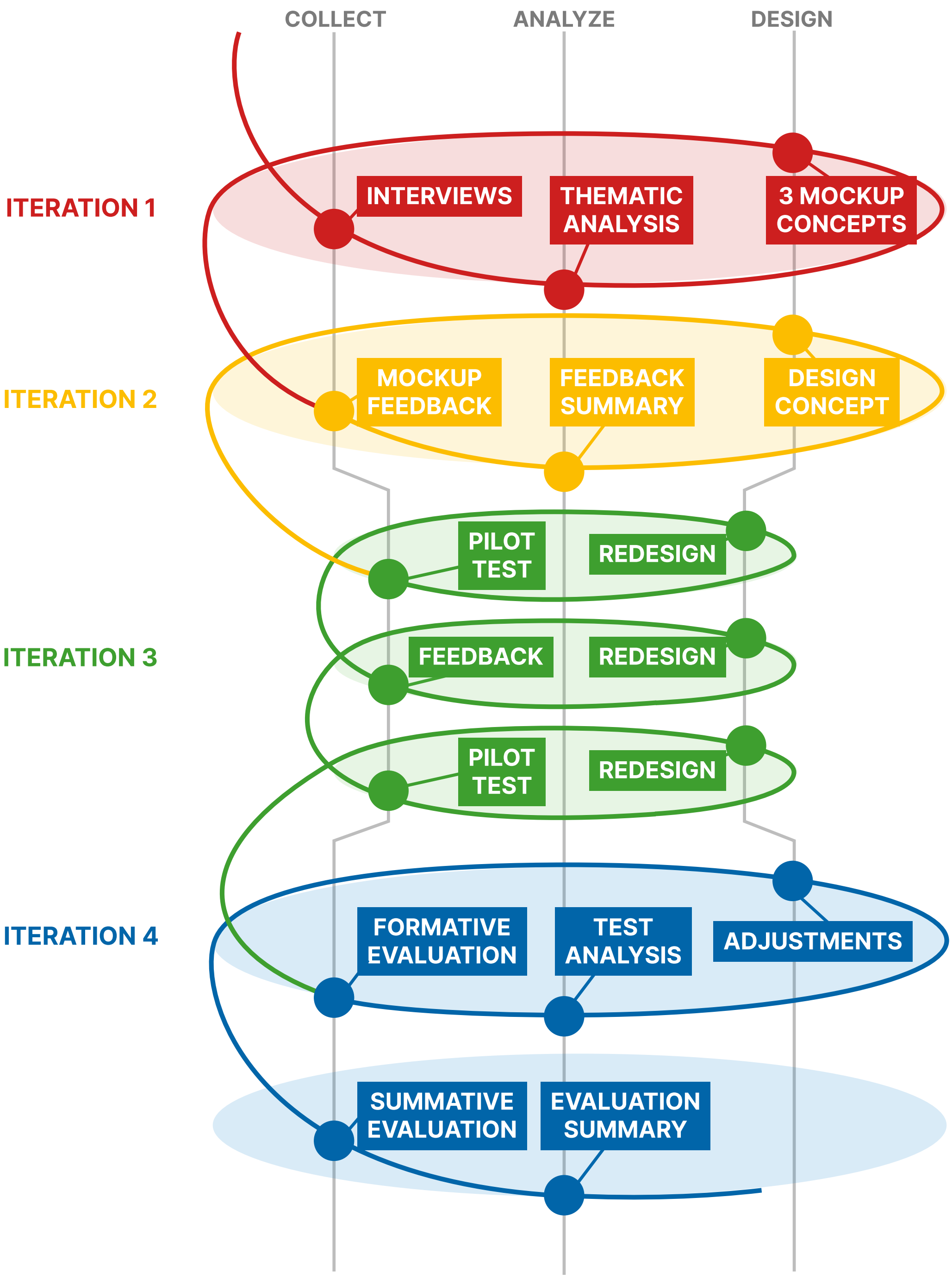

Figure 4.2: Model of the process iterations and what methods they included in terms of the phases Collect, Analyze, and Design.

5

ITERATION 1: Defining the Concept

The first iteration focused on grasping the project area through user interviews. Thereafter, data insights were collected using thematic analysis and requirement synthesis. To finalize the iteration, the first design mockups of the DHS were created and evaluated by users.

5.1 Collect: Deep-Interviews with Users

Semi-structured deep interviews of one hour were conducted with seven participants. Two were conducted in person, and five were remote meetings. The in-person interviews were recorded through both audio and screen recordings, and the online interviews through Microsoft Teams meeting recording function. The participants were sampled in a *purposive*, *snowball*, and somewhat *convenient* manner. This was done by searching through Google for contact information of business analysts in healthcare-related organizations in VGR. When our interview request reached them, some of them forwarded our information to their colleagues as well, making it a snowball effect.

The interview questions were developed with the goal of better understanding the users' needs for the product as well as the context in which it would be used. See Appendix B for the interview questions. They were created based on information that was estimated to be important for the development of mockups later in the iteration. The questions were further tested and developed through pilot interviews. The questions asked about the interviewees work related activities, their work experience, and how they work with development in their organization. The interviewees were also asked about their experience with simulations and computers. A flowchart representing the DHS interaction flow and example scenarios within it was shown to give an idea of its workflow and open up for discussion. The chart showed a flow where first a traffic accident scenario is built or a pre-made one is selected, then algorithms are selected and finally an output is generated. This was done to help them visualize the concept. The examples were based on the Swedish Trauma Alert Criteria [76]. See Appendix C for an example of the DHS flow shown to users.

Furthermore, due to the abstract nature of the DHS concept, software that could be used to inspire the final design was shown as a mediating tool. Such as the programs Matlab and Ansys, and games like Factorio and SimCity. This helped deepen the user's understanding of the concept, as well as allow them to better give feedback on what they thought about it and its potential. The questions were adjusted with each interview, as more understanding of the context grew. Additional questions were asked based on the received answers to gain further insight. Before each interview, the participant had to either be recorded verbally or sign a form, consenting to their answers being recorded. See Appendix A for the consent form.

Table 5.1 shows all of the participants in this project, where the green markings indicate which interviews, tests, and evaluations they participated in. It also shows their current main job title. In addition to their main title, many of them also work as specialist nurses or have a history of working as a nurse or assistant nurse in different healthcare areas. Two participants did not come from a healthcare background. The participants had mixed experiences and occupations relating to healthcare, including: ambulance nurse, organization developer and manager, digitalization coordinator and manager, nurse, assistant nurse, development nurse, carrying a PhD in healthcare, educator, consultant, AI and data strategist. The most common nurse specialization in the group was ambulance nurse of which three participants had experience in.

	Iteration 1	Iteration 2	Iteration 3	Iteration 4	
ID	**Deep Interview**	**Mockup Evaluation**	**Formative Evaluation**	**Summative Evaluation**	**Job Title**
P1					Business developer
P2					Development Manager
P3					Business Developer, Digitalization Coordinator
P4					Business developer
P5					Principal supervisor and PhD student
P6					Director for digital health
P7					Business developer
P8					Business developer
P9					Business developer
P10					Business developer

Table 5.1: All participants in this project, alongside their title and what they participated in. ID refers to the participant's ID, commonly referred to as P#.

5.2 Analyze: Thematic Analysis of Interviews

The recorded interviews were transcribed, some by hand and some through Microsoft Teams' built-in transcription software. During the interview, users were asked to rate their own comfort level using computers on a scale of 1 to 10, with 10 being the highest indicator. Their average comfort level was 8,4. They all preferred to perform their work tasks on computers rather than any other unit, and they all described that they used the Microsoft Suite programs to perform most of their work tasks. The transcriptions were processed further to be synthesized into requirements and themes. The categorization process started with highlighting quotes which had the potential to be derived into requirements for the DHS or showed recurring themes for users. The quotes were then copied into Figma into digital post-it notes and could then be easily moved around for grouping. The quotes were selected based on relevance and if they could be used to identify an important theme that the DHS should manage. The digital post-its were then grouped together and the groups were given names to represent the themes found in the group of quotes. See Appendix D for an overview of the structured themes and quotes.

The discovered themes were given descriptions to not solely rely on the quotes and provide a clear summary of the topic. The analysis provided insights on significant factors within the various organizations and important aspects to keep in mind when implementing digital solutions. Key identified themes for this project scope and their descriptions can be seen below, the full list can be found in Appendix E:

- **Information visualization** - The importance of concisely visualizing information is a fundamental way to avoid cognitive load from information overflow and instill a sense of guidance within the interface. The interface must feel intuitive. One participant mentioned this challenge: *"The big challenge, from our experience both with the [Digital Health Projects], is that we easily end up in, how should I put it... information overflow. And that really is the challenge for us. Because we want to make it simple and fast"*. Use of AI should be transparent and explainable as well as interpretable in order for the user to feel a sense of control. Another participant wondered about the decisions behind algorithms: *"But what was the outcome in terms of how many resources were actually available, how much was needed, and how much was there?"*.

- **User-centered perspective** - The more user-centered design, the better. The importance of taking users into account weighs heavily in good implementation. As one participant emphasized: *"The more user-friendly or intuitive a system is, the better"* . Otherwise, there is a risk of not fulfilling users' needs. Understanding their needs also play a significant role in this goal. Solutions should be adapted to the user. The same participant added: *"We can't afford to have healthcare staff getting stuck in technology"*, underlining the importance of designing systems that empower users rather than hinder them.

- **Systematic and structural implementations** are important for many reasons: Having solutions that work together, instill familiarity within the organization as well as ease of implementation. One participant emphasized this need by stating: *"You have to create structures to implement this. It's not enough to just say, 'Now we have this, let's work with it.' No, we need to build structures that can actually support this way of working"*.

- **Setting parameters and boundary conditions** to investigate resource management, coordination, and effects on the organization is seen as a useful tool for planning and predicting, as well as visualizing. It is also of interest to know which less optimal decisions are made today. As one participant noted: *"There have to be a lot of different applications of this. If we look at the reality I'm in, where we have an inflow of patients, and then you have lots of boundary conditions like how big the emergency department is, how many doctors are on site, and so on."* Another participant added: *"It would be incredibly interesting to be able to change parameters. [...] to easily change the rules of the game, the playing field, that is extremely appealing."*

- **Testing/Simulating** - It is of interest to simulate extreme cases like mass injuries to understand weaknesses and restrictions of the organisation. It's interesting to see how changes in the organisation might affect the outcome. As one participant expressed: *"We know historically how it looks. We kind of know how it looks over the course of a day, it's pretty much the same. But when it comes to what actually happens during mass casualty incidents, we don't fully know."*
- **Resource efficiency** - A potential of the solution is being able to see how the resources are affected by different implementations, and thus saving the most valuable resource, time. Solutions cannot just be better, the most important factor is being time-efficient when used. As one participant emphasized, *"It can't just be good, it also has to save time."* Another important factor to visualize is comparing the implementation monetary costs. Another participant said: *"What, how much does it cost compared to running a full-scale exercise? Like 100 observers coming here and half the hospital being overwhelmed."*

5.2.1 Specifying User Requirements, Desideratum, and Guidelines

Based on the themes that were identified, descriptions, requirements, desideratums, and guidelines could be derived. This was done by rewriting the themes into requirement statements and focusing on what the concept must achieve. They were then iteratively refined and structured. The final list consists of requirements that the DHS *must* fulfill, desiratum that it *should* fulfill, and guidelines that *should be followed* throughout the design. They were further categorized based on what should be implemented back-end and what affects the GUI. Some statements were sorted based on the scope of the project as well. Below are the key points used for the development of this project's solution, see Appendix F for the full list, and Appendix G for how the requirements were mapped from themes.

Requirements
The DHS must:

1. Allow for simulation of different scenarios, its components include:
   (a) Possibility to set parameters and boundary conditions
   (b) Inputs:
      i. Synthetic sensor data
      ii. Components of an incident
   (c) Possibility for selection of algorithms
   (d) Outputs, which should present results insightfully and intuitively:

   i. Resources (personnel, vehicles, medical material) / resource management
   ii. Information regarding triage levels
2. Provide an overview of the simulation
3. Present AI algorithm results in an interpretable/explainable manner

Desideratum
The DHS should:
1. Have clear user benefits
2. Work in a time-saving manner
3. Continuously be developed and improved from user feedback after launching/implementing

Guidelines
1. Development should apply a User-Centered Perspective
2. The solution should instill familiarity
3. The solution should feel intuitive
4. The solution should utilize usability principles

5.2.2 Deriving Functions

After writing the requirements, they were transformed into functions. This was to further aid in the process of structuring the design, and help ensure everything that is needed is included in the later prototypes. Working with functions is also a good way to identify areas for future improvements in later work on a design. The list of requirements was extensive, and thus it was concluded that some things would have to be out of scope due to time constraints. For example, a lack of legislation knowledge. Thus, this area would not be in focus in this project.

To initiate the listing of functions, the requirements were visualized through a tree structure. With this overview, it was easier to derive functions from the requirements. The functions were categorized as *Main Function*, which is the main purpose of the DHS. *Partial Function*, which is a function that fulfills the 6 main requirements as well as the main function, and finally *Supporting Functions* that allow the other functions to be fulfilled.

Main function
- Provide novel insights

Partial functions
- Conduct simulations
- Compare modules
- Provide overview
- Provide transparency regarding algorithms

Supporting functions
- Regulate simulation parameters
- Take input data
- Select algorithms
- Visualize output data

- Provide input
- Provide output

5.3 Design: Solutions Through Low-Fidelity Mock-ups

The preparatory work in previous sections was used to guide the ideation work in conceptualizing three different design concepts for data visualization and simulation creation in the DHS. Each concept was developed in separate sessions. The ideation methods; brainstorming, brainwriting, and braindrawing, inspired the session's ideation technique, but were adapted to fit this project. A session consisted of, firstly, individually sketching a few concepts in a predetermined amount of time, often four concepts in 20 minutes. Thereafter, each sketch was discussed for further improvements or additions. Finally, after discussion and adjustments to align with requirements and functions, the concepts with most potential was chosen to be further developed as a mockup. During ideation, the concepts aimed to be pushed in unique directions to make the mockups distinct. See Figure 5.1 for examples of the sketches created in the sessions. Alongside the sketching, the previously defined functions and requirements were continuously checked to see the limitations of the design and what needed to be added. The finished concepts were then developed as semi-interactive mockups in Figma. Mockup development in Figma was not focused on detailed work, but rather on the interaction flow and general information structure. To achieve this in a time-saving manner, the preexisting design libraries Google's Material Design 3 System [77] and Figma's Simple Design System [78] were used. This allowed dragging pre-made components into the design without having to spend time designing each of them. The mockups were developed collaboratively in a shared design file.

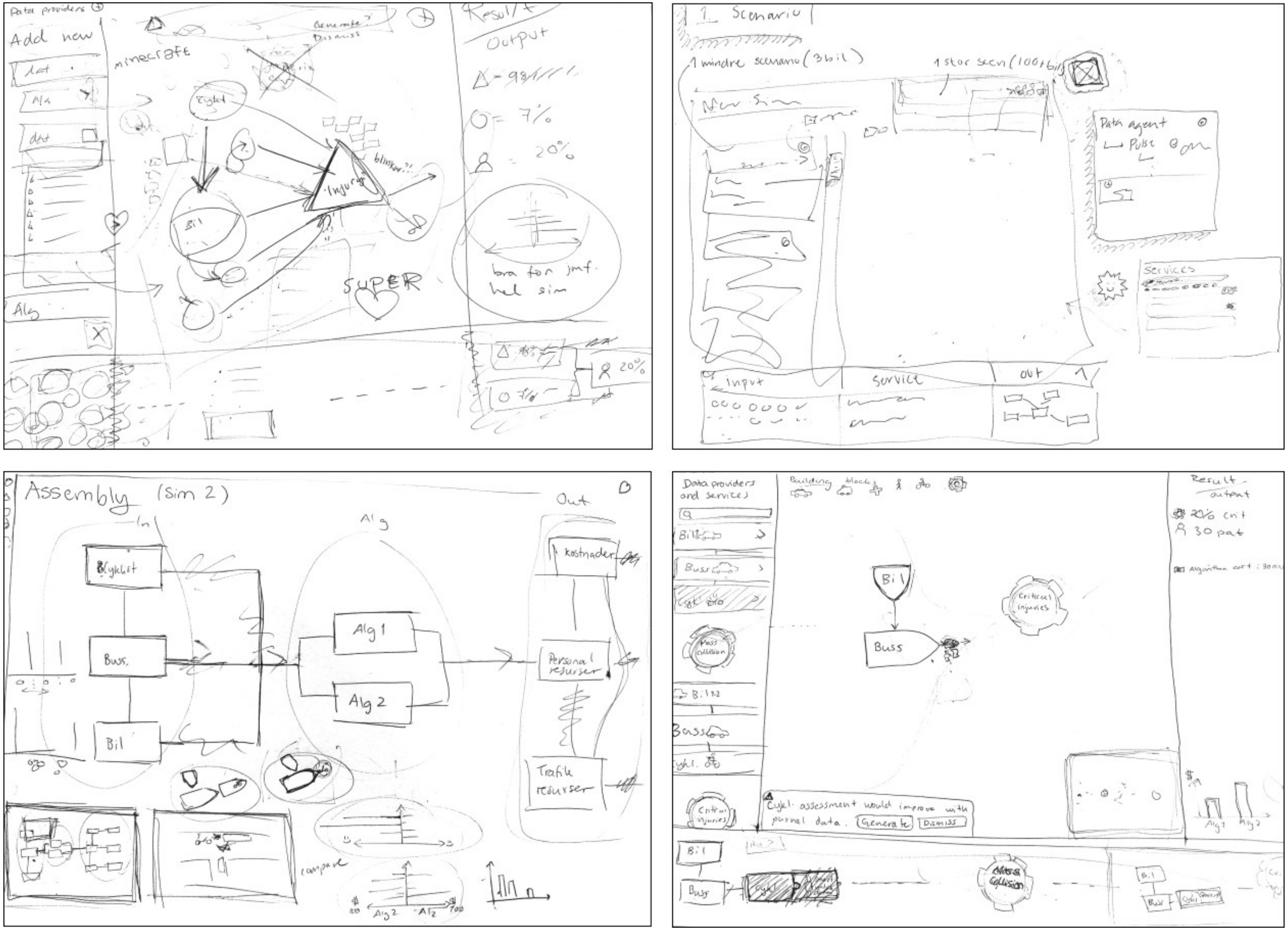

Figure 5.1: Examples of initial sketches for the GUIs of the mockups showing ideas for visualizing components, flowcharts, control panels and result outputs.

5.3.1 Mockup Concept 1: Flow

The first mockup concept, called Flow, focused on visualizing data in a structured manner and provide good overviews of each of the sections of the program. See Figure 5.2 for the design mockup. The interface consists of expandable windows for each section all of which the user can see simultaneously. It consists of a Simulation Overview that lists each data provider and activated algorithm, where the data providers are expandable to show precise data values. It also provides a flowchart connecting each component in the simulation, which works as the simulation builder. The user can add data providers and algorithms into the flowchart, and the program shows the user what data is used as input to the algorithms and how the components relate to each other. The interface also shows the user a complete zoomed-out overview of the flowchart, to make it easy for the user to get an overview of their current simulation. It also provides an algorithm browser window where the user can find suitable services through filtering, tags, and descriptions. Finally, it has a simulation result window which gives the user an understanding of the data used in the simulation and the results of the applied services.

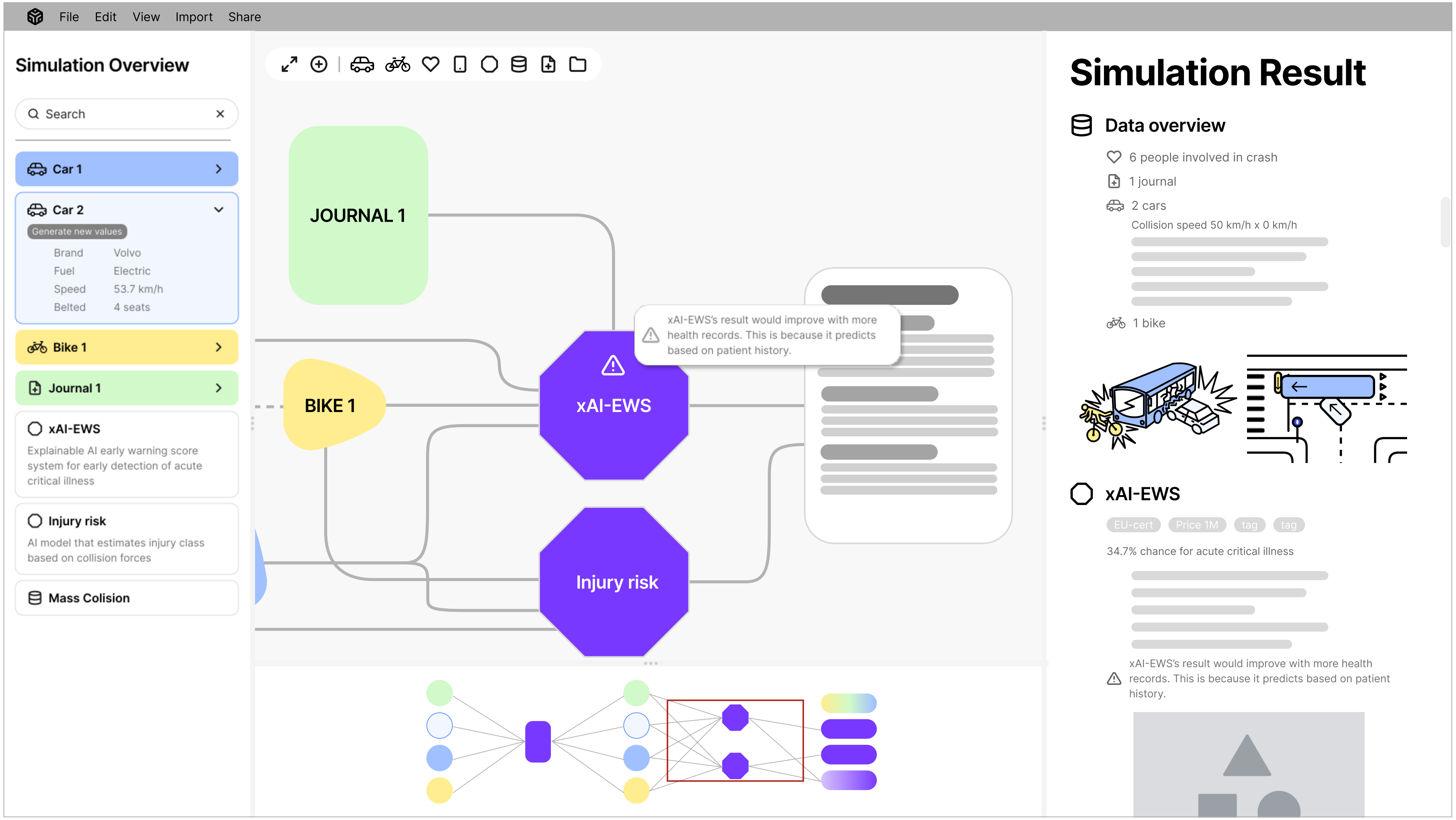

Figure 5.2: The design mockup for the concept "Flow".

5.3.2 Mockup Concept 2: Pages

The second mockup concept, Pages, focused on allowing the user to structure the components in the simulation freely and to divide the program sections into different pages, rather than fitting everything on one page. See Figure 5.3 for the design mockup. It first provides the user with a view that is very unrestricted and has the data providers visualized in a mindmap-like structure. It also includes data as images and graphs, and shows what algorithms are currently selected. It gives the user the possibility to add and remove components freely. Furthermore, it has an algorithm browser on another page where the user can search and get detailed information about available algorithms. The concept also provides the function to import predetermined data into the simulation, such as data specific to the user's organization, such as a hospital. The last navigation page takes the user to a summary page that shows the simulation result in a structured manner. The summary page summarizes the components and the simulation result. Finally, it also provides the option of comparing two separate simulations to allow the user to compare results.

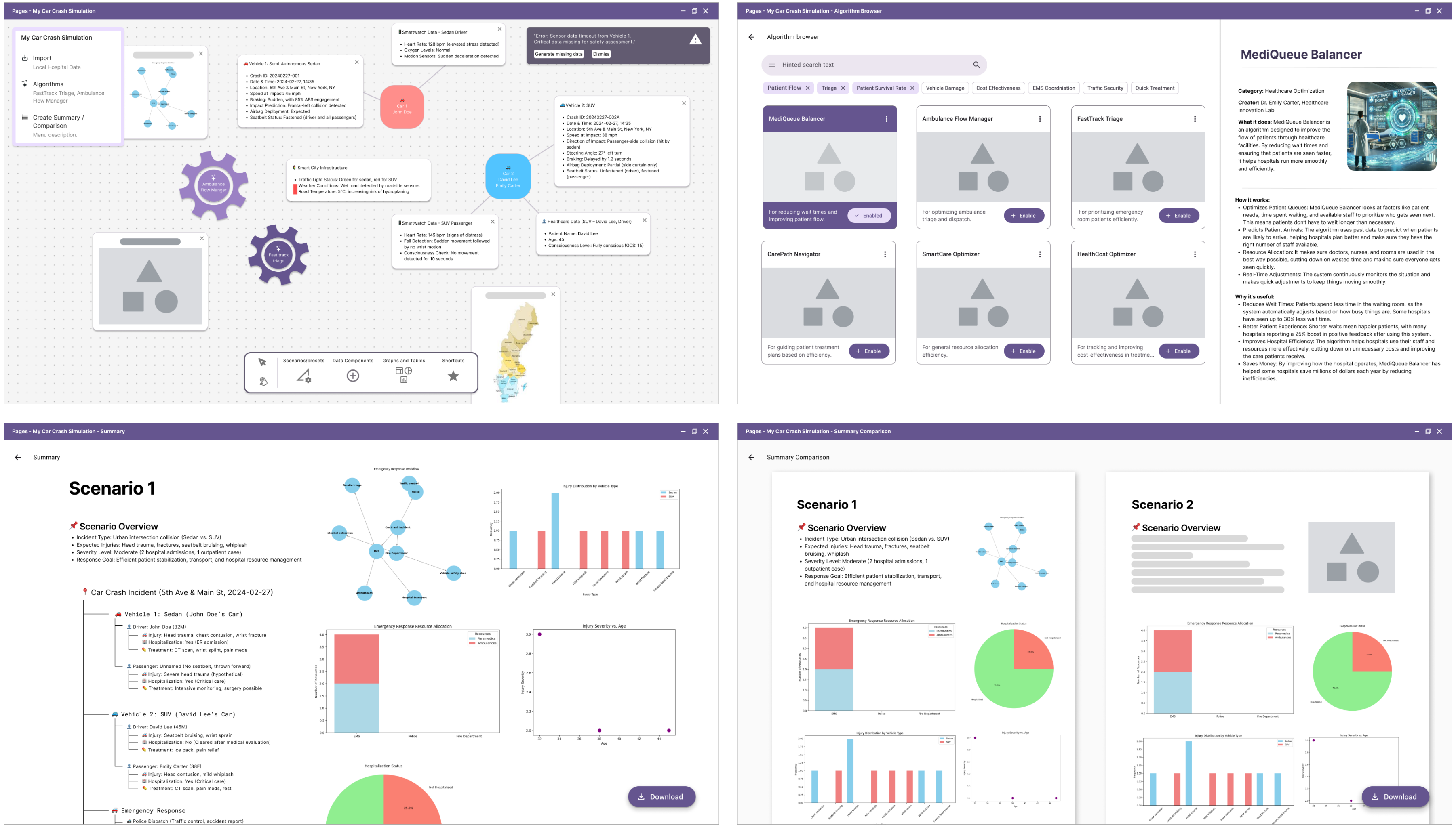

Figure 5.3: The design mockup for the concept "Pages". Pages in reading orientation: Simulation page, Algorithms page, Result Overview Page, Result Overview Comparison Page.

5.3.3 Mockup Concept 3: Dashboard

In the third mockup concept, Dashboard, the structure is not as free-flowing as the previous concepts and has a rather rigid structure. See Figure 5.4 for the design mockup. It allows the user to interactively change parameters through dragging sliders, and see the simulation data update live. The left side bar has divisions connected to the rest of the interface sections. It is possible to add or remove sliders as well as data providers. Locking data components enables further customization of simulations, such as having an outlier. At the bottom left, a smaller algorithm browser can be found. The colored labels show which algorithms are enabled in the simulation. On the right is the simulation result. It displays a summary of the simulation process, as well as showing further improvement possibilities. The graphs are used to save the history of the simulation, which can be used to analyze how different parameter values affect the outcome. Finally, it is possible to go back to earlier simulation steps by interacting with the data points in the graph. With this concept, the design was to be scalable to really big simulations. In previous concepts, the user has to manually add each component and specify its data characteristics. In this one, the user was able to drag on a slider how many data providers they wanted to add, and set mean values for what their shared data would be. For example, you could set the mean age to 25 if you want all your person data providers to be young without having to manually set all their ages to be younger.

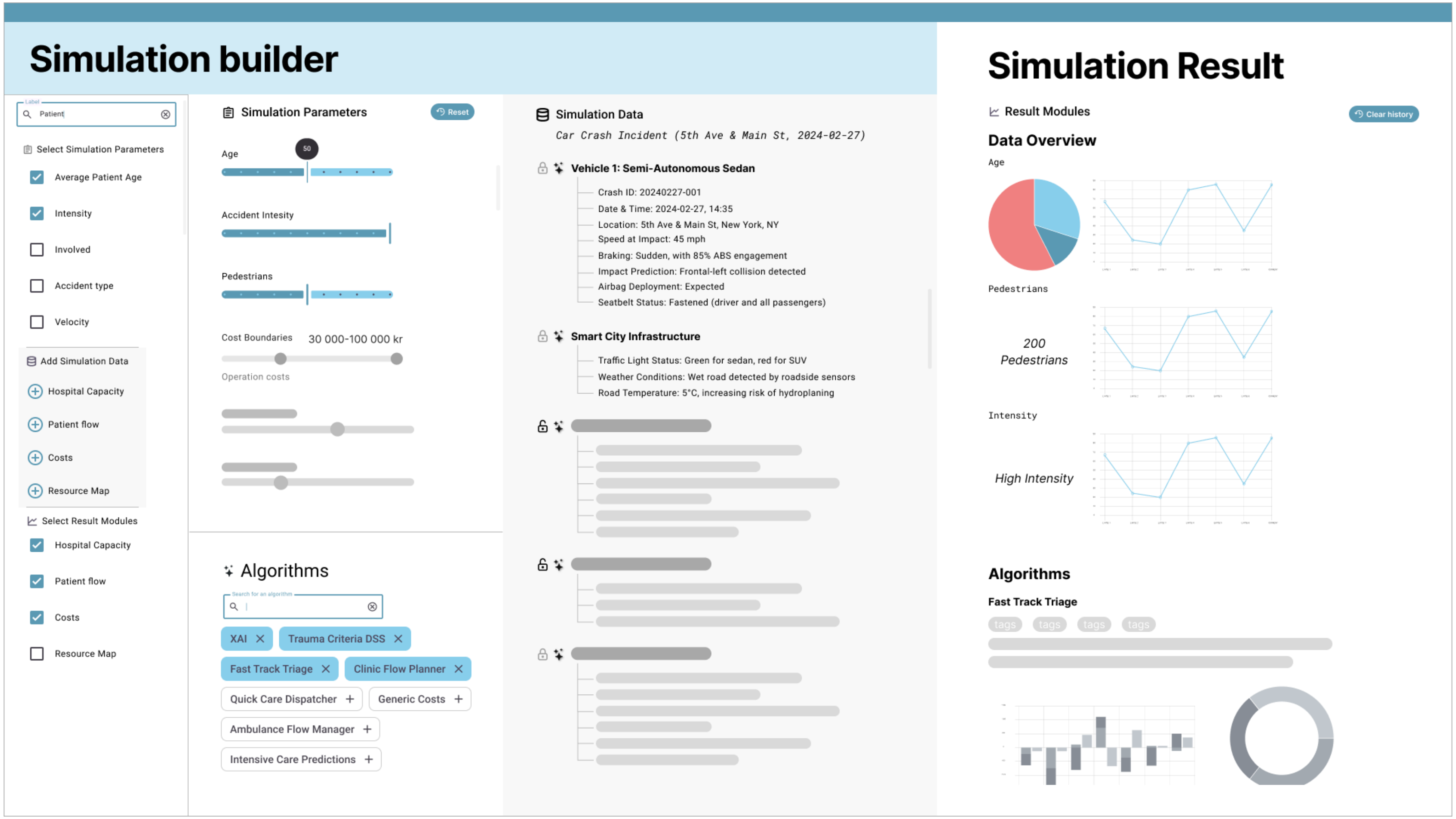

Figure 5.4: The design mockup for the concept "Dashboard".

With the designed mockups, it was possible to enter the second iteration. This will focus on honing in on the concept and developing one prototype from user feedback.

6

ITERATION 2: Develop Concept

In the second iteration, user feedback was collected on all developed design concepts and analysis was conducted on it with regard to preference for each concept. Furthermore, the first functioning design prototype was developed. In parallel, research regarding parameters that could be included in the interface and a simulation scenario was defined. To finalize, the user test was developed.

6.1 Collect: User Feedback Sessions on Mockups

Three users, two of which had partaken in previous interviews and one new to the project, were contacted to schedule feedback sessions with. As our concept was merely provided to select a design direction, we argued that three users would suffice. See Table 5.1 for user participation.

In the interview sessions, which lasted up to 45 minutes each, the participants were free to share feedback and their opinions regarding the mockups. In the sessions, the mockup was first shown, then discussed, and then moved on to the next. The mockups were viewed in different orders for each participant to minimize priming effects. Once all had been discussed, an overview of all three was provided, where the mockups were discussed in relation to each other. The discussion questions provided in the feedback sessions on was:

- What are your thoughts on the concepts?
- What do you find unclear or difficult to understand?
- Which one do you prefer among the three?
- What would you say are the strengths and weaknesses of the different concepts?

During the sessions, the user was also asked to fill out a form which asked the user to evaluate the mockups in terms of intuitiveness, visual appeal, and structure, on a scale of one to ten. The form was added to achieve more comparable data that could be useful when deciding on a final concept.

6.2 Analyze: Mockup Feedback

The feedback sessions were recorded and transcribed, and then added as comments on a FigJam board that contained all the mockups as overviews. A FigJam board is a collaborative tool in Figma for brainstorming. Each color of comment represents a different participant. The comments were structured on top of all the design alongside markings that showed what worked well, brought confusion, or were disliked. See Figure 6.1 for an example of the structured comments for Flow, and Appendix 6.1 for Pages and Dashboard. The comments could then be summarized into more clarified text that, alongside the form, could provide a good base of what elements are preferred and what users would like to see implemented into the final design. The rest of this section describes the results from the feedback compilation for each concept as well as overarching comments.

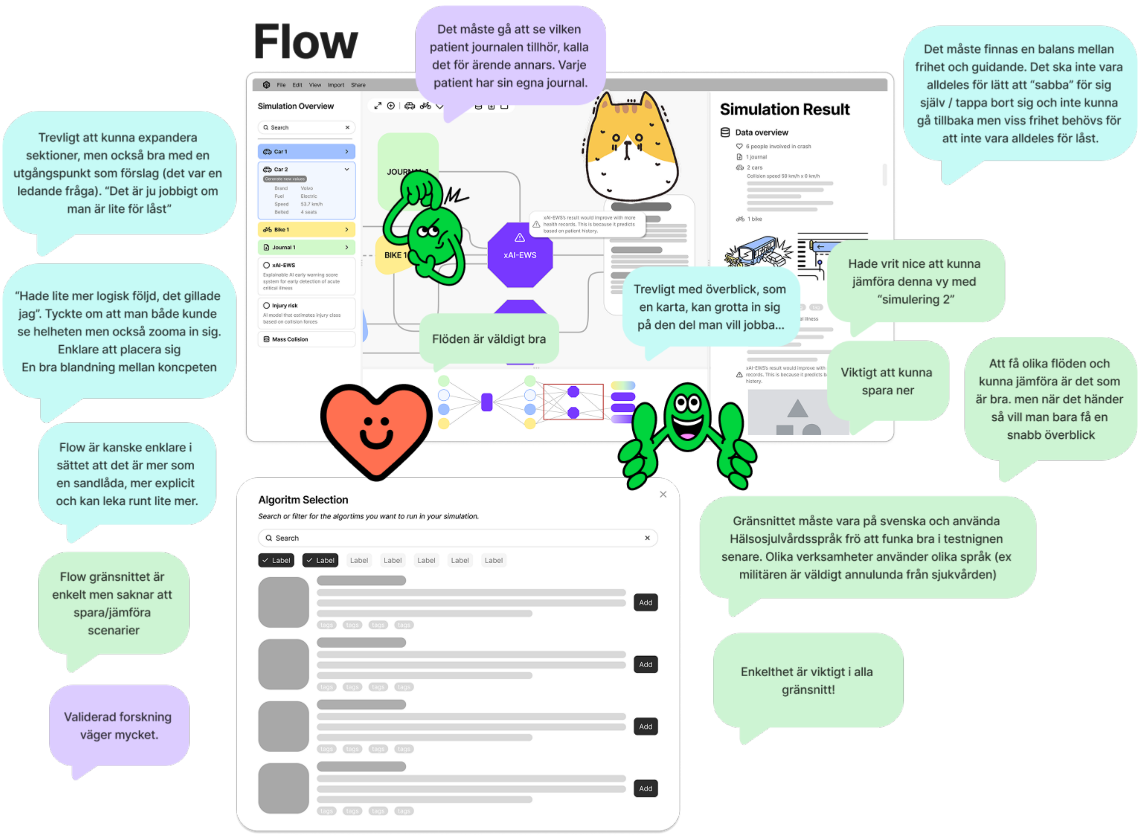

Figure 6.1: The structured feedback from each participant for "Flow"

The positive feedback toward the concept *Flow* was that it worked as a combination of the other concepts. The users appreciated that you could see the whole simulation and its details at once. They thought it was easy to understand and orient, and that the flow in the interface showed logical sequences. They were also approving of the possibility of resizing windows in the interface and emphasized the importance of a good starting point. Critiques regarding the lack of possibility of saving and comparing results of different simulations were mentioned. There was also a need for more specifics regarding the data used, to be able to understand the scenarios better. It was also mentioned that while customizability is nice, you should not be able to ruin the interface to your disadvantage; for example, a button to reset windows to their initial state could be preferable. It was also mentioned that correct terminology is important to raise the validity of the interface. The last comments regarded algorithm selection. It is important to be aware of whether the algorithms suggested by the program are backed by validated science. Finally, Flow was estimated to resemble a Sandbox in its literal sense, where you felt free to play around.

Pages was appreciated for being comprehensible, and for the components and their data were clearly presented. The tangible aspect of the interface, where you can freely drag and insert new material and data providers, was also liked by users. They also liked that the menus were locked in place, making them easy to find. The users expressed appreciation regarding the comparison view in the interface. They further mention a lack of guidance and structure in the interface and that it felt messy in the simulation page. They thought it might be too free and would have preferred a more explicit toolbar. Final critiques were that they missed clearer visual elements, like images, and that the overview (which was well-liked) lies too deep into the program. General feedback expressed that it would be nice to have a button, for example, that can structure all the information in the simulation view. They also expressed scalability concerns and that it would risk being messy with too many components. Understanding probability in the data would also be of interest. Finally, they expressed that the final result should be clearer; right now, it is too information-dense.

The positive feedback on the *Dashboard* mockup referred to its perceived familiarity and intuitiveness. The users mentioned that it reminded them of many of the programs they currently use in their work, with one user stating that *"You don't have to take a course to understand how it works"*. They also appreciated its look and overview structure. Critiques mentioned were that although it's familiar to current programs, the programs used today are heavily criticized for being unintuitive, difficult, and "square" (square referring to a rigid system that doesn't allow for workarounds or mistakes). One participant mentioned that it felt more "engineer-y" (interpreted as being more technical) than the others, which gives the impression that it allows for more possibilities and complex tasks, but with the downside of having a steeper learning curve. Furthermore, feedback was given that people working in healthcare are not spoiled with aesthetics in their current softwares. Thus, it's preferable to focus on usability rather than appearance in the interface. Lastly, users raised that they wish for more realistic data in the example mockups to better understand its function.

The general themes identified throughout the sessions and mockups were that simplicity was a key factor in all the concepts. They also emphasized that correct terminology specific to healthcare was essential to raise immersion as well as having the language within the interface in Swedish. They mentioned that, as Swedish is their workplace language, having this software in English makes it harder to understand and causes disruption. Furthermore, an appreciation for comparison views and summarizing views was raised throughout the sessions. Additionally, a proposal that you could have togglable views that handled the data was mentioned, so you could adapt the visualization based on your simulation needs. A final note is that there were only a few comments regarding service/algorithm selection in the interfaces. We suspected that this might be due to algorithms being an unfamiliar area to them, and thus, they are unsure regarding what they need or lack from an algorithm browser.

From mean values derived from the participants' answers for each question, the result showed clear favorability towards the concept Flow, with the Dashboard coming in second, and finally Pages as least favorable. See Table 6.1 for the mean values for each question and their respective mockup.

The purpose of the form answers was to guide the direction of the final design alongside the verbal feedback. Throughout the feedback sessions, it was found that the opinions of each business analyst varied based on their roles and history. Opinions were especially divided regarding the Dashboard mockup, as some thought it was too "text-based" and, as mentioned earlier, "engineer-y", while others thought it was a more logical approach. This response informed to research possibilities of implementing more than one view in the final interface.

Question	**Flow**	**Pages**	**Dashboard**
Felt intuitive	8.3	5.3	7
Looked nice	9	5	8
Useful Structure	8.6	4.3	7.6

Table 6.1: Question means from feedback form with the highest values marked in green.

6.3 Design: Creating a Prototype

When developing the final design, it was decided to start the design in Figma and then create the prototype through a coded website. Due to time constraints, a scope reduction was done. It was decided to have less focus on the algorithm browser due to the lack of comments on it. Instead, the algorithm browser would stay mostly the same this iteration. It was also decided, based on the feedback, that the prototype design would focus on:

- Simplicity
- Correct healthcare terminology
- Having the interface in their working language, Swedish
- Adaptable visualization of the simulation components overview

To initiate the creation of the final design concept, design elements from the mockups that got positive feedback were restructured. Sections were cut and pasted, and new additions were added using the mockup concept "Flow" as a base. This was done until a satisfactory layout was achieved that followed the comments collected during the user evaluation.

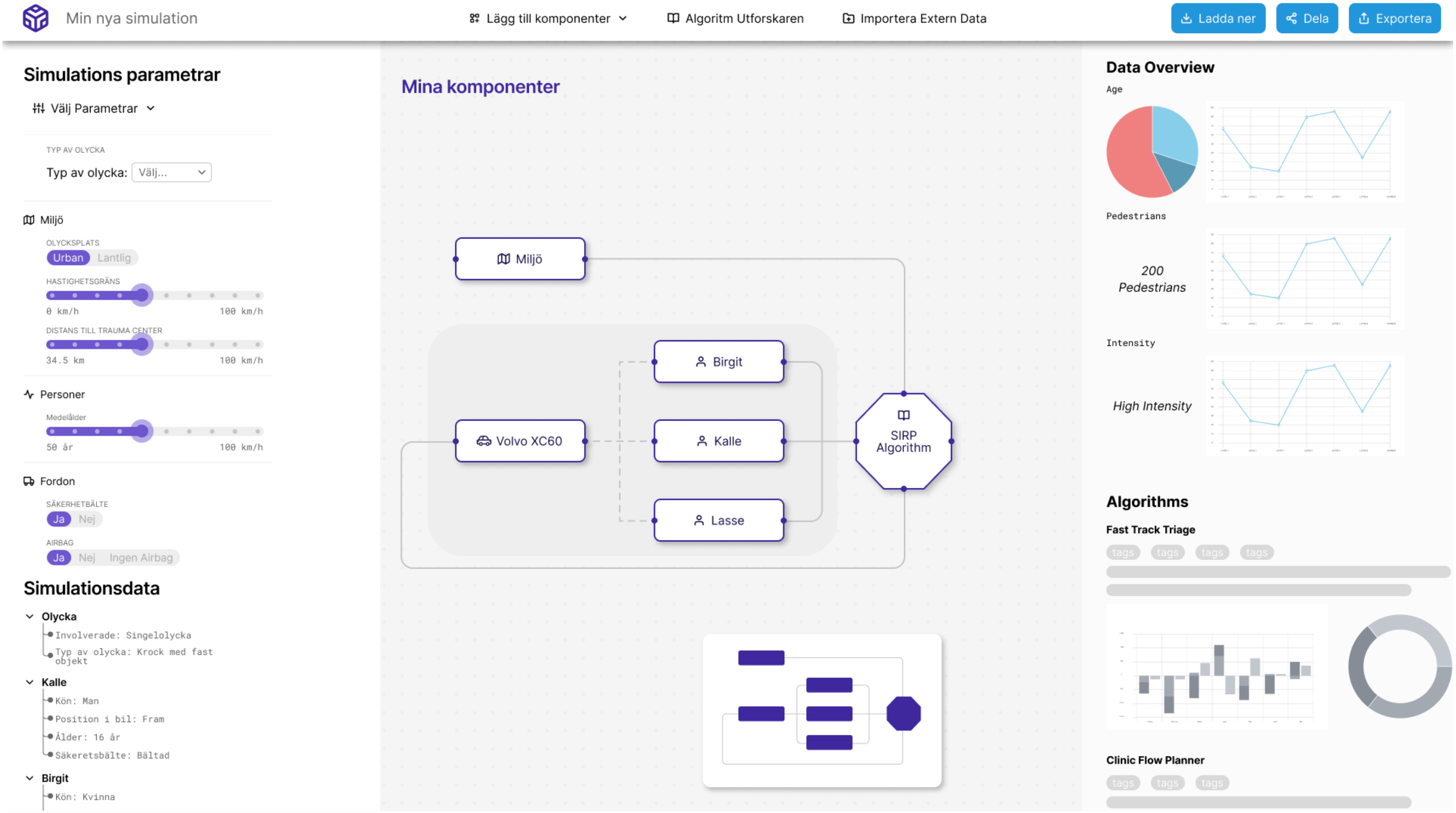

Figure 6.2: First DHS Figma prototype: Simulation view.

The main changes were that a combination of the rigidity from the "Dashboard" concept and the visualization from "*Flow*" could benefit the design. The design elements that were kept and reworked were side panels with information: left side panel for selection of accident type, adding parameter sliders, and a tree-structured list of the components in the current simulation project, and right side panel for a live updating summary of the simulation result. Additionally, knowing that the users were avid users of the Microsoft Office suite, where the ribbon menu is located at the top bar, the algorithm browser and component menu was kept positioned at the top in order to instill familiarity. The visualization of the flowchart and the zoomed-out overview with the mini map were kept from the original mockup "*Flow*". This was done to give an easy overview, something that was greatly appreciated by the users. The algorithm page from the concept "Pages" was kept as a base design. From this sketch, a rework in Figma was created, see figure 6.2. The Flowchart in the middle was made to represent a simple scenario with few components, and the overall style of the interface was made more unified. This rework also included changes that would give the elements a more aligned structure and divisions.

6.3.1 Scenario and Parameter Design

In between creating the interface, a scenario to be visualized in the GUI and used in a user test was developed. A truthful scenario was created To help with immersion when testing. As the final design would not be fully functional, it was decided to thoroughly illustrate one user scenario embedded into the GUI instead.

The fictional scenario depicted a single vehicle traffic accident that had come to an immediate stop on a road with a 70 km/h speed limit in a rural area. The vehicle contained 3 passengers: A 44-year-old man in the front seat, wearing a safety belt; A 16-year-old boy in the front seat, wearing a safety belt; And a 70-year-old woman in the backseat, wearing a safety belt. In the accident, the car hits a fixed object during the day when it is not raining. The accident occurred 28 minutes from the closest trauma center.

This scenario were derived based on the parameters that are used in the triaging algorithm SIRP [22] and OSISP [8] that calculates injury severity for each passenger in the car. These algorithms, as well as their parameters and our fictional scenario were to be displayed as the data and components in the GUI of the DHS. When a user pressed "add passenger" in the program, the data connected to one in our scenario was to be displayed. And when users pressed "add SIPS algorithm", it was to be added into the simulation and generate fake results. To achieve this, an output for each of the algorithms, i.e., a severity score, was needed. The fictional severity score can be seen in Table 6.2.

Algorithm	**Adult, 44**	**Youth, 16**	**Elderly, 70**
SIRP Severity Score	70 %	78 %	91 %
OSISP Severity Score	56 %	64 %	89 %

Table 6.2: Fictional severity scores for each passenger.

Other than the scenario, the data available from the car itself was of interest to visualize the scalability of the DHS and understand how it would present data provided from different data collectors. Thus, based on parameters discussed by Nishimoto et al. [22] and Buendia et al. [8], the following car-collected parameters were selected to be presented:

- Seatbelt use: Yes
- Accelerometer reading: 96.4 g
- Location of impact: Front
- Delta-V: 71.78 km/h
- Vehicle model year: 2015
- Vehicle weight: 1850 kg
- Vehicle model: Volvo XC60
- Vehicle speed: 71.78 km/h
- Distance to nearest trauma center: 34.5 km
- GPS coordinates of the crash: 57.6282762, 12.4156136

The scenario data, parameters and algorithms were then able to serve as a base to illustrate the DHS functionality and interactive elements.

6.3.2 Programming the Prototype

With the design finished in Figma, it was decided to program it into a webpage. The first high-fidelity version of the prototype was develop through programming. The code was made using the programming languages HTML, CSS, and TypeScript together with the React and Tailwind frameworks. The first step was to investigate the feasibility of coding the whole interface. Existing React components were gathered for time efficiency. These components were ready-made visual elements in code, which could easily be added to existing programmed interfaces.

To visualize the prototype, a user scenario with pre-fixed data was created, see Chapter 6.3.1 for details. The determined data was structured as a tree, with the scenario as a root, and its branches and leaves were vehicles, patients, and other data, see figure 6.3.

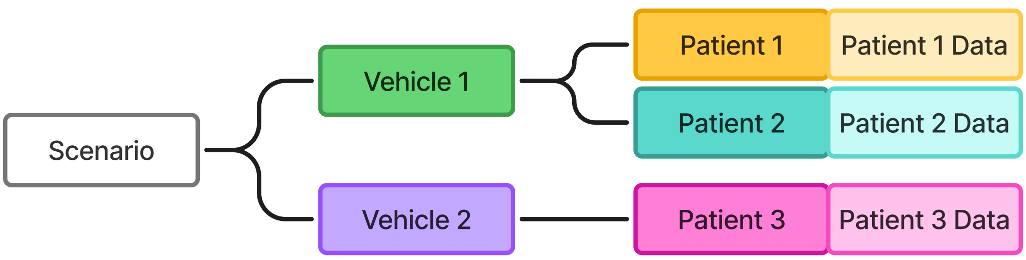

Figure 6.3: The structure of the data in an example scenario.

A diagram of the data was created using the tool PlantUML Class Diagram to get an overview of the data structure in a code format. The structure of the visual representation was then coded.

When the components had been tested and were working as expected, more infrastructure work was coded. Data models were created in TypeScript. After the modeling was done, the infrastructure was made by adding the data from the predefined scenario mentioned at the start of this section.

The scenario data resided in different depths of layers within the interface code. Different components within the interface needed to have access to this data. To handle the complexity of the interface, React's Context function was used. Instead of passing the data from component to component in several steps and in the end reaching the end destination, components nested deep within the interface can send data directly to the Context residing on a higher level in the code. Context can then directly further that data into other components in the interface, see figure 6.4.

The resulting coded interface can be seen below in Figure 6.5. The design is based on the elements mentioned above. Every button has an interaction. It is possible to add all the different parameter sliders, and to interact with slider thumbs to select values, although they are not connected to dynamically change the result. Menus are expandable and collapsible. It is possible to freely add data components.

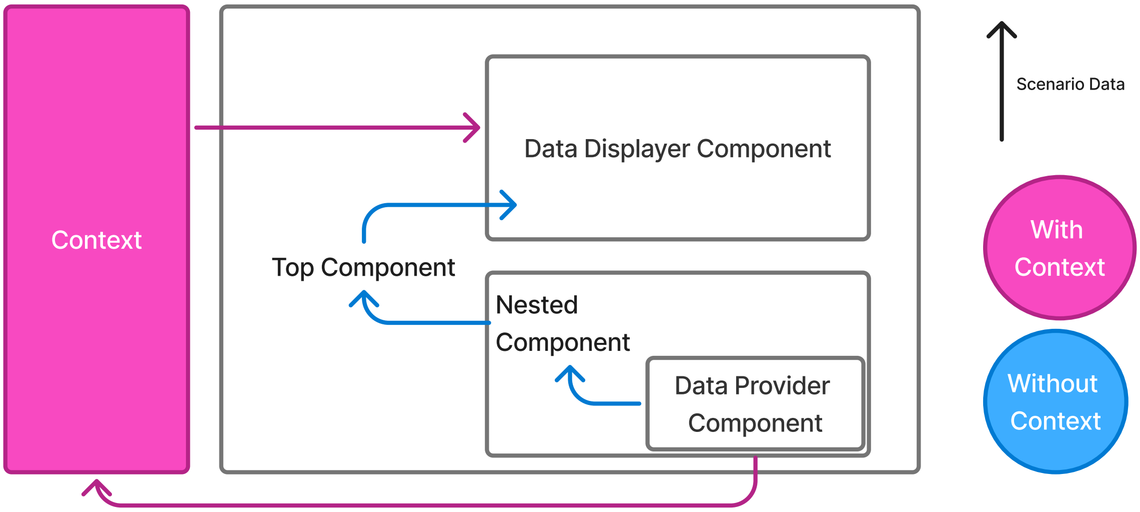

Figure 6.4: How the data would flow in the code with and without Context.

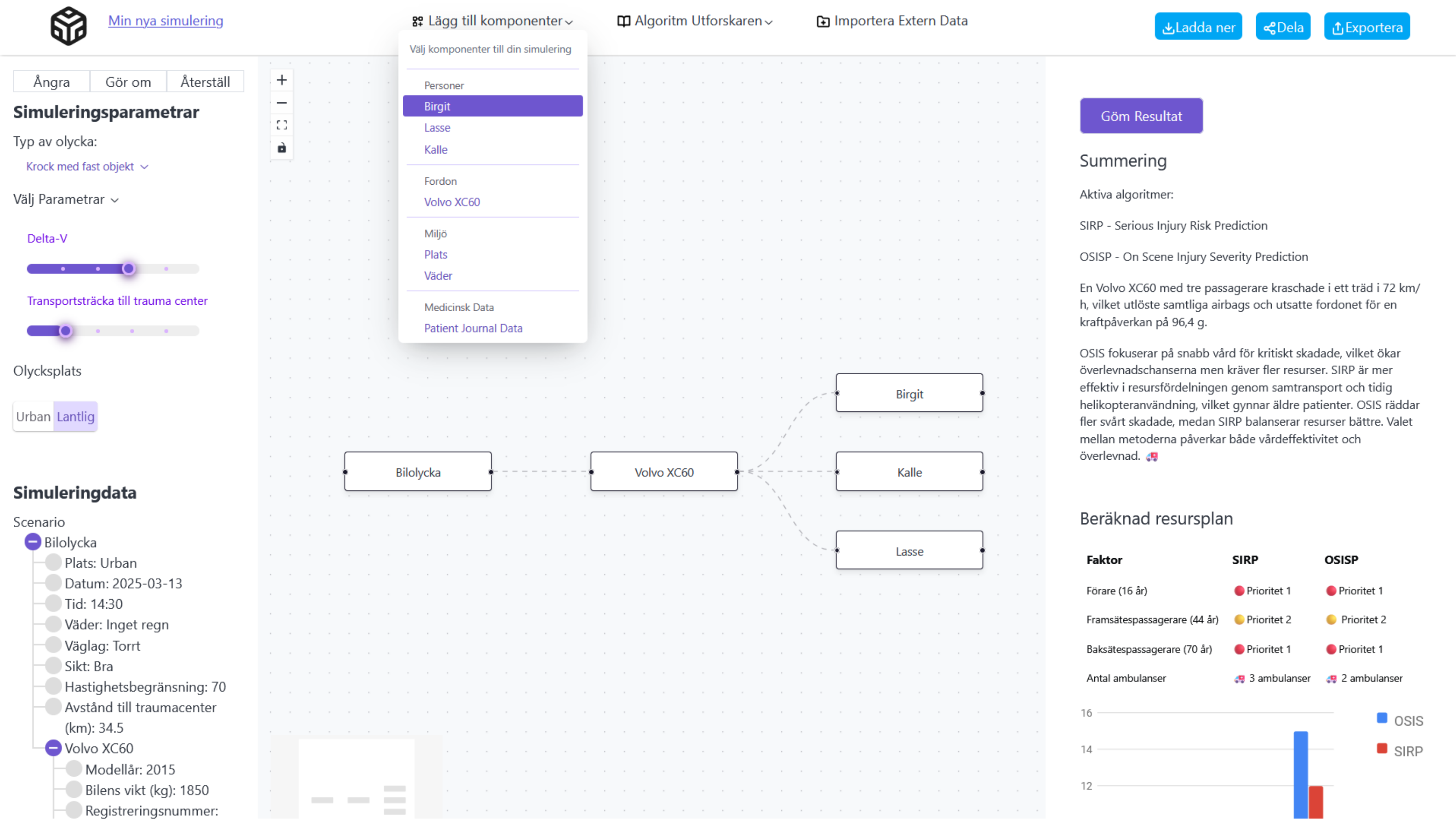

Figure 6.5: Web interface: Simulation with results.

6.3.3 Design of the Usability Test

A user test was developed in parallel with the design and scenario specification. The test consisted of eight tasks that the user needed to perform. See the list below for tasks and their descriptions. It was developed so the user would switch between two tabs in an online browser. One tab showed a questionnaire, where the user got to fill out their participant ID, as well as receive instructions for the test. The questionnaire also probed the user to answer the Single Ease Question (SEQ) (see Chapter 4.5) after they thought they had completed each task. The SEQ asks the following: "Overall, how difficult or easy was the task to complete?". The user could answer this on a scale from one to six, where six was very easy and one was very difficult. In the other window, the user performed the tasks in the Figma prototype.

To start the test, participants were informed that their voice and screens would be recorded, and they needed to consent to this data being collected (see Appendix A for the consent form). This was done to be able to derive the data from the sessions without interruption. Afterwards, they received a description of the concept and the intent for the interface. Thereafter, they received a short description of the test they were about to perform, alongside the instruction that they were to think aloud.

The test then started with the user reading a scenario text that described the components and parameters the user would be interested in adding to the simulation. See Appendix I for the instruction text. The following tasks were then performed, with each task being followed by the SEQ in the questionnaire (translated from Swedish using ChatGPT):

Task 1. New project
- Create a new project.

Task 2. Set the type of accident
- Set the accident type to *"Collision with a fixed object."*

Task 3. Add the people involved
- Add (in order): *Car, Senior (65+), Child/Youth,* and *Adult.*

Task 4. Use Algorithm: SIRP
- Activate the algorithm *"SIRP"* for your simulation.

Task 5. Parameters
- There is an interest in understanding how different parameters affect the outcome. In car crashes, it is often relevant to know the change in speed (*Delta-V*) at the time of impact, as well as the distance to the nearest trauma center. Add the relevant parameters for your scenario:
- *"Delta-V"*, set it to **70 km/h**
- *"Transport time to trauma center"*, set it to **30 minutes**

Task 6. Graphical View
- Switch to the graphical view.

Task 7. Use Algorithm: OSISP
- Activate the algorithm *"OSISP"* for your simulation.

Task 8. Download
- Download the result.

The tasks were deliberately kept simple, typically involving only a few interactions, to allow for focused evaluation of individual sections of the interface. They will commonly be referred to as T1, T2, T3, T4, T5, T6, T7 and T8 throughout the report. Once all tasks were completed, the final part of the questionnaire consisted of the ten questions from the System Usability Scale (SUS). The user was to rate their opinion of the prototype as a whole based on the questions, ranking them from one to six, where one is "strongly disagree" and six is "strongly agree" (see Chapter 4.5 for the SUS questions).

The metrics that would be applied to the collected data were also decided. This was important to ensure sufficient data collection to be able to perform a thorough usability analysis. The selected metrics for data collection were the following (see Chapter 4.5 for descriptions of the metrics):

- Completion rate
- Number of errors
- UI error mapping
- Task time
- ORE
- TBE
- SUS questionnaire
- SEQ questionnaire
- Think-aloud protocol

With the coded prototype, interface scenario, and user test developed, iteration three began. The third iteration will focus on pilot testing and redesigns of the DHS.

7

ITERATION 3: Refine Prototype

This chapter presents the third iteration, refining the prototype until it was ready for user testing. This iteration consisted of three smaller iterations alternating between the Collect and Design phases, repeated until the prototype reached a satisfactory state. The first iteration dramatically changed the prototype, while the rest were tweaks. After going through the iterations, there will be a walkthrough of the changes made. Finally, it will present the first user-tested version of the DHS prototype.

7.1 Collect: Pilot Usability Tests and Feedback

With the finished web-based interface, it was time to conduct usability tests. In preparation for this, small iterations of the Design and Collect phases were done. The tests were performed on three participants, S1, S2 and S3, see table 7.1. Based on the their comments, necessary changes were made.

Pilot Participants	Description
S1	Design Student
S2	Design Student
S3	Design Student

Table 7.1: Participants for the pilot tests. Where S# refers to their participant ID number.

This section will present each of the Collect phases performed in this iteration, and the next will discuss how the design changed between each phase. The first web-based prototype, along with the corresponding user test, was evaluated by a design student. This test was used to evaluate whether the testing procedure, form, and interface were ready for real user testing. Below are the main remarks from the test:

- Adding components was done at the top bar, while most other actions were on the left (see figure 6.5), making the interaction flow inconsistent. The participant said: “I find it very hard to know what I’m supposed to do here... the flow feels unclear.”
- The flowchart in the center (see figure 6.5) took up the majority of the screen but was not interacted with. This created a mismatch in visual hierarchy and functional importance. The participant mentioned:

> “I wonder what I do with this in the middle? Because it takes up a lot of space, but I don’t do anything with it. [...] it feels like you should have a different priority on what’s on the website [...]”

- The initial scale was 1-5 in the questionnaire. This was unclear to the participant, particularly the meaning of selecting the middle value. As a result, the scale was made 1-6 for future tests to encourage participants to take a stance and avoid neutral responses.
- Once it was familiar that some functions resided at the top bar, tasks became easier. However, a back button in the algorithm browser was needed.

The feedback provided induced some major changes in the design, which led to an extensive overhaul. A decision was made to go back to Figma entirely as well.
A completely new high-fidelity prototype was then made which was shown to the project’s supervisor. The user test and design were shown, and the supervisor gave design critiques of the new GUI. The main takeaways from this session were:

- The design needed further iteration to establish a cohesive design language throughout the interface.
- Redundant buttons that did not lead to new views or actions should be removed and instead categorized as potential future features.
- The Algorithm Browser did not visually or functionally feel integrated with the rest of the system. There was a design inconsistency: most features were embedded within the simulation page, while the Algorithm Browser existed as a separate page.

The final collection phase was done on three design students. They were allowed to run the final user test and interact with the prototype. After they had performed the user test and filled in the SEQ and SUS questions (see 4.5 for the questions) a broader discussion commenced regarding the design. User identified challenges were discussed as well as possible solutions and redesign. We also invited one of the pilot users to discuss alongside another pilot user to see what they agreed upon and where they had different opinions. The comments that we thought were suitable to implement were then compiled into a list that could easily be referenced when updating the design. Key feedback points include:

- **Positive Feedback**
  - The 1–6 scale in the test form prevents neutral/middle choices.
  - Appreciated overview fitting on screen, no need to scroll.
  - The action of adding an algorithm was perceived as easy.
  - Notification that a project was created was appreciated (but could be more visible).
- **Negative Feedback / Usability Issues / Bugs**
  - Button for creating a new project appeared disabled and unclear due to being gray
  - The button for switching between flowchart and list view was too small and poorly positioned.
  - The label “Explorer” (Utforskare) for the algorithm browser caused confusion, leading users to believe that selecting an algorithm was optional. The

wording gave the impression that the feature was for optional exploration rather than a necessary step for activating one.
- Users were unsure whether adding a new algorithm would replace the existing one or allow multiple algorithms. There was also confusion about how many algorithms should be added and whether the order was important. It was further unclear when algorithms were successfully added.
- The parameter sliders were difficult to use due to a small click target area and its value was unclear. The interface lacked clarity on which slider was active and highlighting the component in the list was misleading. Participants mentioned that sliders should support dragging or allow direct input instead of only adjusting by sliding. There was also a bug where a slider value reset when another parameter was added. It further was unclear how they related to the selected parameters, making adjustments confusing.

7.2 Design: Redesign Prototype and Layout

This section discusses all the changes that were made based on the pilot and feedback sessions. It will go through the changes and give a final overview of the design. From the feedback of the first pilot (as presented in Section 7.1), it was decided to completely redesign the interface. To effectively execute the new design, new sketches of the design were made (see Figure 7.1). Furthermore, the sketches were transferred as wireframes into Figma, and each of the interactions the user would need to perform during the user test was detailed (see Figure 7.1). Mapping the frames made it easier to understand which components were needed for an Minimal Viable Product (MVP) for testing, which made it easier to focus on design. It was also necessary to understand the workarounds that were required when developing the prototype in Figma, such as lacking text input fields.

The sections from previous designs were still necessary, but their distribution on the page needed to be improved. For instance, the *component overview*, previously located in the bottom left corner, needed to be enlarged to better indicate that it provides detailed information about the data providers added to the simulation. As a solution to this, and to use the space efficiently, it was decided to have two views of the program that the user can change between. One that shows the simulation components in a text-based view, and one that shows it in a visual, flowchart-inspired view. Furthermore, the function for adding data components was also redesigned to reside in the left side bar with other functions that affect the simulation's content, compared to previously when it was placed at the top bar. This change was inspired by natural mapping, where the user groups items together that affect the same thing. See Figure 7.2 for the change.

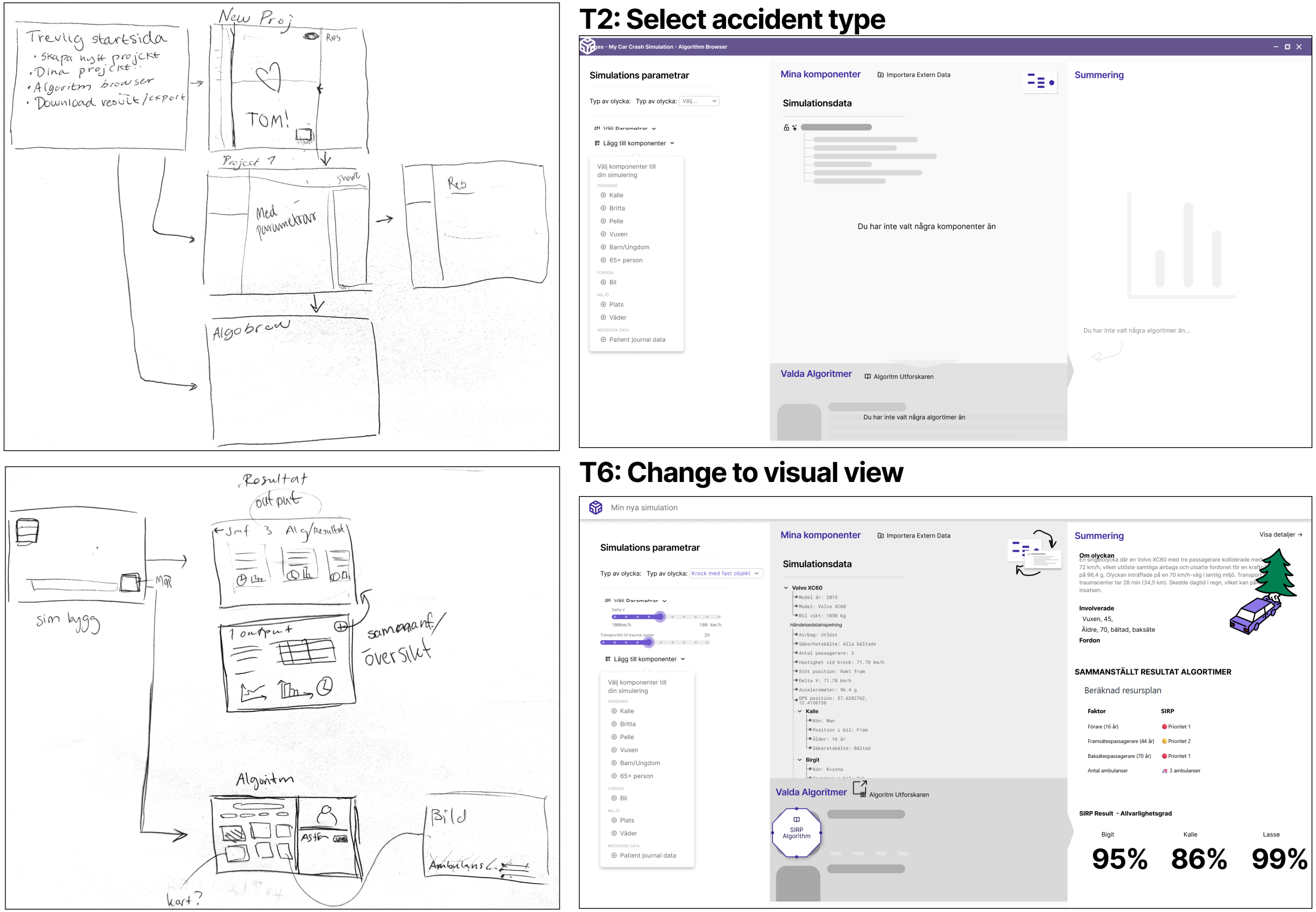

Figure 7.1: Sketches and wireframes mapping the required components in the DHS redesign.

As a base to build the design, Figma's design library, Simple Design System, was used [78]. Alongside this, our own design elements were included, and the necessary interactions were developed. Throughout this design realistic data and algorithms were included to raise immersion for users' testing. To complete the design, a cohesive color palette with strong contrast was selected to support user comprehension and ensure clarity within the interface. The palette consists of varying shades of purple and grayscale.

After the feedback session, the design focus was on clearing redundancy and unifying design language. The removed redundancies were, for example, navigation on the homepage, a more detailed result view, and export buttons. Additionally, the algorithm browser and its animations were redesigned to better align with the updated design. The algorithm browser was originally based on the Material Design 3 system, which visually contrasted with the Simple Design System, contributing to a disconnect within the program. By redesigning the algorithm browser as an embedded overlay that aligns with the Simple Design System, the section saw significant improvements, see Figure 7.2 for an overview of the redesign.

The comments from the last pilot tests were discussed with the participants regarding how the design could be improved. The changes that occurred regarded positions of interactive elements, such as sliders and buttons. Furthermore, the comments referred to how the design could be changed to increase visual clarity, such as increasing contrast and changing colors, see Figure 7.2 for an example of a visual clarity adjustment.

7.3 The DHS Interface Version 1

All the changes were added to the Figma high-fidelity prototype, which eventually resulted in a prototype that was ready for user testing with the target users. This section will now present the design and how its interaction works. To better see each frame of the prototype, see Appendix J.

When the user starts the prototype, they land on the home page. The home page presents users with a list of cards that represent their old projects, as well as the possibility to press "Nytt projekt" (New project). The old project card contains the project name, the applied *algorithms*, and an image of the *component overview as a graphical view*. This layout was chosen to help users remember the differences between projects using visual elements. If the user presses a card, they will be taken into that project file, and if they press New project, they will be taken into a new project.

In the new project, the user receives a green pop-up that states "New project created". Other than that, it is an empty page that consists of four main sections they can interact with to start building their simulation. See Figure 7.3 for the interaction on the home page and the four sections of the sandbox simulation page.

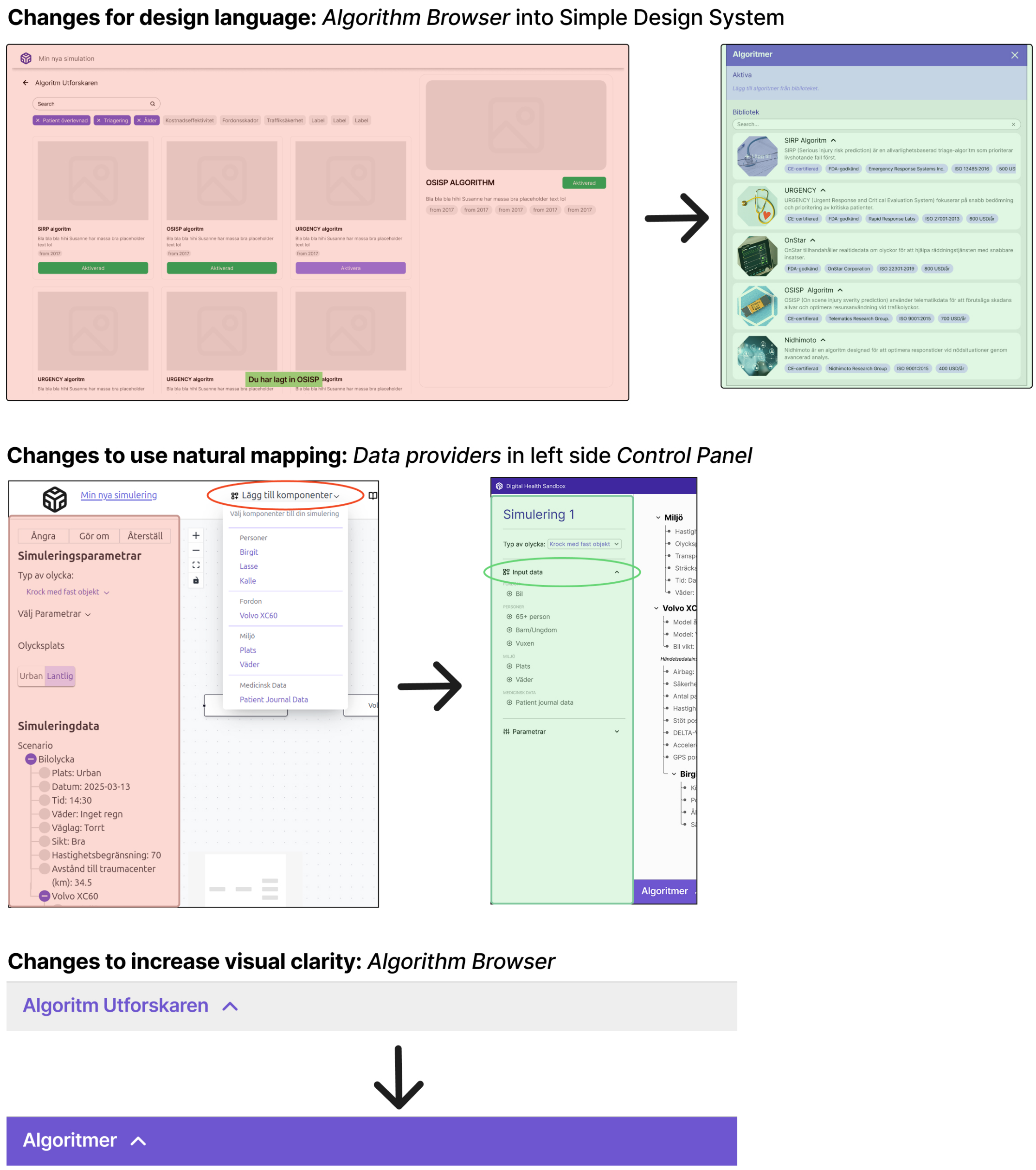

Figure 7.2: Changes made to the main window from the pilot user test.

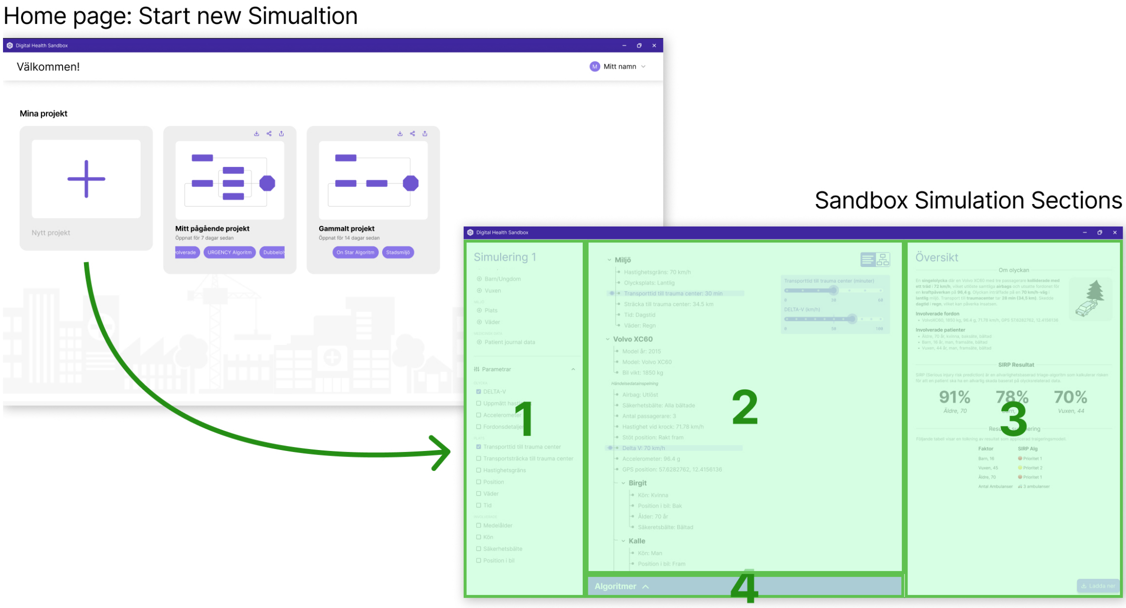

Figure 7.3: The interface start page and what happens when you click "new project". It also slices the simulation page into four main sections.

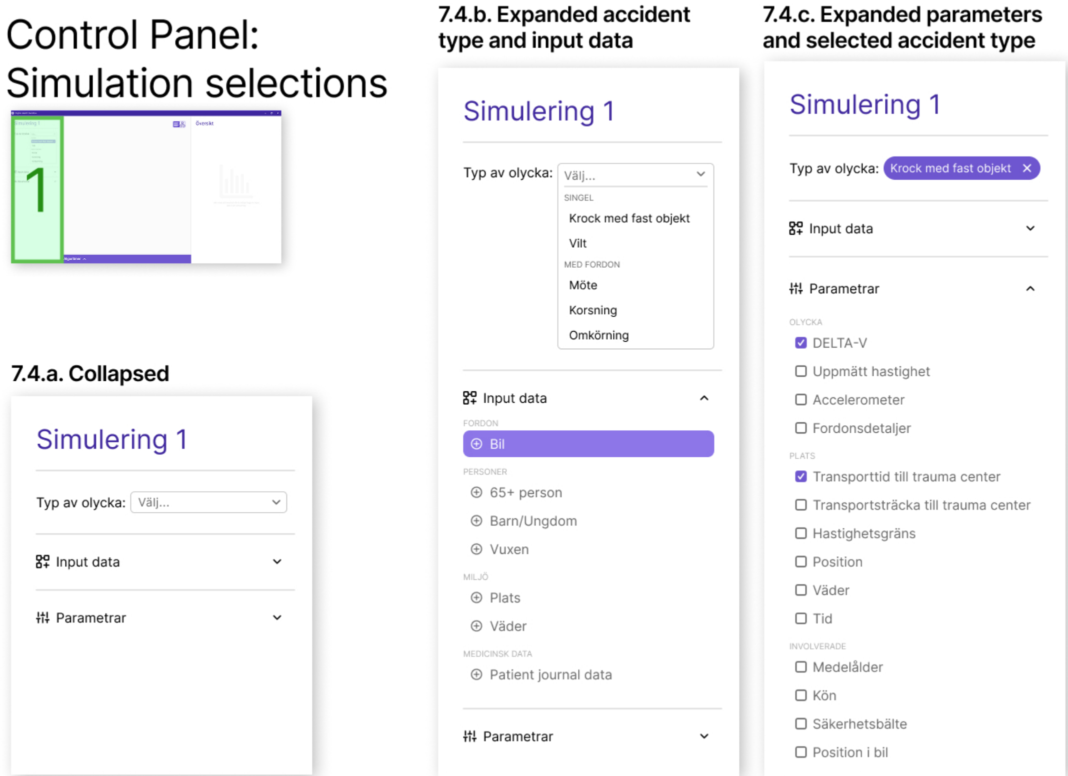

Figure 7.4: Section 1 of the interface, called the Control Panel. Contains functions for adding and changing components in the simulation.

In the *Control Panel* (also called section 1), see Figure 7.4 , the user performs most of the tasks that affect the content of the simulation. The user is met with the collapsed version of the *Control Panel* (7.4.a in Figure 7.4) and can then press the chevrons to expand each part of the section (7.4.b and 7.4.c in Figure 7.4). The user initiates the simulation by pressing the drop down menu next to "Typ av olycka:" (*accident type*) which then shows a list of different types of car accidents the user can select one from. Continuing, by expanding Input data, it is possible to add *data providers* into the simulation. A list of a few different types of providers appears, which users can add to the simulation. Once a *data provider* is added, they have randomized data values attributed, which then can be changed by the user. Following this, if the user expands "Parametrar" (*parameters*), a list of parameters that the user can add to manipulate the simulation appears. By clicking the checkbox, the parameter is added to *the component overview*. Throughout the *left sidebar*, the user receives feedback based on mouse movements. For example, when the mouse hovers over an interactive object, both the mouse and the appearance of the object change to hint at interaction.

Moving onto the *component overview* (also called section 2), see Figure 7.5. This section presents information about all the current selections for the simulation, and it is where users can change data details. When starting a new simulation, this section is empty except for the bottom bar and button at the top right. As the user then adds simulation components, it takes on the appearance of 7.5.a, except for the sliders and highlighted purple areas. See Figure 7.5 for references of 7.5.a, 7.5.b,and 7.5.c. The data is presented in a collapsible tree structure where all the data attached to each data provider is presented. The user can use the chevrons to minimize this view if they do not want all the data details on display. Furthermore, if a *data provider* includes another *data provider* as well, such as a passenger in a car, this is displayed as a branch to the tree.

Parameters are displayed at the top right, and their respective affected data is highlighted in purple, as shown in 7.5.a. The order of the *parameters* is mapped to the order their respective data appears in (transport time appears first in the data provider tree, and therefore its slider is also first). The slider is used so the user doesn't have to enter specific data values to each *data provider* affected by that *parameter* when they want to make bigger changes to the simulation data. If they want to enter specific values, they can press that value in the data provider tree and change it using the keyboard.

To change between the *component overview's list view and graphical view*, the user needs to press the button 7.5.c. The icons on the buttons aims to hint to the user which view is currently displayed, and which they can change to. 7.5.b shows the *flowchart view*. Within it, each simulation *component* is displayed in a visual manner, where they are all represented by a shape. The lines between the components show how they are connected. The purpose of the *graphical view* is to make it easier for the user to understand the connectivity of the simulation components.

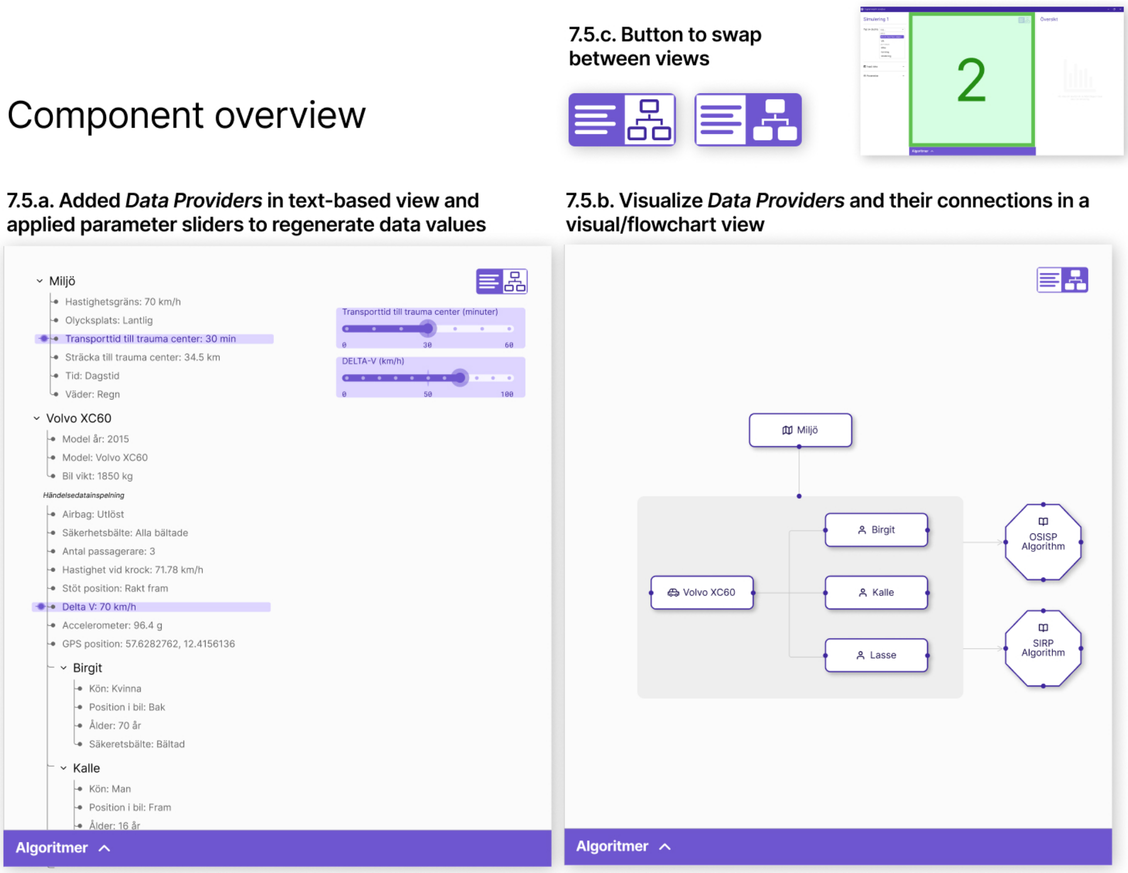

Figure 7.5: Section 2 of the interface, called the component overview. Contains information about data providers and the option of different visualization views.

In the *simulation result* (also called section 3), see Figure 7.6, the user receives an overview of the result from their simulation. 7.6.a is the view that the user sees when they start a new empty simulation, see Figure 7.6 for references of 7.6.a, 7.6.b, and 7.6.c. The 7.6.b view is what the user sees once they have added *data providers* to the simulation. The overview generates a description of the data added that follows the selected accident type. Furthermore, it provides the bare necessities of data values that are needed to understand the characteristics of the *data providers*. This is done to make it easy for users to understand the content of the simulation.

7.6.c displays the *simulation results* when *algorithms* have been added to the simulation as well. In this instance, two *algorithms* have been activated, and their estimations of severe passenger injury is displayed. The result is presented to show what differences exist when comparing the results from the *algorithms*. At the end, there is a summary of what triage level the corresponding percentages would require based on the healthcare emergency centers' standards.

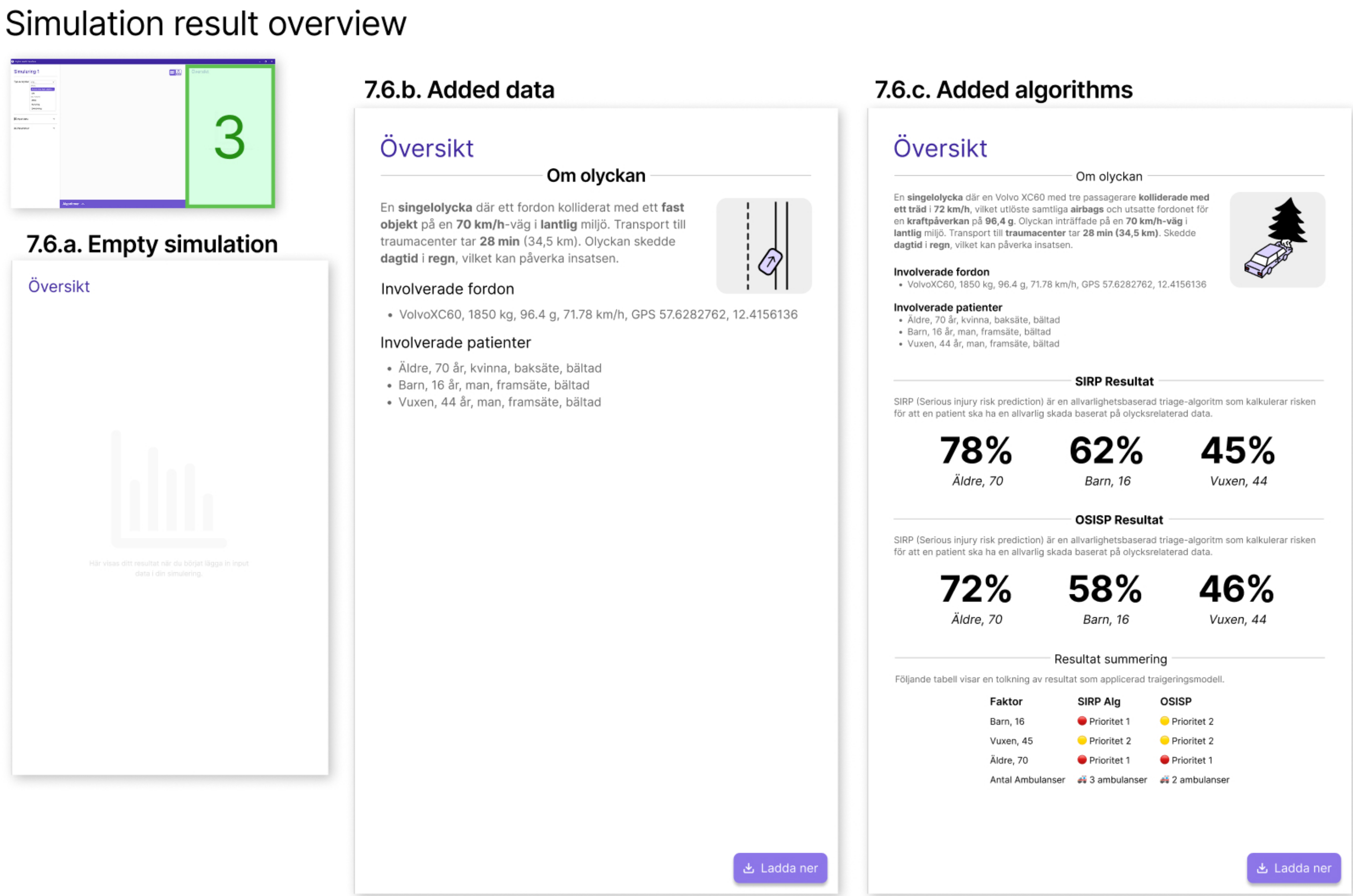

Figure 7.6: Section 3 of the interface, called the Result Overview. Contains the result from the simulation and information about each data provider.

Finally, in the *algorithm browser* (also called section 4) the user is allowed to explore, add, and remove *algorithms* to the simulation. To start, the user needs to press the 7.7.a button to have the *algorithm browser* (7.7.b) open as an overlay over section 1. See Figure 7.3 and Figure 7.6 for references of section 1 and 4, and images 7.7.a, 7.7.b, 7.7.c, and 7.7.d. With the overlay displays a library of *algorithms* (gray area), and an area that presents activated *algorithms* (light purple area). The user can use the search bar to search for the *algorithms* they are looking for or to find filtering options.

When the user hovers over an algorithm card (7.7.c), the color of the image changes to purple to signify action. The user needs to press the card to activate it. When this is done, the card image quickly changes color to green, to give the user feedback that it has been successfully applied. In the algorithm card, the user can press the chevron to get more information and details about the *algorithm.* The purple tags in the cards contain information about the algorithm. As this could be an easy way to quickly browse and learn about different algorithms, as well as to use as categories for filtering the library. At last, in 7.7.d the user has activated two *algorithms* in the simulation. To exit the *algorithm browser,* they need to press the chevron again.

This version of the GUI will now be tested on users, and based on their feedback, redesigned further. This will be done in iteration four.

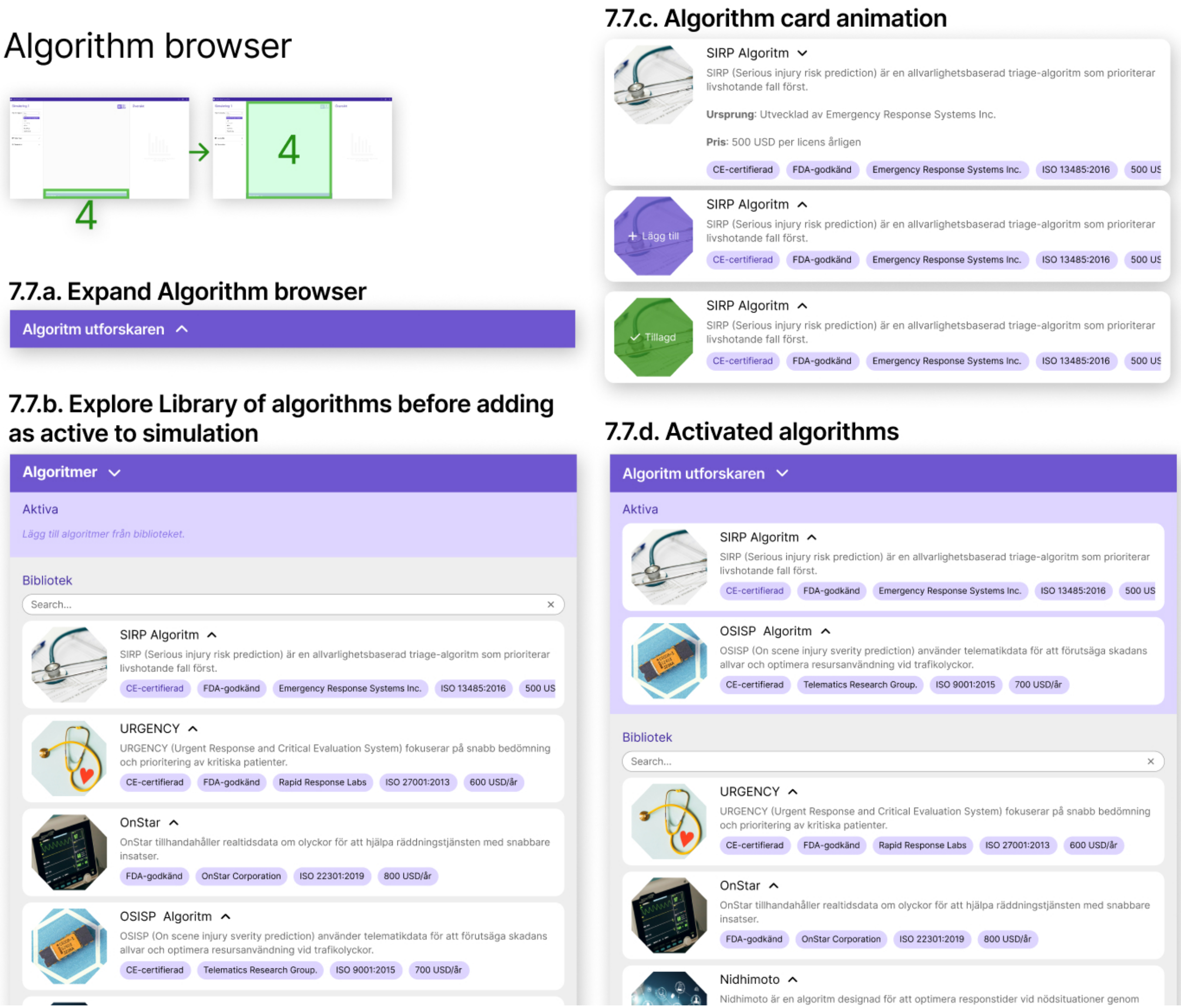

Figure 7.7: Section 4 of the interface, called the Algorithm browser. Provides the user with the possibility to browse for algorithms and add/remove them to the simulation.

8

ITERATION 4: Finalize High Fidelity Prototype

This chapter provides an overview of the formative evaluation and usability testing process that was performed on the high-fidelity prototype developed in the third iteration. Furthermore, it presents the adjustments that were made based on insights derived from the testing sessions. Finally a summative evaluation is presented.

8.1 Collect: Formative Evaluation

The test was conducted both through online calls and in person. In total, 7 participants performed the usability test, see Table 5.1. All but one of the users had been involved in previous sessions connected to this project. All of them were business analysts in healthcare.

The data in the collected video and audio material from the usability test sessions were transcribed and reworked into manageable units. The audio material was transcribed using Microsoft Teams' built-in transcription service. The transcriptions contained the think-aloud comments, which could then be used to find quotes regarding the Usability experience. From the recording following data for each task was collected:

- Time for completing or giving up on a task (in seconds)
- Number of clicks for completing or giving up on a task
- Number of wrong clicks before completing or giving up on a task
- UI mapping of wrong clicks (for example, where the user miss-clicked)
- Completion of the task (1 = successful completion, 0 = failed/gave up on task)

8.2 Analyze: Data Analysis

With the derived data from transcriptions and screen recording measurements, the data analysis could begin. The analysis would focus on measuring the achieved usability in the system.

8.2.1 Effectiveness

Effectiveness was calculated in terms of completion rate. The completion rate was calculated by adding the completion values and then dividing by the number of participants. This results in a percentage for users who completed a task. A failed task is counted when a user gives up. See Figure 8.1 for the completion rate.

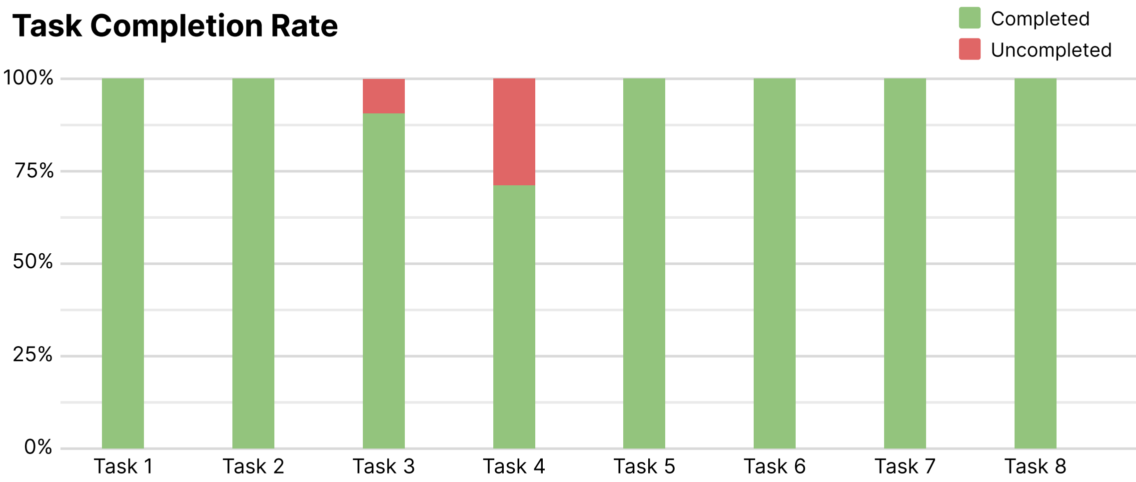

Figure 8.1: Graph illustrating completion rate for each task in the usability test. Where green is percentage completed and red is percentage failed task.

Furthermore, effectiveness was calculated in terms of clicks and error clicks for each task. The error clicks were counted as the number of clicks that did not move the user towards completing the task. Alongside this, the ideal number of clicks towards completing a task was calculated in the prototype. The number of clicks was counted until a user completed the task or gave up. For the data analysis, Figure 8.2 shows the ideal amount of clicks alongside the mean amount of clicks per task. Figure 8.3 shows how many error clicks each participant took to complete each task. The error-clicks per task was chosen as it clearly shows how means might have been skewed regarding extreme values.

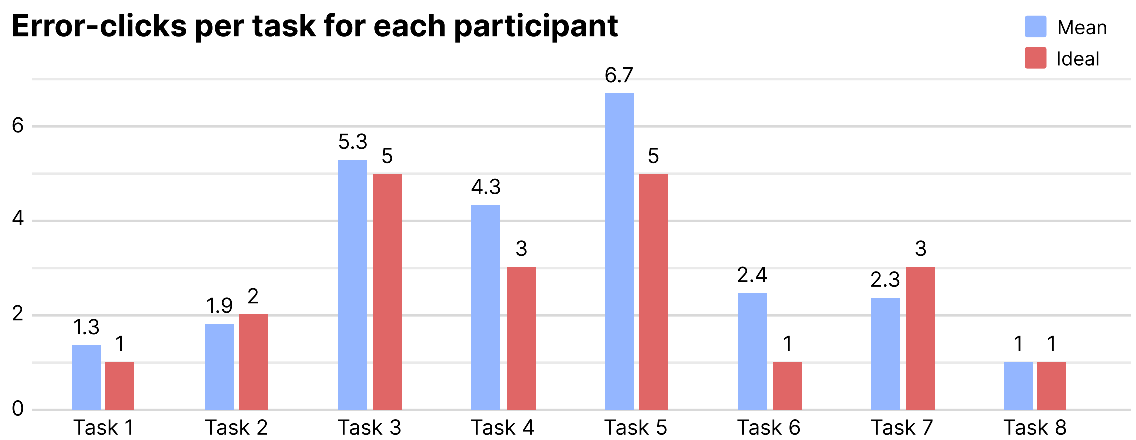

Figure 8.2: Graph illustrating the mean values for clicks per task, compared to the ideal amount of clicks, in the usability test.

Alongside knowing the number of errors, it is of interest to understand when and why they happened. To illustrate the GUI's problem areas, error UI mapping was done as a chart where wrong clicks or actions were annotated, see Figure 8.5. This was possible to map using the think-aloud transcriptions. The map showed circles for the number of users who misclicked, not total clicks. The miss-clicks were also illustrated with the intention behind, for example, when a user presses "expand" on an algorithm card, it is not necessarily wrong; however, if they do so because they think that will add the algorithm, it is a miss-click.

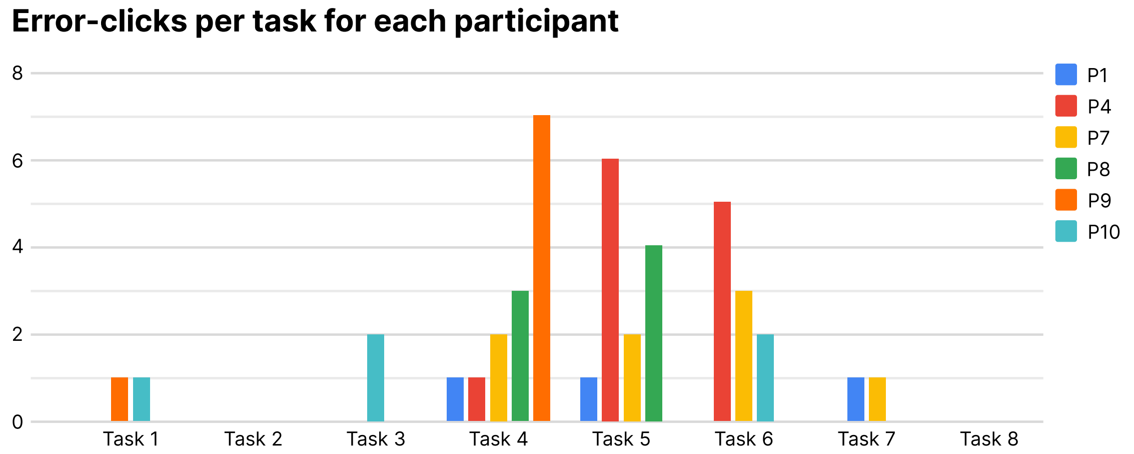

Figure 8.3: Clustered bar chart illustrating the amount of error-clicks for each task per participant in the usability test.

8.2.2 Efficiency

Efficiency was measured in terms of time spent on each task. This is presented in Figure 8.4 with a graph depicting the measurement for each user. This choice was made to illustrate potential outlier values and highlight challenging tasks. Efficiency measured through the Overall Relative Efficiency metric resulted in 89.07 % success rate of tasks compared to failures. Efficiency measured through the Time Based Efficiency metric resulted in a completion of 0.07 tasks/second.

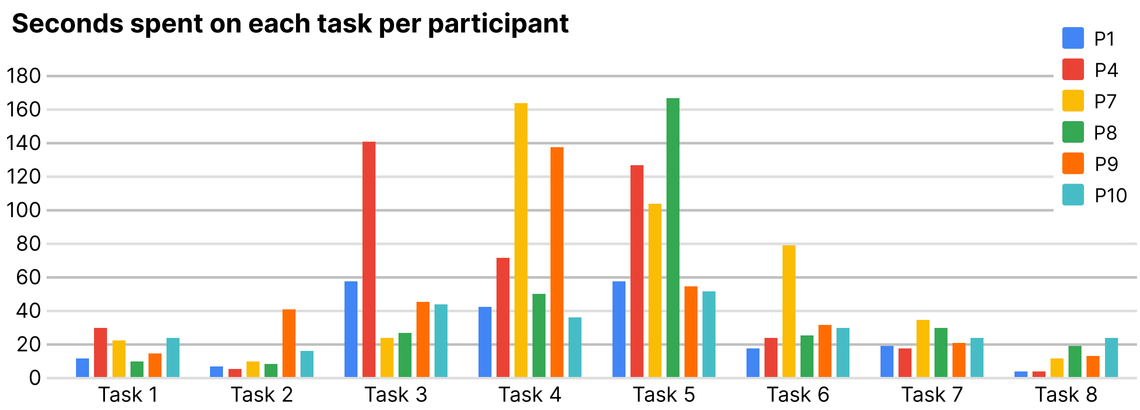

Figure 8.4: Graph presenting time spent on each task for each user in the usability test (in seconds).

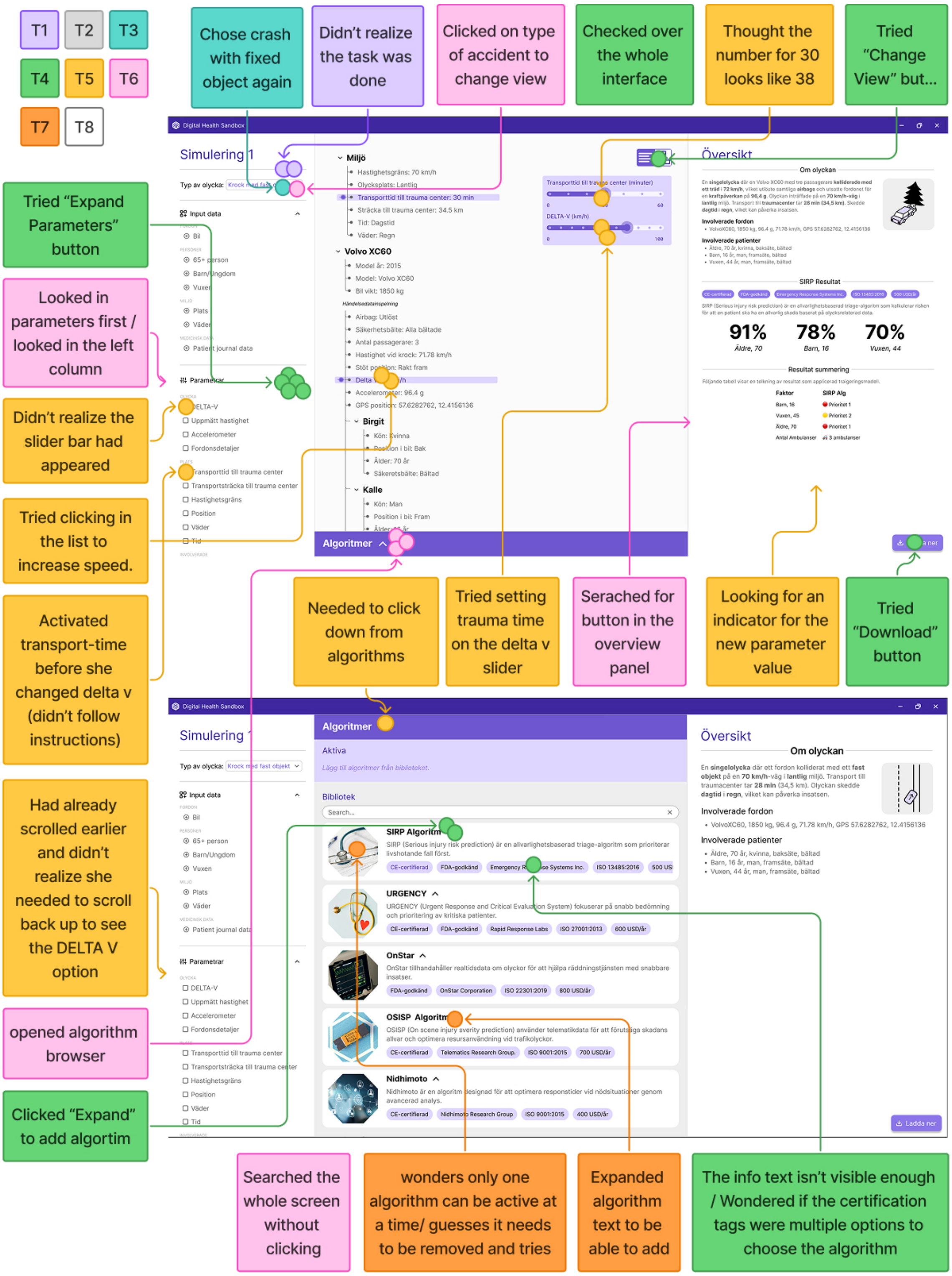

Figure 8.5: Error mapping of user miss-clicks in the usability test. Where each dot represents a user error, alongside a description. The colors refer to different tasks.

8.2.3 Satisfaction

Satisfaction was measured using the SEQ after every finished task (see Figure 8.6 for SEQ means per task). It was also measured through the SUS questions at the end of the usability test (see Figure 8.7 for SUS response rate and mean. The data was derived from the usability test questionnaire.

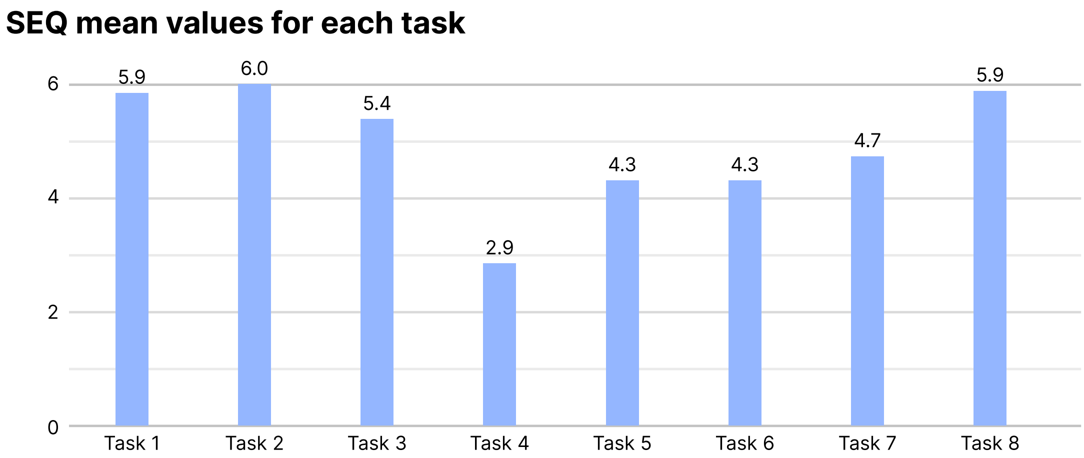

Figure 8.6: Graph depicting the mean SEQ score for each task in the usability test.

8.2.4 Analysis of Think-Aloud Transcriptions

Due to the think-aloud protocol applied through the usability test, verbal data was collected. In addition to the usability metric, this data gave further insight into the user experience. The recordings from the usability tests had been transcribed using Teams' built-in transcription service. Quotations from these transcriptions could then be selected to form a complementary analysis, inspired by the thematic analysis process. The themes from this analysis were categorized based on tasks, general positive and negative feedback, and suggestions for change, rather than the traditional way of forming emergent themes throughout all data.

For the first three tasks, participants generally commented that the tasks were easy to complete. However, a few remarks indicated some initial confusion about how the usability test was structured or intended to function, i.e., they were unsure if they had completed a task. One such expression was the following: *"I'm not sure if I'm doing it right, but at least what I'm doing is simple"*.

In T4, more comments referred to the experienced difficulty of the task. One such comment was *"It's about understanding, which is something I'm missing here"*. This referred to the user finding it difficult to understand what activating "SIRP" meant. They expressed that they struggled with the task because they didn't know what the algorithm was or what it did.

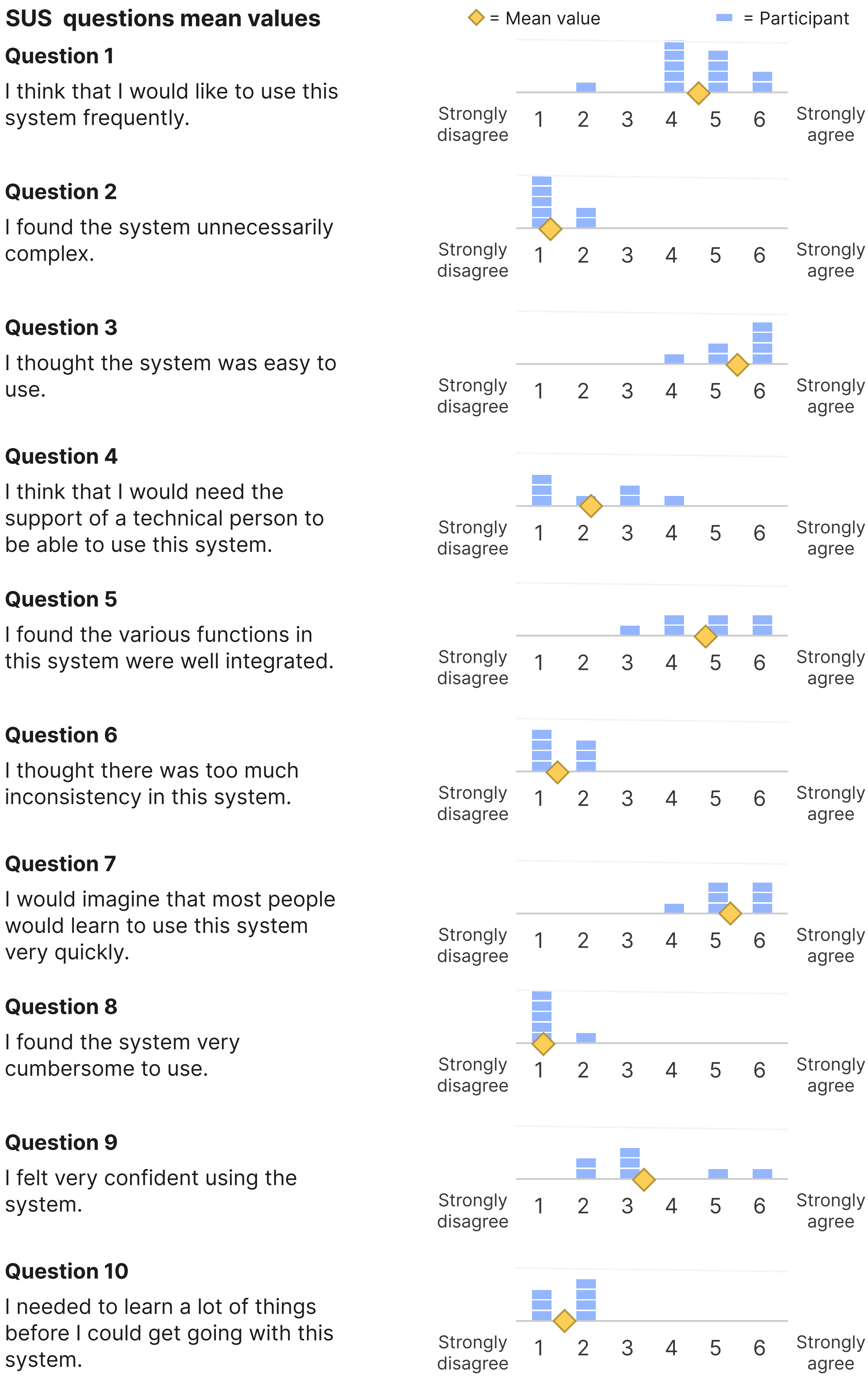

Figure 8.7: Bar graphs depicting the means of each SUS question from the usability test, alongside bars indicating how users responded.

Furthermore, one comment stated that: *"The task was easy, but I didn't understand what to do".* meaning they found the task easy once completed, but had difficulty understanding and locating the necessary steps. When the users revisited the same action in T7, most of them had learned how to do it this time. One participant said: *"It was very simple because now I understand that algorithms are there".* This showed that although there was confusion regarding the placement of the button, users were able to learn how to interact with it to complete the task.

T5 was a challenging task for some users, with confusion arising regarding how to adjust the parameters. The main takeaways from this task were that the font size was too small and difficult to read, as well as that the scale for each slide should be the same or similar. During T5, there were a few comments of interest. Firstly, one stated after completing the task that *"Now I would have really liked to save when I got this far".* This was also expressed by users in different tasks, but clearly showed a desire not to lose work. In terms of usability, users expressed that the task was *"Not quite as easy as the first ones, but still easy."*, and *"It's also the first time; if you've done it before, it's a completely different matter."*

T6 was a confusing task for some users, mainly because they had a hard time finding/understanding the function of the button that performed the task. One user stated that *"It wasn't hard to change it, but a little hard to understand".* Furthermore, one user expressed concern regarding whether this program would be accessible for older users. The user reflected on fearing misclicking without an undo option, which discourages exploration in software with unclear interaction cues. The user said, *"I wouldn't have dared to do that either, I think, if I had been ten years older. Maybe it should be graphic environment (text) above this, for example?".* To finalize, T8 was a simple task that no one expressed any particular thoughts about other than that they thought it was easy.

Following the task-specific comments were the ones that reflected general critiques and positives from the overall user experience. The following list summarizes some of the key quotes from these themes. General Critiques that emerged were among the following:

- *"Healthcare staff are good at healthcare matters, we have found that they are quite bad at everything else, and then you may need to have a clarification on what it is called (Ex, technical terms, or explicit wording)".*
- *"I really need more parameters to be able to make an assessment of whether it's correct or not. [...] So I think that as it stands now, it's far too simple for me."*
- *"I think it was the first time, the first time, then once you've done it once, it just happens."*

The following quotes are a selection of the overall positive comments stated regarding the program and its usability:

- *"I think most people would learn to use the program quickly. Yes, I think so. Then there are always reluctant people and those who are not very good at computers at all."*
- *"I think it's an interesting program, and it would be fun to see it in several*

contexts to see the benefits of it."

- *"It's not unnecessarily complicated, even though it is complex."*

Other than the previously mentioned quotes, there were a few more suggestions for tweaks and changes that were also brought along to the next design phase. If these suggestions were feasible in this design iteration, they were implemented and otherwise, they would be left for future improvement possibilities of the design.

8.3 Design: Adjustments of the Final Prototype

Most tasks were completed without issues. However, as mentioned earlier, some problematic areas and pain points needed to be addressed in the next version of the interface, see Appendix K for the design changes that were made. From the usability test feedback, the main problem areas included: finding and navigating the algorithm browser, the icon for changing views is unclear, some confusion was caused due to lacking dialog components, use of sliders was not intuitive, and some users pointed out flaws in our testing form and confusion because we used unfamiliar algorithm abbreviations.

The worst performing task was finding the algorithm browser and activating an algorithm. It was difficult to find, and many found it hard to understand how to activate them. The interface was designed in an overly sophisticated way. Some expressed that they would prefer an always-visible button which said "Add" or "Activate" instead of the on-hover transitions. Most users intuitively checked the left-hand bar for activating an algorithm. This feedback caused the change of moving the algorithm to the left side and grouping it with the other function that needed the user to perform a simulation-changing action. Another pain point was the unclear icons to change the component overview from a list to a flowchart. Despite being avid computer users the users still needed a lot of clear guidance from the interface. Some were scared to click around in fear of destroying something or just not knowing how the prototype worked. From this information, it was decided to change the button from only icons to icons and text.

Furthermore, changing the values of different parameters was unclear due to the sliders appearing far in proximity to what they affected, and the intuition was to navigate to that parameter in the list. The slider's appearance was changed to appear beside the corresponding parameter, and the function to input text was added as well. However, it was not entirely functional. You had to click to "type". Moreover, users kept mentioning that they wondered where the simulation project was saved when created or when the result was downloaded. This prompted us to make a dialog popup as it would normally do when saving something in your computer. More familiarizing elements that were added were undo, redo, and save buttons, although not functional. Finally, changes were even made to the usability test itself thanks to user feedback. Instead of having information about the task both in the header and description, the header only included the task number and the task information was only in the description. Lastly, the task description for the algorithm was updated to include the full form of the abbreviation along with a brief explanatory description.

8.4 Summative Evaluation

Only individuals who had participated in the previous usability test were invited to take part in the final summative evaluation. A total of four users participated in this final usability assessment. They completed the same usability test as before, with minor modifications. In addition to responding to the SEQ and SUS questionnaires, participants were asked to reflect on and compare their experience with the updated interface versus the previous version. The metrics were collected and analyzed using the same methods described in Section 8.2.

8.4.1 Collect: Usability Measurements

Overall, the results showed improvement compared to the previous usability test. In terms of effectiveness, only two participants made any error clicks, with each making just one. Three tasks (T3, T4, and T5) deviated slightly from the ideal number of clicks. The shortest path to achieve T4 was through 3 clicks, while the observed average was 3.25. T3 and T5 had an ideal of 5 clicks, with an average of 4.75. All participants successfully completed every task, resulting in 100% task completion.

Regarding efficiency, task completion times were generally consistent across participants, with most tasks taking between 2 to 10 seconds to complete (see Figure 8.8). However, some challenges arose in T4 and T5, where users were asked to activate an algorithm and locate the browser. One participant took 137 seconds to complete this part, due to requiring a restart after accidentally progressing too far into the interface. Additionally, Participant 4 spent a significant amount of time on T7 and T8, while Participant 7 took longer on T4 and T5. The new measurements showed a TBE value of 0.11 tasks/second, and an ORE of 100% due to everyone successfully completing the tasks.

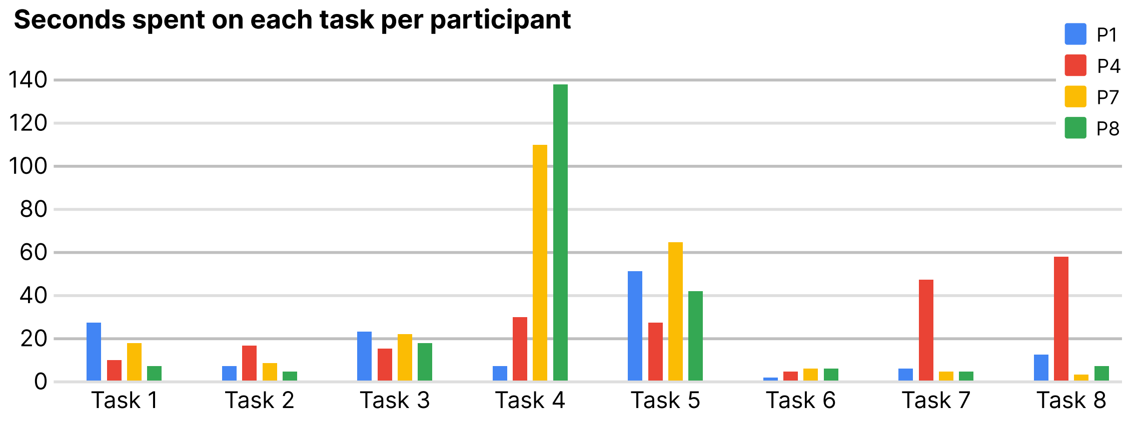

Figure 8.8: Graph presenting time spent on each task for each user in the summative evaluation (in seconds).

The satisfaction levels generally improved compared to the previous evaluation. The tasks at the beginning and end, where users interacted with dialogue elements, received slightly lower ratings than before (see Figure 8.9). The most notable improvements were observed in T4 and T6. Overall, user satisfaction showed a positive outcome.

Most of the SUS responses have shifted since the previous test, with questions 8 and 10 showing only minimal differences. The most notable changes are observed in questions 3, 4, 5, and 9. See Figure 8.10 for the changes.

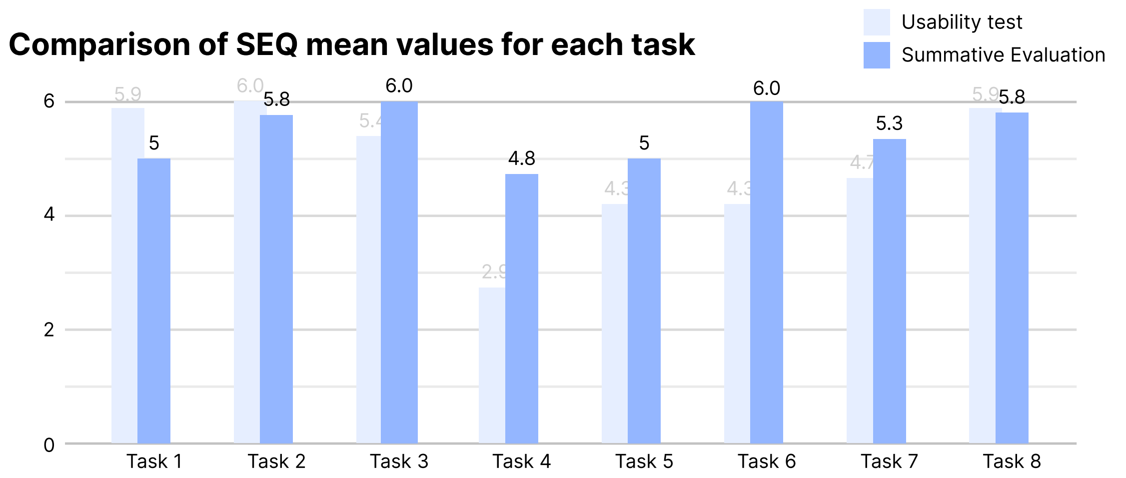

Figure 8.9: Graph depicting the mean SEQ score for each task, from both the usability test and summative evaluation.

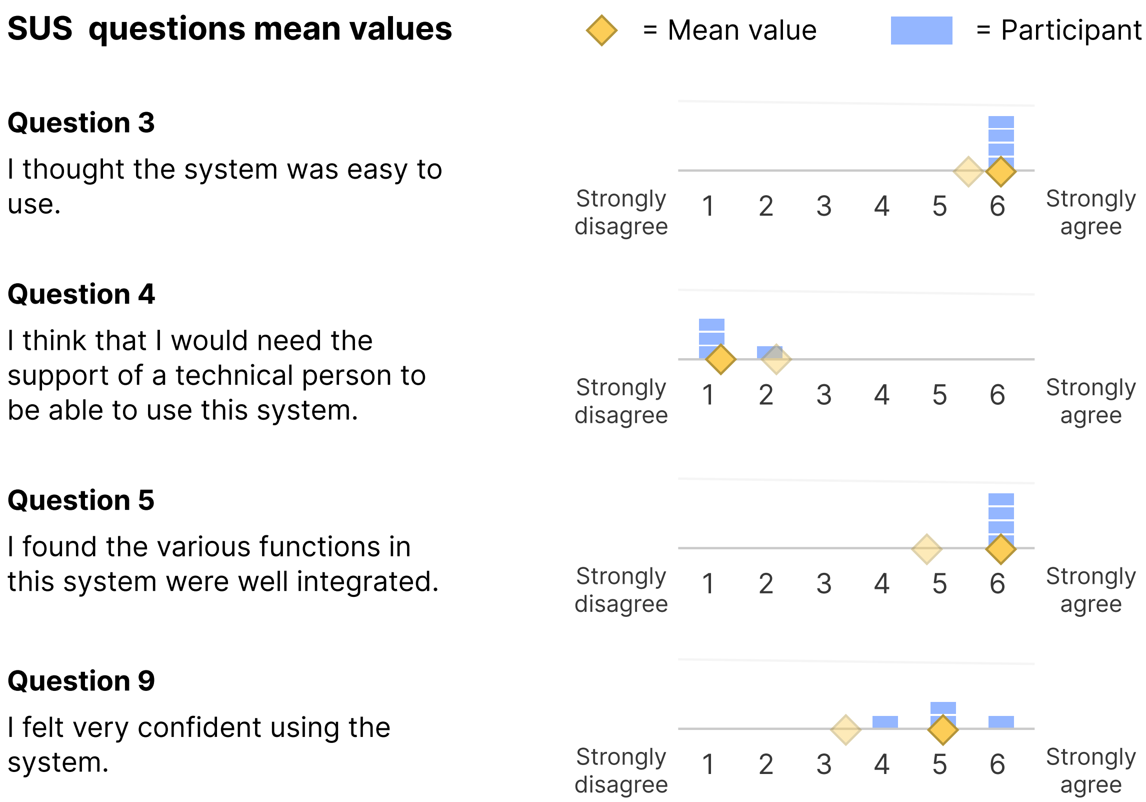

Figure 8.10: Bar graphs depicting the means of SUS questions from the first (faint) and second usability test, alongside bars indicating how users responded.

8.4.2 Analysis: Summative Evaluation

The feedback from participants was generally positive, with noticeable improvements in tasks involving the interface flow and algorithm activation, particularly T4 and T6, which received higher satisfaction scores (see Figure 8.9). T2 and T3 were perceived as very straightforward, with participants describing them as easy and intuitive. In contrast, T1 and T8 presented some confusion; users were unsure whether additional input was required after initiating a new project, as the pre-filled fields disrupted their expectations. Although the interaction itself was simple, the absence of naming and saving options, combined with pre-existing data, disrupted users' expectations and did not align with their typical workflows, leading to confusion.

T4 demonstrated a significant improvement, as users found it easier to locate and activate the algorithm feature, though some confusion remained regarding the browser component, partially due to unclear task instructions. T5 took more time for one participant because they accidentally clicked a button that advanced them too far into the interface, which added to the task time. T6 benefited from a more prominent button design, improving discoverability, although one participant acknowledged that their previous experience helped. T7 and T8 took longer for one user, primarily due to the Microsoft Teams video overlay interface obstructing parts of the screen, and one participant experienced hardware issues with their mousepad, affecting performance on T4 and T5. This is still an improvement from the previous evaluation where the longest task time was 160 seconds, compared this one taking 137 seconds at most. Despite these challenges, overall satisfaction increased, especially in areas where design adjustments were made.

The feedback gathered through the SUS responses highlighted both optimism about the system's potential and recognition of areas for growth. Several participants expressed that while the system currently lacks the data depth to fully mirror real-world conditions, its future promise is strong, especially with the inclusion of more parameters. One participant noted, *"You're definitely on the right track"*, while others emphasized how valuable the tool could be in decision-support contexts, helping shift judgment from subjective impressions to more objective, data-driven assessments.

Despite the overall positive impressions, users noted that familiarity and repetition would be key focus aspects for a successful design. While most did not find it difficult, one participant remarked that *"you need to use it a few times to really find all the buttons"*. Others mentioned the need for basic support tools like a quick reference guide or occasional help. A few responses reflected broader observations on technological proficiency in the workplace, suggesting that usability may depend as much on user background as on system design. Overall, participants found the system intuitive, although some expressed the need to learn specific terminology or underlying concepts like SIRP to fully understand all elements.

Participants further identified a few areas that could benefit from more improvement. One recurring issue was difficulty locating the *algorithm browser*, as the button lacked visual prominence. This hindered quick recognition and may have affected task efficiency. In contrast, tasks involving view changes, adding parameters, and modifying them were completed without issues, indicating improvements in those aspects of the interface.

Participants also made suggestions for enhancing clarity and feedback within the interface. For example, one user recommended displaying a number next to the “Algorithms” label, such as “(2)”, to indicate how many systems are currently active, or alternatively, using a clearer phrase like “Activated: Two systems.” Additionally, some minor usability behaviors emerged, such as assuming the middle panel was still active after switching views, likely due to its recent interaction. One participant thought that during this iteration of the design, it was much easier to guess where features were located. Which suggests learnability over time.

When comparing their experience with the updated interface to the previous version, participants noted clear improvements in usability and clarity. They found the new layout more intuitive and appreciated the use flow. One participant highlighted how this sequence created a logical and user-friendly process: *"I liked that you select from the side, then click, and get the result. It felt like a good flow"*. The addition of visual elements and clearer labels was also positively received, particularly in the algorithm browser, where the combination of icons and text helped users better understand their options. However, small issues like text size and visibility of the algorithm browser icon were mentioned as areas for further refinement.

Participants found the interface more logical and easier to navigate, although one acknowledged that their familiarity from the previous test might have contributed to this perception. Some noted that explanations and color cues, such as the highlight of a component in the list view when a slider is added, helped them understand and differentiate between interface elements more easily, especially helpful for those less experienced with digital tools. The system was described as "clear", with one participant commenting, “*You’ve made the flowchart and list clearer, even for someone who’s not a computer nerd.*” Although one person mentioned previously finding the algorithm structure less intuitive, the general consensus was that the updated design offered a smoother and more understandable experience.

This finalizes our concept and prototype generation for the DHS project, see Appendix J and K for the detailed images of the concept. The following chapter will answer the research question and discuss our findings from the project.

9
Result

In this project, the research question: *What is the effect of User-Centered Visual Design (UCVD) on the usability outcomes of a digital health simulation sandbox interface?* was explored.

Based on the research presented in this thesis the answer to this RQ reads as follows: applying the UCVD process has a positive effect on measured usability when applied to a digital health simulation sandbox interface. The DHS concept manages a complex range of elements which all need to be visualized in the GUI. This ranges from how the data providers in the simulation and their connectivity should be displayed, to how the results from the simulation should be intuitively presented to the user. The results suggest that the application of UCVD aided the process of achieving good visualization elements throughout the design, and that this was reflected in the successful usability test.

To answer the research question, the method UCVD was followed to develop a high-fidelity GUI prototype and concept of a *Digital Health Sandbox* used to simulate traffic accidents and apply digital health triaging algorithms. To measure the usability achieved through the application of this design, usability tests occurred in two iterations of the process.

By augmenting UCVD methods with embedded UCD principles, an interface that handles complex data yet is user-friendly can be created. Our hybrid approach demonstrates the potential of combining structured user-centeredness with visual focus. These findings may provide a foundation for future developments of digital health simulation sandboxes centered around visualization and usability. Our findings indicated that the UCVD method occasionally lacked the detail required to develop effective and usable UI controls that aligned with user needs. For example, in early user involvement where the goal was to understand their requirements of the DHS. To address this, elements from the more common UCD methodology were incorporated, which proved to be a valuable complement to the UCVD process. The primary fault identified in UCVD in this project emerged during the first iteration, also called the *Early envisioning phase* in UCVD, where the process had too brief of an emphasis on user understanding and requirement definition. However, for the DHS this phase was critical, particularly given the complexity and "wickedness" of the design problem adressed. To establish a solid foundation for the concept development, the more structured approach of UCD was integrated to some of the design phases. This was done since UCD divides UCVD's broader analysis phase into two separate phases, namely, “understand context of use” and “specify user requirements." After completing the initial iteration, however, the project returned to UCVD's more agile framework, as the structured UCD components became too rigid and time-consuming relative to the scope and constraints of our project.

Both usability tests proved that the GUI achieved a high degree of usability according to the metric results. The first usability test showed that the usability was good, but some areas needed improvement to increase task completion rates. The errors made by users were analyzed, and clearly showed areas which needed to be redesigned. A redesign was made and tested, and it proved that many challenges had been resolved satisfactorily. Each of the effectiveness, efficiency, and satisfaction metrics had increased, leading to a 100 % task completion rate. See Figure 9.1 for an overview of the DHS GUI and see Appendix K, for the entirety of the final DHS design. This finalizes the result of the DHS project, and the following chapter will discuss the results in terms of critiques, generalizability, and future development.

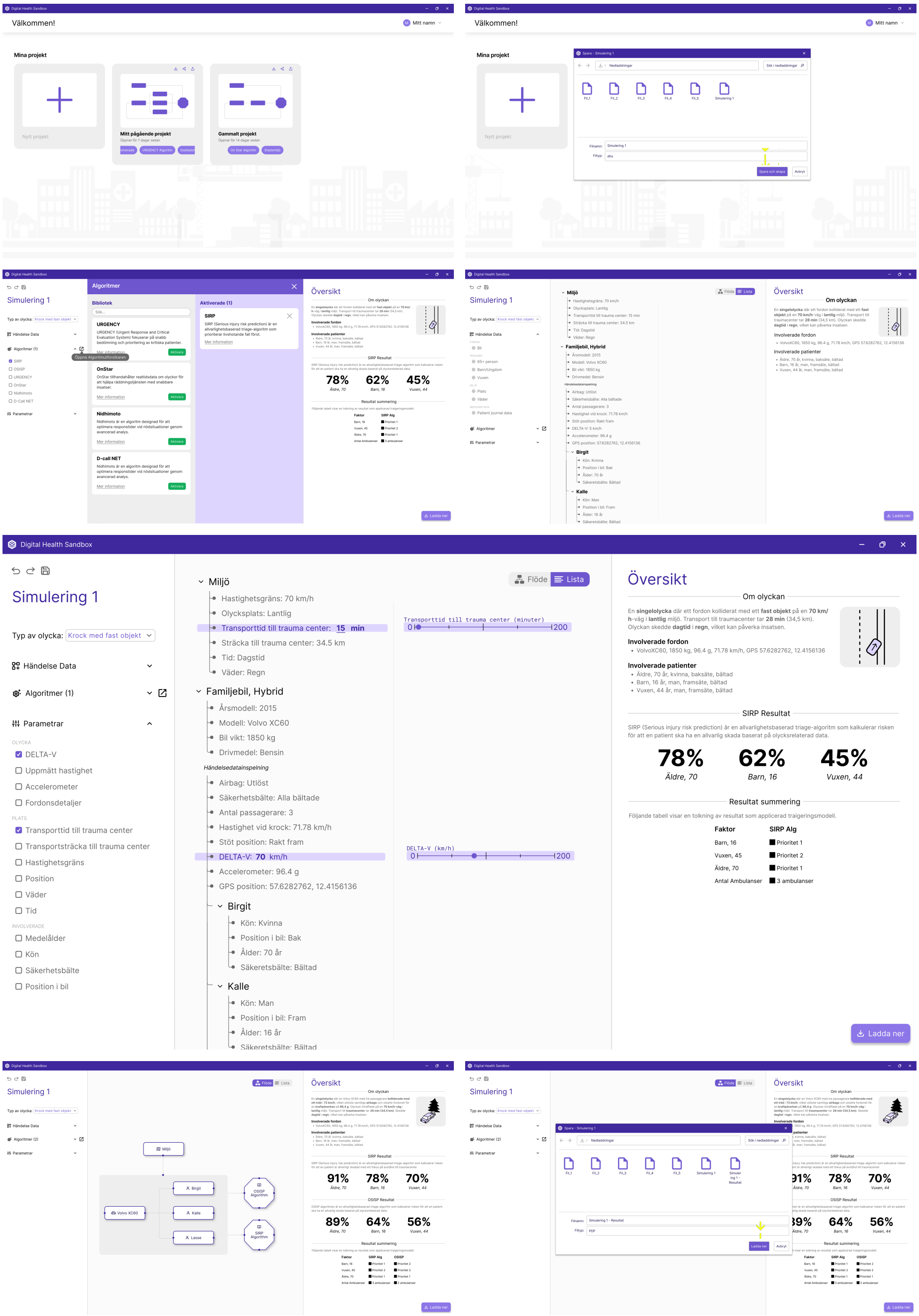

Figure 9.1: Collage of a selection of frames available in the DHS. The largest image shows the view when the user can adjust parameters in the sandbox.

10 Discussion

The discussion chapter will discuss and reflect upon this project and the result achieved to answer the research questions. It begins by examining the process used and how it limited the results achieved. Then, it reflects upon the generalizability of the result and how UCVD can be used to achieve usability in other projects, as well as our suggestions for improving the method. Thereafter, the ethical implications of the development of the DHS are presented, and areas for future work and discovery are discussed. To finalize, a conclusion of this master thesis project is provided.

10.1 Process and Limitations

This project achieved satisfactory results in terms of usability, however, a few process-related limitations were identified that could be addressed in future iterations. Business analysts within healthcare operate in a resource-intensive and time-sensitive field. Being the primary user group, a strategic allocation of their limited availability was required. As a result, user involvement was concentrated in the initial interview and the first user testing session, where it was believed the impact would be greatest. In retrospect, greater user participation during the mockup feedback phase may have provided a more user-centered concept direction for the DHS and its design. However, the decision was also made to prioritize time efficiency, as the project's timeline and the users' limited availability made frequent feedback loops difficult to implement. Ideally, more regular and iterative feedback would have enabled quicker adjustments and a more user-centered development process. In future projects, having a closer and more continuous collaboration with end users would likely lead to stronger alignment between design decisions and user needs.

Given the complexity of the design challenge, a wicked problem involving multiple stakeholders, the scope was intentionally narrowed to focus on the needs of business analysts. However, broader engagement with a more diverse set of stakeholders and users from varying backgrounds could have improved the design solution and its usability. Wassink et al. [41] underscores the influence of “Worldview Gaps” in information visualization, emphasizing that users interpret and process information differently depending on their mental models. This further brings importance to including diverse perspectives in the design process to increase understanding and improve usability. While the final solution achieves high usability for business analysts, further improvements could likely be achieved through the inclusion of a wider range of users.

Factors that could have compromised the reliability of the usability tests were identified. Due to user availability constraints, tests were conducted both in person, using our own devices, and remotely, where participants used their personal devices. This led to the test being carried out on inconsistent screen sizes and aspect ratios. This resulted in critiques of the GUI that were specifically related to the UX of the prototype of that size. An example of this was text and icons appearing too small, which negatively impacted usability. A standardized testing setup with equipment that would present the interface as intended would likely have managed these issues. Additionally, technical disruptions occurred in a few instances during online sessions. This included a malfunctioning scroll function on the user's device and parts of the interface being hidden due to the Microsoft Teams video overlay, both of which led to increased task times and user errors.

Task instructions also presented weaknesses. More detailed and descriptive instructions could have reduced user confusion, particularly at the beginning of the test. Uncertainty about task sequence and purpose was observed. A fully functional prototype could have allowed more natural interaction, thus improving usability. A trial run using a different interface before testing the DHS could have increased user confidence and reduced early-stage errors. Errors decreased as participants became more familiar with the test format. Furthermore, in our tests, errors sometimes required our interference if users stepped outside the boundaries of our prototype's functions. Improving error handling is likely to strengthen user confidence in future iterations.

The influence of observer presence and the think-aloud protocol may also have affected the user test. It resulted in some users talking a lot when performing the task, which increased task time compared to others. Being observed may also affect users' overall performance due to feeling nervous or stressed. An additional version of the test without direct observation might have allowed more natural behavior and interaction, as well as improving test validity. Seeing the usability achieved in a different setting would be an interesting addition to the project.

The complex structure of the DHS, both backend and through its GUI created some challenges when developing the prototype. Initially in the project, there were many ideas regarding how interactions with the program could be visualized, how simulations could scale properly, and how components were visualized and updated with changes. However, for the scope of this project, it was realized that there would not be time to implement each idea into the prototype. An initial solution to be able to achieve some of our desired interactivity was through programming the prototype using React (See Chapter 6.3.2). Opting for a software prototype was intended to make interactions smoother and more natural, compared to using Figma. Programmed interfaces typically allow more functional control. For example, by enabling users to drag sliders freely or explore the simulation without being locked into a predefined path.

However, as inexperienced web developers, some unanticipated problems were faced. Such as, state management of the web interface and the program's lack of a well-structured backend. A well-made backend would have made it easier to change the visual design elements while keeping functionality. We still believe that a software prototype would have supported interactions better than Figma, but ultimately, the decision was made to continue with Figma. A positive effect of developing the prototype in Figma was that it enabled rapid design iterations and increased time to focus more on refining the visual presentation and conducting user testing. The Figma prototype effectively conveyed the conceptual design. Most of the desired interactions were possible to implement through conditional flows, and the animations that responded to the users' actions worked as if it would have been developed through code. Its polished visuals helped communicate the system's intent. The downside was that users had to interact with the prototype in a specific sequence, which affected error prevention and recovery. In future iterations, a software prototype would better support natural interaction flows, particularly as the concept matures and demands more complex data behaviors.

10.2 Generalizability

Users involved with this project expressed that there was a dissatisfaction among healthcare professionals regarding current GUIs used in healthcare. They often mentioned that they were used to poor usability, and that the graphics of the interface were less prioritized to them. The most important factor to them was the program performing its tasks well and being robust. However, some users' past negative UI experiences may have caused hesitation and a fear of making mistakes during our user test. For example, they often sought the ability to save progress and were hesitant to explore the interface. This highlights the need for clear feedback and error-tolerant systems. We argue that using UCVD more in GUI development processes can be a good way to raise usability for UI controls and interface structures. Furthermore, UCVD may be preferable to UCD when developing systems that require strong visuals to properly convey GUI elements and data. However, the findings of this study suggest UCVD may be lacking in the first iteration in terms of understanding user needs, in particular when applied in a healthcare context. To complement this, additional phases may be necessary to implement to develop a thorough understanding of the users. This aligns with Shneidermans [30] suggestions for specifically designing for healthcare, where designers' understanding of medical context is a key component to achieving usable design.

The UCVD method is typically applied to traditional forms of information visualization, such as rendering data. In this project, however, its application in the context of a GUI designed to facilitate information visualization was explored. The aim was to investigate how UCVD could influence the usability and overall design of the interface, not just the visual representation of data. Specifically, a focus was placed on the final stage of the information visualization process as defined by Liu et al. [44], which involves the controls of the user interface to interact with the visualized data. The outcome was an interface where visualization elements were embedded throughout the entire design. The study's findings suggest that UCVD supports inclusive design and enables broader user engagement across professional roles in healthcare. Users with non-technical backgrounds showed interest and openness toward using technologies like AI and algorithms when the interface is clear and supportive. For example, there was a desire to understand the digital health triaging algorithms used in the usability test. This reflects the users' interest in digital tools within healthcare. We argue that when UCVD is applied to products in the healthcare sector, it shows promise to facilitate collaboration by lowering technical barriers and improving understanding through usability. The users shared that being a part of the design process increased engagement and created a sense of contribution to future healthcare practices. Thus, UCVD is a suitable practice to use more in healthcare development as it relies on user participation. As UCVD was able to facilitate high usability in the end design, it's a suitable method to implement into healthcare and other domains that require good visualization and usability to aid organizational development.

10.3 Ethical Implications

One of the main ethical concerns with this project is that it aims to embed new ML and AI technology into the healthcare sector. Concerns about trusting decision-making processes on ML models are a pre-existing dilemma. On one hand, algorithms process information more quickly and objectively than humans. On the other hand, black box structures and self-fulfilling prophecies have historically unintentionally harmed groups of people affected by that model's decision [79]. As this project may incentivize and enable users to implement more AI and ML, it's important to minimize its associated risks and not undermine its consequences. Furthermore, as the DHS works to simulate real-world scenarios to aid decision-making, there is a risk to the product's trustworthiness. Suppose the DHS results are hard to interpret, understand, are wrong, or in any way provide a skewed perspective. In that case, it may negatively affect the decision-making process and result in suboptimal workflows, wasted resources, and compromised patient outcomes. This makes it even more important for AI to be accurate and interpretable.

In addition, the DHS may handle sensitive data in the future, which introduces ethical concerns about privacy, security, and potential misuse. If such data were to fall into the wrong hands or be used without proper safeguards, it could lead to serious consequences for patient safety and trust. Right now, this is managed by only working with synthetic data, but real data will probably need to be incorporated in some way in future process. It is also important to consider who the tool is designed for. As it stands, the system is tailored toward business analysts rather than frontline medical professionals such as nurses or physicians. Without inclusive design that considers the needs and workflows of these broader user groups, the system risks being exclusionary or difficult to implement in diverse clinical environments. Moreover, the parameters and algorithms used in the system must be inclusive, transparent, and reflective of diverse patient populations to avoid reinforcing bias or inequity in healthcare delivery. Maintaining a clear boundary where AI supports rather than replaces clinical judgment is essential for preserving trust, ethical responsibility, and high-quality care.

An important ethical consideration when discussing the increasing presence of AI and algorithms in healthcare is how these technologies may impact the professional judgment of healthcare professionals. Bornemark [80], [81] raises a concern that as digital systems become more prevalent, clinical experience and intuitive decision-making risk being de-prioritized in favor of data-driven outputs. At the same time, vast amounts of data are being logged in healthcare settings, placing a significant administrative workload on professionals and potentially shifting focus away from direct patient care. In this context, we believe that the role of AI in healthcare should not be to replace professional judgment but to support it. A more ethically sustainable direction would be to use AI as a tool for relieving healthcare workers of routine documentation tasks: automatically capturing, organizing, and analyzing relevant data. This would free valuable time for professionals to concentrate on what algorithms cannot replicate: holistic understanding, empathy, and the clinical intuition that often determines the quality of care [80], [81]. By leveraging AI to assist rather than substitute, we can both enhance care outcomes and safeguard the critical role of human expertise in healthcare.

10.4 Future Work

Several findings from this project point to valuable directions for future development. A notable issue was the misunderstanding by some participants regarding the system's intended context. Some interpreted it as a tool for acute care rather than scenario-based decision support for planning purposes. This highlights the need for clearer contextual framing within the interface to ensure users understand its scope, purpose, and limitations from the outset.

Another important aspect to address is scalability. This project focused on a limited scenario with a small number of components, but the long-term goal is to enable simulation of mass casualty incidents involving hundreds of dynamic elements. Ensuring the system's architecture, performance, and visualizations can handle such scale, without compromising usability, will be of high importance. Scalable solutions must also account for increased cognitive load and decision complexity. This requires thoughtful interface design and efficient filtering or grouping mechanisms.

Given that the DHS is not a one-size-fits-all solution, future iterations should explore multiple design approaches. Iterative user testing will be important, especially focusing on edge cases such as unusual input conditions, large datasets, or atypical use scenarios. Moving beyond non-interactive mockups, using functional software prototypes will allow for a more realistic evaluation of user interaction patterns, particularly around dynamic elements like input controls. To capture more authentic user behavior and reduce potential effects of feeling observed, future studies should include test environments with a hidden observation approach.

In the future, a successful project could interest municipalities and counties who make long-term, costly decisions about healthcare processes in their respective regions. Developers of digital health technologies could take an interest in the sandbox software for testing and understanding scenario differences as well. The stakeholders further include patients and the public at large, since the DHS works to facilitate development in healthcare and clinical assessments using digital health technologies.

This affects the patients as they are a part of the integration of the new methods, practices, and products introduced in their care. The public is affected as their taxes fund these developments, and they and their loved ones will be affected by its results. Expanding the participant base to include a more diverse range of users such as nurses, physicians, administrators, patients, as well as engineers and developers, can help ensure the system accommodates a wider variety of perspectives and workflows. This diversity supports greater generalizability and inclusiveness in design decisions.

Future work could also include A/B testing of different visualization frameworks to determine which approaches best support clarity, usability, and decision-making efficiency. Lastly, continuous maintenance and gathering of feedback from users will be essential for the program's development, longevity, and integration into healthcare.

10.5 Conclusion

In the age of big data, accessing information is rarely the challenge. The difficulty rather lies in presenting that data in a way that is both intuitive and actionable without overwhelming the perceiver. When done effectively, such visualization has the potential to drive innovation in healthcare by improving patient outcomes, optimizing resource use, and supporting better working conditions. This project explored how data from traffic accidents could be used to simulate triaging scenarios within a sandbox environment, enabling evaluation of interventions within the healthcare system. Through the development of the Digital Health Sandbox, the UCVD process alongside UCD process was applied to examine its effect on usability. Our solution explores how complex, data-driven systems can be made more usable and comprehensible to diverse healthcare stakeholders.

The findings suggest that UCVD is particularly valuable in contexts where users must interact with large volumes of heterogeneous data through UI controls and visual outputs. By centering design around usability, the DHS prototype shows potential regarding support in decision making and bridging gaps between clinical, analytical, and technical roles. Ultimately, usability and high-quality visualization are not peripheral features, they are central to enabling confident, efficient, and collaborative decisions in healthcare planning and innovation.

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A

Consent Form (SWE/ENG)

The following text is the consent form that participants filled in before every session they partook in. The first is the original version in Swedish. The second is the English version provided by Chalmers University.

CHALMERS

Samtycke och information om behandling av personuppgifter i studentarbete

Jag samtycker till att mina personuppgifter i form av **namn**, **yrke**, **e-postadress** samt **ljudupptagning** från intervjun får behandlas av Chalmers tekniska högskola för studien:

Web-Based Interface Design for Simulating Work Flows in Healthcare Contexts.

Syftet är att samla in intressenters åsikter och användarupplevelser som sedan ska användas för att designa ett användarvänligt gränssnitt för användning inom vårdkontext.

Information

Personuppgifterna kommer att hanteras på följande sätt:

De kommer att delas inom en grupp av 2 studenter under examensarbetets gång från vecka 5, 2025, till vecka 27, 2025. Den slutgiltiga rapporten kommer att publiceras publikt. Intervjuerna kommer att transkriberas och användas som underlag till slutsatser i rapporten. Samtliga referenser till intervjuer kommer endast beröra dess innehåll och de deltagande kommer att vara anonyma.

Ditt samtycke gäller tills vidare. Du har rätt att när som helst ta tillbaka ditt samtycke. Detta gör du genom att kontakta onsu@chalmers.se , wilmabe@chalmers.se eller registrator@chalmers.se. Om du återkallar ditt samtycke kommer vi upphöra att behandla personuppgifter vi samlat in med stöd i ditt samtycke. Vissa uppgifter kan komma att sparas pga. Chalmers skyldigheter enligt svensk arkivlagstiftning.

Chalmers tekniska högskola, 412 96 Göteborg, med org. nr 556479-5598 är personuppgiftsansvarig. Du hittar Chalmers integritetspolicy på www.chalmers.se.

Som registrerad har du rätt att få information om hur dina personuppgifter behandlas. Du har rätt att få felaktiga uppgifter rättade, överflödiga uppgifter raderade, begära att behandlingen begränsas och uppgifter överförda till en annan aktör. Du har även rätt att lämna klagomål till Integritetsskyddsmyndigheten (IMY). Har du frågor rörande Chalmers behandlingar av personuppgifter kan du kontakta Chalmers dataskyddsombud på dataskydd@chalmers.se.

Jag samtycker till att Chalmers tekniska högskola behandlar personuppgifter om mig i enlighet med ovanstående.

Ort	Underskrift
Datum	Namnförtydligande

CHALMERS

Consent and information about processing of personal data in student thesis

I agree to my personal data in the form of: name, occupation, email address, and audio recordings from the interview being processed by Chalmers University of Technology for the study:

Web-Based Interface Design for Simulating Work Flows in Healthcare Contexts.

The purpose is to gather stakeholders' opinions and user experiences, which will then be used to design a user-friendly interface for use in a healthcare context.

Information

Your personal data will be handled as follows:
They will be shared within a group of two students during the course of the thesis work from week 5, 2025, to week 27, 2025. The final report will be published publicly. The interviews will be transcribed and used as a basis for conclusions in the report. All references to interviews will pertain only to their content, and participants will remain anonymous.
Your consent is valid until further notice. You have the right to withdraw your consent at any time. You do this through contacting onsu@chalmers.se, wilmabe@chalmers.se, or registrator@chalmers.se

If you withdraw your consent, we will cease processing personal data we have collected with the support of your consent. Some information may be saved due to Chalmers obligations under Swedish archive legislation. Chalmers University of Technology, org. No. 556479-5598 is personal data controller. You can find Chalmers privacy policy at www.chalmers.se.

As a participant you have the right to receive information about how your personal data is processed. You have the right to have incorrect information corrected, redundant data deleted, request that processing shall be restricted and data transferred to another actor. You also have the right to submit a complaint to the Swedish Authority for Privacy Protection (Integritetsskyddsmyndigheten). Do you have any questions about Chalmers's processing of personal data contact Chalmers's data protection officer at dataskydd@chalmers.se.

I agree that Chalmers University of Technology processes personal data about me in accordance with the above.

Place:	Signature
Date:	Name clarification

B

Interview Guide (SWE/ENG)

The following text is the interview guide that was followed during user interviews in iteration 1. The first version is the original, and the second is the version translated into English using ChatGPT.

Intervjuguide

Introduktion

- Börja med att ge en GDPR blankett. (muntligt samtycke vid distansintervju)

- Introduktion av projekt (finns redan pytteliten i gdpr men bra att förklara lite mer konkret)
    - Vi vill veta allt idag, mer om dig o din verksamhet
    - Vi har fått i uppdrag av Chalmers forskarteam att undersöka och utforma ett gränssnitt som ska användas för resurseffektivisering inom sjukvården med inriktning på trafikolyckor. Just nu behöver vi veta lite om delarna i verksamheten och undersöka lite hur vi ska börja bygga gränssnittet.

Arbetsroll, arbete

- Arbetserfarenhet?
    - Vart jobbar du?
    - Vad är din arbetsroll?
    - Hur länge har du jobbat? Vad har du haft för roller tidigare? (Inom trafik/vård)
- Vad behöver man tänka på, vad är det som behövs?
- Som del av utveckling av verksamhet, vad kollar du på? Hur fungerar utvecklingsarbetet?
- Vad har du för arbetsuppgifter, använder du datorprogram/teknik för att utföra dem? (vilka?)
    - Hur använder du dom? Hur används dom?
    - Är det något du tycker är jobbigt med dem? Bra? Dåligt? (omformuler lite? Irritationsmoment?)

Datorvana

- Om du skulle skatta hur bekväm du är med att använda datorer på en skala 1-10 där:
  1 - Det är rätt överväldigande
  10 - Jag har inga problem med det.
- Har du en preferens av plattform? (Dator, platta, mobil etc.)
    - + Varför? (Vill ta reda på vad de är mest vana att använda

Sandbox/Simuleringar

- Har du någon erfarenhet av att utföra simuleringar?
    - Inkluderar alla typer: spel/professionellt/forskare
        - Om har använt såna program - vad har uppskattats? Vad har varit jobbigt?
- Vi tänkte utveckla ett koncept där man kan leka runt med komponenter och simulera scenarion som tidigare nämnt
- Visa figma flowet (de får gärna hjälpa oss att fixa bättre scenario eller komplettera)

- Visa VUE Flow (math operation och färg)
- Hur känner du för ett sånt här verktyg, och…
    - Vad behöver man tänka på, vad är det som behövs?
    - Som del av utveckling av verksamhet, vad kollar du på? Hur fungerar utvecklingsarbetet?
    - Simuleringsprotokollet (output) - vad kan vara bra att ha med / visa exempel
    - Hur bra fungerar smartwatches som sensor?

- Det var alla frågor vi hade för idag, har du något du vill ta upp som vi inte gick igenom?

- vi tänkte att det skulle vara bra att involvera användare under utvecklingen så vi undrar ifall det hade varit möjligt att få input på ett designkoncept vi kommer ha utvecklat om ca 2 veckor?

Interview Guide

Introduction

- Begin by providing a GDPR consent form. (Verbal consent for remote interviews.)
- Introduce the project (it's briefly mentioned in the GDPR form, but it's good to explain a bit more concretely):
    - Today, we want to learn everything—more about you and your organization.
    - We have been assigned by a research team at Chalmers to investigate and design an interface intended for improving resource efficiency in healthcare, with a focus on traffic accidents. Right now, we need to understand more about the components of your work and explore how we might begin designing the interface.

Work Role and Tasks

- **Work experience**
    - Where do you work?
    - What is your job role?
    - How long have you worked there? What roles have you had previously? (Related to traffic/healthcare)
- What needs to be considered in your work? What's important?
- As part of the development of your organization, what do you look at? How does development work function?
- What are your main tasks, and do you use any digital tools/technologies to perform them? (Which ones?)
    - How do you use them? How are they used?
    - Is there anything you find difficult, useful, or frustrating about them? (Rephrase slightly: any pain points?)

Computer Proficiency

- On a scale from 1 to 10, how comfortable are you with using computers?
  1 – It's quite overwhelming
  10 – I have no problem at all

- Do you have a preferred platform? (Computer, tablet, mobile, etc.)

        - Why? (We want to understand what they're most used to using)

Sandbox/Simulations

- Do you have any experience with performing simulations?

    - Includes all types: games/professional/research

        - If they have used such programs: what did you appreciate? What was challenging?

- We are planning to develop a concept where you can experiment with components and simulate scenarios as mentioned earlier.

- Show the **Figma flow** (they are welcome to help refine the scenario or suggest additions).

- Show the **VUE flow** (math operations and color coding).

- How do you feel about this type of tool, and...

    - What needs to be considered, what is important?

    - As part of the development of your organization, what do you look at? How does development work function?

    - **Simulation output** – what would be good to include / show as an example?

    - How effective do you think smartwatches are as sensors?

Wrap-up

- Those were all the questions we had for today—do you have anything you'd like to bring up that we haven’t covered?

- We are planning to involve users during the development process, so we were wondering: would it be possible to get your feedback on a design concept we will have developed in about two weeks?

C

Initial DHS flowchart concept

Below is an image of the initial flowchart representing the DHS interaction flow and example scenarios brought to interview to open up for discussion and bouncing ideas.

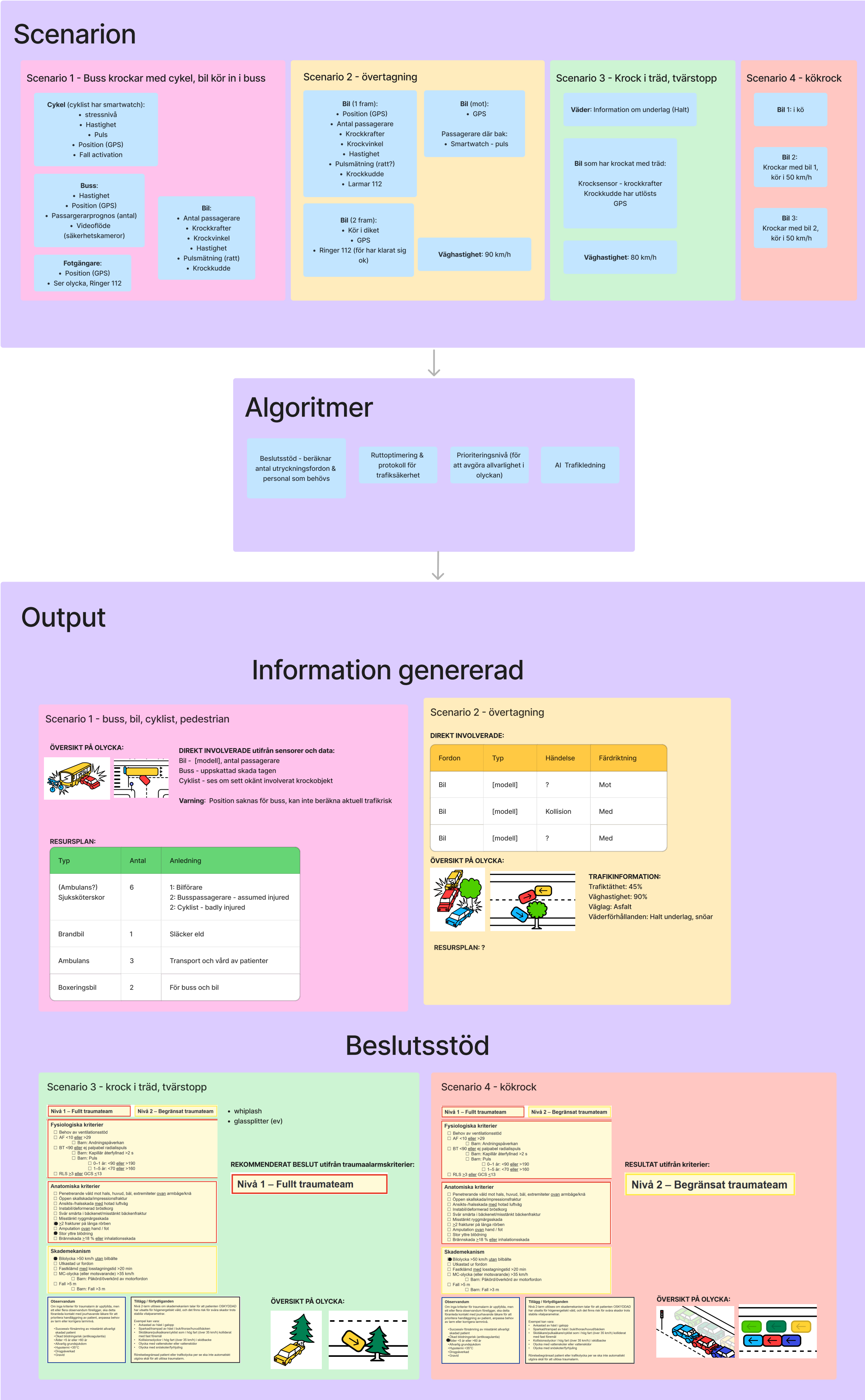


Figure C.1: DHS Interaction Flowchart

D

First Thematic Analysis

The following image illustrates the thematic analysis of the user interviews. The answers were where the color of the post-its represents different participants.'

E

Themes from Thematic Analysis of Interviews

The following list presents the themes that were identified during the thematic analysis of the interview questions, divided into sections.

Themes regarding Project work for the Healthcare Sector

- *Multidisciplinary cooperation* - Projects within healthcare often concern various organizations. The wide involvement in these types of projects means that many disciplines and stakeholders need to collaborate. This is something important to keep in mind when designing a solution - different disciplines have varying approaches and perspectives in use cases.
- *Information visualization* - The importance of concisely visualizing information is a fundamental way to avoid cognitive load from information overflow and instill a sense of guidance within the interface. The interface must feel intuitive. Use of AI should be transparent and explainable as well as interpretable in order for the user to feel a sense of control.
- *Attitude towards new technology and implementations* - Users vary in reciprocity and openness towards new solutions. Knowledge about the new tool helps the users build trust. It is important to understand that users may need space for processing the loss of an old system while phasing in a new one. Fostering a positive environment for learning and using new solutions is valuable in the process of adding a new solution to the system. Additionally, if the new solution is reminiscent of the old one, the chance of reciprocity is higher thanks to a feeling of familiarity.
- *Patient security* - Healthcare is a high-risk environment. People risk dying if they do not receive the needed care. Due to the high stakes, patient security always comes first when considering new implementations. For this reason, solutions should be ethical and non-discriminatory.
- *Cyber security* - Solutions must ensure patient integrity. Many laws and regulations surround digital implementations.
- *Slow implementation in healthcare* - Due to healthcare organizations being very large and affected by laws and regulations, change is slow. There are many steps when implementing changes. However, slow change due to regulations works in favor of patient security.

- *User feedback after launch* - To ensure solutions' adaptation to the system, it must be susceptible to user feedback and needs to be regularly updated.
- *User-centered perspective* - The more user-centered design, the better. The importance of taking users into account weighs heavily in good implementation. Otherwise, there is a risk of not fulfilling users' needs. Understanding their needs also play a significant role in this goal. Solutions should be adapted to the user.
- *Digital health* - Digital health solutions can limit full utilization of senses; the consequences of this should not affect the quality of care. With digitalization, it is possible to give the patient more mandate to decide in a timely manner when to turn to healthcare while at the same time reducing the amount of redundant work surrounding patient contact. Additionally, with the use of a digital tool, there is a possibility of putting everyone on the same communication level, especially regarding keeping the patient in the loop. Finally, digital health must be quality tested, it must be informative, and make use of medical data to provide benefits.
- *The Development process of implementing AI in an organization* - When implementing AI in healthcare, both in-house solutions as well as commercial ones are considered. Solutions are tested and iteratively improved.
- *Testing* - Is an essential part when implementing new solutions in health care.
- *Resource efficiency* - The Accuracy of both input data and output is of high importance to not waste resources.
- *Continuity* - decisions and processes need to be easily accessible for continuous upkeep within the organization.

Themes regarding Implementation

- Systematic and structural implementations are important for many reasons: Having solutions that work together, instill familiarity within the organization as well as ease of implementation.
- Focus on the work environment culture is necessary to help with implementation.
- Software intercompatibility is favorable.
- Surrounding factors such as laws, regulations, technology, and stakeholders play a big part in the implementation process.
- *Attitude towards new implementations* - Healthcare is usually a stressful environment, and the comfort of old systems, caused by old habits, hinders learning new systems. By fostering an environment where it is easy to learn as well as difficult to go back to old systems, the chances of successful implementation increase.
- *Clear benefits using the tool* - for successful implementations, the profits and merits of the new solutions must be clear.

Themes regarding Concept potential

- Comparing algorithms is of interest to understand their pros and cons.
- Over-triage is favorable rather than under-triage.
- It's important to understand the cause in when investigating incidents.
- Setting parameters and boundary conditions to investigate resource management, coordination, and effects on the organization is seen as a useful tool for planning and predicting, as well as visualizing. It is also of interest to know which less optimal decisions are made today.
- *Testing/Simulating* - It is of interest to simulate extreme cases like mass injuries to understand weaknesses and restrictions of the organisation. It's interesting to see how changes in the organisation might affect the outcome.
- *Resource efficiency* - A potential of the solution is being able to see how the resources are affected by different implementations, and thus saving the most valuable resource, time. Solutions cannot just be better, the most important factor is being time-efficient when used. Another important factor to visualize is comparing the implementation monetary costs.

F

Requirements

The following lists the requirements that were derived from the themes identified during the thematic analysis. The list is divided into requirements for backend and GUI features, desideratum and guidelines.

Requirements

Backend

The DHS must:

1. Facilitate Patient Security
2. Facilitate Cyber Security
3. The DHS should be ethical and non-discriminatory.

Graphical User Interface

The DHS must:

1. Allow for simulation of different scenarios, its components include:
   (a) Possibility to set parameters and boundary conditions
   (b) Inputs:
      i. Synthetic sensor data
      ii. Sensor data/ data from heterogeneous sources
      iii. Components of the current organization workflow
      iv. Components of an incident
   (c) Possibility for selection of algorithms
   (d) Outputs, which should present results insightfully and intuitively:
      i. Time
      ii. Money
      iii. Resources (personnel, vehicles, medical material) / resource management
      iv. Coordination plan
      v. Planning
      vi. Predictions
      vii. Effects on the organization
      viii. Limits of organization
      ix. The resulting benefits of the simulations should be clear
      x. Warns of scenario risks
      xi. Get improvement suggestions based on 1biii
      xii. Causes of an incident

   xiii. Warn about ethical and discrimination risks
   xiv. Information regarding triage levels
2. Know of current laws and regulations to be able to use them for feasibility measurements of implementation
3. Allow for comparison between different modules, such as algorithms and scenarios (to understand their pros and cons)
4. Provide an overview of the simulation
5. Present AI algorithm results in an interpretable/explainable manner
6. Align with laws and regulations considering health care

Desideratum

The DHS should:

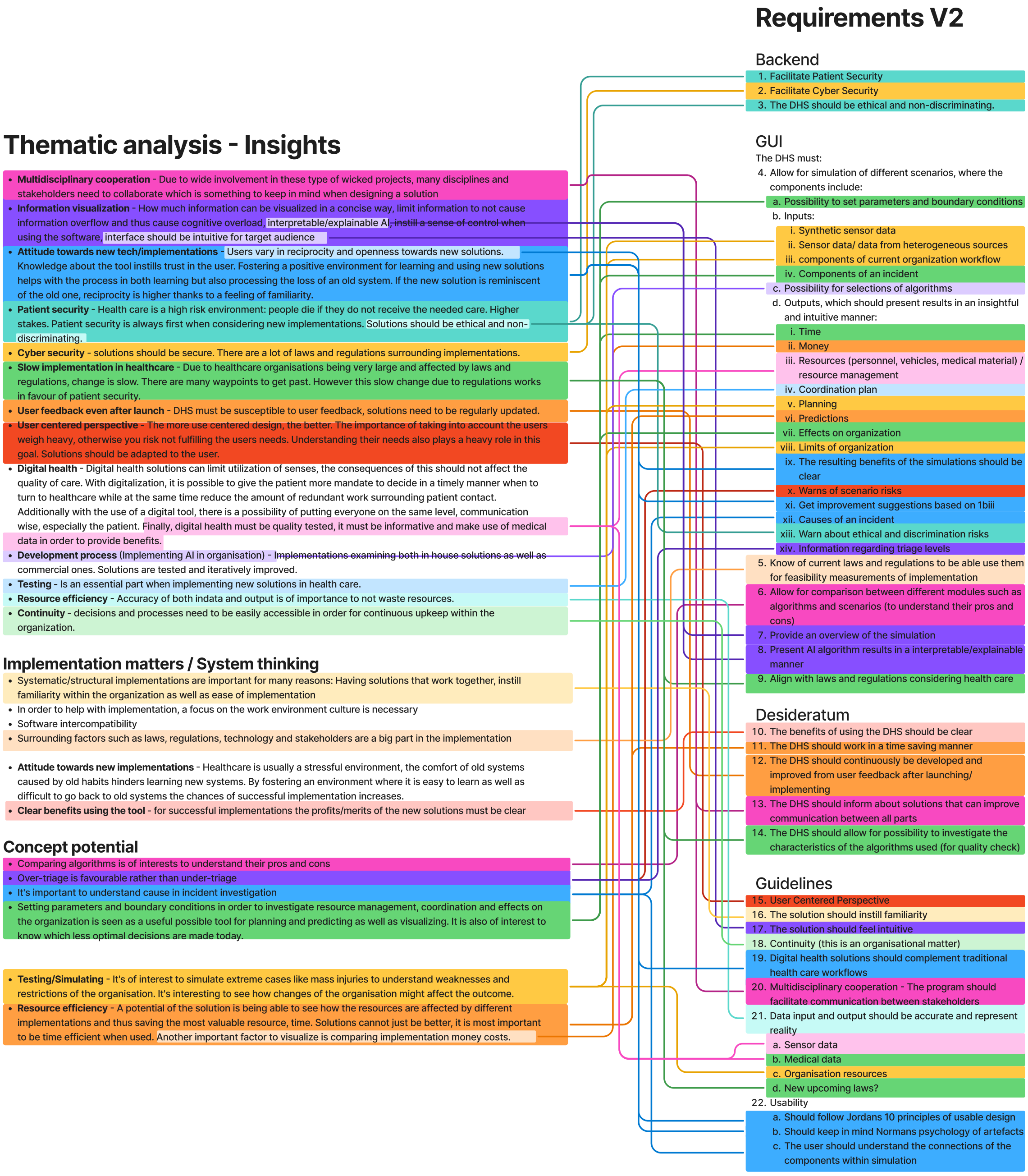
1. The benefits of using the DHS should be clear
2. Work in a time-saving manner
3. Continuously be developed and improved from user feedback after launching/implementing
4. Inform about solutions that can improve communication between all parties
5. Allow for the possibility to investigate the characteristics of the algorithms used (for quality check)

Guidelines

1. User-Centered Perspective
2. The solution should instill familiarity
3. The solution should feel intuitive
4. Continuity (this is an organisational matter)
5. Digital health solutions should complement traditional health care workflows
6. Multidisciplinary cooperation - The program should facilitate communication between stakeholders
7. Data input and output should be accurate and represent reality
   (a) Sensor data
   (b) Medical data
   (c) Organization resources
   (d) Align with new upcoming laws
8. The solution should utilize usability principles

G
Requirements mapping

The following figure depicts an illustration of how the requirements were derived from the themes.

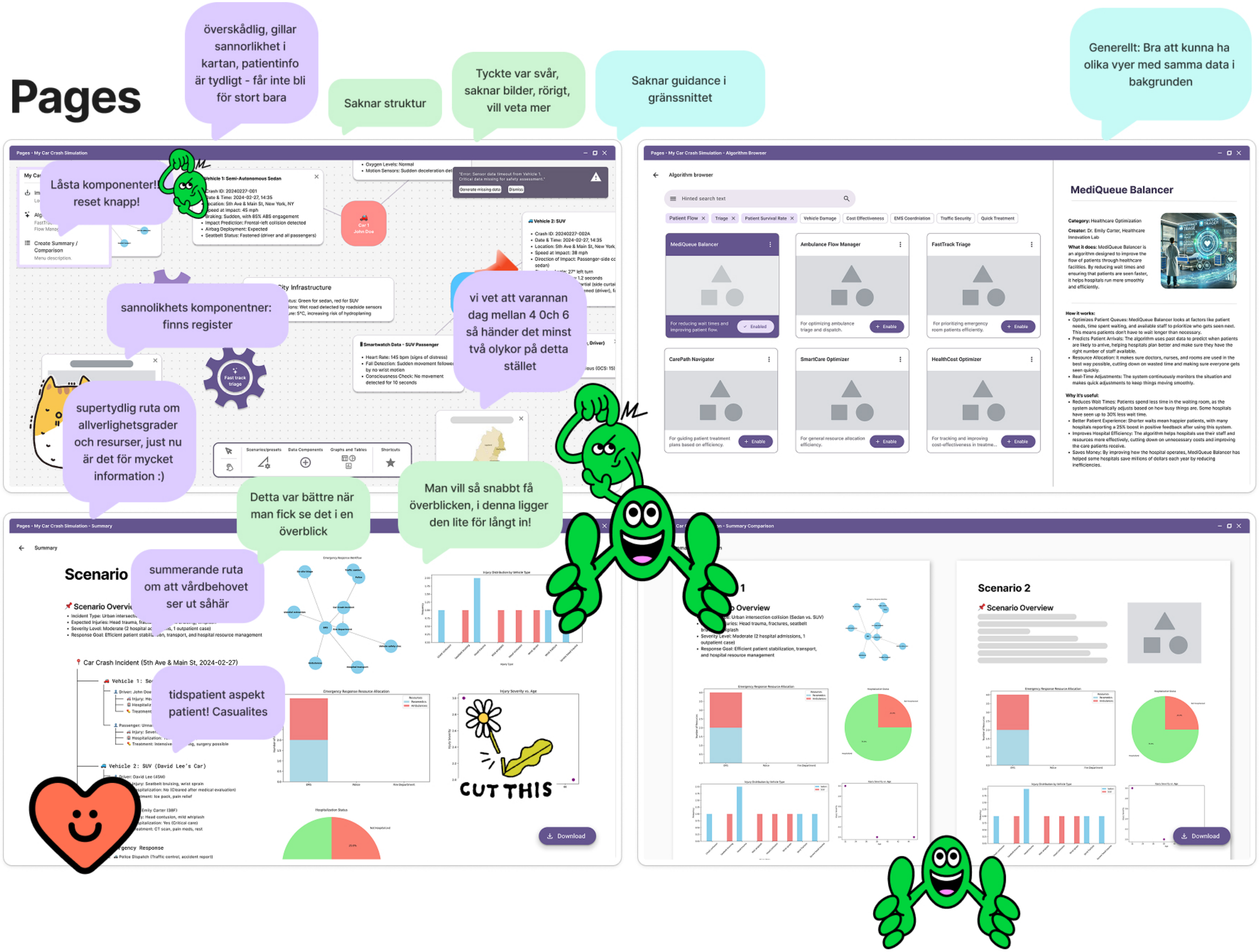

Requirements V2
Backend
1. Facilitate Patient Security
2. Facilitate Cyber Security
3. The DHS should be ethical and non-discriminating.
Thematic analysis - Insights
• Multidisciplinary cooperation - Due to wide involvement in these type of wicked projects, many disciplines and stakeholders need to collaborate which is something to keep in mind when designing a solution
• Information visualization - How much information can be visualized in a concise way, limit information to not cause information overflow and thus cause cognitive overload, interpretable/explainable AI, instill a sense of control when using the software, interface should be intuitive for target audience
• Attitude towards new tech/implementations - Users vary in reciprocity and openness towards new solutions. Knowledge about the tool instills trust in the user. Fostering a positive environment for learning and using new solutions helps with the process in both learning but also processing the loss of an old system. If the new solution is reminiscent of the old one, reciprocity is higher thanks to a feeling of familiarity.
• Patient security - Health care is a high risk environment: people die if they do not receive the needed care. Higher stakes. Patient security is always first when considering new implementations. Solutions should be ethical and non-discriminating.
• Cyber security - solutions should be secure. There are a lot of laws and regulations surrounding implementations.
• Slow implementation in healthcare - Due to healthcare organisations being very large and affected by laws and regulations, change is slow. There are many waypoints to get past. However this slow change due to regulations works in favour of patient security.
• User feedback even after launch - DHS must be susceptible to user feedback, solutions need to be regularly updated.
• User centered perspective - The more use centered design, the better. The importance of taking into account the users weigh heavy, otherwise you risk not fulfilling the users needs. Understanding their needs also plays a heavy role in this goal. Solutions should be adapted to the user.
• Digital health - Digital health solutions can limit utilization of senses, the consequences of this should not affect the quality of care. With digitalization, it is possible to give the patient more mandate to decide in a timely manner when to turn to healthcare while at the same time reduce the amount of redundant work surrounding patient contact. Additionally with the use of a digital tool, there is a possibility of putting everyone on the same level, communication wise, especially the patient. Finally, digital health must be quality tested, it must be informative and make use of medical data in order to provide benefits.
• Development process (Implementing AI in organisation) - Implementations examining both in house solutions as well as commercial ones. Solutions are tested and iteratively improved.
• Testing - Is an essential part when implementing new solutions in health care.
• Resource efficiency - Accuracy of both indata and output is of importance to not waste resources.
• Continuity - decisions and processes need to be easily accessible in order for continuous upkeep within the organization.
GUI
The DHS must:
4. Allow for simulation of different scenarios, where the components include:
a. Possibility to set parameters and boundary conditions
b. Inputs:
i. Synthetic sensor data
ii. Sensor data/ data from heterogeneous sources
iii. components of current organization workflow
iv. Components of an incident
c. Possibility for selections of algorithms
d. Outputs, which should present results in an insightful and intuitive manner:
i. Time
ii. Money
iii. Resources (personnel, vehicles, medical material) / resource management
iv. Coordination plan
v. Planning
vi. Predictions
vii. Effects on organization
viii. Limits of organization
ix. The resulting benefits of the simulations should be clear
x. Warns of scenario risks
xi. Get improvement suggestions based on 1biii
xii. Causes of an incident
xiii. Warn about ethical and discrimination risks
xiv. Information regarding triage levels
5. Know of current laws and regulations to be able use them for feasibility measurements of implementation
6. Allow for comparison between different modules such as algorithms and scenarios (to understand their pros and cons)
7. Provide an overview of the simulation
8. Present AI algorithm results in a interpretable/explainable manner
9. Align with laws and regulations considering health care
Implementation matters / System thinking
• Systematic/structural implementations are important for many reasons: Having solutions that work together, instill familiarity within the organization as well as ease of implementation
• In order to help with implementation, a focus on the work environment culture is necessary
• Software intercompatibility
• Surrounding factors such as laws, regulations, technology and stakeholders are a big part in the implementation
• Attitude towards new implementations - Healthcare is usually a stressful environment, the comfort of old systems caused by old habits hinders learning new systems. By fostering an environment where it is easy to learn as well as difficult to go back to old systems the chances of successful implementation increases.
• Clear benefits using the tool - for successful implementations the profits/merits of the new solutions must be clear
Desideratum
10. The benefits of using the DHS should be clear
11. The DHS should work in a time saving manner
12. The DHS should continuously be developed and improved from user feedback after launching/ implementing
13. The DHS should inform about solutions that can improve communication between all parts
14. The DHS should allow for possibility to investigate the characteristics of the algorithms used (for quality check)
Concept potential
• Comparing algorithms is of interests to understand their pros and cons
• Over-triage is favourable rather than under-triage
• It's important to understand cause in incident investigation
• Setting parameters and boundary conditions in order to investigate resource management, coordination and effects on the organization is seen as a useful possible tool for planning and predicting as well as visualizing. It is also of interest to know which less optimal decisions are made today.
• Testing/Simulating - It's of interest to simulate extreme cases like mass injuries to understand weaknesses and restrictions of the organisation. It's interesting to see how changes of the organisation might affect the outcome.
• Resource efficiency - A potential of the solution is being able to see how the resources are affected by different implementations and thus saving the most valuable resource, time. Solutions cannot just be better, it is most important to be time efficient when used. Another important factor to visualize is comparing implementation money costs.
Guidelines
15. User Centered Perspective
16. The solution should instill familiarity
17. The solution should feel intuitive
18. Continuity (this is an organisational matter)
19. Digital health solutions should complement traditional health care workflows
20. Multidisciplinary cooperation - The program should facilitate communication between stakeholders
21. Data input and output should be accurate and represent reality
a. Sensor data
b. Medical data
c. Organisation resources
d. New upcoming laws?
22. Usability
a. Should follow Jordans 10 principles of usable design
b. Should keep in mind Normans psychology of artefacts
c. The user should understand the connections of the components within simulation

H

Feedback Mapping of Mock-ups

The following images present how the feedback from the mockup sessions was structured for each of the mockup Pages and Dashboard.

3 Pages


överskådlig, gillar sannorlikhet i kartan, patientinfo är tydligt - får inte bli för stort bara
Saknar struktur
Tyckte var svår, saknar bilder, rörigt, vill veta mer
Saknar guidance i gränssnittet
Generellt: Bra att kunna ha olika vyer med samma data i bakgrunden
Låsta komponenter! reset knapp!
sannolikhets komponentner: finns register
vi vet att varannan dag mellan 4 0ch 6 så händer det minst två olykor på detta stället
supertydlig ruta om allverlighetsgrader och resurser, just nu är det för mycket information :)
Detta var bättre när man fick se det i en överblick
Man vill så snabbt få överblicken, i denna ligger den lite för långt in!
summerande ruta om att vårdbehovet ser ut såhär
tidspatient aspekt patient! Casualites
MediQueue Balancer
Algorithm browser
Scenario
Scenario 2
Scenario Overview
CUT THIS
Download


Det böver inte vara snyggt! Spelar ingen roll, användbarheten är viktigast
Påminner om många program de använder idag i sjukvården. exempelvis bockar, hur man öppnar olika saker
Dashboard: känns mest familjär, intuitiv, man behöver inte gå en kurs för att använda! Enklast!
kinematike, hastighet och bromstäcka, tvärstopp, utsatt person, Distans till sjukhus, Glesbygd eller storstad, synlig blödning, mägd, misstänkt skallskada, blek kallsvettig, ornormal andning, ingen andning, normal andning, fastklämd, gott ur bilen själv eller är kvar, risker på platsen - väderlag - lekage - brinna - givitig gas - om airbags utlös, pratar patienten
1
Dashboard
Simulation builder
Simulation Result
Typ av bil, plats (gbg, landet), hur ser miljön ut + stereotyper om ett område. Gamla bilar i norrland/vänderlek i olika regioner
Barn är väldigt viktigt att poängtera spannet är viktigare än average, och antal tillgängliga enheter - i hela vgr finns det 85 amulanser på dagtid, och en helikopter - i gbg runt 20 ambulanser - 18 är upptagna. man kan brya 15 ambulanser på deras uppdrag
Snygg, översiktlig
Data Overview
Algorithms
Algortims
Förtydliga vad parametrarna är i grafen
“Ingenjörig... Fler möjligheter men kanske inte lika enkel”. Gemene man kanske inte kan hoppa in direkt utan en genomgång.
Mest familjär - liknar systemen som används nu. Bokning, journal etc. Dock väldigt svåra att hitta i och inte intuitiva. Väldigt fyrkantiga.

I

Instruction Text User Test

The instruction text at the beginning of the user test questionnaire read as follows (translated from Swedish using ChatGPT):

You will get to try out the simulation program DHS Sandbox today! The purpose of the program is for you, as a user, to build simulations using various components and settings. The goal of the simulations is to test and compare results between different algorithms. The simulations deal with various traffic accidents, where the user can decide on the type of accident, number of vehicles, number of passengers, and more.

You will now carry out a usability test where you will follow a scenario that a user might encounter. You will complete eight tasks in the program. After each task, you will need to answer a question in the survey to proceed to the next one. Once all tasks are completed, you will be asked to answer a few more questions.

Assignment: Improved Triage of Traffic Accidents with Digital Healthcare Solutions

You work as a business developer and have recently received an incident report regarding a traffic accident where the triage process for ambulance personnel was considered suboptimal. The accident was a single-vehicle crash on a country road, where a car with three passengers veered off the road and collided with a tree. When the emergency call reached the dispatch center, the event was given high priority, but was still triaged lower than a few other simultaneous accidents. According to the incident report, this accident should have been given a higher priority, which could potentially have impacted the emergency response. Your task is to investigate whether there could be a digital healthcare solution, such as an algorithm or decision support tool, that could be implemented in the future to improve the triage of traffic accidents. You are interested in exploring which algorithms are currently available on the market and how they differ from one another. The goal is to identify a potential solution that can improve future traffic accident triage and ensure that the correct priority is assigned in critical situations.

J

Third Iteration of DHS

The following images show the prototype design of the third iteration of the DHS.

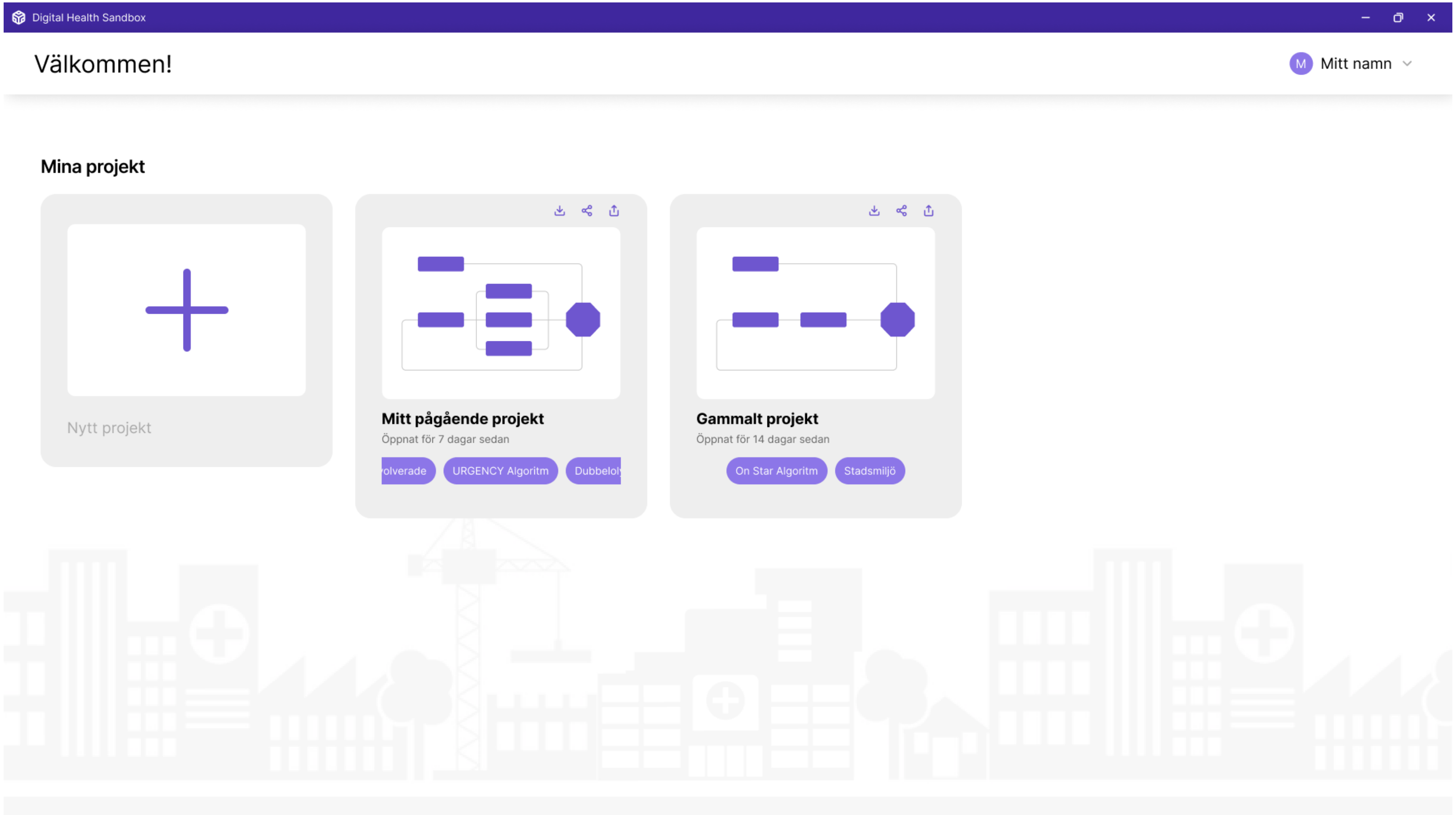


Figure J.1: DHS Homepage.

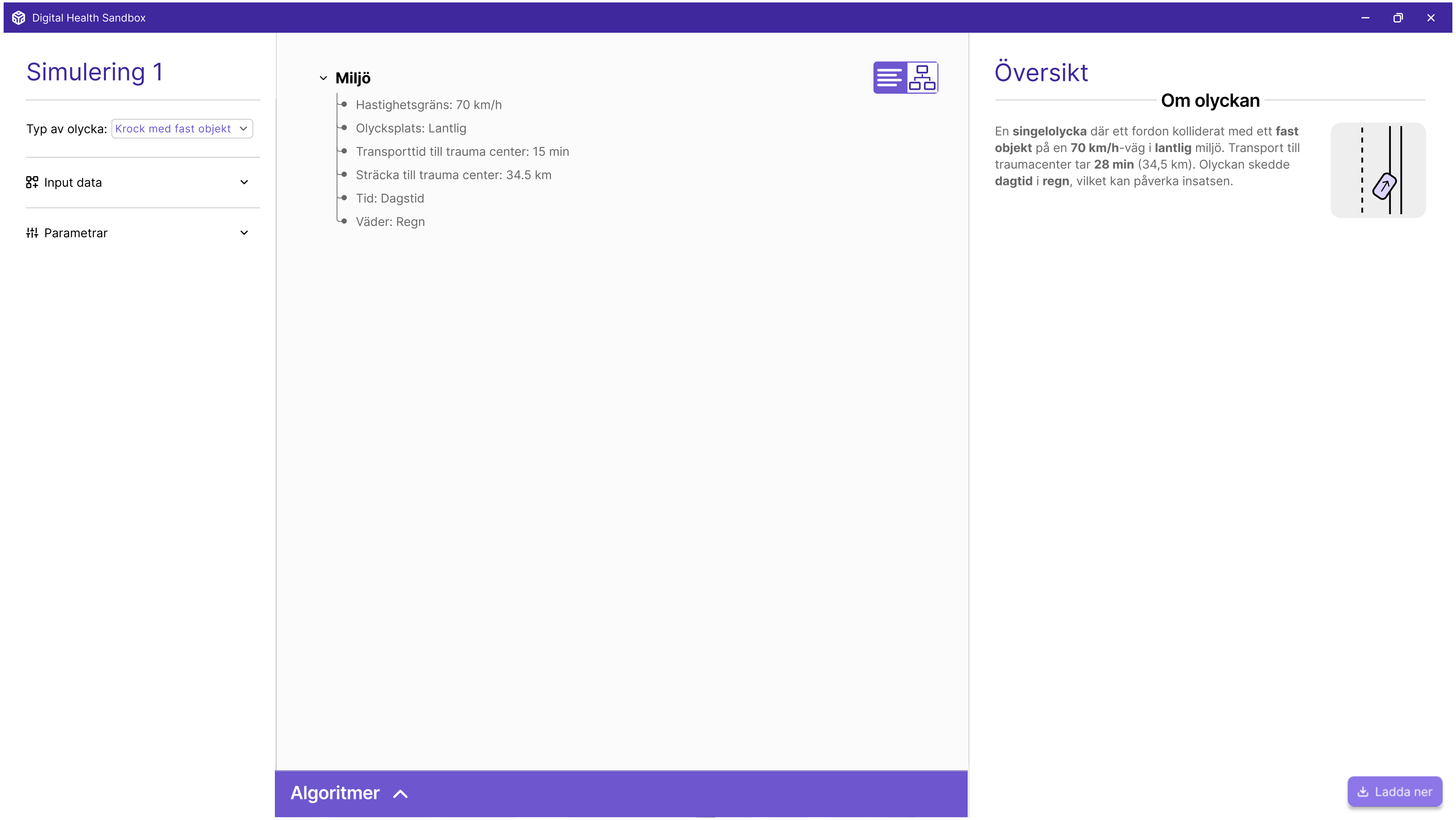


Figure J.2: DHS Simulation start.

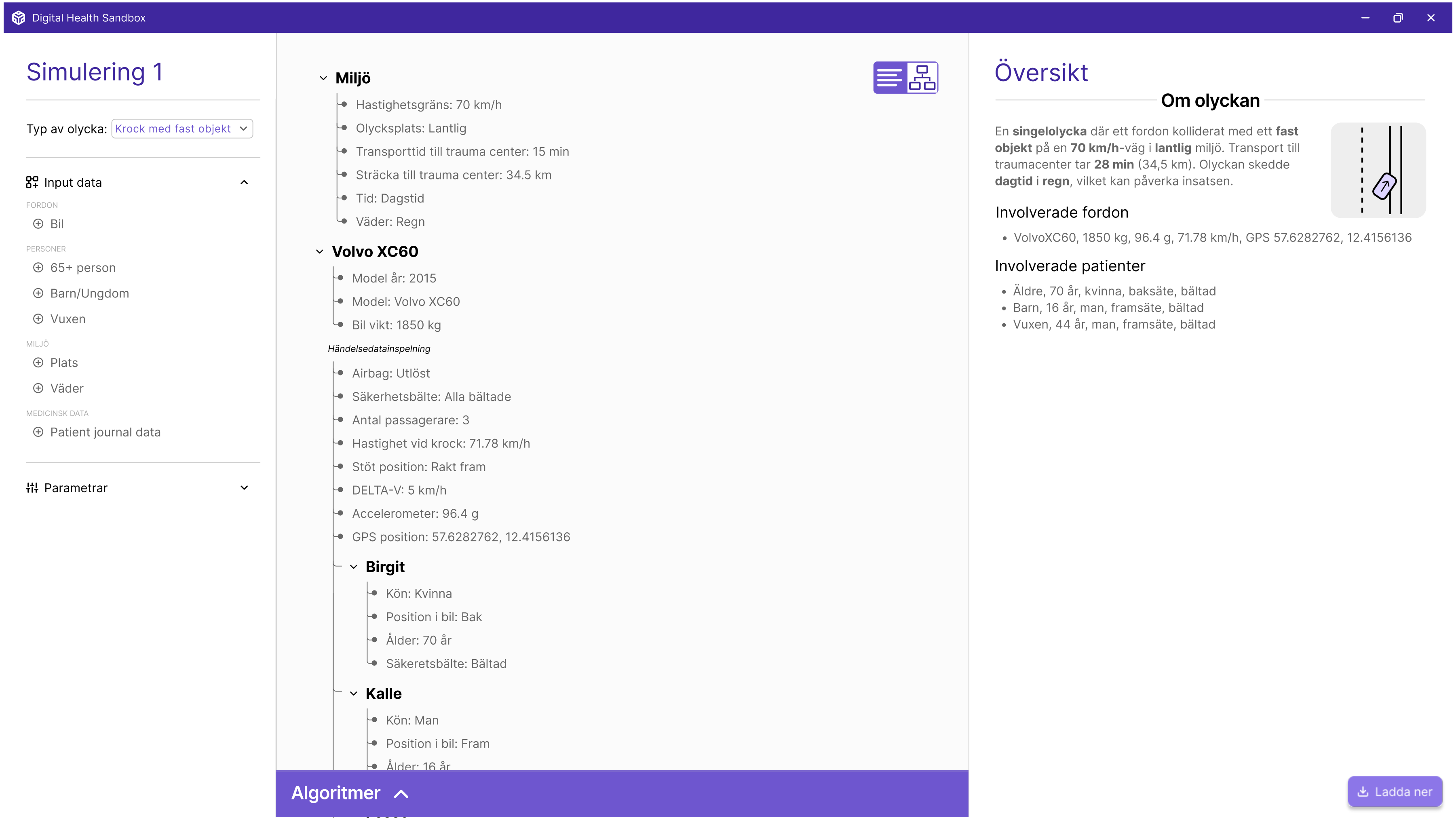


Figure J.3: DHS Input Data Added.

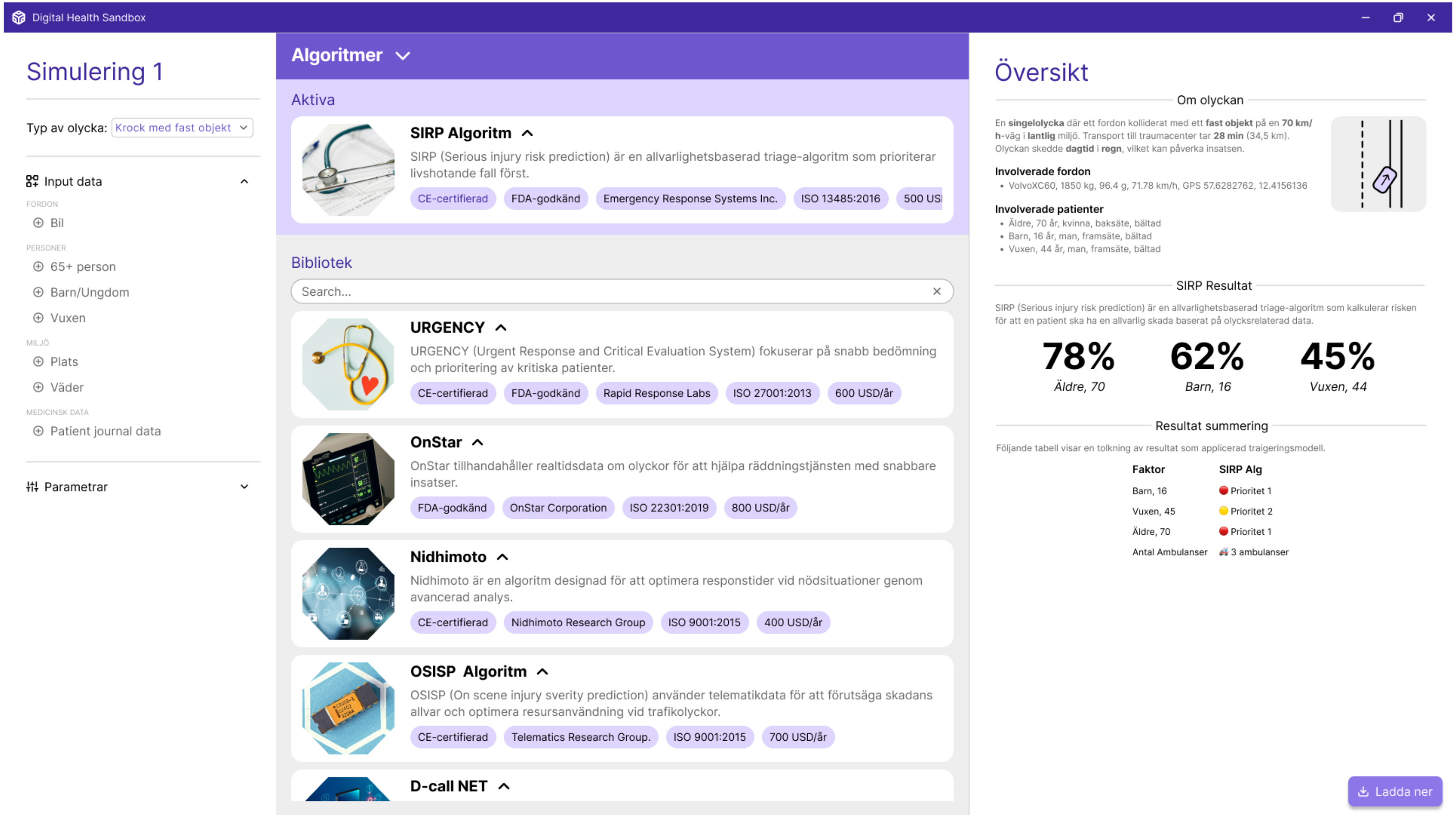


Figure J.4: DHS Algorithm Browser, one active algorithm.

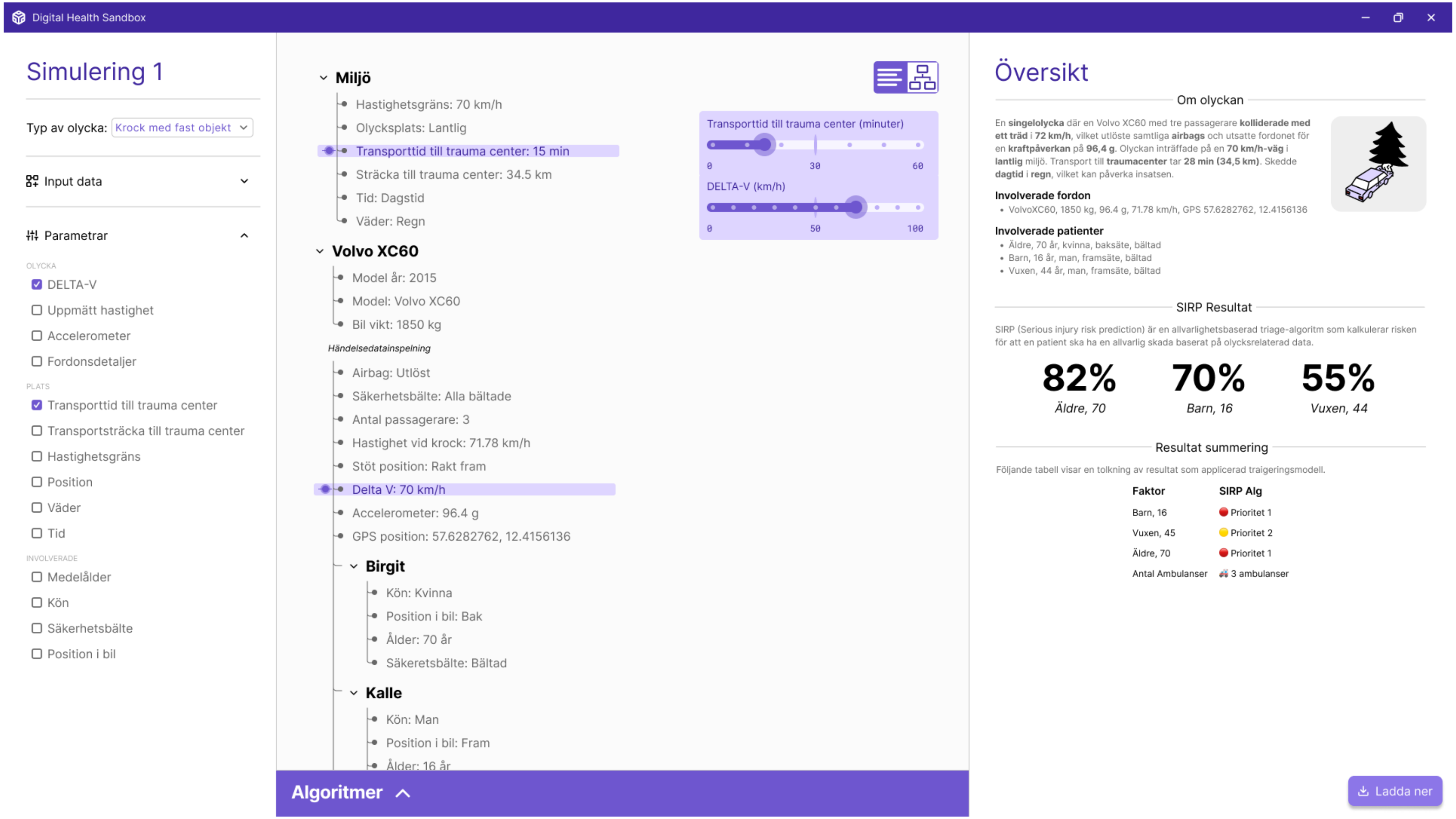


Figure J.5: DHS Added Parameters and Adjustment Sliders.

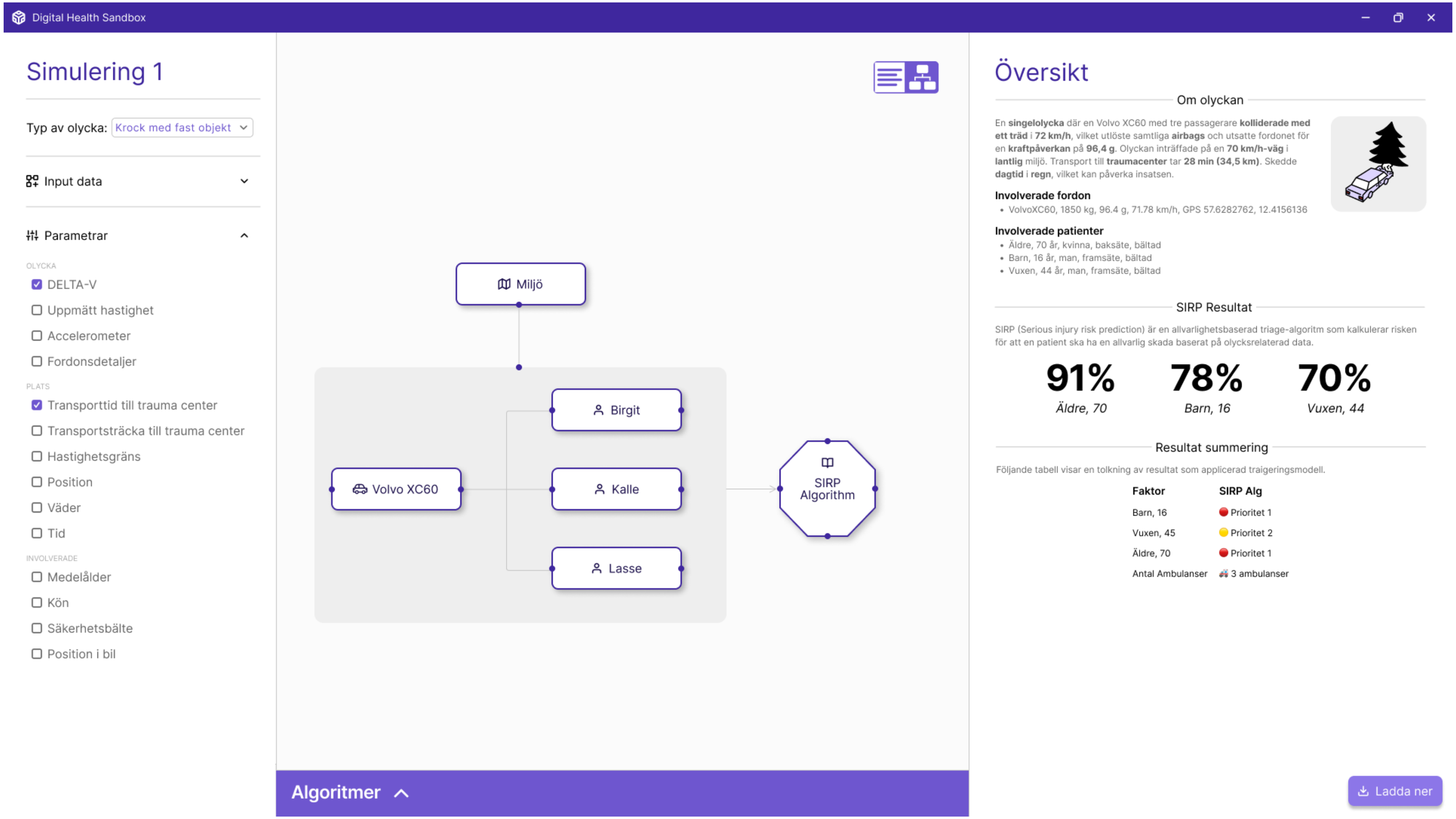


Figure J.6: DHS Visual View of Components.

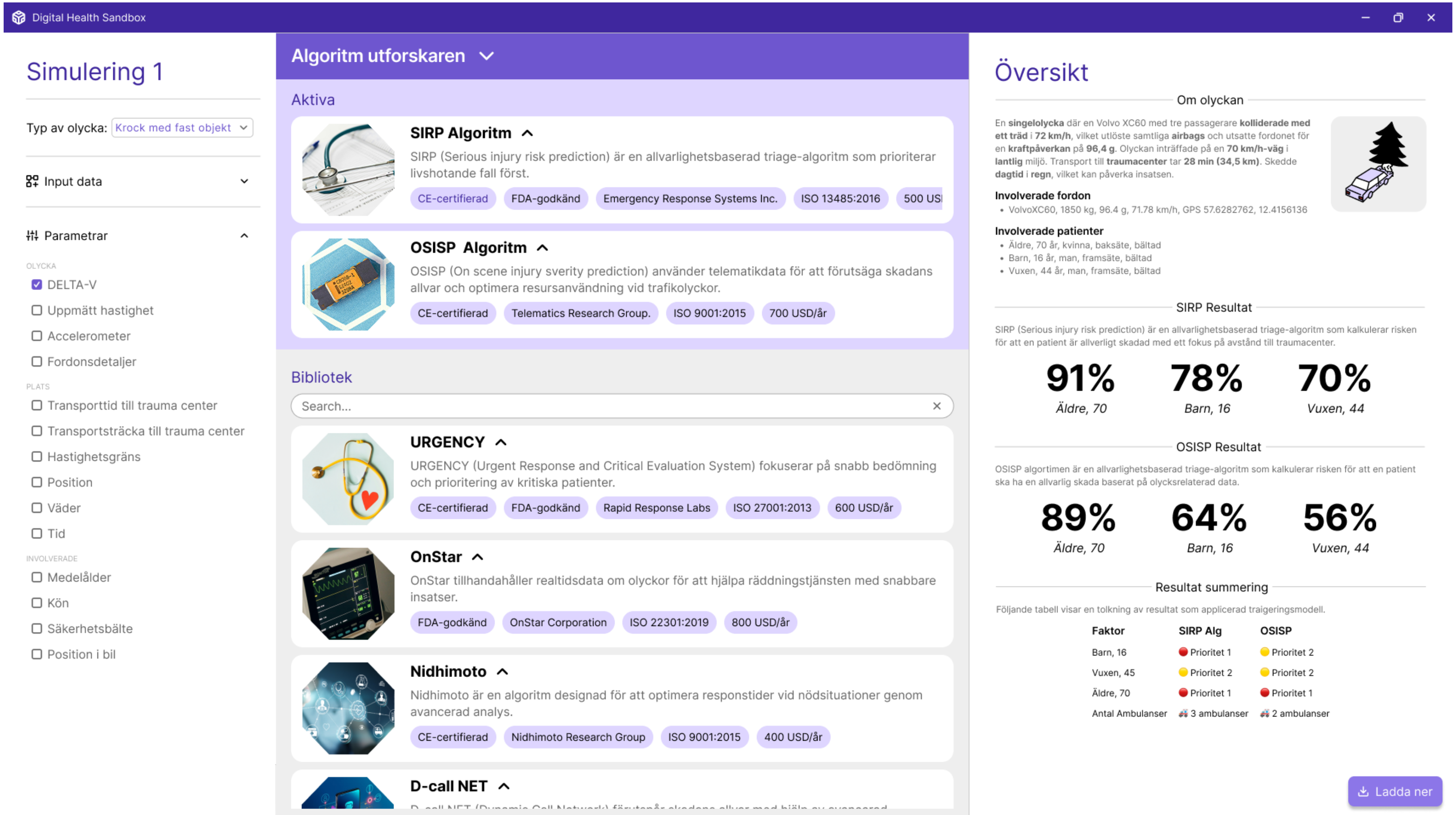


Figure J.7: DHS Algorithm Browser, two active algorithms.

K

Fourth Iteration of DHS

The following images show the design and specify the changes made in the fourth and final iteration of the DHS.

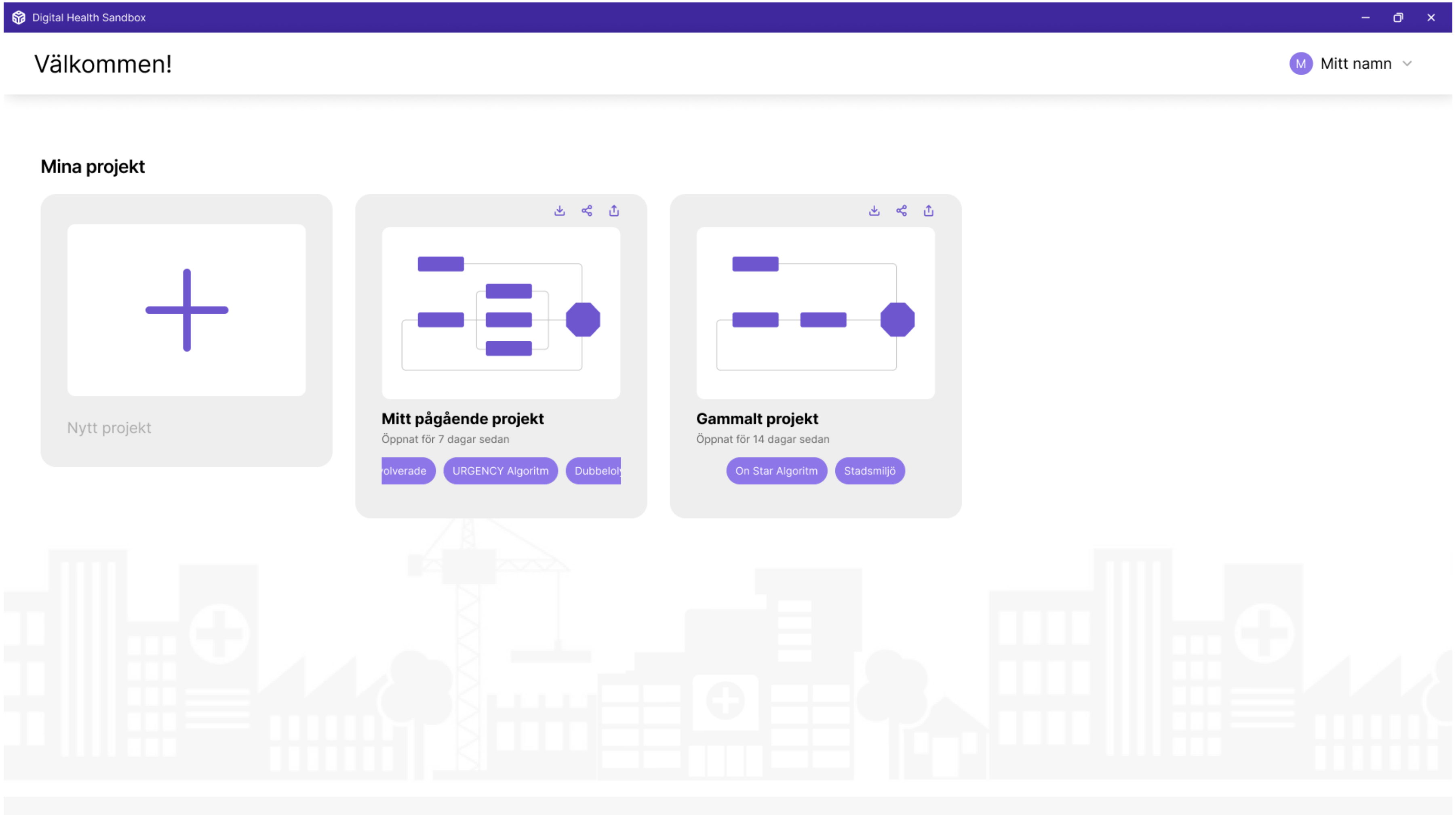


Figure K.1: DHS home-page where you can choose if you want to revisit an old project or start a new.

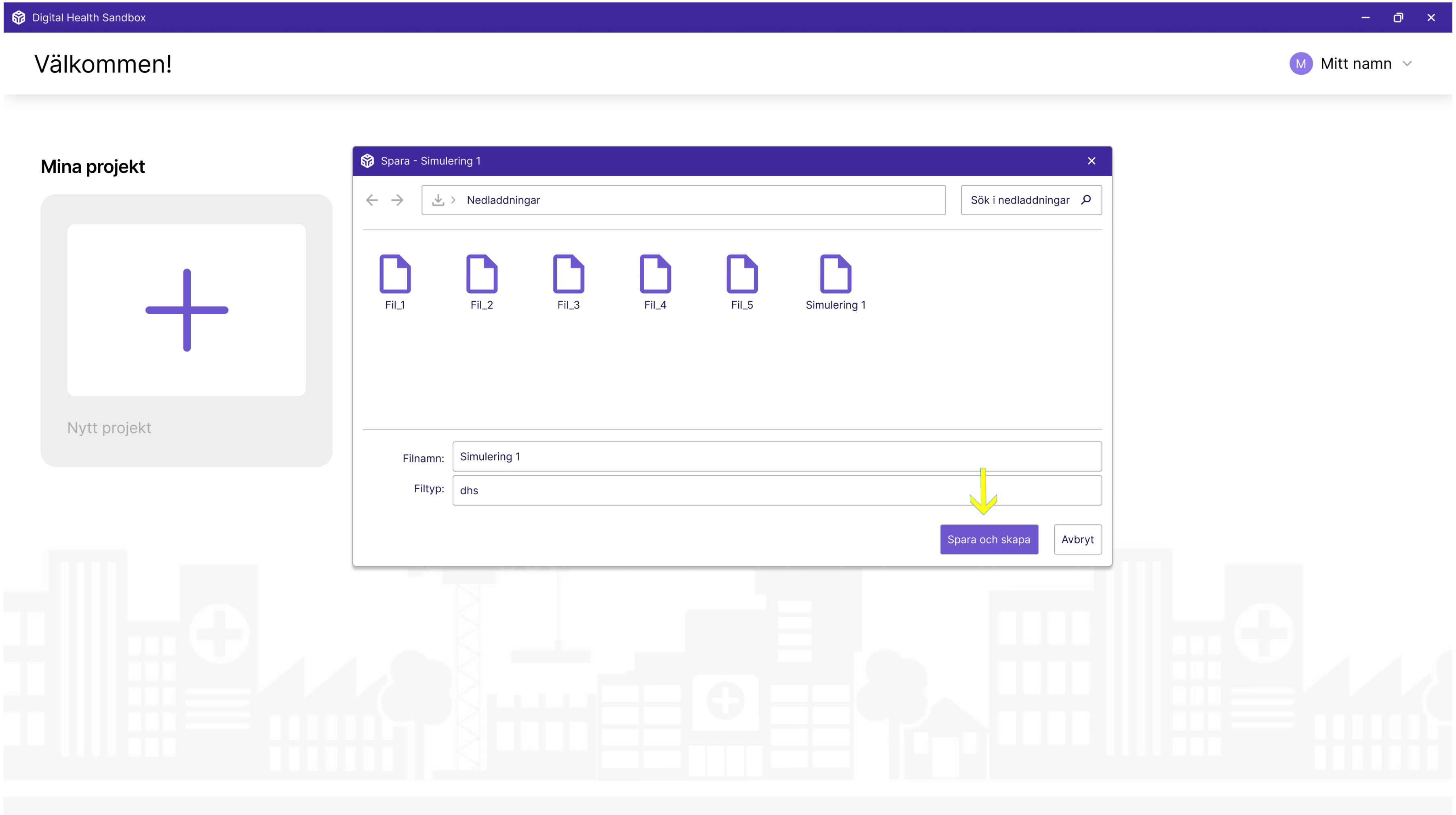


Figure K.2: DHS Updated Homepage with an added step where users have to choose where to save and name their document.

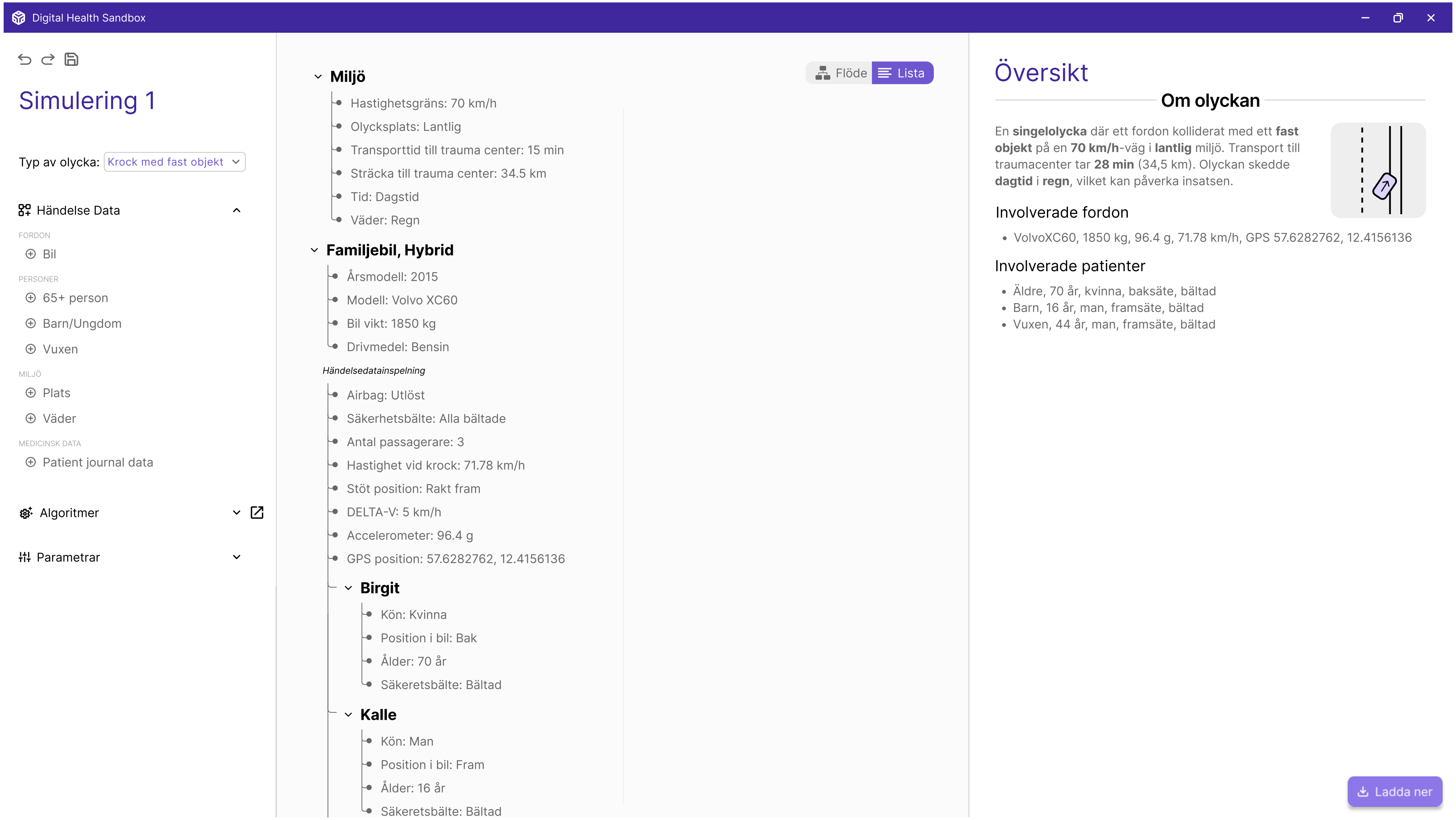


Figure K.3: DHS simulation page. As you have selected *accident type*, and added *data providers*

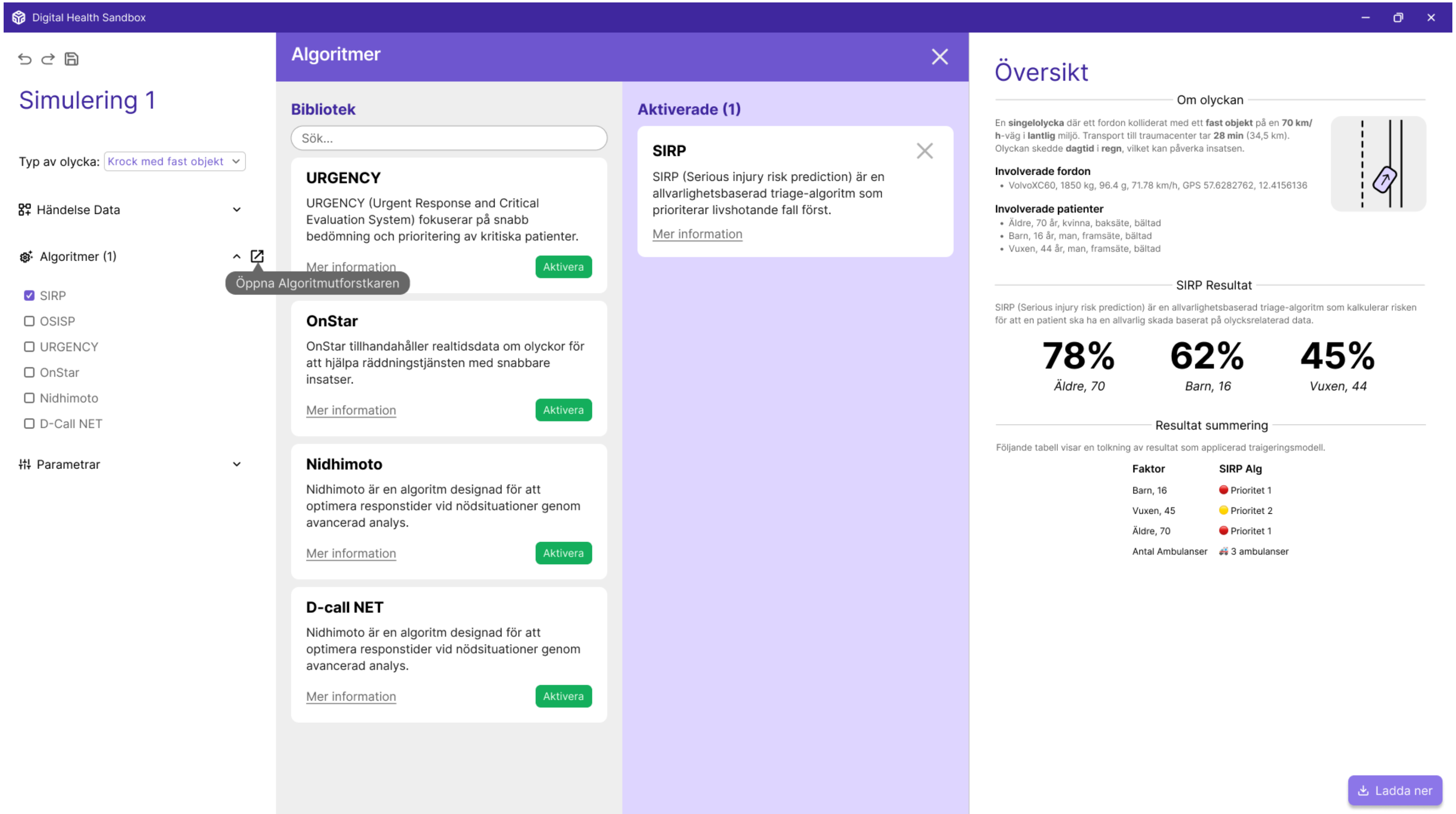


Figure K.4: DHS simulation page showing the *algorithm browser* with one *algorithm* activated. Both the browser location changed, tooltips were added, and the design of the browser changed.

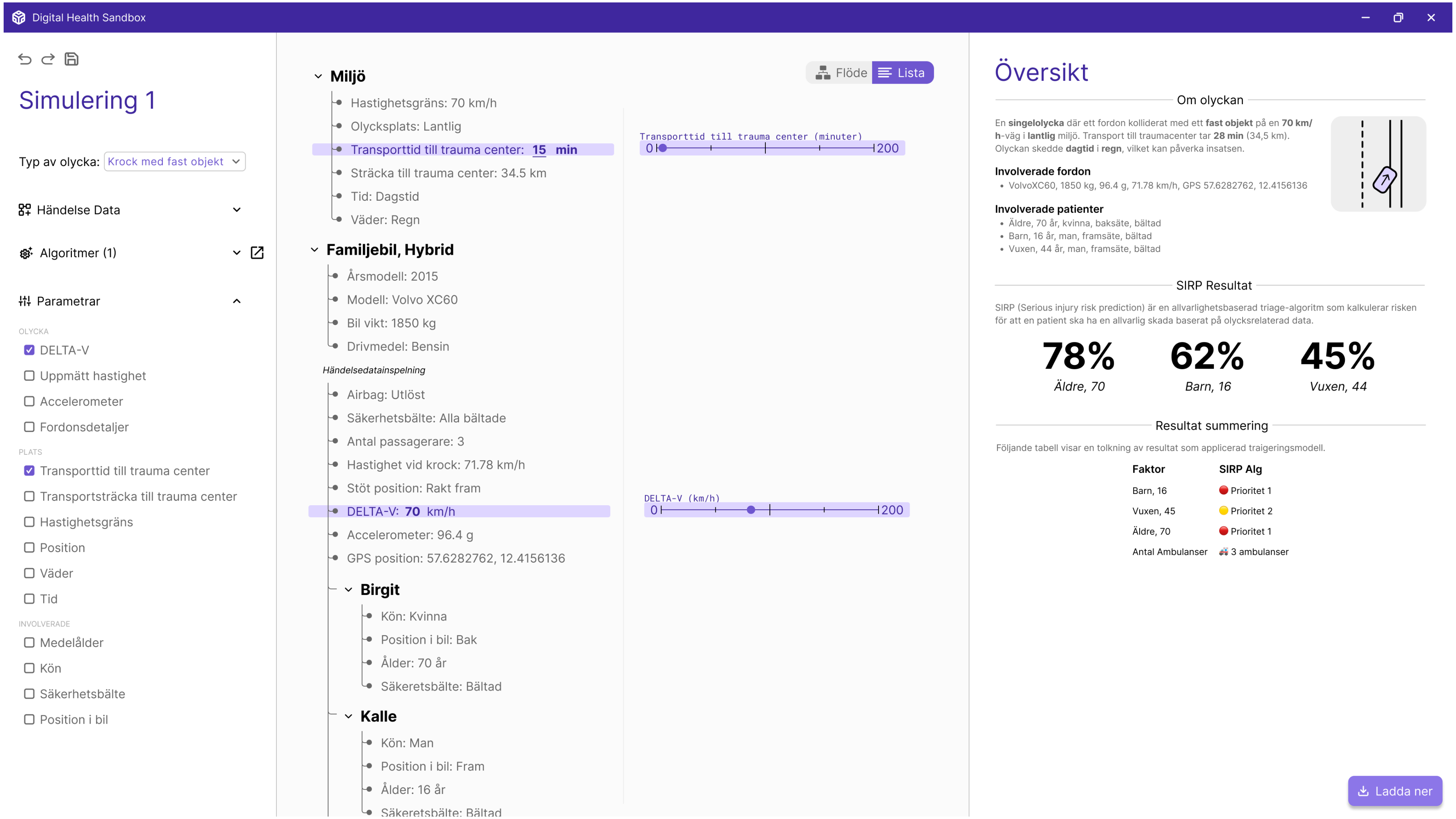


Figure K.5: DHS simulation page showing two *parameters* activated and the sliders used to adjust them. The sliders are now added next to the parameter they change. Furthermore, the button to change view was updated to include text.

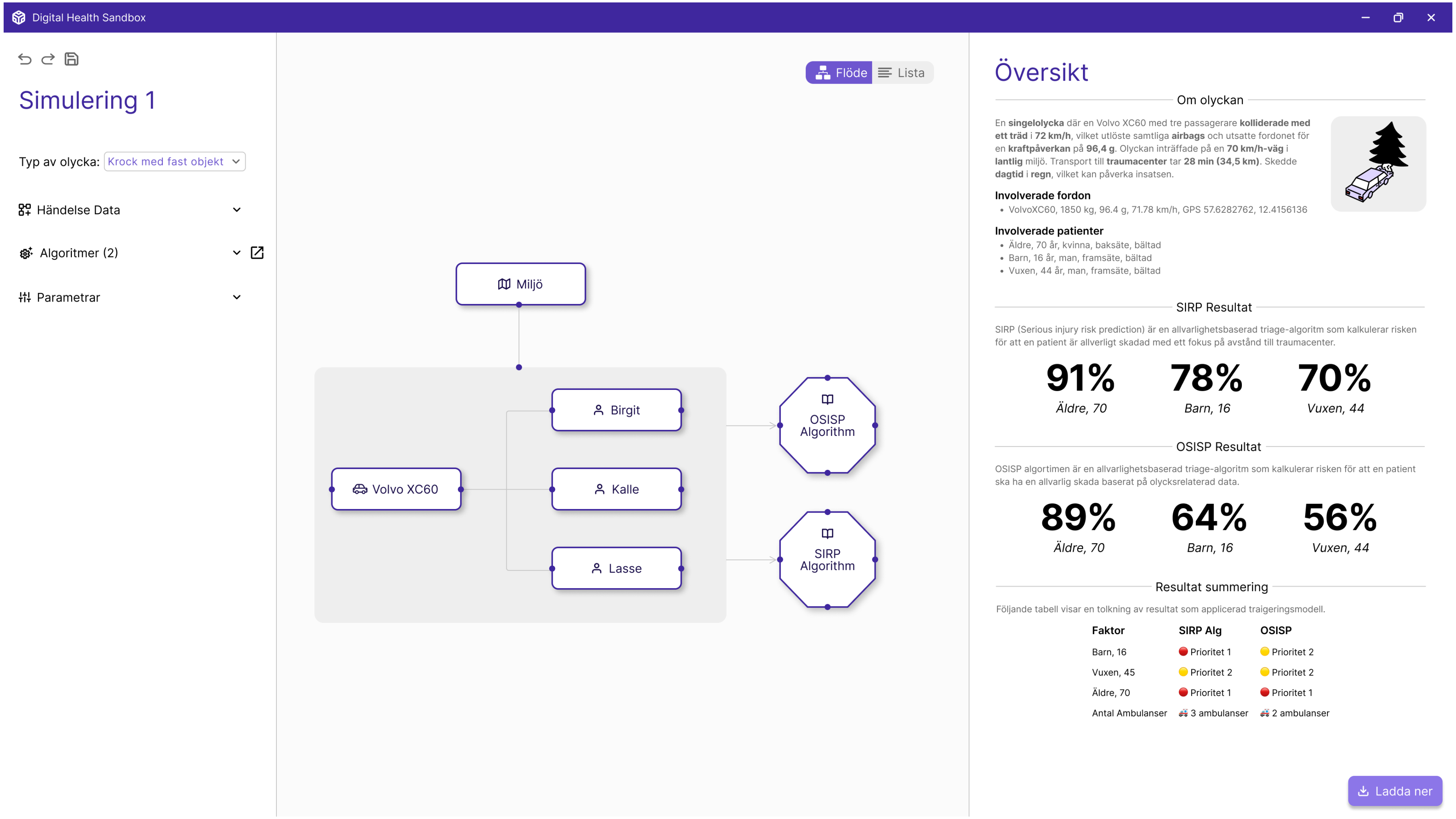


Figure K.6: DHS simulation page showing the *component overview's graphical view*, connecting each *component* in the simulation.

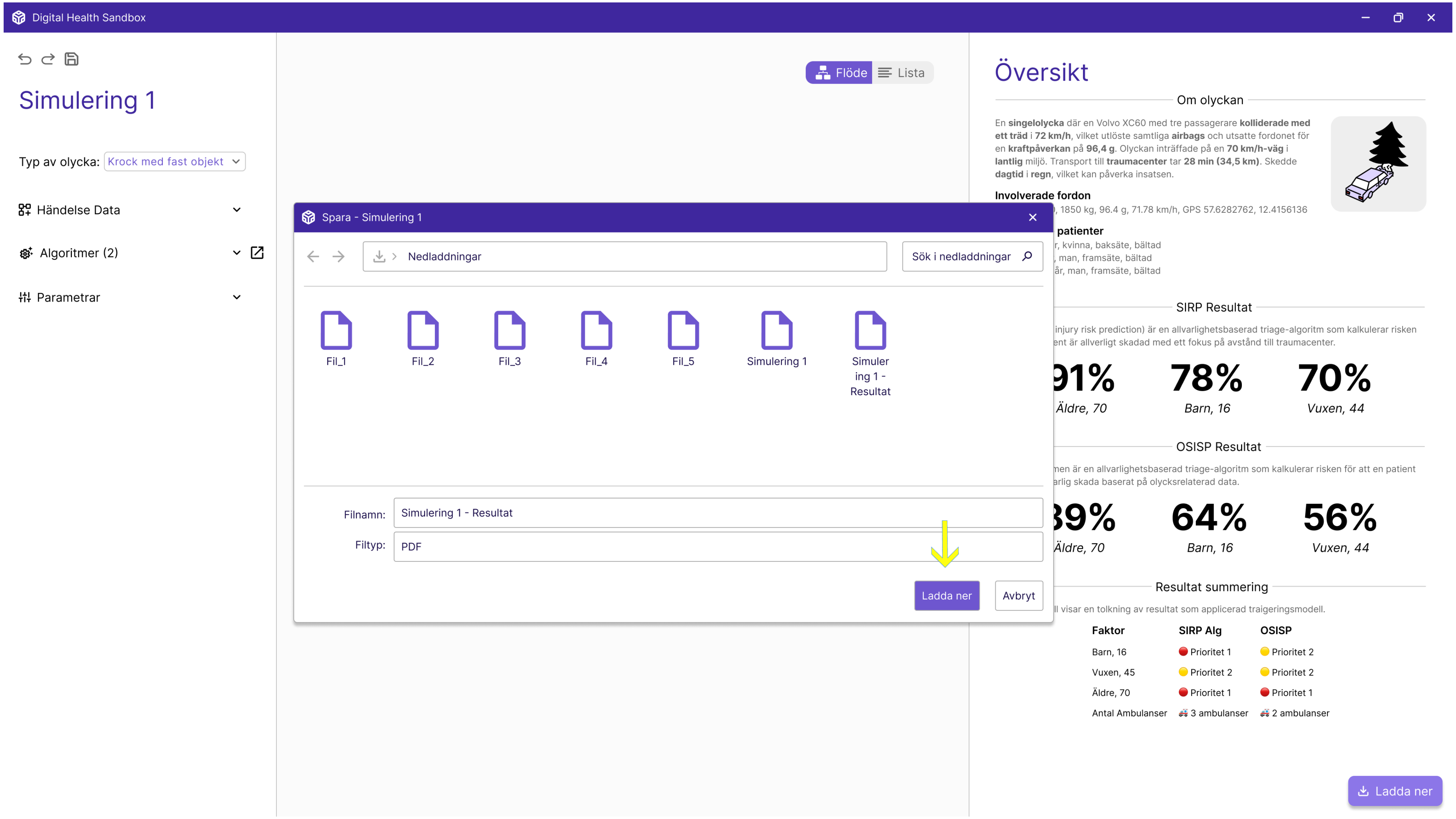


Figure K.7: DHS updated download button, where the users now have to select where they want to download the result.

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