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Universal Design of ICT

Identifying and mitigating barriers to situational awareness in Emergency management information systems

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Preface

Calling an emergency agency is not something you would like to experience. But I have personally been in contact with all three of them: police, medical emergencies, and fire. So, I know what important job all the operators working at these emergency centrals are doing. None of us wants to talk with them, but we all are appreciating having them on the line as soon as an accident has occurred. To write a master thesis that deals with both emergency management and universal design has really been educational, interesting, and very exciting. This is interdisciplinary research in many ways, and I am thankful for having this opportunity to write this assignment. It has taught me systematic literature review, how to conduct observations and interviews, and how to interpret data.

This Thesis wouldn´t have been anything without my supervisors Terje Gjøsæter and Weiqin Chen. Thank you so much for giving me this opportunity, and for finding me this topic. I am grateful for all advise and many hours together, you are super! I would also like to a thank Sykehuspartner, and 110 Sør-Øst and 110 Øst for letting me inside your centrals and for a warm welcoming. And thanks to all the interviewees for their time, opinions, and personal thoughts.

I must also thank my husband Espen Skårsmoen for supporting me to quit my job and to follow my dream on taking this master program in universal design. And for all empathy and advise along the road. I am looking forward to exploring universal design out there in the world and I hope to be a good ambassador for this important field within computer science.

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Abstract

Universal design is the design of products, environments, ICT programs and services that makes it possible to be used by all people to the greatest extent possible, without the need of adaption. Disabilities are something many can think of as permanent, but sometimes there are a specific situation that is hindering us from achieving our goals, this is called situational disabilities. When emergency operators in a control room handles critical situations, stress and anxiety, or data overload and attention tunnelling are examples that can lead to a temporarily cognitive disability. This situational disability is hindering them from situational awareness which is necessary to act fast when responding to people in need. The idea is that by finding barriers that is hindering them from situational awareness, and when or where these barriers occur. Then it is possible to look at how universal design can reduce the barriers operators encounter in emergency management information systems by using suitable design principles. To discover barriers an observation pilot at Sykehuspartner´s observation center, two observations at 110 Øst and Sør-Øst, and six semi-structured interviews are conducted. Four of the responders have experience from the emergency center that handles fire (110) and two from the emergency center for medical emergencies (113). The 7 principles of universal design, Shneiderman´s eight golden rules, WCAG, and Principles of designing for SA are the design principles used to address how the interface should be developed to support situational awareness. There are no observation and interviews conducted at the police (112) this time. The result is based exclusively on qualitative data. The results from the data collection and analysis of these shows that most barriers lay in the technology or the human-computer-interface. By using design principals some concrete solutions are suggested: Improvement or search engine, development of an Overview interface, inform about mandatory text fields, separate incidents, better organization of workspace, and a training program for new operators.

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1.0 Introduction

When your house is burning, there has been a car crash, a landslide or avalanche, you would like to get help as soon as possible. You need to call for help. Is it an accident on a large scale, perhaps more people will call to get help? The emergency center receives the calls, organizes resources, and the emergency agencies respond. Hopefully they are quick and efficient, and you will get the help you need. Because a fast response is crucial to decrease the number of injury and deaths (Luokkala & Virrantaus, 2013).

When you call an emergency center, the first thing they would like to know is the address you are calling from, since this is crucial information to create an incident case or send out recourses. When they know the location, the scope, and the severity, it is time to organize resources. Some accidents require cooperation between the three emergency agencies: fire and rescue, the police, and the medical emergency communication center. Normal workflow is when one operator receives the call and another operator organizes the resources. To receiving calls, get information about the caller, information telling them where they are located, different maps, information about available resources, the weather or car models, and to create an incident task, the emergency operators are using Emergency Management Information Systems (EMIS).

It takes the emergency agencies 7 minutes from the call is received and until the first fire engine is at the location, and Oslo fire and rescue department is responding to approximately 12500 accidents a year, this is an average at 1,43 times per hour (*Brann- og redningsetaten*). Together with contingency in focus, the technology has grown in high speed. New buildings have integrated fire alarms directly to the emergency management system, the fire fighters are using systems giving them the information they need about the area they are responding to, smart phones, 5G, etc. All of this has enhanced the way we today can save people and be saved.

While technology and contingency awareness have taken us far, advanced engineering have also created even more room to make human mistakes. Looking at aviation, with very innovative technology, we do know that some planes crash from time to time. A previous study found that the main causal factor of plane accidents was poor situational awareness (SA), which addresses the importance of developing and designing for better SA for pilots and air traffic controllers (Stanton et al., 2001). It is also reasonable to believe this is highly relevant when developing EMIS as well, as the emergency centrals are processing information from EMIS at the same time as they are communicating with people in crisis.

Endsley and Jones describe SA as being aware and understand what the information you perceive means to you now and in the future. It consists of three levels; perception, comprehension, and projection, and is usually applied to operational situations. Driving a car, treating a patient or regulate traffic is example on jobs and functions that needs SA (Endsley & Jones, 2004). When an accident is caused by poor situational awareness, SA demons or SA errors may get the blame for this, as these distractions are the factors that makes people unaware and can be considered as barriers. A barrier is something that prevents something else from happening or makes it more difficult. It can be a protection like a security system, but in this context, barriers are something that prevents SA, and the goal is to mitigate these barriers.

Requisite memory trap or data overload are examples on how a situational awareness demon can influence a situational cognitive disability. Our short-term working memory is short and not broad, and systems relying on the operators memory may cause major accidents, when say a pilot needs to remember complex air traffic control instructions not visible in any system (Endsley & Jones, 2004). Stress factors including time pressure, mental workload, and uncertainty, together with working environment with high level of noise, heat or cold, or poor lightning is also other demons Endsley and Jones mentions that can impact people to suffer from situational disabilities.

While the terms of SA and SA demons comes from Safety science, the EMIS are as much IT systems used for processing data and to communicate. The ICT terminology are talking about human-computer interaction (HCI), user interface (UI) and user experience (UX). Human errors are often accused for being the cause of indicates and loss of SA, rather than the design of the system, when a socio-technical perspective insinuates that SA demons is a consequence of the interaction between the operator and the system (Radianti et al., 2021).

Universal Design (UD) is the design of the environment, and the environment may be buildings, products, and services in our society (Begnum, 2020). The design should meet the needs of all people who wants to participate and use these environments, and universal design benefits everyone by creating what we surround our self with accessible, usable, convenient and a pleasure to use (Burgstahler, 2020). Some might relate the term universal design in to creating design for those with reduced sensory or motor abilities, or design for those with cognitive disabilities and mental health conditions. When designing an emergency management system, the end user is probably not blind, and it is not easy being a fire fighter in wheelchair. But some situations are extreme, and responders can experience disabilities based on what is happening around them. It can be hard seeing the mobile phone when you are surrounded by smoke, and it challenging to use it if you injure your hand. It is even harder for a fire fighter to hold a phone when using heavy glows and watch the screen using a face covered mask, and the surrounding still covered with smoke.

There is a difference between permanent, temporary, and situational disability. Deaf and blindness are permanent disabilities, an ear infection and cataract are temporary, while someone surrounded by noise, or a distracted driver is situational unable to hear or see. In these extreme situations research talks about situational disabilities. Personnel working on emergency communication centers are using emergency management systems but are not themself involved in dangerous situations. However, they dispatch many calls every day, and the situation they are in may be very stressful. These situations can be experienced on the same level as cognitive disabilities and mental health conditions, depending on how people act in stressful and unusual settings and how experienced they are in their profession.

1.1 Problem statement

Universal design today a part of national and international legislation and standards, and a part of UN sustainable development goals. UD are meant to include those with impairments to be a part of society and be able not only to work, but also be independent. Based on the difference between permanent, temporary, and situational disabilities, some may experience situational disabilities in certain sequence of events. Even if most operators at emergency centrals and first responders are not suffering from severe immobility or are sensory impaired, they can still have reduced sight, be color weak, have reduced hearing, or be sensitive to stress. Universal design is said to be necessary for some, useful for all. Based on what we know about SA, SA demons and SD, designing for EMIS are important, especially when the world is being more digitalized, and the technology introduced is getting more complex.

This research will examine what the barriers the operators are meeting today when using EMIS, and what factors are causing these barriers by looking at how operators are interacting with EMIS in a control room. In this research this will be done by observations at two emergency centrals, followed by semi structured interviews. UD is beneficial when designing other ICT solutions. There is more research on ex. UD and EMIS used by volunteers in crises, but little research on UD and EMIS in control rooms. That is why this research will look at how design principles can be implemented in control rooms to mitigate the barriers for situational awareness the operators are meeting when they are interacting with emergency management information systems there. It is reasonable to believe that knowing the factors and SA barriers it will be easier to design for improved EMIS.

1.2 Research Question

RQ1: What are the barriers that hinder operators in control centers to achieve SA in an EMIS?

RQ2: How can these barriers be mitigate using design principles?

This research wants to explore the SA errors operators in control rooms can meet when using EMIS that hinder them from situational awareness. For this it is necessary to address potential SA demons and when they occur. Further, when the first question is addressed, and it is reasonable to believe that there are such barriers, it will be possible to look at a selection of universal design principles and guidelines, and how these can be interpreted and used to mitigate or remove some of these barriers. Recommended suggestions will be relevant.

2.0 Literature Review

This chapter presents background and look at what previous research have been done in the science fields related to the problem statement in this thesis. UD of EMIS is a little investigated area, and that is why this literature review also will consist of research from science fields outside UD of ICT. Regarding the research question, areas touching towards organizational psychology, safety science, medical science, aviation etc., may also be relevant to the literature list. These science fields are discussing similar questions concerning especially SA and different aspects of SA barriers in the meeting between human and computer using management systems. There are however some different terminologies used, and this review will try to compare the research done and link it to universal design principles, and the research question.

2.1 Search criteria

To look for relevant literature for this thesis, a combination of words for the literature review is necessary. The research questions look at the barriers that hinders SA in EMIS, and how we can use UD and design principles to mitigate these barriers, the search criteria need to be a combination of the key concepts of the research question, and synonyms of these. In the research questions the key concepts are SA, EMIS, UD and barriers. Since barriers is a broad search word, SA demons will be the main barrier, and synonyms for SA demons will be a part of the search criteria.

Key concepts and synonyms

This is a list of the key concepts SA, EMIS, UD and SA demons, which are relevant for the thesis, and synonyms of these.

Table 2.0.1 List of Key Concept

SA	EMIS	UD	SA demons
Situation(al) awareness	Emergency management information system	Universal design	Situational awareness demons
Situation(al) understanding	Emergency management system	Design(ing)	Situational awareness weakness(es)
Situation(al) assessment	Emergency management	Design standards	Situational awareness barriers
Situation(al) measurement	Disaster management	The 7 Principles of Universal Design	SA errors
	Information systems for crisis response and management		Barriers

Synonyms and other words related to the key concept

This is a list showing the key concepts and words related to the key concepts.

Table 2.0.2 List of synonyms and word related to key concept

SA	EMIS	UD	SA demons
Human Behavior and Performance (HBP)	Emergency teams	Disability model	Distraction factors
	First responders	WCAG	Situational disability
	Emergency centre	HCI design approach	
	Disaster managment cycle	10 Heuristice evaluation of UI	
	Emergency Managment	Usability Heuristic	

	Technology		
	Simultaneous location and mapping (SLAM)	User Interface (UI)	
		User Experience (UX)	

List of combinations of search

Based on the key concepts, synonyms and related words, a combinations of search criteria were made, and Google Scholar has been the only search motor involved in this literature study.

Table2.3 List of Combinations of Search

(Situational awareness) (Situational awareness) OR (Situational awareness demons) AND (emergency) (Situational awareness demons) (Situational awareness demons) AND (emergency) (Situational awareness demons) AND (emergency management) (Situational awareness demons) AND (Emergency management) AND (universal design) (Situational awareness demons) OR (Situational awareness) AND (universal design) (Situational awareness error) (Situational awareness error) AND (emergency management system) (Situational awareness error) AND (situational awareness demons) (Emergency management system) (Emergency management information system) (Emergency management) AND (universal design)

(Emergency management system) AND (design)

Based on this search approach, not much relevant material was found. Much of the literature are relevant for other industries or were towards robotics rather than human SA. Based on the relevant articles it was easier to swap to the search method, snowballing. By reading relevant research articles, other relevant articles were found. UD within the EMIS is not a very explored research field, so relevant search in Google Scholar was also represented as references in already important literature.

Most research on SA and SA demons have roots from the 90´s and beginning of 2000, meaning it seems like this research is established, and there has not been much evolution in that area after, except from more industries are starting to adapt this approach as well. SA + UD is also established as a research field, so it has been relevant to look at literature that looks at SA and UD together.

This literature review focuses on topics discussed initially in the introduction of this thesis, and based on the research and research question, the next section will start by explaining emergency management and the technology used in EM, SA, and further SA demons and SA errors, and aspects of disabilities and situational disabilities, as this may create the barriers using EMIS. UD will be explained together with a selection of design principles and guidelines. Finally, a summary of this chapter is presented.

2.2 Emergency management information systems (EMIS)

EMIS are used by several rescue teams like the police, fire personnel, health personnel, civil defense etc. (Nini, 2020). This section explains emergency management in general, who are the Stakeholders, and what technologies are used.

2.2.1 The Emergency Agencies

In Norway the three emergency agencies Fire, Police and Medical emergencies (AMK) are separated and are contacted with three different phone numbers. In some situations, like bomb threats, fire in building, accident in tunnel, person in water, avalanche, and car accident, all three emergency agencies are connected in a triple alert dialog over the emergency network.

Each emergency agency is working through an interview form designed for type of incident when talking to a caller. It is also developed a form for use under a triple alert to make sure each emergency agency is getting enough information based on type of accident.

This table shows the three emergency agencies, their telephone numbers, and what they may be referred as:

Figure 2.1 The Emergency Agencies

- The fire department: Fire fighters, Fire
- The police: Police
- Medical emergencies: AMK, ambulance, medical care

2.2.2 Understanding Emergency Management

To understand how EMIS works, it is necessary to understand emergency management. In the literature they mention both four and five phases' models of emergency management. The four phases model consists of mitigation, preparedness, response and recover (*The Four Phases of Emergency Management*), while the five phases models starts with prevention as well (*5 phases of emergency managment*).

- <u>Prevention</u> – focus on preventing hazards from happening no matter if they are natural, technological, or caused by humans (*5 phases of emergency managment*). Building flood barriers in case of a storm or heavy rain, increase cyber security awareness to hinder cyber-attacks, and prevent crime or terrorism, together with planning and good design standards are examples on how we can prevent some accidents (*5 phases of emergency managment*).

- <u>Mitigation</u> – is the effort to reduce or prevent future loss of life and property by reducing the impact disasters and emergencies (*5 phases of emergency managment*). An example is to build a house with fire resistant walls and distance to the neighbour to prevent wildfire. Mitigation activities take place before and after emergencies (*The Four Phases of Emergency Management*).

- <u>Preparedness</u> – is the never ending cycle of planning, organizing, training, equipping, exercising, evaluating and taking corrective action (*5 phases of emergency managment*). Training and exercising is looked upon as the most important steps of preparedness (*The Four Phases of Emergency Management*).

- Response – the phase where the reaction to the occurrence of the disaster or emergency happens. The actions are expected to save lives, reduce economic loss, and relieving suffer, and this phase is depending on the coordination and management resources operating the emergency management information or communication systems (*5 phases of emergency managment*). Response actions may include activating the *Emergency operation center*, evacuation of affected citizens, offer shelters and care, emergency rescue, medical care, firefighting, and rescue (*The Four Phases of Emergency Management*).

- Recover – consists of the activities after an emergency period, and this is where it is important to restore critical community functions (*5 phases of emergency managment*). The recovery starts immediately after the disaster, and the goal is to bring the affected areas back to normal. This consists of clean-up, economic assistance, rebuilding infrastructure, and sustained mass care (*The Four Phases of Emergency Management*).

2.2.3 Stakeholders

Finding the stakeholders of Emergency management information systems and understanding their use of different technologies based on different roles during the emergency phases is a way towards finding potential hinders on experiencing SA, and on how universal design can help, based on what kind of technology they are using. Explained earlier, by Gjøsæter et al. (2020), in their study on UD of ICT for Emergency Management from Stakeholders´ perspective, they categories the stakeholders like this:

Table 2.0.4 Overview of Emergency Management Stakeholders, Gjøsæter et al. (2020)

First responders	– are trained people and organizations who provide help when disaster occurs, like search and rescue team, police, fire personnel, health personnel, civil defense etc. Their need of ICT varies from getting overview of affected area, or available resources, and communication.

Volunteers	– can aid both in a sporadic and systematic way. They can be on-site and remote, and they will need ICT tools for physical and digital volunteers, for coordination and communication.
Control room personnel	– are observing, comparing, putting together and interpreting data and distribute information to the decision makers. This ICT technology might be complex, and consists of web-based reports, communication technology, mobile technology, etc. It is necessary for them to be able to get crisis overview and share this with relevant stakeholders.
Decision makers	– responsible for logistics and resources.
Governmental Agencies	– police, fire personnel, health personnel, civil defense.
NGOs	– Red Cross, Doctors Without Borders, CARE, Amnesty
Experts	– scientists, designers, developers ICT who have extra knowledge about disaster and emergency management.
The public	– citizens that are affected or in danger. This can be the general public or particular members of the public.

Based on the study UD of ICT for Emergency Management form Stakeholders ´Perspective, Gjøsæter et al. (2020) notice that there is an overwhelming focus on the public, which is represented by 38% of the papers they reviewed. In comparison with First Responders with 11%, Decision Makers with 11%, Control room personnel with 6%, and Experts with only 5%, it is clearly seen a variability of research focus, and based on this a distinct gap.

Control room personnel are using complex ICT technology and need to process a lot of information very fast in a stressful environment, but they are only represented in research with 6%. This shows that it is reasonable to believe that this is an area interesting to further investigate, and that it is possible to find barriers related to the research question in this thesis.

2.2.4 ICT technologies used in emergency management

Research on UD of ICT for Emergency Management from Stakeholders´ perspective makes it necessary to investigate what kinds of technology these stakeholders are using in their work (Gjøsæter et al., 2020). Gjøsæter et al. (2020) are in their study referring to Aman et al. (2012) who did their review of ICT applied on common tasks during times of emergency. By collecting papers touching the breadth of technology used in emergency, with focus on search criteria within the ACM CHI Conference on Human Factors in Computing Systems (CHI) and the Information Systems for Crisis Response and Management (ISCRAM), and keywords including: “emergency”, “information systems”, “disaster relief”, “floods”, “earthquake”, “tsunami”, “hurricane”, “cyclone” and “fire-fighting” in their search combinations (Aman et al., 2012). Out of over 100 papers, they ended up crating a categorized list with these technologies, which is presented in Gjøsæter et al. (2020) research:

Table 2.0.5 Categorized list with technologies used in EM Gjøsæter et al. (2020)

Communication	Technology for communication among first-responders, the public and the victims, and information creation, dissemination and validation.
Event detection and assessment	Technology used towards disaster prevention, early response and damage mitigation.
Warning	Technology used to alert and inform the public potential danger.
GIS Support	Map-based technology to communicate and collaborate.
Decision Support	Technology to suggest possible action and aid in decision making.
Training	Technological tools used to train first-responders for any emergency response activity.

Navigation	Technology to assist in navigation, especially when paper maps are useless.
Evacuation	Technology used to assist in evacuating and emptying affected areas.

2.3 Situational awareness

Situational awareness (SA) is a term of decision making (Endsley & Jones, 2004), and a concept known from aviation, the army and through healthcare (Stanton et al., 2001). It is about being aware and understand what the information you perceive means to you now and in the future, the comprehension of their meaning, and projection of their status in near future (Endsley & Jones, 2004), and is the contrast between a person and the environment (Nini, 2020). SA is the dynamic reflection and orientation on a situation by an conscious human, and gives the opportunity to reflect on the past, present and future, as well as the potential features of the situation (Bedney & Meister, 1999). SA generates the momentary knowledge and behavior required to attain the goals specified to performance in the environment (Smith & Hancock, 1995). The term of SA has two sides; it is both a mental process and a product of this process (Stanton et al., 2001).

2.3.1 Situational awareness theories

There are three main definitions of situational awareness (Stanton et al., 2001): Endsley and Jones (2004) definition emphasizes perception and understanding of the world, the three-level model. Smith and Hancock (1995) define SA in terms of the interaction between the individual and the world, the perceptual cycle. And Bedney and Meister (1999) talk about SA in relation with mental models and an understanding of present system, the interactive sub-system approach (Stanton et al., 2001).

The three- level model

The most used SA model in litterateur is the three-level model of situational awareness by Jones and Endsley (1996). This was first created to understand aviation tasks but are later found in research related to other industries such as disaster response, maintenance, medicine, military, power systems, and transportation, and any task that requires people to keep track of events is a candidate to use this model (Stanton et al., 2001). This model is divided into three hierarchical levels of SA, and follows a chain of information processing, from perception, through interpretation, to prediction (Endsley, 1995). This approach has roots within a cognitive model of human activity in a dynamic system (Stanton et al., 2001). The three levels of SA are:

Level 1 SA: *Perception* of the elements in the environment.

This is the lowest level of SA, and is about perceiving status, attributes, and dynamic elements in the environment. In a cockpit, this may include keeping all relevant system and flight data (Endsley & Jones, 2004). Perception of information may come through visual, auditory, tactile, taste, smell, or a combination, verbal and nonverbal communications contribute to Level 1 SA(Endsley, 1995). A previous study by Jones and Endsley (1996) shows that 76% of all SA errors in pilots were related to not perceiving needed information. More about this is explained in the section about SA demons.

Level 2 SA: *Comprehension* of current situation.

The second step in achieving good SA is understanding what the data perceived mean when reaching goals, and it involves integrating pieces of data to form information related to the goals the operator wants to achieve (Endsley, 1995). An example on how elements can create a picture of what is going on is when a driver looks at time and distance with fuel available (Endsley & Jones, 2004). Level SA 2 is related to experience, and a less skilled individual may achieve a lower Level 2 SA despite achieving the same Level 1 SA as more experienced colleagues(Jones & Endsley, 1996). In comparison to Level 1 SA, Jones and Endsley (1996) found that approximately 19% of SA errors in aviation involved problems with Level 2 SA, people can see or hear the necessary data but are not able to understand it correctly.

Level 3 SA: *Prediction* of future status.

This is the highest level of SA and is connected to the ability to predict the future, based on what the person perceived and comprehended in Level 1 SA and Level 2 SA (Endsley, 1995). Prediction lets an operator make proactive decisions, an army commanders can project which direction the enemy will approach, and act based on that, and pilots can project the movements of other aircrafts and anticipate problems in advance (Jones & Endsley, 1996). Projection is a good tool to make strategies and responses to events but are mentally demanding for the operator (Endsley, 1995).

The interactive sub-systems approach

The interactive sub-system is presented by Bedney and Meister (1999), and this theory suggests a functional model of orientational activity that comprises eight main function blocks. This approach is interactive, cognitive, and sub-system, and it does not specify processes traditional to cognitive phycology like perception, memory, thinking and action execution (Stanton et al., 2001). It says that the processes involved depends on the nature of the task and goals of the individual, and this approach is based on the Activity Theory (AT) (Stanton et al., 2001).

Bedney and Meister (1999) presents three levels of activities in AT: orientational, executive and evaluative. When orientating the person develops a subjective model of reality, which leads to meaningful images of reality and expected future situations, and this component includes explorative elements that can be mental and practical (Lagervik et al., 2006), and includes what Endsley and Jones (2004) defines as SA. The executive level includes decisions and performance to reach desired goal (Bedney & Meister, 1999). The evaluative level of the action through feedback, and based on this correlation of action can affect the orientational and executive level (Lagervik et al., 2006).

The perceptual cycle

The alternative view of situational awareness the Perceptual cycle approach (Smith & Hancock, 1995) where SA is looked upon as the result of the interaction between the person and the world. This approach is based on the human information process, where the operator has a mental model of the presented situation (Stanton et al., 2001); to complete this process, the person must search for understanding and missing parts. This mental model is changing constantly, and the person needs to fill new holes (Stanton et al., 2001).

2.2.3 Summary of the three SA theories

The literature found in this literature review are representing the Tree-Level Model (Jones & Endsley, 1996) in more or less all of the research papers relevant to the research question. The interactive sub-system (Bedney & Meister, 1999) seems rather complex, and harder to relate to the research question in this literature review. The same for the Perceptual Cycle approach (Smith & Hancock, 1995), which shows the interaction between the person and the world. The Tree-Level approach is also further developed to get to understand SA demons and SA errors, which is highly relevant to this literature review and study, meaning further explanation of SA will be on background of Jones and Endsley (1996), and the next section will give an introduction to SA demons (Endsley & Jones, 2004).

2.3 Situational awareness demons

While there are several definitions on Situational awareness and how humans are aware and understand their surroundings (Stanton et al., 2001), Endsley and Jones (2004) are in their book about designing for situational awareness, explaining Situational Awareness demons. If operators are to receive the greatest benefit from Endsley's three levels of SA, they need to understand which barriers create the greatest challenges to developing and maintaining SA (Gasaway, 2008). SA demons are the factors that weaken SA in many systems and environments, and by that, Endsley and Jones (2004) are presenting *the eight major SA demons*. There are also studies defining SA errors (D´Aniello, 2018), since SA demons lead to different kind of SA errors this section will cover this as well.

2.3.1 The Eight Major SA demons

The eight major SA demons are presented in this section.

Attention tunnelling

Some tasks consist of collecting several pieces of information in the environment, this is called attention sharing (Endsley & Jones, 2004). Focusing on one area to then ignore what is critical from another area, is what they call attention tunneling, when operators are missing out on important information that will make them understand the whole situation (Endsley & Jones, 2004). A study from aviation done by Jones and Endsley (1996) found that 35% of all SA errors fell into this category where people were attending to other task-relevant information and lost focus on important aspects of the situation.

Requisite memory trap

This is about how much information our short-term or working memory can handle, and for how long (Endsley & Jones, 2004). When a system is over dependance on the operator's memory for response to alarms under critical situations, this can lead to a SA bottleneck (Endsley & Jones, 2004), when the human memory is central when it comes to SA. Instead of pilots remembering complex air traffic instructions, this information could be more perceivable, presented on a screen (Jones & Endsley, 1996).

Workload, anxiety, fatigue, and other stressors (WAFOS)

Stress and anxiety can occur in many situations, no matter you are a doctor, fire fighter, cashier or receptionist (Endsley & Jones, 2004). These stressors can be triggered by own well-being at stat, self-esteem, career advancement, or at high-consequence events, and other factors like time pressure, mental workload and uncertainty (Endsley & Jones, 2004). Physical stressors like high level of noise or vibration, heat or cold, or poor lightning are also factors mentioned, and further WAFOS which steal attention and working memory, and are affecting SA level 1 and 2 (Endsley & Jones, 2004).

Data overload

When there are more data available than can be processed by the human bandwidth causes data overload (Endsley & Jones, 2004). Rapid switch of data creates a need for information intake, and this outplaces the sensory and cognitive system at the operator(Endsley & Jones, 2004). People can only process a limited amount of information, and this decreases with even more sensory information at hand, that is why Endsley and Jones (2004) suggest that by designing the data to be presented in certain ways, the data can be experienced more slowly, and people can process it without data overload.

Misplaced salience

The color red, movement and flashing lights tends to catch more attention than other features (Endsley & Jones, 2004). When these salience objects or information takes away attention from other important data or output; this can be big billboards in Las Vegas taking away the attention from drivers, loud noises, large shapes and other things people can perceive and removes their attention are other examples on potential misplaced salience (Endsley & Jones, 2004). With carefully use, Endsley and Jones (2004) says it is a good way of drawing attention in critical situations or to enlighten highly important information, and are important tools when designing for SA as well. Misplaced salience on aircraft panels can be very dangerous if it removes attention from critical information from an anonymous instrument, while natural misplaced salience may be difficult to prevent (Endsley & Jones, 2004). Endsley and Jones (2004) are making a point out of the engineered systems and the power a designer may have to carefully avoid unnecessary use of light, buzzers, alarms, and other signal taking away attention.

Complexity creep

Complexity is a problem when systems got so many features, people find it hard to understand how it works (Endsley & Jones, 2004). Complexity creep relates to data overload, and the more feature, the more complexity (Endsley & Jones, 2004), and these complexities slows down the ability to perceive and understand information (Stratmann & Boll, 2016). A pilot not understanding the complexity of an automated flight management system might lead to tragedy (Endsley & Jones, 2004) if they don´t understand what the system is doing and what it would do next (Wiener & Curry, 1980). Endsley and Jones (2004) do also suggest decreasing complexity to prevent the need of more training, which leads to the risk of forgetting subtle system nuances.

Errant mental models

Errant mental models explain how a person based on previous experience misinterprets new data (Endsley & Jones, 2004). A pilot may misinterpret a display in a new aircraft by using the mental model correct for the previous aircraft, or a doctor may misinterpret important symptoms for a diagnose based on earlier assumptions for another diagnose (Endsley &

Jones, 2004), and they suggest standardization and limited use of automation models as keys to help minimizing circumstances of errant mental model.

Out-of-the-loop syndrome

Automation can help SA by reducing unnecessary workload when it is performing good, but automated systems can also undermine SA by taking people out-of-the-loop (Endsley & Jones, 2004). The automation when not involving the human before there is a problem, or if the warning system failed, and they never got to know something went wrong, that is the SA demon (Endsley & Jones, 2004). As humans relies more on automation, avoiding the out-of-the-loop syndrome is critical (Endsley & Jones, 2004).

2.3.2 SA Errors

While SA demons are the main factors that affect SA, SA demons lead to different kind of SA errors at the three levels of SA, and typical errors and their relations to SA demons are explained by D´Aniello (2018). The table under describes how D´Aniello (2018) relates potential SA error caused by SA demons in each level of SA.

Table 2.0.6 Potential SA error caused by SA demons, (D´Aniello, 2018)

Level 1 SA SA demons related: Attention tunneling, data overload, memory trap, workload, and stressors. SA errors: • Data not available because of bad system design or failure in the communication process. • Data difficult to perceive because of system or environment issues. • Can´t observe data because of attention tunneling or high workload.

• Misperception of data because of false expectations, or operator misread the data. • Memory failure because of lack of memory and data overload.
Level 2 SA SA demons related: Wrong mental model, attention tunneling and memory trap. <u>SA errors</u>: • Poor mental model causes misunderstanding of perceived information. • Operator adapts the mental model for another system which causes a misinterpretation of the current situation. • Over-reliance on default values in model when there is an absence of real-time data. • Memory failure hinders operator to process perceived information.
Level 3 SA SA demons related: Attentional tunnelling, misplaced salience, and memory trap. <u>SA errors</u>: Errors happens when the operator can´t predict the future stat of what has been understood at level 2 SA. Poor mental model is often the cause of this. Other two factors with bad impact on all three of the SA levels is the need of managing and maintaining multiple goals in memory and when performing tasks, and some operators are not good at handling this. Default schema can also lead operators to be less receptive to important signals, caused by attention tunnelling.

D´Aniello (2018) mentions two other factors with bad impact on all three of the SA levels, which is the need of managing and maintaining multiple goals in memory and when performing tasks, and some operators are not good at handling this. Default schema can also lead operators to be less receptive to important signals, caused by attention tunnelling (D´Aniello, 2018).

2.3.3 How to disclose and prevent SA Demons

By understanding the eight SA Demons and how they are decreasing SA, it is possible to look at further literature on how they can be disclosed and be prevented. In the analysis done by Radianti et al. (2021) they are searching Google Scholar and Scopus to look for relevant collect articles on Endsley AND Demons AND "situational awareness" OR "situation awareness". Out of 73 articles, they ended up analyzing 32 articles after in-depth reading. They conducted a Content Analysis (SA) which is a method used to analyzing communication using qualitative or quantitative data, with both inductive and deductive methods (Elo & Kyngäs, 2008).

The findings after Radianti et al. (2021) analysis shows that humans are to blame in most SA errors, and technology is less mentioned in the discussions of understanding SA demons. But even so, they clams that with the increase of adoption of digital technology in Emergency Management, it is necessary to understand the role of this technology in SD and SA, and there by apply Universal Design principles when designing SA-supporting technology (Radianti et al., 2021). They suggest that UD can mitigate the SA Demons by improving the interaction between operator and system, based on what they learned in Gjøsæter et al. (2019). In relation to the research question in this thesis; *How can these barriers be mitigated using UD and design principles.* Radianti et al. (2021) believe UD can mitigate the SA demon, and further work may find out how the HCI can be better in EMIS by using UD principles.

Radianti et al. (2021) say future research should investigate:

> *"1) the causes of human-errors when technology is involved and contributes to human-errors, 2) the key technological challenges that need to be addressed, 3) design of technology to reduce human-errors and enhance SA, 4) user-oriented information presentation and the technology design that support user interactions through different modalities and devices"*, Radianti et al. (2021).

2.4 Disabilities

Disability is a condition that makes it hard for a person to participate in certain activities because of the impairments this person might have, or can´t interact with the environment because of individual health conditions (*Disability and health*, 2021). While disability is the hinder, accessibility is the goal, like being able to access the top floor in a wheelchair because of the elevator or access the online banking as a blind person because the interface supports input and output with braille boards and text-to-speech (*Accessibility for the Disabled - A Design Manual for a Barrier Free Environment*).

2.4.1 Some definitions

When explaining disabilities, there are also a couple of other well-known related definitions that should be explained with this brief overview of what lays in the definitions Impairment, Disability and Handicap, developed by World Health Organization (*World Programme of Action Concerning Disabled Persons*):

Table 2.0.7 WHOs definition of Impairment, Disability and Handicap, (*World Programme of Action Concerning Disabled Persons*)

Definition	**Explanation**
Impairment	Refers to a problem with a structure or organ of the body
Disability	Any restriction or lack (resulting from an impairment) of ability to perform an activity in the manner or within the range considered normal for a human being.
Handicap	A disadvantage for a given individual, resulting from an impairment or disability, that, limits or prevents the fulfillment of a role that is normal, depending on age, sex, social and cultural factors, for that individual.

WHO is also, beside explaining disabilities as something related to an individual health condition, including personal and environmental factors like negative attitudes, inaccessible transportation and public buildings, and limited social supports as disabilities (*Disability and health*, 2021).

Impairment groups

This is the four impairment groups:

- Motor
- Sensory
- Cognitive
- Mental Health Conditions

2.4.2 Situational disabilities

When it said that UD is “Necessary for Some and Good for Everyone”, it means that UD is especially important for those with more long-term impairment, while UD also is good for others in given situations. Like when you can hold and use the mobile phone with one hand because the other hand is holding a bag, or you can watch a video with subtitle in a situation where it´s not suitable to listen to it. In emergency situations high sound, smoke and shaking ground can make it hard to use hardware or software like we usually use them, which leads to Situational disabilities.

Previous mentioned research says most paper relevant to UD of ICT in Emergency Management is focusing on the public, compared to other stakeholders like first responders and control room personnel (Gjøsæter et al., 2020). Another research claims that UD of ICT for Emergency Management together with Situational Disability also is an unexplored area and should not only investigate the public but also first responders and other stakeholders (Gjøsæter et al., 2019).

Persona Spectrum

The Personas Spectrum shows that disabilities occur to everyone and can experience this temporary condition, and under is the Personas Spectrum illustrated by Microsoft Design (*Inclusive 101 & Activities*) on types of disabilities in a specter. Personas can detail the characteristics of a person, both positive and negative, and it decides why a user needs or wants something. Spectrum helps to understand mismatches and motivation across a spectrum (Pacella, 2019).

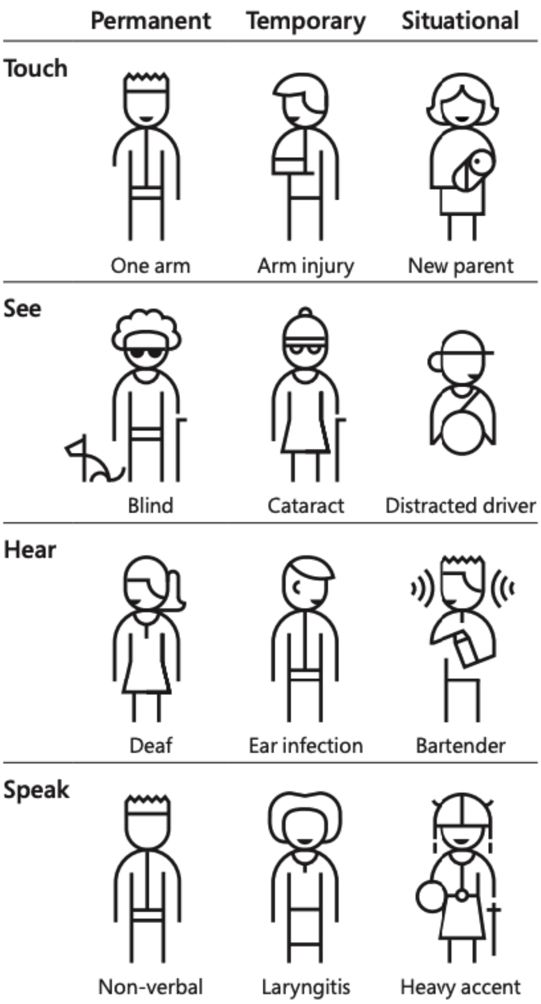

Figure 2.0.2 The Persona Spectrum of Disabilities, (*Inclusive 101 & Activities*)

2.4.3 Situational Abilities in Disaster

To examine the occasions of Situational Abilities in disaster, Gjøsæter et al. (2019) created some imaginary but potential scenarios, with stakeholders presented by personas, and looked at actions and potential SD they might encounter. With the research question on finding SA barriers in EMIS in mind, looking closer to Gjøsæter et al. (2019) findings of first responders and control room personnel seems appropriate.

In the first scenario Gjøsæter et al. (2019) they present an Earthquake in a city, and the second scene is a fire in a mall, and based on these scenarios they cover needs of SA and potential SD. The first responder must achieve SA trough observation and communication equipment to be able to help as many as possible, and situational factors are stress, crowd, noise, cognitive overload, and shaking ground caused by earthquake, or smoke and caused by fire (Gjøsæter et al., 2019). Risk of SD are reduced hearing, dexterity, and cognitive disability caused by stress, and loss of vision because of smoke during fire, and potential consequences are reduced ability to use mobile communication equipment, and therefor take wrong decisions because of communication problems (Gjøsæter et al., 2019). The Control Room Personnel on the other hand needs to perform observation, analysis, decision-making and communicating orders, situational factors are information overload through multiple information channels, and stress from life-and-death-affecting decision making, and based on this, the SD risk is cognitive stress, and the consequence of this is error in judgement caused by information overload (Gjøsæter et al., 2019).

In the tables under, Gjøsæter et al. (2019) are showing their findings for first responders and control room personel.

First Responderes

		Situational Disability Triggers
Perceive		
	Touch	Hot/cold/wet/protective gear leading to loss of feeling
	Vision	Dust and/or smoke
	Hearing	Noise/alarms
	Cognitive (understand, interpret)	Language barriers, information overload
Action		
	Speaking	Dust and/or smoke in the throat, language barriers
	Moving	Protective gear, crowds, panic
	Fine-motorics /dexterity	Panic/stress, protective gear
	Cognitive (plan – act)	Information overload, confusion (wrong communication channel, forgetting protocol)

Figure 2.0.3 SD Triggers in the Field, (Gjøsæter et al., 2019)

Control Room Personell

		Situational Disability Triggers
Perceive		
	Touch	
	Vision	Many screens and blinking lights
	Hearing	Noise/alarms
	Cognitive (understand, interpret)	Information overload
Action		
	Speaking	
	Moving	
	Fine-motorics /dexterity	Stress
	Cognitive (plan – act)	Information overload, confusion (wrong communication channel, forgetting protocol)

Figure 2.0.4 SD Triggers in the Control Room, (Gjøsæter et al., 2019)

Based on their findings by using personas to cover potential situational disabilities among stakeholders in disaster situations compared to the use of SA demons to find barriers to SA, Gjøsæter et al. (2019) conclude that SA demons are not covering all issues of loss of SA caused by SD, especially for stakeholders like the public and first responders. When it comes to Control room personnel, the SA demons cover SD like vision SD, hearing SD and cognitive SD to understand and act, but to not cover dexterity, which is the ability to manipulate control room equipment caused by stress, which can be influenced by cognitive SD and motoric SD like shaking hands and sweat. (Gjøsæter et al., 2019). So based on these findings, it looks like SA demons are suitable to use when designing for EMIS used in control rooms.

2.5 Universal Design and other design principles

Universal design is said to be necessary for some, useful for all. Universal design is the design of the environment, and the environment may be buildings, products, and services in our society (Begnum, 2020). The design should meet the needs of all people who wants to participate and use these environments, and universal design benefits everyone by creating what we surround our self with accessible, usable, convenient and a pleasure to use (Burgstahler, 2020). This can be the sink at the restroom, the doors in a house, a scissor, a keyboard, and the online banking system we use when paying bills.

Universal Design of ICT systems for emergency management may have an important impact on removing SA barriers and make the systems usable for a diverse group of users, also for those who are affected by situational disabilities (Gjøsæter & Radianti, 2018; Radianti et al., 2017).

2.5.1 UD and HCI Guidelines

There exists multiple UD and HCI approaches, principles, and models on how to meet good design criteria. This section is showing a limitation of two of these design approaches, that is actively used in this thesis to find out how UD can be used to mitigate barriers for best SA using EMIS.

The 7 Principles of Universal Design

The 7 Principles of Universal Design was developed in 1997 by a group of architects, product designers, engineers, and environmental design researchers. The purpose is to guide the design of environments, products and communications (*The 7 Principles*; Burgstahler, 2020), and can be adapted when designing and developing EMIS and organizing emergency centrals. These are the 7 Principles:

Table 2.0.8 The 7 Principles of Universal Design, (Burgstahler, 2020)

Principle 1: *Equitable Use.* The design is useful to people with diverse abilities, a website or a system is accessible to everyone, including people with different impairments. This includes providing the same means, provisions for privacy, security, and safety available, and making the design appealing should be equally to all users.
Principle 2: Flexibility in Use. The design accommodates a wide range of individual preferences and abilities. Providing choice of method and accommodate right- and left-handed access and use are examples on flexibility.
Principle 3: *Simple and Intuitive Use.* Use of the design is easy to understand, no matter the user´s experience, knowledge, language skills, or current concentration level. A control room panel with many buttons that are clear and intuitive employs this principle. It should also eliminate unnecessary complexity, accommodate a wide range of literacy and language skills, arrange information consistent with its importance, and provide effective.
Principle 4: *Perceptible Information.* The design communicates necessary information effectively to the user, despite the user´s sensory abilities. Use of different modes like

pictorial, verbal and tactile for redundant presentation of essential information, contrast between essential information and its surroundings, and differentiate elements in ways that can be described, like instructions and directions.
Principle 5: *Tolerance for Error.* The design minimizes hazards and the adverse consequences of accidental or unintended actions. Programs or systems are giving feedback, guidance, and warnings when the user is making inappropriate selections, provide fail safe features and discourage unconscious actions.
Principle 6: *Low Physical Effort.* The design can be used efficiently and comfortably, and with minimum of fatigue. The operator can maintain a neutral body position, use reasonable operating forces, and minimizing repetitive actions, and sustained physical effort.
Principle 7: *Size and Space for Approach and Use.* The design provides appropriate size and space for approach, reach, manipulation and use, no matter body size, posture, or mobility. A clear line of sight for any seated person, make reach to all components comfortable both seated and standing, and a variation of hand and grip size.

Shneiderman's Eight Golden Rules

Ben Shneiderman is an American scientist with expertise in human-machine-interaction, and he proposed these principles based on his experience, and the eight golden rules are supposed to help designers to solve problems with the goal of making a user-friendly design(Shneiderman, 1997). This guide may overlap with Jacob Nielsens 10 Usability heuristics for user interface design that will not be presented in this thesis.

"This guide is good for mobile, desktop and web designers", (Shneiderman, 1997).

Table 2.0.9 Shneiderman´s Eight Golden Rules (Shneiderman, 1997)

1. **Strive for Consistency**. Consistent sequences of action should be required in similar situations. Like throughout identical terminology, consistent use of color, fonts and layout. Exceptions are required confirmation of delete commands, or errors related to the interaction, like wrong password.
2. **Seek Universal Usability.** Understand the needs of diverse users and design for a simplified content. Add features for less experienced users, and for experts to enrich the interface design and improve perceived quality.
3. **Offer Informative feedback.** There should be interface feedback for every action. This can be modest for frequent and minor actions, and more substantial for infrequent and major actions. Good example is visual presentation of objects of interest.
4. **Design Dialogs to yield closure.** Sequences of actions should be organized with beginning, middle and end. Completing a group of tasks gives the user satisfaction of accomplishment, a sense of relief, a signal to drop a plan from their minds, and indicates they can prepare for next task.
5. **Prevent Errors.** Design the interface so that the user cannot make serious mistakes. If an error or mistake is done, the system should offer instructions for recovery.
6. **Permit easy reversal of actions.** Actions should be reversable. This feature relieves anxiety since an error can be undone.
7. **Support users in control**. Experienced users desire to be in charge of the interface, and the interface should respond to their actions. Surprises or changes in familiar behavior, having difficulty in obtaining necessary information, and not being able to reach their goals are examples.
8. **Reduce short term memory load.** Humans have a limited capacity for information processing in short-term memory. Designer must avoid interfaces that require the user to remember information on one display to use on another display.

2.5.2 WCAG and legislation

Web Content Accessibility Guidelines (WCAG) 2, developed through the W3C process by individual and organization, with a goal of creating a standard for web content accessibility, that meets the needs of individuals, organizations and governmental sector (*Wcag 2 Overview*). With four Principles; Perceivable, Operable, Understandable, and Robust, followed by Guidelines related to each principle, and with Criteria on three levels A, AA and AAA, where AAA is the hardest criteria to reach to experience full accessibility (*How to Meet WCAG*).

From 1.January 2022 WAD EU´s Web Accessibility Directive and WCAG 2.1 implemented into the Norwegian Equality and Anti-discrimination act, with requirements to the public sector (*EUs Webdirektiv (WAD)*).

2.5.3 Principles of designing for SA

There are also developed principles on how to design for better situational awareness, with the goal that creating system interface designs that will let the operator perceive information quick and with little cognitive effort (Endsley & Jones, 2004). These principles are relevant to this thesis where they are giving concrete guidelines on how to design for better SA in the light of the SA demons.

Table 0.10 Principles of Designing for SA (Endsley & Jones, 2004)

Principle 1: Organize information around goals (goal-driven processing) The information should be organized around the operator´s major goals, and not being presented in a technical manner. It is necessary to analyze and address what data and information is required to reach each goal. When there is multiple displays the information must be logically grouped to ensure that the needed data is provided.
Principle 2: Present Level 2 information directly – support comprehension The attention and working memory are limited, so considering which displays are

providing information to enhance comprehension will be good for SA. Prioritizing, congruence between data values and requirements, and the effect of various factors on other systems and operators' goal are examples on level 2 SA requirements.
Principle 3: Provide assistance for Level 3 SA – Projection Projection is the most advanced part of SA and requires a well-developed mental model. Systems providing projections for future events may be especially beneficial for less experienced operators. Examples on information necessary for level 3 SA is live trend displays and graphic changes in parameters over time.
Principle 4: Support global SA (data-driven processing) A SA problem occurs when the attention is directed to one system or set of information, while other important elements are being ignored. Displays that provide the operator with "the big picture" or global SA may be needed, and a high-level overview of situation should always be provided.
Principle 5: Support trade-offs between goal-driven and data-driven processing Make sure that the goal-driven (principle 1) and the data-driven (principle 4) approaches complements each other. Use of colors, light and load sounds from the systems may be salient features drawing away attention from the current goal.
Principle 6: Make critical cues for schema activation salient Critical events should activate critical cues, and these critical cues need to be determined and make salient in the interface design.
Principle 7: Take advantage of parallel processing capabilities Supporting parallel processing of information is beneficial for SA. Operators have a limited ability to take in an amount of information visually, while they are more able to process the information visual and auditorial simultaneously. Tactile information simultaneously together with visual or auditory information are other examples.
Principle 8: Use information filtering carefully Previous thoughts about information filtering are that it is aiding SA, and that it is better to present only the information the operator needs at any one time. But this approach has

shown to degrade SA instead. By presenting information clearly, whit the operator in charge of determine focus area is better than computer-driven strategies that provides a smaller set of information.

2.6 Summary

This Literature review searched for research and articles related to the research questions presented in the introduction of this thesis. Understanding Emergency Management, EM Stakeholders, and relevant technology used when developing EM systems, and further SA, SA demons and SA errors as barriers, and Situational disabilities, told what research is already exists and can be explored.

In Gjøsæter et al. (2019) findings on how Endsley and Jones (2004) SA demons do not cover dexterity on Control room personnel when doing a Scenario study, might already be an important finding when looking at potential SA barriers using EMIS in stressful situations.

Radianti et al. (2021) findings showed that humans are to blame in most SA errors, and technology is less mentioned in the discussion of understanding SA demons. However, as we are getting more digitalized, technology are playing a bigger role in SD and SA, and that is why UD and HCI approaches must be involved when developing EMIS (Radianti et al., 2021).

3.0 Methodology

This chapter will present different methodologies that are relevant for this project, choice of methodology, how this methodology has been and will be used in this research, ethical perspectives, including how data will be collected and stored.

The first section will look at qualitative and quantitative methodology, advantages and disadvantages, and argumentation for choice of method. This research will be done in the environment of operators using EMIS so there will be a discussion on use of ethnography or HCI Case Study as methods, and further look at observation and interview, and how this can be used to collect data for the research.

This chapter also covers the ethnical perspective on collecting personal data used in research, how Norsk Senter for Forskningsdata (NDS) will be informed about the research project, the rights of the participants, and how data will be properly stored.

2.1 Quantitative and Qualitative Methodology

This section will look at qualitative, quantitative, or mixed methodology, and an argumentation for chosen method will be presented. Qualitative or quantitative methodology are widely used research techniques. When doing research for this thesis it is possible to use these methodologies to look for any barriers in EMIS. And if there are any barriers, why and how this is the case.

2.1.1 Quantitative Methodology

Quantitative methods are often used to determine relationships, and will typically be presented in numerical form, and be described as a table, graph or statistic measurement like average variances or correlations (Kaiser, 2019). Quantitative methods like queries are low in cost, you can collect large samples, and can be done within a short timeframe. Quantitative method can be used to find out if something is a trend or a problem, and can further be used as a part of mixed method together with qualitative method, to see why this is so (Kaiser, 2019).

2.1.2 Qualitative Methodology

Typical for qualitative method is to study people in their natural setting, look at their behaviours, understand how people make decisions, how social, economic, cultural or physical context may influence their way of living, and how this is related to any researchers issues (Hennink et al., 2020). The language is used actively in the qualitative method, and the data is collected through interviews, observation and in text (Lazar et al., 2017). Qualitative methods may be time-consuming, be high in cost and can be done with smaller samples (Salminen et al., 2020).

2.1.3 Mixed Methodology

Mixed methodology is what the name suggests, a mix or a hybrid between qualitative and quantitative methodologies (Tagen George, 2022). The researcher combines elements from both methodologies by using techniques suitable for the research project, and an example can be collection of data using survey (quantitative methodology) for data gathering and further analyzation together with interviews (qualitative methodology), and further transcription, coding and analyzing this data (Tagen George, 2022). A mixed methodology can give the research both statistics and an in-depth understanding of a potential problem (Tagen George, 2022).

2.2 Ethnography and HCI Case Study

Ethnological research and Case Study are qualitative methodologies and are both relevant for this research. They can help understanding the use of EMIS and can reveal potential SA demons and barriers. That is why this section will look at Ethnography and HCI Case Study, and investigate benefits and limitations of both research methods.

2.2.1 Ethnography

Ethnography is a research methodology especially used by user experience professionals, where the goal is to describe a group of human, an institution, interpersonal behaviours, and material productions (Angrosino, 2007). Ethnological research is used to understand the problem, the context, the culture, or the group interactions (Lazar et al., 2017). This methodology is known for observing the participants for years in an anthropologist matter, while usability practitioners will support a specific design problem, due to the method's ability to collect more accurate and reliable data when answering a scenario question (Logan). This can be done by working and socializing with employees at a 110 central for a month. Methods available within an ethnographic study includes observation, interviews, and surveys, this to develop an understanding of the relevant domain, audience, processes, goal and context of use (Logan).

Ethnography in a HCI perspective is most valuable in an early stage of a project to support future design decisions but can also be used to evaluate an existing design. This is often used for very complex design problems because it can identify and analyze unexpected issues (Logan). Ethnography methodology is time-consuming, both when it comes to data collection and data analysis. People may not act as natural in shorter studies when a stranger is interacting their comfort zone, trust should grow over time, something that may affect the result of the data collection (Logan). Ethnographic research can investigate few cases, and often only one case at the time, so it is more suitable for one particular case.

2.2.2 HCI Case Study

HCI case studies are a qualitative methodology, based on real-world experiences, and the goal is to:

- Exploration: Understand a problem,
- Explanation: To understand context of use,
- Description: Documenting a system, context, or process, and/or
- Demonstration: Showing a potential new solution (Lazar et al., 2017).

To do this, the researcher can do in-depth examination of a small number of cases, in real environments, with real users, doing real tasks (Lazar et al., 2017). A HCI case study will try to understand how someone is using a system or a particular technology, rather than how fast someone can complete a task, and typical data sources in a case study may be artifacts, observations, interviews, and documents (Lazar et al., 2017). Designing a Case study consists of find what to understand, create a hypotheses, plan the granularity of what to focus on when analysing the data, and having a data analysis plan (Lazar et al., 2017).

Types of case studies are Intrinsic to investigate something specific in a given context, and Instrumental to generate general insights (Lazar et al., 2017). Case studies can also be divided into embedded and holistic, where embedded case studies are analyzing multiple units, while holistic case studies are looking at one unit (Lazar et al., 2017).

The benefits of case studies are the opportunity to collect a large amount of personal information, they can help formulating hypotheses, they can build a case for further research, discover new insight, and can get insight to improve the design (Lazar et al., 2017). As Ethnographic methodology, a Case study is also time-consuming, can be high in cost, and the limitation in amount of cases give smaller samples of data compared to quantitative methodologies like survey (Salminen et al., 2020). It is also important to remember that the researcher may be biased, and that it is hard to cover all aspects of an issue because of limited evidence (Yin, 2003).

2.3 Choice of Method

This research wants to investigate if there are barriers in EMIS causing SA demons. This statement can have been challenged by using quantitative method like a survey to support this claim. But based on the findings in the literature study, the pilot at Sykehuspartner, two observations at 110-centrals, and six interviews, it is safe to say that there are such barriers, and that is why further research will be done by using qualitative methodology, and observation and semi-structured interviews will be main parts of the data collection. Section 2.4 will explain the observations and the semi-structured interviews.

A HCI Case Study will be used as the approach in the research. An embedded Case studies make it possible to analyze three units: Sykehuspartner, 110 Sør-Øst, and 110 Øst. And gives a rich in-sight in how the operators experience and work with EMIS. The hypothesis is that the operators at meeting barriers, and may be hindered from SA, and the observations together with interviews will hopefully give answers on what barriers they meet, and why. Not being biased or not covering all aspects may be challenging, but a HCI Case Study will still give a great opportunity to understand how the operators preforms their job, how they interact with technology, and see how stressful situations have an effect on them when interacting with the EMIS.

2.4 Data Collection

This section describes how data was collected by observing operators when using EMIS in their natural work environment, and interviewing operators. Before the observations and interviews, guides were created with questions and categories. The observation guide was created based on expectations of how an emergency centre environment is, how it is to work there, and a pilot observation at Sykehuspartner. While the interview guide was created based on the observations, and further the essence of this thesis.

2.4.1 Participants and procedure

The analysis and results are based on one pilot observation at Sykehuspartner, two observations at 110 Sør Øst and 110 Øst, and six interviews. Four were proceeded with operators from 110, and two responders have previous experience as operators at AMK 113, that receives medical emergency calls.

The interviews with the 110 operators were proceeded at in a meeting room located at their central location, while the operators from AMK were proceeded digitally using Teams. A Dictaphone was used for audio recording, and the transcription was done by using the built in dictation service in Word.

The participants are anonymous, and no names will be used in this thesis. Because of the small sample of participants, the geographic and demographic information will also be anonymized, since this information may reveal their identity. The table under gives a small demographic overview of the responders in the interviews.

Table 0.1 Demographic overview of the responders

Age	Gender	Experience in central
30-62	Male: 5 Female: 1	2-12 years

Quotations from the observations are referred as O1 and O2, and quotations from the interviews are referred to the six responders, R1-R6.

Table 0.2 Quotation reference

Observation	Respondent
O1-O2	R1-R6

Responders R1-R2 and R5-R6 have experience from 110, and responders R3-R4 have experience from AMK.

2.4.1 Observation

“Look at behaviour, listen to perceptions,” Crabtree (1999). Observation lets the researcher observe verity of situations and understand them, they will get a backstage pass, were others don´t have access (Kawulich, 2012). Observations will provide a rich details description of settings in the field, and rich notes can be photographic (Kawulich, 2012). But this form of data collection does also require good memory and rich notes, and not all researchers find it easy to describe what they are observing (Kawulich, 2012). Other things to consider when observing is the fact that not everything is relevant and interesting for the project, and some people are not comfortable being observed (Kawulich, 2012).

Before observing operators, an observation guide was created so that I could follow a list of what I knew I wanted to learn and understand in advance. The observation guide was tested in an observation pilot. The observation will be used to build up an understanding of how EMIS are used, how EMIS are sharing information and tasks, how operators work, how stressful situations are handled, is the system intuitive or are the operator trained to understand the system, and how the operators act in these situations. In a Universal Design (UD) perspective how is information presented with colour, contrast, and size. I wanted to do an observation by taking part of their work environment, but also do direct observation when operators need concentration and must not be disturbed.

Before doing observation, an observation guide was created to have a plan for what to look for. This was categorized into a thematic framework covering Hardware, Software, the operators, potential SA demons and barriers, UD and WCAG challenges, HCI, how the central was organized, and barriers to look closer at.

Table 0.3 The Observation Guide

Category	Topics
Hardware	- Screens - Computers - Telephones - Radio - Mouse and keyboard - Headset - Mobile Devices - Etc.
Software	- Amount of programs - Screen pictures - "Noise" on the screen Light Blinking Other visual noise - Sounds - Colours - Maps Colours Icons - Updates Integration Changes Crash/Freeze - Interaction between software and hardware - Systems and connection to databases and servers
Human	- The people/ The Operators Background Experience Digital knowledge - Their opinion: What do they like What they don't like Opinions on potential improvement
SA demons and	- SA demons Overload

barriers	Memory trap etc. - Language barriers - Dialog under stress - Work around
Universal Design (UD)	- The UD perspective - Screens - Software Colours Fonts Contrast - Web accessibility principles: 7 Principles of UD, Nielsen´s 10 Usability Heuristics etc.
Human Computer Interaction (HCI)	- Demonstration of workflow - HCI under training for position - HCI under Stress - Multitasking - Navigation in a program - Navigation between programs - The meaning of signals
The Central	- Geographical area - Local workflow: Connection with ambulance and police ("Trippelvarsling") Escalation Traffic on the line - Cooperation with ambulance and police - Routines and flow for evacuation of the central
Findings	- Possible barriers

Observation will be important to get an in-sight before creating an interview guide, when interviewing operators later in this project by using semi-structured interview as methodology. In the beginning of phase 2, observation was planned in two alternative ways, depending on what kind of agreements it was possible to make, to have alternatives when collecting data relevant for this thesis. Visiting 110-emergency centres was the main goal being the core of this thesis but visiting the operation- and observation centre at Sykehuspartner was an alternative if contact with 110 was not possible.

Sykehuspartner are observing all medical system at all hospitals in Helse Sør-Øst, and some of these systems are critical when it comes to life and health, and the operators may experience stressful situations when many alarms go off at the same time. They are a part of the Norwegian emergency management team and are using EMIS Helse SIM. The landslide in Gjerdrum December 2020 and 22. July in Oslo are examples on major incidents they had to act and be a part of.

Sykehuspartner responded quickly to the request to come for observation. In the planning and development of the observation guide for Sykehuspartner, 110 Sør-Øst responded. This made a good opportunity to use the observation at Sykehuspartner as a pilot to be more prepared for the observation at 110 Sør-Øst in Tønsberg. After the observation at 110 Sør-Øst, 110 Øst replied, and an observation appointment was made with them as well. This gave the research three units to investigate in the HCI Case Study.

2.4.2 Semi-structured Interview

Interviews give the opportunity to go-deep, get detailed responses, they can be open-ended and exploratory, and even with specific questions, interviews are also flexible (Lazar et al., 2017). Compared to surveys, interviews are harder to conduct, and it consists of hard work when it comes to time, the responsibility of listening and taking notes, a lot of afterwork and less data material (Lazar et al., 2017). Even so, the advantage of using interviews and the need of these detailed data from the operators, makes this method suitable for the thesis.

Semi-structured interview is a mix of structured interviews, the questions are predetermined, and unstructured interviews, none of the questions are predetermined, within a preterminal thematic framework (Tegan George, 2022). These interviews are more flexible, open-ended, and can help the researcher to see patterns, if the questions are asked in an organized and developed system (Tegan George, 2022).

To conduct a semi-structured interview can be divided into five steps; what is the goals and objectives, designing the questions, recruit participants, decide on how the interview will be recorded, and at last conduct the interviews (Tegan George, 2022).

The advantage of semi-structured interview is the mix of structured- and unstructured interviews; it gives you comparable and reliable data, gives the researcher flexibility in form of asking follow-up questions, the thematic framework is prepared and a two-way communication won't be distracted, and it gives detailed and rich data when answers can be clarified, elaborated and rephrased during the interview (Tegan George, 2022). The disadvantages include low validity, it can be hard to compare responses, it may be a risk of research bias when the researcher asks leading questions or seek prejudiced answers, and it is not easy to develop good semi-structured interview questions when balancing planned and spontaneous questions for participants with a different will to share (Tegan George, 2022).

After the pilot observations at Sykehuspartner, 110 Sør-Øst and 110 Øst, an agreement of coming back for interviews was made. This was also mentioned in the e-mail they got in advance of the observations. All responded positively on participating in interviews and this was helpful in the planning of having a meeting room at their location, and operators who wants to participate.

It was important to make the operator feel comfortable and relaxed to build trust between us, and to make the interview be more of a conversation, where the operator is in charge. A semi-structured interview will make it possible to go deep by creating questions sorted into categories, and the operator can talk freely until I got the answer. The interviews were recorded auditorial and saved as a mp3-file. It was six responding operators, and the interviews were approximately 1 hour long.

Interviewguide

Semi-structured interview was used as methodology for the interviews, and the interview guide was organized into five main parts:

Table 0.4 The Interview Guide

Introduction	Talking about themselves, their background, experience, digital knowledge, about their training period as a new operator, about their workspace, and use of systems.
About the systems they are using	Workflow in the systems, human-computer interaction (HCI), if the systems are intuitive or not, their tasks in the systems, how much time they spend on proceeding tasks, what the systems demands from the operator, the design of the systems, and use of warning signals.
Barriers	How their experience of the systems in demanding and stressful situations, and if they are experiencing any barriers at any time using the systems, or if there are situations where the systems should help them proceeding any tasks, are preventing them from doing the next task, and demands to much of their cognitive capacity.
Potential improvements	The operators were asked, based on their answers, if they had any ideas or hope for improvements, and what that may be.
End part	They were asked to say what was on their mind.

2.4.3 Data Storage

The data collected from the interviews will be stored at Oslomets cloud service, OneDrive. OneDrive requires two-steps verification. Audio recordings are personally identifiable, and must be protected even if the audio does not consists of personal sensitive material.

2.5 Method for Analysis

Thematic analysis is one of the most used methods for analyzing qualitative data, and are applied to set of text from interviews or transcription (Caulfield, 2022). This lets the researcher examines the data to identify topics, ideas and patterns, and the most common approach is the six-step process, developed by Braun and Clarke (2006): Familiarization, coding, generating themes, reviewing themes, defining and naming themes, and writing. Thematic analysis is used to find people´s views, opinion, knowledge, experience or values, and are a letting the researcher interpreting data in a flexible matter (Caulfield, 2022).

Inside thematic analysis, there are two different approaches: Inductive and deductive approach, where an inductive approach is allowing the data to determine the themes, while deductive approach involves coming to the data with some preconceived themes, based on expected theory or knowledge (Caulfield, 2022). When indictive or deductive approach is chosen, the six-step process can start (Braun & Clarke, 2006).

2.5.1 Analyzing findings

To analyze the answers, an analysis for was developed to systematically organizing the findings from the interviews and observations. The categories were based on what the operators were telling and their challenges. The factor describes where or what to find the challenges. Keywords helped explaining the findings with few words, and the quotation are the statement of a finding. Interview and time help to get back to the quotation in the recorded interview, and comments are notes to say something on how this is a problem, how this can relate to other findings, and thoughts on how this could be implemented into results or how this can be improved using universal design.

Table 0.5 Analysis Form

Category	Factor	Keywords	Quotation	Interview	Time	Comment
Training	Situation					
Workplace	Technology					
Workflow	Human Factor					
Warning	Human-Computer interaction					
Stressors						
Position						
Design						

When all the findings were added into the analysis form, one form for each category was created. The challenge was described and was connected to type of barrier and design principle.

Table 0.6 Analysis form looking at challenge, type of barrier and design principles.

Challenge under category	Type of barrier or demon	Design Principles
Describing each challenge described in interview or observed under observation.	Barrier or challenge described in a design principle or Endsley´s SA demons.	Which design principle may solve this type of challenge: - WCAG - 7 principles of universal design - Endsley´s Designing for SA

2.6 Ethical Consideration

To protect the interests of the participants in this study, this research will follow ethics and privacy standards. The research study aims to conduct transparency, credibility, and liability, and the researcher must respect the participants rights and the agreement that was consented. Their privacy, security and anonymity must be ensured. It is important to build trust between the researcher and the participants.

This research follows the ethical guidelines for research at Oslo Metropolitan University. The guidelines are based on the Act relating to Universities and University Colleges, the Act relating to Ethics and Integrity in Research and Pursuant regulation, and the ethical norms at The Norwegian National Research Ethics Committees (*The ethical guidelines for research at OsloMet*, 2022). This research will be reported to NSD, and interviews will not be conducted before NSD has approved the research project and how the participants interests are protected.

4.0 Results

This chapter presents the results of the findings of this study. The first section explains the pilot at Sykehuspartner HF. The second section explains the observations and the results and findings from the observations at 110 Øst and Sør-Øst. The third section explains the results and findings from the interviews divided into categories. And the last section is a summary of the pilot, the observations, and the interviews.

4.1 The Pilot

To understand how it is to work in an emergency or control centre under stress, and how operators are using management system, Sykehusparter´s observation centre was visited. A pilot observation guide was created, and this was later revised before the observations at the emergency centres 110 Øst and Sør-Øst based on the experience from this pilot. This pilot was also the foundation for further development of an interview guide later in the project.

This observation centre is observing all critical systems used at the hospitals in Helse Sør-øst, the southern and eastern part of Norway, and is divided into nine healthcare trusts (HF). This observations centre is also connected in major incidents where many people are involved and must delegate resources to make sure that all hospitals can receive patients, and that the location of the incident is getting medical equipment from the hospitals. A major incident with many people involved is rare, and this requires a huge adjustment for the operator involved, if the day otherwise was calm. This is the result from the pilot.

4.1.1 The pilot observation

The observation took place under a maintenance routine, where all servers are being disconnected and connected. The operators at the observation centre are getting a written message from the system owner that the server is going down, and the system owner is giving the operator message back when the server is supposed to be back on. The operators are observing all alarms, and if everything is fine, they will check this server out, but if there is still an alarm going, they must communicate back to the system owner that the server and system are still down after the maintenance.

For the users at the hospital, the server being turned off may first be experienced as a drop. In worst case, if the backup server is not being connected or the server is not getting back on, the system is not working at all. Deepening on which system that is down, this may have a big impact on routines and the level of stress at the hospitals and be critical in the matter of health and lives.

The table under is showing the geographical area Sykehuspartner is covering, how the environment in the central was during the evening and night, and how the operator's workspace was organized.

Table 0.1 Sykehuspartner geographical area, the Central & Workspace

Geographical area	**The Central**	**Workspace**
Sykehuspartner HF is owned by Helse Sør-Øst and supports all hospitals trusts in this region: Akershus universitetssykehus HF, Oslo universitetssykehus HF, Sunaas HF, Sykehuset i	- Low lightning - No systems or alarms with sound - Quiet chat on Skype, only typing. - Two operators on watch cooperating	One curved desktop, and each operator are using two large, curved monitors. - One mouse - One keyboard

Vestfold HF, Sykehuset Innlandet HF, Sykehuset Telemark HF, Sykehuset Østfold HF, Sørlandet sykehus HF, and Vestre Viken HF	- Main wall with 12 tv-monitors showing OBM and DIPS status.	

The main observation systems are Operation Bridge Manager (OBM) and Microsoft System Center Operations Manager (SCOM). Helse CIM is a management system used for safety and emergency, used by the Norwegian Directorate of Health, Norwegian institute of public health, and all HFs including Sykehuspartner HF. Skype is the main communication system used between the observation centre and the system owners, and all communication went in a silent mode with written messages. DIPS is the interaction system between Sykehuspartner HF and the other HFs in Helse Sør-Øst.

Table 0.2 Sykehuspartner Systems

Software	**Type of System**
Operation Bridge Manager (OBM):	Observation system
Microsoft SCOM: Surveillance system for the servers.	Observation system
Helse CIM	Management system for safety and emergency
Skype	Communication system
DIPS	Interaction system

4.1.2 Findings from the pilot

The observation at Sykehuspartner HF was meant as a pilot to understand how it is to work in an emergency or control centre under stress, and how operators are using management system, before doing the observation at emergency management centres. The observation centre is also connected when there is major national incident where many people are involved, and need good SA to manage this stress. From this pilot, some issues were observed:

Table 0.3 Findings from the Pilot

Challenge	**Barrier**	**Design Principle**
Consistent use of colours	Factor: Technology	Shneiderman´s eight golden rules R1 WCAG 1.3.3 Sensory Characteristics and 1.4.1 Use of color
Physically organization	Factor: HCI SA demon Attention tunnelling Requisite memory trap	7 principles of UD P3, P6 Shneiderman´s eight golden rules R5
Alarms	Factor: Technology SA demon Misplaced salience Out-of-the-loop	

	syndrome	

Consistent use of colours

Different use of colours when the systems are displaying criticality. When OBM is using a colour spectre of four colours, SCOM is only using three. This can cause confusion, especially in stressful situations, and the operators at the control centre believed this could lead to misperception. The systems were also using different date formats, which also was confusing. The table compairs the meaning of the colours:

Table 0.4 Colour explanation of Warning signals

Color	Icon	OBM	SCOM
GREEN		Information	OK
YELLOW	!	Warning	
ORANGE	!!	Major	Warning
RED	X	Critical	Critical
		YYYY-MM-DD	DD-MM-YYYY

Stive for consistency, like identical terminology, consistent use of color, fonts and layout (Shneiderman, 1997). This is two different systems, but it could be a nice feature to predefine the colors and the criticality to suit the central and it´s users and other systems.

The colours were supported with icons. And they could see the meaning of the codex by holding the mouse pointer over the chosen colour. WCAG is specifically saying that colour is not to be used as the only visual means of presenting information, success Criterion 1.3.3 Sensory Characteristics and 1.4.1 Use of color (*Wcag 2 Overview*). The colors together with the icons are not a solid method of presenting information and could have been visual together with written information. Both because the use of color is not consistent in the two systems, and because color weak people could misinterpret this warning signals.

Physically organization

All alarms must be organized into blocks, where each block represents a particular system. This organization is done manually by the operators. All de alarms are lying in a list, and the operator must drag and drop the alarm to the correct block. The operators say that it easy to drop the alarm into the wrong block. In hectic situations where a system owner wants to know if there are any warnings they need to know about, the operator may provide incorrect information because they have ignored an alarm laying in another block.

This challenge can be related to the SA demon Attention tunnelling, where focusing on one area is drawing attention away from other critical area, creating an attention tunneling (Endsley & Jones, 2004). There are many alarms going off during maintenance evenings, and the manually organization that could have been automated, are forcing the operator to focus on this job, instead of following up on the alarms and notifying the system owners. Requisite memory trap can also relate to this challenge, where the system is dependent on the operators´ response to the alarm in critical situations (Endsley & Jones, 2004). The attention is drawn to a task that could have been automated, and a task they are most likely to perform incorrectly.

The design guide 7 principles of UD´s Principle 3, simple and intuitive use to eliminate unnecessary complexity and provide efficiency (Burgstahler, 2020). Organizing the alarms manually are not efficient, and together with principle 6, low physical effort, the operator will also minimize repetitive actions. The possibility of making mistakes can also relate to Shneiderman´s eight golden rules, prevent errors, design the interface so that the user cannot make serious mistakes (Shneiderman, 1997). The system should also offer instructions for recovery, while the operators at Sykehuspartner will not know the error without checking for it themselves.

Alarms

Some challenges they are meeting with the alarms are:

a) There are often delays, so even if everything is fine, the alarm is still showing in their system.
b) There are many false alarms, so a small drop may trigger an alarm, and the delay makes the alarm continue to show in the system.
c) And because of a & b, they need human confirmation from the system owners. And all this communication goes through a silent, written chat.

This challenge can be related to the SA demon Misplaced salience, where some objects or information takes away attention from other important data (Endsley & Jones, 2004), in this case the delayed or false alarms. This challenge can also relate to the SA demon Out-of-the-loop syndrome, where the automation are not involving the operator before something is a problem or the warning system fails (Endsley & Jones, 2004).

The principle of designing for SA, make critical cues for schema activation salient, are supporting the ide that critical event should activate critical cues. The problem is the delay in the system, so the operators cannot trust the alarms. The warning system fails, and all surveillance must be done manually by asking each system owner if they got contact with their own servers and databases. This alarm systems should be robust and precise if such design principle is to have any value.

4.1.2 Summery of the pilot

This pilot had a great value. The pilot observation guide was tested for further development for the next observations. It was interesting to watch the operators during a hectical maintenance evening, even if nothing critical happened. These centrals have their own vibe, and the operators are focused, but are free to chat when the situation is calm. It was instructive to see how the operators were interacting with the systems, and how much impact on the workflow the systems have. The challenges observed that had the most negative influence on the operators were the not consistent use of colours to explain criticality. How the operators had to manually move alarms into blocks, and how easy it was to do mistakes. And how the alarm system was to a small extent reliable.

4.2 The observations

This section describes the observations at 110 Øst and Sør-Øst, where they are located, the emergency centrals, their workspace, the operators, and the systems they are using. The challenges that were observed will also be presented as findings. After the pilot observation, a complete observation guide was developed. It was much like the last draft but was customized to fit an emergency centre. It is not allowed to bring any digital equipment into the centrals, so the observation was documented with pen and paper. This is the result from the observations.

4.2.1 Geographical area, workspace, and hardware

To understand the geographical area these centrals are located at, the working environment inside the centrals, and the operator´s workspace, two tables organized by location are presented.

Table 0.5 Geographical Areas 110 Øst & Sør-Øst

110 Sør-Øst	**110 Øst**
110 Sør-Øst covers the geographical area Vestfold og Telemark, and the old Buskerud.	110 Øst covers the geographical area old Østfold, Follo, and Romerike.

- Mountains, Forest, and Sea - Several cities - Popular areas with cabins all year - A lot of traffic - Approximately 750000 people in this area at all times.	- Forest and Sea - Several cities - Popular areas with cabins during summer - Heavy traffic - Approximately 750000 inhabitants live in this area.

Table 0.6 The Centrals 110 Øst & Sør-Øst

110 Sør-Øst	**110 Øst**
- Low lighting - Sound from the telephone, the noise detector, and the operators talking with callers, the ambulance emergency centre (AMK) or the Police. - Main wall with 8 TV monitors showing Live traffic view, News, and a map from the fire stations in the district. - A digital clock. - A large touchscreen primary used to show Windy premium, an advanced weather forecaster application. - A Locus Mobile device. - Emergency suitcase with radios if all systems are shutting down, or	- Low lighting - Sound from the telephone, the noise detector, and the operators talking with callers, the ambulance emergency centre (AMK) or the Police. - Main wall with 10 TV monitors showing live traffic, Locus Scala, the news. - A digital clock. - Back wall with one information monitor. - A Locus Mobile device. - Emergency suitcase with radios if all systems are shutting down, or in case of a major incident in the area and the operators need to evacuate.

in case of a major incident in the area and the operators need to evacuate.	

Table 0.7 The Workspace 110 Øst & Sør-Øst

110 Sør-Øst	**110 Øst**
Curved desktop - 5 monitors - 1 touch screen - 3 mice - 2 keyboards - 1 headset - A radio	Curved desktop - 5 monitors - 1 touch screen - 2 mice - 2 keyboards - 1 headset - A radio

4.2.2 The Operators

Most of those working at the 110-emergency centrals are fire fighter or have a fire technical background. Some are having a background from the police. Most will say it takes between one and two years before an operator are fully educated and comfortable with most systems and situations. There is an advantage to have a good geographical knowledge of the area they are supporting, but most 110 centrals in Norway are centralized and are covering large geographical areas, so this is not a requirement. It is important to be a calm person, be empathic and understand other people. The caller is often in an emergency, and the operator must try to calm the caller down and at the same time get as much information as possible. The operators under these observations were all social, and being a good team player is said to be a good quality.

The most challenging aspect of being an operator at a 110-emergency centre is receiving calls from people in major incidents, especially if children are involved. It can be hard to calm the caller down and understand the situation. This can be caused by language barriers, it is not always easy to search addresses when some callers also use local names of certain areas, or the caller´s stress level does not necessary correlate with severity. But the fear of receiving a call concerning own family or friends are the first thing the operators mention as the biggest stress element, when they get the question about what stressors at work.

4.2.3 Software

This is a small description of the most relevant systems observed at the centrals, and the table shows where the systems are used, followed by a system explanation.

Table 0.8 The Systems 110 Øst & Sør-Øst

110 Sør-Øst	**110 Øst**
Vision: Main EMIS	Vision: Main EMIS
Locus: Today for automatic alarms	Locus: Today for automatic alarms
Windy Premium	Windy Premium
E-Call	E-Call
Crash Recovery	Crash Recovery
Video link	Video link
	Detec Next *

*Detec Next is in 110 Øst for observation of one specific area.

Vision

Vision Is the main EMIS system they use today, with an integration with Locus. This is “the old system” which is going to be replaced with a new version of Locus system that fulfils the functions Vision and Locus together are doing today.

Locus

Locus today is the system used for automatic alarms, but the operators are also searching for position in this system, and sends it to Vison, where the incident is opened. 110 are today waiting for a new Locus version that will replace this older system together with Vision.

Windy premium

This weather forecast system is used to keep track of weather and wind. This system is especially important when there is a wildfire or accident with dangerous cargo, and the operators are using this as a desktop system and are displayed on a big TV in the central.

E-Call

Emergency call (E-call) are connected to the phone system provided by the car supplier. Many new cars are equipped with an emergency button inside the car, and when this is pressed, the car supplier gets an emergency call which they will further connect to the emergency agency in the correct country.

Crash recovery

This system is used in situations where it has been a car incident and the fire fighters needs to get a view of the car model to see technical features like placement of batteries, electricity and gas tanks etc. The operator will find the correct model by searching the registration number of the vehicle. This system can only be used by one operator at the time, it is not often in use, and it can be integrated into Locus, but they are not today.

To share information from crash recovery, the operator needs to take a photo of the PC display with a mobile Locus device, that is placed on the floor in the central. The photo is sent to the same mobile device installed in the fire engine. This is not a very handy way of sharing information, and the operators hope this can be done more agile in the future.

Video link

In some emergencies the operator would like to see the situation to get a fuller picture. In these cases they can send a video link to the caller, and the caller can film the accident.

> O2 “I don´t think video link is suitable in most cases here at 110. The caller is forced to watch the accident through the mobile phone. And we are losing focus of the caller that we should take care of.”

Some of the operators do not think it is a good idea to use video link in traffic accidents. The public should not have to film injured people, since this can feel intrusive and dramatic. But it can be helpful in situations where a caller number two are observing a fire from a distance and will give both the operators in the central and the fire fighter on the way an overview of the situation.

> O2 “In some cases it is nice when a caller number two can observe the fire on a distance. Then we can observe the fire from the outside until the fire department is at site.”

Detec Next

Detec Next is used by 110 Øst. The old town in Halden is protected area and therefor a system called Detec Next is installed. This system is installed with cameras, infrared cameras and heat detectors, and an automatic alarm alert 110 Øst if it senses unregular temperature changes.

4.2.4 Routines and Workflow

1.operator, the interviewer: Receives the call and starts the interview of the caller. Starts by getting the address or location and opens an incident case in the system. Types in information about the incident into the opened incident. If the emergency network is connected and more agencies are on the line, the operator is informing the caller about this.

2.operator, the listener: Is working parallel with the interviewer. Is listening to the conversation and may help if it is hard to find the location. The listener is organizing resources and is connecting to the emergency network if this is necessary.

Triple alerts: The connection between the police (112), AMK (113) and fire (110). In cases where more than one emergency agency must be involved: fire in building, traffic accidents and accidents in tunnels, accidents in water and at sea, avalanche and landslide, acute pollution, bomb threats, and accidents with many people involved are examples on when the emergency network is connected.

The listener is connecting to the emergency network when escalation is needed. The interviewer is orally communicating with the other emergency centres. They are sharing place, type of emergency, and scop.

4.2.5 Findings from the observations

The observation at 110 Sør-Øst and 110 Øst gave an understanding of understand how it is to work in an emergency centre and how operators are using emergency management information systems. From the observations, some challenges were observed:

Table 0.9 Findings from the Observations

Challenge	Barrier	Design Principle
Workspace	Factor: HCI SA Demon Attention tunneling	The 7 principles of UD P6,P7
Position	Factor: HCI SA Demon Attention tunnelling WAFOS	Designing for SA: SA 1
Hidden information	Factor: Technology SA Demon Complexity creep	Designing for SA: SA 1
Wrong information	Factor: Technology SA DemonErrant mental model	
Detec Next	Factor: Technology SA Demon Misplaced salience Errant mental models	Designing for SA: SA5

Workspace

The operators are equipped with a doble set of mouse and keyboard, one set for each Vision and Locus. Some are also using a mouse on the telephone display, which is a touch screen, because it can hard to get good precision using the fingertip. The organization of the three-meter-long desktop with software and hardware in relation to the operator's workflow, with the main system on the left side and the telephone system to the right, does not seem to be well considered.

This challenge may lead to Attention tunneling when the operator is to focused on one side of the desk, and is missing out on important information or actions on the display on the other side. These challenges can be related to the 7 principles of UD, principle 6: Low physical effort, the design can be used efficiently and comfortably, and the operator can maintain a neutral body position. And principle 7: Size and space for approach and use, where the design should provide appropriate reach and use, no matter body size, posture or mobility (Burgstahler, 2020).

Position

Finding the position is critical to be able to open an incident. It is flexible, and they can search for the address in both Vision and Locus, but the operators preferer Locus. In Locus the hole search (street + house number and municipality) is done in one column, while in Vision they need to search the name of the street and use a drag down menu to choose the house number.

The search engine in both systems is sensitive to spelling mistakes, so the operators are trying to spell as little as possible when searching.

> O1 "Type as little as possible, but do not type the name wrong!"

> O2 "There are some local names that are harder to search for, like B R A veien. You can´t type braveien or bra veien."

It is suggested that a spelling- or autocorrection could have been integrated into the search engine and the information field.

> O2 "It might have been a good idea to integrate an autocorrection or autocomplete program in both the search field and the comment field, so that both address search and typing information into the incident are going

much faster."

This challenge may lead to attention tunneling when much time and focus must be used on one task and can miss out on other important information from the caller, other systems, other operators, or warning alerts. Finding the address is crucial and is described to be a huge stressor that might follow the operator through the call also after the address is found. This can relate to WAFOS, where stressors can be triggered at high-consequence events and time pressure, and WAFOS can steal attention and working memory (Endsley & Jones, 2004).

It is not easy to find a suitable principle or guide for this challenge, but organizing information around goals so that the operator can perform is something to aspire for, and a search engine more capable of helping with use of autocorrection or autocomplete can be a solution.

Hidden information

There are some possibilities to store personal information in Locus in cases where the caller might be a threat to the fire department, and they must bring police assistance. This is not sensitive data saying anything about medical diagnosis, but a line saying, "may cause a threat, bring police assistant".

During the observation one of the operators got a call that seems normal given the circumstances, but because of local knowledge, the operator recognized the address and checked the information box, where information about the caller may be stored. Some callers may be dangerous, and in these cases the fire department must bring police assistance. The system does not provide the operator this information automatically, and this information lays hidden behind multiple options and actions.

Complexity creeps may slow down the ability to perceive and understand information (Stratmann & Boll, 2016), and in this challenge it seems like the operators must eighter understand the danger and seek for more information, or always seek for more information. This information is not provided in cases where this is needed.

This information box can be a helpful feature, but not so often in use. When organizing information around goals this box should be highlighted if there are important information stored.

Wrong information

During the observation there was a fire in a modernistic villa. The operator used the map to look at the position and street view to get an impression of the house and the area around. The house on the street view map was a house from the 60-70´s. Later the local newspaper posted pictures from the scene, and there was a modernistic house and not the old house from the street view map, that house was replaced.

Errant mental model explain how a person based on previous experience misinterprets new data (Endsley & Jones, 2004). This challenge shows that wrong data can have an impact on decision making and could give consequences if the information is wrong, where the old villa was exchanged with an apartment building.

There are not easy to find a suitable principle for this challenge, but the operator should be able to trust the information the system provides.

Detec next

Detec Next is probably calibrated to alert on a too low temperature, meaning that every time the sun is shining on a roof with metal or glass, someone is having a barbeque in a backyard, or an excavator is digging for a couple of hours, an alarm goes off. The operator must check the cameras to see if there is a fire and close the alarm. The problem lays in the number of false alarms and this steeling focus from other incidences, and if Detec Next alert at the same time as another accident and the operator postpones checking this alarm the one time there is a fire. The operators must gamble on a phone call from attentional people nearby together with the alarm just in case they are ignoring it for a minute. Detec Next reminds them of the boy who cried wolf.

This challenge is related to misplaced salience when it draws away attention from other tasks, are warning the operators when there is no threat, or pop-up windows are hindering the operator in a conversation regarding other accidents. An errant mental model will say that this is a false alarm again and the data can be misinterpreted (Endsley & Jones, 2004).

The salient feature is drawing away attention from the current goal (Endsley & Jones, 2004), but this alert should not be ignored. A solution can be support of trade-offs between goal-driven and data-driven processes. And these sensors should be calibrated to be more trustworthy.

4.2.6 Summery of the observations

The observation at 110 Sør-Øst and 110 Øst were educational and interesting. The operators were welcoming and shared their experience and way of working during a day with pleasure. The observations made a good foundation for further work with an interview guide based on predictions and new knowledge.

The main findings during the observations were:

- The operator’s workspace was not well-considered in any of the two centrals. This may lead to attention tunneling and physical exertion.
- Finding the position of an accident is precarious and was a huge stressor. This because the address must be found before an incident can be created in the system and to send out resources, and because the search engine is sensitive to spelling mistakes.

- The hidden information box seemed to be rarely in use, but in cases where it could be helpful, it was hard to find or easy to forget about. The information was important, and the consequences could be catastrophic, given that the fire department responded to a dangerous person with weapons without police escort.
- The system provided wrong information, the house on the street view was replaced. When the geographical situation is something else than what was expected, can lead to wrong decision making.
- Detec Next was told to be stable in other areas, but it was probably not calibrated, and this was leading to many false alarms. The consequences were misplaced salience and errant mental model.

4.3 The interviews

This section describes the result from the interviews. These findings are divided into challenge categories: Training, workplace, routines and workflows, warnings and signals, position, design, and triple alert. All category section starts with an overview table describing the challenge, which factor is affected by the barrier, type of SA demon if any, and design principal suggestions:

Table 0.10 Participant and observation description

The 7 principles of UD	Shneiderman´s 8 golden rules	Designing for SA
P1-P7	R1-R8	SA1-SA8

Each section is followed up by describing the challenge with statements, and further how types of barriers are affecting this challenge, and which design principles that may be used to mitigate these. This is the result from the interviews.

4.3.1 Training

Training means both the period a new operator needs to learn and be confident with the systems, and the training experienced operators need to keep their knowledge maintained.

Table 0.11 Training Challenges

Training challenge	Barrier	Design Principle
The time it takes to learn the systems	Factor: HCI SA Demon Complexity creep	The 7 principles of UD: P3 Shneiderman´s 8 golden rules: R2
Different guidance	Factor: Human Factor SA Demon Complexity creep	The 7 principles of UD: P2
Learned and trained, not intuitive and self-explanatory	Factor: HCI SA Demon Complexity creep	The 7 principles of UD: P3
Training maintenance	Factor: Situational SA Demon Complexity creep Requisite memory trap WAFOS	The 7 principles of UD: P3, P5 Shneiderman´s 8 golden rules: R1, R7: Support users in control

Change of focus is trained.	Factor: Human Factor <u>SA Demon</u> Attention tunnelling	<u>Designing for SA</u> SA1, SA2
The consequences of making mistakes	Factor: Technology <u>SA Demon</u> WAFOS	<u>The 7 principles of UD:</u> P5 <u>Shneiderman´s 8 golden rules:</u> R3, R4, R5
Low level of mental capacity	Factor: Human Factor <u>SA Demon</u> Attention tunnelling Requisite memory trap WAFOS Data overload Complexity creep	<u>The 7 principles of UD:</u> P3, P4 <u>Shneiderman´s 8 golden rules:</u> R8 <u>Designing for SA:</u> SA1, SA2, SA4, SA7
A new system will be even more complex	Factor: Technology <u>SA Demon</u> Complexity creep	<u>The 7 principles of UD:</u> P3, P4 <u>Shneiderman´s 8 golden rules:</u> R7 <u>Designing for SA:</u> SA1

The time it takes to learn the systems

It takes much training and time to feel safe and confident using the systems. Most training start with system training outside the emergency centre. They need to learn the systems well before they are ready for answering callers. This training period takes approximately 1-3 months, and up to a year before they feel safe interacting with the systems. Talking to the callers is not the only challenge in this job, but learn the systems well, and remember all features. This can also relate to the training for maintenance aspect, where some features are rarely in use, and new and experienced operators must train and maintain this knowledge.

R1 “I think it took around one year before I felt a good workflow. I remember someone told me when I started that it would take one or two years to be a good operator. This includes the use of the systems and handling the caller, but there are many features you rarely use, so automate these things takes extra time.”

This can be seen in context of the SA demon complexity creep, where the system got so many features that people find it hard to understand or remember how it works (Endsley & Jones, 2004). By decreasing complexity may lead to reduction in the need of more training.

The use of principle 3, simple and intuitive use in “The 7 principles of UD” suggests a design which is easy to understand no matter experience, consistent information arrangement to eliminate unnecessary complexity (Burgstahler, 2020). Shneiderman´s second golden rules suggest the seek for universal usability, meaning that the design should simplify the content, by adding features suitable for less experienced users and the experts (Shneiderman, 1997).

Different guidance

This challenge relates to how long it takes to learn the system, and that there is hard to learn a practical workflow when the operators are using the system differently. There are often different operators that are teaching new operators how to learn the systems. But it is hard to learn the systems when it is different operators, with different workflows that are learning how to do tasks.

R1 “When you are new and are training to be an operator, especially in the beginning, there are not always the same person with you from time to time. They are maybe doing one thing in three different ways, and then it´s up to you to understand how you should do the task.”

This challenge can relate to the SA demon complexity creep when there are many features' people are finding hard to understand, and Endsley and Jones (2004) do also suggest decreasing complexity to prevent the need of more training.

This may come in conflict with “The 7 principles of UD” principle 2: flexible in use, that supports provision of multiple choices (Burgstahler, 2020). It can be positive having options, but many operators are getting confused when That is why it is important to pay attention to this challenge and develop good routines for training for a consistent navigation for training purposes.

Learned and trained, not intuitive and self-explanatory

The systems are not intuitive, you don´t know how to use them without practice. Most of the interaction with the systems are learned and trained, compared to the systems being intuitive and self-explanatory.

R1 “I felt, when I started here, that the systems were a small extent of self-explanatory. They are developed for this kind of work, and that requires training.”

R6 “I am actually not sure what is self-explanatory.”

R3 “I would say that perhaps 90% is training… You know as a professional what to fill out in the forms and what you want to know, but when things are happening fast, not much feels intuitive. You must ask your colleague if you don´t understand something, there are not much you can figure out on your own.”

This challenge is also connected to SA demon complexity creep, and as the operators explains the systems they use as not self-explanatory, it demands a lot of training to know how to use them and maintain this knowledge. Again, principle 3, simple and intuitive use, in “7 principles of UD” explains that systems should be designed in an intuitive way, and Scneiderman´s second rule explains universal usability, involving a design that is simplifying the content.

Training maintenance

You need to train for different scenarios and use of features to not forget how to use the systems when something rare occurs. Parts of the systems are not being used that often and this knowledge must be maintained. Operators working extra may quit because they rarely use the systems.

R6 “There are some functions in the systems you don´t feel you are managing, and it is a barrier to use the system.”

R3 “This is the reason why I stopped taking extra shifts. I didn´t have enough continuity in my training. I knew how to do the job, and I have a professional understanding, but it was about performance in the systems, it failed a bit for me.”

This challenge is situational, some features or systems are used in rare situations, like accidents with dangerous cargo. The SA demons that relate to this challenge are requisite memory trap, WAFOS, and complexity creep. When a system is dependent on the operators' memory to respond, but the operator do not remember how to respond, this is said to be the requisite memory trap, it can lead to a SA bottleneck (Endsley & Jones, 2004). Stress and anxiety are stressors that are triggered by the operators well-being and self-esteem, together with mental workload and uncertainty (Endsley & Jones, 2004). If the operator is insecure and does not know to handle the system in a certain situation, WAFOS is the demon that is affecting the operators´ SA. Complexity creep is also affecting SA when the system gets too many features, and the operator does not know how to handle all of the, so by decreasing complexity can prevent the need for more training, which reduces to the risk of forgetting subtle system nuances (Endsley & Jones, 2004).

Making the design simple and intuitive may reduce the need of training and maintenance. A system tolerance for error can provide more feedback and guidance and can be an assistance when the operator is insecure. When there are consistency sequences of action in similar situations (Shneiderman, 1997), it can be easier for the operator to remember action that are rarely in use. This can also relate to Shneiderman´s support user in control where surprises or changes in familiar behaviour should be avoided.

Change of focus is trained

An important part of the training is to learn to move the focus between several screens and systems.

R4 "The information pops up over four or five displays, visually in a 180 degrees display bow. When you are stressed, your focus is "here", du are not focusing on things on the other displays. A habituation is to learn where to focus, also when the level of stress increases."

R3 "It demands trained and acquired simultaneous capacity and knowledge of the systems. You can´t mess around wondering how to solve tasks in the system when you are receiving emergency calls. All your cognitive capacity must be used on the caller and the information you receive, and a minimum on the systems."

This challenge is related to the SA demon Attention tunnelling. If the systems provide an information overview, training for attention sharing may not necessary. Designing for SA, principle 1 recommends organizing information around goals, and it is necessary to address what information is required to perform each goal. When data is multiple displayed, the information should be logically grouped (Endsley & Jones, 2004). Principle 2 suggests that level 2 information is presented directly, and the attention and working memory are limited, so considering which displays are providing what information to enhance comprehension will be good for SA (Endsley & Jones, 2004).

The consequences of making mistakes

For a new operator a stressor is the fear of using the system wrong since this will have big economic consequences or be a risk for life and health. It is easy to do mistakes, especially in stressful situations.

R5 "The most demanding thing, in my case, was perhaps the fear of making mistakes. It may have economic consequences if a resource is sent out by a mistake. And it is easy to mis click!"

WAFOS is when stress and anxiety occur, and the fear of making mistakes that would have serious consequences in the form of financial loss, or the risk of life and health, triggers this SA demon.

To avoid such errors, the 7 principles of UD, principle 5: tolerance for error, and

Shneiderman´s 8 golden rules: offer informative feedback, and prevent errors, may minimizing hazards and the adverse consequences of accidental or unintended actions (Burgstahler, 2020). And the interface should give feedback for every action to raise awareness that a mistake is about to be made (Shneiderman, 1997).

Low level of mental capacity

The system should require a low level of mental capacity, so that the operator can use on the caller and the information that is given. The operators are today indicating that this is not the case.

R3 “It requires an extremely high level of mental capacity to use the systems. It requires acquired and trained simultaneous capacity and knowledge of the systems. You shouldn't sit around wondering how to solve things in a system when you are receiving emergency calls. Basically, most of your cognitive capacity should go to the caller and the information it provides, and minimally to the systems.”

This statement can be interpreted to apply for all SA demons, but maybe particularly for attention tunnelling, requisite memory trap WAFOS, data overload, and complexity creep. The operators must share their attention between the system and the caller, and the system should not demand any cognitive capacity. Information should be more perceivable and maybe easier to collect. If the operator is insecure and struggles with process this can lead to stress and anxiety, and things like time pressure and mental workload can trigger this stress, which steals attention and working memory (Endsley & Jones, 2004). Endsley and Jones (2004) are also suggesting that by designing the data to be presented in certain ways, the data can be experienced more slowly, and people can process it without data overload. Complexity is a problem when systems got so many features, people find it hard to understand how it works. This relates to data overload, and the more feature, the more complexity.

To overcome some of these barriers the 7 principles of UD suggest a simple and intuitive design, with no unnecessary complexity. Emphasis essential information so this will be more perceivable. Shneiderman´s 8 golden rules recommend reduction of short-term memory load by avoiding interfaces that requires the operator to memories information, this information should be displayed.

Endsley and Jones (2004) are with the 7 principles of UD also recommending organization of information around goals, and the operator´s goal is to perceive information from the caller and provide assistancy. The system should support comprehension of the situation and this can be done by prioritizing between data values and requirements (Endsley & Jones, 2004). Supporting global SA by providing the "whole picture", and letting the operator parallel process information with use of visual and auditorial information simultaneously may also have a positive impact on the SA (Endsley & Jones, 2004).

A new system will be more complex

Some of the operators says that the new system (that they are waiting for at the 110 centrals) won´t be more intuitive, it will present more options and functionalities. Good for some, not for others who have lower technical skills. While other operators are looking forward to a new system and believe this will be more intuitive and easier to use.

R6 "It will be many new features and functions in a new system. If this are options you don´t use every day, you need to maintain the knowledge of how to use them, then it can be hard to remember how to do it after months."

This challenge can be related to the SA demon complexity creep. The design should be simple and intuitive in use, and all information should be perceivable and essential information can with advantage be redundant presented, sound and image together are an example. By supporting users in control, the interface will behave familiar and respond to their action (Shneiderman, 1997). This is also related to the designing for SA principle organizing information around goals, where it is recommended that information should be logically grouped to ensure that needed data is provided (Endsley & Jones, 2004).

4.3.2 Workplace

The workplace is described as the area the operator is practicing work tasks. From the observation, this is described as a long desk with four monitors, doble up with computer mice and keyboards. The Main system is on the monitor on the left side and the phone system with the emergency network is to the right.

Table 0.12 Workspace Challenges

Workspace challenge	**Barrier**	**Design Principle**
Organization of workspace	Factor: HCI SA Demon Attention tunnelling	The 7 principles of UD: P6, P7 Designing for SA: SA1
Two main systems	Factor: Technology	The 7 principles of UD: P6, P7

Organization of workspace

For the operators at both 110 Sør-Øst and 110 Øst are pointing out that there is a bad organization of hardware together with the systems on the three-metre-long desk. The telephone system is to the right and the main systems is to the left, while both could have been organized in the centre of the desk to support low physical effort, Principle 6 in The 7 principles of UD (Burgstahler, 2020), the design can be used efficiently and comfortably, and the operator can maintain a neutral body position.

This is said by three different operators:

R6 “It is a lot of twisting and turning of the body to be able to use all functionalities.”

> R2 “When you are answering a call, you would have to go all the way back to the left side to type in, and then you must go all the way back up to hang up the phone after. It is much going back and forth during one hour!”

R5 “For me this is okey because I am young and my body is fine for now, but if I did struggle with back- or neck problems, I think this would be challenging.”

These statements can also be related to the same UD principles, Principle 7: Size and space for approach and use, where the design should provide appropriate reach and use, no matter body size, posture or mobility (Burgstahler, 2020). Having any mobility problems or being a shorter person may experience this as an even bigger problem, but all over this is not an efficient human-computer-interaction.

This way of organizing the workspace can also relate to the SA Demon, Attention tunneling (Endsley & Jones, 2004). The operator may miss out on important information when the size of the desk is big, the operator is focusing on the system to the left and are not aware of new information or actions on the phone system to the right or on any other monitor.

This is also related to the interaction between the operator, the hardware and the software, and it might be an idea to organize the software and hardware in a way that the operator can perceive necessary information fast and efficient, without any physically strives. This can be connected to the Designing for SA principle 1, organize information around the operator´s major goals, and when there is multiple displays, the information should be logically grouped to ensure that the needed data is provided (Endsley & Jones, 2004).

Some of the operators know that they have a better way of organizing the telephone system and are hoping for a similar solution at their centrals as well.

R2 “At another central they the telephone system is in front of them, incorporated as a part of the desk… So, the phone is easily accessed.”

R3 “You shouldn´t underestimate how the operator feels that day and noise in the working environment, this is other things that take focus away from the systems. The design of the workplace is probably the biggest barrier in many cases. If the operator knows the system well and the system works well, things are arranged for good situation awareness. But the environment is important and will have an impact as well.”

Two main systems

There are currently two main systems at 110: Vision and Locus. This double up with systems are causing the double set of mouse and keyboard, together with an extra mouse for the telephone system. The operators are working parallel in these two systems and need to change hardware back and forth. Even this is a temporary solution, the new system is already delayed with over a year, and the operators have been working like this for some years.

R1 “It´s not the most appropriate way of working, but I haven´t experienced anything else, so I´ve just dealt with it.”

This challenge can be related to both principle 6 and 7 in “The 7 principles of UD”. Letting the operator use one set of mouse and keyboard will be more efficient and comfortable, is minimizing repetitive actions, and the operator may be able to reach all components more comfortable (Burgstahler, 2020).

4.3.3 Routines and workflow

Workflow means the routine the operators performs when they are doing their tasks from start to end. The workflow is often decided by a certain routine that all operators are following, but also the different ways of navigating in the system to reach their goals.

Table 0.13 Workflow Challenges

Workflow challenges	**Barrier**	**Design Principle**
Work arounds	Factor: HCI SA Demon Complexity creep Errant mental model Misplaced salience	Designing for SA: SA1, SA2, SA3, SA8
Too focused of the system	Factor: HCI SA Demon Attentional tunnelling	Designing for SA: SA4
Integrate forms	Factor: HCI SA Demon Attentional tunnelling	Designing for SA: SA1, SA2, SA3
Obligatory elements	Factor: HCI	The 7 principles of UD:

	<u>SA Demon</u> WAFOS	P3, P4, P5 <u>Shneiderman´s 8 golden rules:</u> R3, R4, R8 <u>Designing for SA:</u> SA1 <u>WCAG</u> 3.3.2 Labels or Instructions
Bias information	Factor: HCI <u>SA Demon</u> Misplace salience	<u>The 7 principles of UD:</u> P2 <u>Designing for SA:</u> SA1, SA2, SA4, SA8
Separate incidents from each other	Factor: Technology <u>SA Demon</u> WAFOS	<u>The 7 principles of UD:</u> P3, P5 <u>Shneiderman´s 8 golden rules:</u> R1, R3, R5, R6

Work arounds

The operators are choosing to do some tasks "the hard way" so they don´t forget to do them in critical situations that rarely occurs. This workaround starts already when the operator is creating the task. Instead of right clicking on the address that pops up, they will lock this window, and start searching. They are eliminating shortcuts.

R6 "A challenge we see, is that when you doble click on the caller, you can easily create an incident right away. But when you can´t place where the caller is, and you have been following this simple routine, you have forgotten how you are searching and creating an incident the more challenging way. You can be stuck."

R6 "My team is always starting from scratch by searching for the address the caller is giving us and create an incident that way. We never use the short cut, which is right click on the address that shows up, we remove it."

This can be related to the SA demons complexity creep when the complexity of the system is forcing the operators complicate their routines, contributing to errant mental model. Organizing information around goals and reducing the complexity of the systems can contribute to a design that is intuitive and the operator must not train on using certain features. Helping the operator by presenting level 2 information directly can also have a positive impact.

Too focused of the system

It is easy to be too focused of the system. Especially around filling out the form. This is connected with the interview form, and how integration of this in the system would let the operator write less and use the attention on the surroundings. The operators need to communicate with each other, and other systems on other screens and alarms needs attention.

R6 "You can get really focused on the system, and are missing out on what is happening around you in the central… You are missing out on the communication between the operators because you are too focused on the system."

This can directly be linked to attention tunnelling, when all focus is on one system or set of information and all other information is out of reach. Displays that provide the operator with "the big picture" or global SA may solve this (Endsley & Jones, 2004).

Integrate forms

Interview templates should be implemented into the system, so the operators could crouch off elements on a check list, instead of using time on writing down answers. Today this interview forms are PDFs they would need to have on a separate screen, and some are also reading these forms on paper, instead of integrated into the system. This could save a lot of time and making the process more agile. Some think it takes longer time to write, and feel too old and slow for the job, even if they have a high level of knowledge and competence beside this.

R6 "I mentioned the interview forms and integrate these into the system. It would save us a lot of time. It will be easier to just hook of, instead of writing everything… As it is now, when you are interviewing the caller, you must write everything before you can ask the next question"

R2 "This computer stuff, younger people are much faster when they are writing and clicking and so on. So, there´s a fact, maybe I´m too old to work here, but at the same time, I have a lot of experience. A team should consist of a diverse group of people. It´s not enough to be good on the computer."

The system is demanding much focus when the operator is writing information, which can lead to attention tunnelling. Organize information around goals in this setting can be the interaction of interview forms and the operator can check of received information instead of writing it down. This is also connected to presentation of level 2 information directly, which is the suitable interview form.

Obligatory elements

The operator is filling out a form. The template consists of many elements, but do only need to fill out accident type, who is calling, and the position. There are no marks or a star beside the parts they must fill out. If something is missing, the won´t be informed before they are trying to go to the next step: a message pops up saying that an element is missing.

R6 "No, there are no explanations in the system, we have learned how it is, we starts from top and are going down. But we do not have to fill out everything… We must fill out incident type, type of caller, and address. But these fields are not marked in any way… It is first when you are trying to move on, that the system is telling you that not all obligatory fields are filled in."

A simple and intuitive system should provide help and support the operator to understand what to do. Mandatory fields can be highlighted or marked so that the operator knows that this information must be provided to go to next task. WCAG 3.3.2 Labels or Instructions can be met if the input data is clear. This can support the tolerance for error aspect were feedback, guidance and warnings should be provided to avoid inappropriate selections. Design dialogs that yield closure can make it easier for the operator to complete tasks, and this can be a way of organizing information around goals.

Bias information

The system is giving the operator information that let them predict the cause. The operator is supposed to start from scratch, when they have medical history, they can draw conclusions on information that is not relevant this time. The information could be available in the system, but not the first thing the operator is presented with. Or the operator should get help to not to draw a conclusion to early, and hinder bias.

R3 "There are also medical history, which you are not supposed to look at because you should start all over again every time someone is calling. Because if someone had panic attacks a couple of times before, you may believe this is happening now, while it might be a heart attack. So, some functions should be used carefully."

R3 "I started by saying that we shouldn´t look at medical history, but personally, it makes it easier. If you have an overview and the system is helping you to avoid bias and decision traps, it could be useful having the history in front of you." This challenge is related to misplaced salience, as it is important to draw attention to important information, but with careful use since the operator are not going to be affected by medical history but start from scratch. Making the system flexible in use together with organization of information around goals can contribute to better situational understanding. Information filtering should be used carefully, and the respondent suggests that the system should find a compromise between new and old data.

Separate new events

It is hectical and stressful in situations where there are many calls at the same time. The calls may be about the same event, or it may be a new event. These situations demand more multi-tasking, and it is easy to make mistakes. One part is the challenge where it is hard to separate the events from each other in the system, but the system could also priorities calls from outside of the geographical area where many are calling from.

R3 "If there was a bigger accident, we had to separate many callers. You had to understand if this was the same accident, a new accident in the same area, or something else. You had to focus on the map to see where these accidents were. It can be two traffic accidents in one city, so you must Hold your tung straight when there are many callers at the same time!"

This challenge can be related to WAFOS, where the operator want´s to perform fast and efficient, but it is hard to find needed information and this can lead to mistakes. The system should be simple and intuitive, and if the operator is doing a mistake feedback is provided, and this can be corrected.

4.3.4 Warnings and signals

Warnings and signals are a normal feature in an emergency centre and provides the operators with important information, but some alarms are challenging to perceive or can reduce SA.

Table 0.14 Warning Challenges

Warning challenges	**Barrier**	**Design Principle**
Warning signals with sound and visual presentation	Factor: Technology SA Demon Misplaced salience	The 7 principles of UD: P4 Designing for SA: SA7
Popup signals	Factor: Technology SA Demon Misplaced salience	Designing for SA: SA5
Missing critical warning signals	Factor: HCI SA Demon Misplaced salience	Designing for SA: SA6
The intention is stress	Factor: HCI SA Demon	Designing for SA: SA6

	Misplaced salience	

Warning signals with sound and visual presentation

Warning signals with use of sound are easy to overhear or overlook in situations with many events/incidents. They can adjust the sound on their own speaker. Warning signals with sound are helpful but should be more visual as well. The visual signal is presented on a screen opposite of their main working display, making these signals hard to detect or react to.

R1 “We got phone calls, and automatic fire alarms may pop up. This alarm got its own sound, so we have learned that when that sound comes, it is an automatic fire alarm.”

R2 We need to deal with it. If there is a fire in a populated area, this will generate many callers. So, when you are concentrating on a caller, this sound hammers around you. It´s maybe 20 people in the line, so this sound knocks in!

R1 “It can be hard to notice… We are dependent on sound and image to catch it and can be hard to notice both if we are in the middle of something critical.”

R1 “What´s best of sound or something visual, sound perhaps? That´s best when your eyes are not on that display. We are using many monitors and the focus can be on the other half. So, sound is a good concept… It can be low sometimes, it depends on noise in the central… But we have a speaker that we can adjust, we got one each, so we all got different sound level”

R5 “The sound is okay, and it is blinking. So, you will see a light signal when there is a phone calling. But this is on the display all over to the right, so won´t see it if you are working on the monitor in front of you or to the left.”

This challenge is related to misplaced salience and occurs when the operator is focused on one system and does not respond to a warning signal because it is out of reach. This can be solved by making the information more perceivable, and this can be supported by parallel processing. Displaying all critical information within reach is an example on a solution.

Popup signals

Some automatic alarms are using popup windows on the display. This can get in the way of the job the operator is doing by interviewing a caller and are a huge stressor. The operator may also lose focus and concentration.

R1 “You are getting used to it, you know that this box will pop up when you are answering a phone call. And you are used to ask where they are, and you can see if this is on the address that pops up or somewhere else. And they are not at that address you just close that window.”

R6 “We have this system called Detec Next- If you are in a conversation with a caller and are logging into an incident, and this Detec window pops up, it will block the other system you are working in. It is an alarm, so that window opens up automatically.”

R6 “You can lose your focus, absolutely. You must take action, do something about it, before you can continue on the task you where doing. And if you just lay the window down, it will pop up again.”

This is related to the SA demon misplaced salience, and the designing for SA support trade-offs between goal-driven and data-driven processing can be used in the correct manner. The operator should be warned but this may be done without interrupting current goal.

Missing critical warning signals

The emergency network is being ignored in stressful situations with a higher level of noise and much going on in the systems. Officers in the field are having problem getting in contact with the emergency centre.

R6 “I´m also working out there, as a fire fighter. I know that they are missing out on things in the central. The emergency network, that one is easy to forget.”

This can be related to the SA demon misplaced salience, there might be something else stealing their attention. Critical events should activate critical cues, which should be made salient in the interface. This sound could be better precepted with a visual salient closer to their focus area. Make critical cues for schema activation salient can be a solution.

The intention is stress

Some warning signals are meant to stress the operators. In situations where there are no available recourses. The function is to remind the operator to prioritize the incident. This is extremely stressful for operators and officers out in the field.

R4 “Sometimes, you don´t have any resources, and the system will continue blinking for a long time. This is something that will stress everybody, and it should do. We are pot of resources, and we have evaluated a situation as life threatening.”

When the intention is stress, it could be linked to critical cues for schema activation. This is relevant when the operator must be warned to be able to prioritize correct. Make critical cues for schema activation salient can support the operator on prioritizing resources.

4.3.5 Position

The position is the most important information the operator are getting from the caller to be able to respond and send out resources.

Table 0.15 Position Challenges

Position challenges	**Barrier**	**Design Principle**
Position is very important!	Factor: HCI SA Demon Attention tunnelling WAFOS	Designing for SA: SA1
The search engine	Factor: Technology SA Demon Attention tunnelling WAFOS	Designing for SA: SA1
Pre-defined position	Factor: Technology SA Demon Misplaced salience	Designing for SA: SA1

Position is very important!

Position is the most necessary information the operators need to create an incident, and they need position to send out resources. When the operator is struggling finding the location, they will bring this bad feeling throughout the rest of the interview with the caller.

R1 “Too be able to create an incident you need a position, an address, or a point. The position is really important! You can´t send out resources or create a log without it.”

R2 “When you know that the technology has come so far, it feels so unnecessary to do all these operations to find the correct position, instead of “smack” straight in!” Not finding the address may lead to attention tunnelling when the operator must use all mental capacity on finding a position and are missing out on other information from the caller or in the surrounding. Organizing information around goal can contribute on making this critical task easier and the operator can proceed the process.

The search engine

The search engine used to find addresses are not robust and are sensitive to spelling mistakes. The search engine is limited, and they must add information in a certain order.

R2 “It is not easy to search for a position if you are not searching in the correct order, with address field, object field, and location field. You must do things in a certain order.”

R5 “Spelling mistakes, that´s a stressor. Especially when there are time critical accidents.”

R4 “It is sensitive for spelling mistakes. Like Strand gata or Strandgata, like typo.

Some street names are not easy to write, and you need to spell it correct, there are no room for mistakes."

The search engine is an important part of finding the address. So as this can relate to attention tunnelling and organization information around goals, and could get help from modern technology like autocorrection.

Pre-defined position

The home address pops up. This is disturbing, and the operator can 1) open incident with wrong position, 2) ask caller if they are at that address, and they may answerer yes because the address is familiar, and 3) most operators will always search for the address as a work-around, and this pop up is an extra unnecessary click and distraction.

R1 "Back to position, it would have been nice if you could open an incident with as few clicks as possible, and that the position just pops up because it knows where the caller is. Just one confirmation click and done. That would have saved much energy."

R1 "You are getting used to it, you know that this box will pop up when you are answering a phone call. And you are used to ask where they are, and you can see if this is on the address that pops up or somewhere else. And they are not at that address you just close that window."

R4 "If you as someone if they are at the address that pops up, and they yes because they hear their home address, and that is familiar. And then we are sending resources to that address, but they are not home."

This challenge relates to the challenges pop-ups and bias information.

4.3.6 Design

The design of the interface is connected to choice of font size, contrast, colours and icons. Design is also the way the all information is organized in order to perceive it without problems.

Table 0.16 Design Challenges

Design challenges	Barrier	Design Principle
The font size is not consequential	Factor: Technology	The 7 principles of UD: P4: Shneiderman´s 8 golden rules: R1
Use of colours and icons	Factor: Technology	The 7 principles of UD: P4 Shneiderman´s 8 golden rules: R1 Designing for SA: SA1
It is hard to separate incidents	Factor: HCI SA Demon WAFOS	The 7 principles of UD: P3, P5 Shneiderman´s 8 golden rules: R1, R3, R5, R6
Redundant content	Factor: Technology SA Demon	Designing for SA: SA8

	WAFOS	

The font size is not consequential

Different size of fonts in different systems. Makes it harder to change focus between the systems. A problem more reported by those over 50 years using glasses. By zooming up to preferred size comes at the expense of the content.

R1 "The two systems are developed with different font sizes. It is a smaller size in Locus… I can zoom in I bit, but you can´t zoom in too much because then you will lose content."

R2 "Locus, well I´m using glasses, but that system is using a small font size. And the font size is small compared to Vision. So, I hope they will design a new version with bigger font."

This challenge relates to WCAG 1.4.4 Resize text, where the content satisfies the Success Criterion if it can be scaled up to 200%, that is, up to twice the width and height, without losing content or functionality (*How to Meet WCAG*). It is not clear how much zoom that is affecting the content, but the operators are having problem with the size in Locus, also with glasses. This is also related to the principles supporting perceptible information and strive for consistency.

Use of colours and icons

Use of colours to separate severity of the incidents: green, yellow and red. And to separate between different types of calls. Colours are very positive for those who can see them, this will let them perceive and understand the information fast. This information is also presented in writing, but it takes much longer time to perceive the information this way. It should be a better alternative together with the use of colour.

R1 “I am colour weak on red and green, but it hasn´t been a problem here. I can also see traffic lights. It´s more having problems separating the lingonberries from the bush, it becomes greyer.”

R2 “I like the use of colours, it helps a lot! But if I became colour weak one day, then I would see it as a big disadvantage.”

Beside using icons in maps and to mark resources (vehicles) in the field, it is suggested that ikons can be used to explain incident types together with colour and written explanation.

R6 “There are some icons. The fire engines are showed with icons. But it is a good idea to use icons to separate different incidents together with colours.”

To meet WCAG 1.4.1 Use of colour the colour should not have a meaning assigned to it without other information conveyed to support colour weak persons. This is also related to the principles supporting perceptible information and strive for consistency.

It is hard to separate incidents

The system is experienced chaotic in stations with many incidents, all of them is listed up, but are hard to separate. The operator must open each incident and check the address to see if this is the incident that is being updated. The font size is small. One is suggesting colours and icons for separation.

This may lead the operator to log in another incident. This is especially hard in situations with many incidents going on at the same time, and the level of stress is high.

R5 “If we are having many incidents, I would have to work differently. I must pay more attention because it is easier mix the incident and log into the wrong one… And this log cannot be erased. And you must write a new log that says that the last one was incorrect.”

R6 “The system can feel chaotic when there are many incidents. All of them are listed up but could have been sorted out in a better way. But again, colour codes may be an idea.”

This challenge is related to WAFOS and the operators are describing increased level of stress when they cannot separate the incidents. The interface should be simple and intuitive and tolerant for errors to support the operators.

Redundant content

Much content is rarely or never in use. The operators must separate options relevant in each case. The interface could highlight all necessary information, 30% of the system, so the focus is on what they will use.

R1 “There are much content that is rarely or never in use, so rarely that it could have been hidden somewhere else. There are many features displayed, you are getting used to it, and are ignoring most of it. But it is complicating the system a lot especially in the beginning… I would say that maybe 30% of the features are in use frequently, and the rest rarely.”

This is related to WAFOS, and the statement says that only 30% of all features are used. The interface should be simple and intuitive, and information filtering can be used if it is used carefully.

4.3.7 Trippel alert challenges

Trippel alerts is when all three emergency agencies are connected, but this is also relevant for situations where two emergency agencies are cooperating.

Table 0.17 Triple alert Challenge

Triple alert challenge	Barrier	Design Principle
Non-verbal information sharing	Factor: HF	Designing for SA: SA1

Non-verbal information sharing

More agile way to share address or position between police, AMK, and fire. Some 110 centrals and AMK centrals can exchange accident positions nonverbally in the system, but in some regions and with the police this information must be exchanged verbally. Verbally information can lead to misunderstanding.

Both 110 Sør-Øst and Øst are centrals with the possibility to share position in Locus with AMK in their district.

R5 “AMK and us, we can share position in the system.”

R2 “Something goes directly, you can transfer position in a map in Locus. If you get a conversation from AMK they can send the position directly, the police can´t do this. For sure, this simplifies things a lot!”

While the responder from AMK in a different district cannot share position and other information in any systems with the police and 110. All communication must go verbally.

R3 “What´s problematic is not having the possibility to share anything with your partners at the police and fire. We used to do this before, and I know this is possible in some districts now, it simplifies the process extremely, by having the possibility to share this kind of visual information that you can watch in a map. It releases a lot of your cognitive capacity, instead of explaining this verbally together with everything else.”

In situations where position must be shared verbally, the flow in the conversation is not always optimal. The operators can meet problems when they are trying to hear the information. And since position is very critical to be able to open an incident and send out resources, they need to catch this fast. This again can affect their ability to perceive other important information about the accident.

R5 “When the police are triple alerts, they are giving us the address, before the interview starts. If I didn´t catch the address and I´m struggling with the search, and they continue by talking about the accident, I will have to go back and ask for the address again. You are so focused on the address and are missing out on other information.”

The reason why the possibility of sharing information differs from one district to another, and between emergency agencies, is said to be caused by different interpretations of the law. A law clarification could have been developed at the ministries, or a clearer guidance from each directorate. This topic is outside this thesis but impacts the emergency agencies´ ability to communicate some information in a more efficient way.

R4 “This is something the lawyers are arguing about. There is an example where they in Innlandet are sharing position in the map, and that´s okay there, because the lawyers said it was okay. And in other districts, the lawyers said no.”

4.3.8 Summary of the interviews

The interviews with operators from 110 and AMK gave a great insight in how they are working and interacting with the EMIS. All responders were open and honest, and this gave a good foundations for further investigation of the challenges they are meeting, and how they relates to SA demons, and design principles.

The main findings of the interviews were:

- Training routines for both new operators and operators that are going to maintain knowledge should be developed. Complexity creep and stress seems to be the major problem, and simple and intuitive design can be a solution to prevent this challenge.
- Work arounds is when the operators intentional are doing tasks more complicated not to forget how to operate certain features. This is related to the training challenge.
- Better organization of workspace may reduce attention tunnelling, together with high physical effort. Organize information around goals is a suitable principal.
- To focused of the system can steel attention from other systems and communication in the control room. This is a software challenge but is also related to better organization of workspace.
- The operators thinks that better integration between systems will make HCI easier. They are working with interview forms that are guiding them through what they must

ask for in certain accidents. These forms could have been integrated in the system and would reduce typing.

- The system is not providing information about mandatory input data in forms. The form consists of multiple fields, but not all of them are required content. The feedback will display first when the operator wants to go to the next task.
- Warning signals are both visual and audible, but the sound can be weak, and the visual signal may be displayed outside the operator's attention field. This is also related to the organization of workspace and attention tunnelling.
- Position is very important information; this gives the opportunity to open an incident task and respond. Not finding the address is a stressor, and the search engine is sensitive to spelling mistakes and are not equipped with auto correction or autocomplete.
- Pop-up windows can display with some automatic alarms and can interrupt other assignments and interview with caller. This can lead to requisite memory trap. The pop-up window is also displaying with the caller´s home address, even if the caller is not home. This is also related to work arounds where this pop-up box will immediately be closed because the operator starts with searching for the address given by the caller.
- It is hard to separate the incident when there are many accidents at the same time. They must open the incident to see if it is the correct one. Use of colours and icons is suggested by the operators to improve the design.

4.4 Summary of the findings from the pilot, the observations, and the interviews

This section present data of the findings on how the challenges are connected to the factors, SA demons, and the design principles. Based on the findings in the pilot, observations, and interviews there are possible to look at trends.

Factors

The majority of all challenges was considered as being caused by the human-computer interaction or by technology. This may show that most of the challenges are caused by weak design and technology, and that to get a better situational awareness, SA must be taken into account when developing EMIS.

14% may be caused by human factors and relates to the training aspect. Only 3% was considered as directly being caused by the situation where the operators must train to maintain knowledge in different incident situations that at rare.

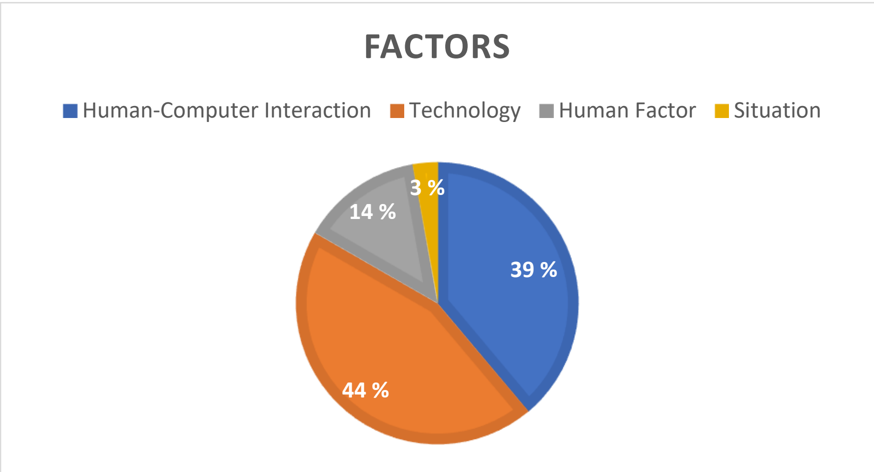

Figure 4.0.1 Factors

SA Demons

A few challenges were caused by weak design that can be corrected by following WCAG. These challenges are regarding colour, contrast, and font size. But most challenges were considered caused by one or more SA demons. The SA demons that are most represented are WAFOS, complexity creep and misplaced salience, followed by attention tunnelling. This can be interpreted in a direction saying that the system itself can be the stressor, and that is so because of the complexity of the system and misplaced salience disturbing the operator´s focus. This may further cause attention tunnelling.

Errant mental model, requisite memory trap and data overload are not main SA demons but can also be related to the systems and how the development and design affects the operator. None challenges were linked to the Out-of-the-loop syndrome in this research.

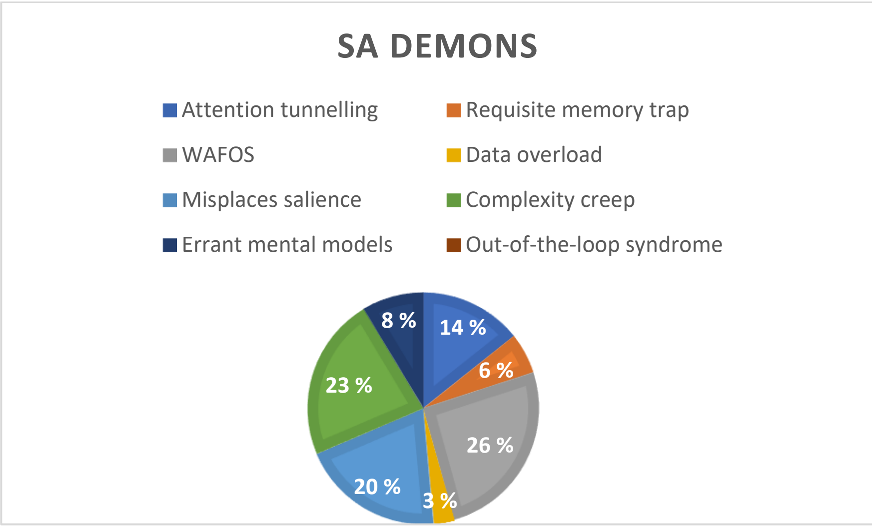

Figure 4.0.2 SA Demons

The 7 principles of Universal Design

Looking at which design principles that may solve some of these challenges the 7 principles of UD was considered as relevant because of the purpose to guide for better design of environments, products and communications (*The 7 Principles*; Burgstahler, 2020).

31% of the challenges were linked to the UD principle simple and intuitive use, followed by 21% perceptible information and 17% on tolerance for error. Low physical effort, size and space for approach and use, and flexible in use which is more related to motoric movements and the space where also well represented.

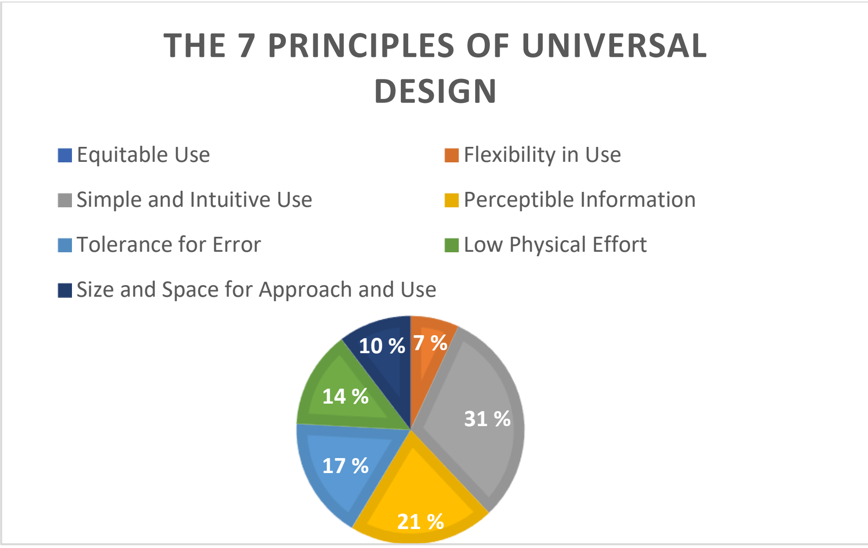

Figure 4.0.3 The 7 principles of Universal Design

Shneiderman´s Eight Golden Rules

Shneiderman´s Eight Golden Rules was considered as relevant because of the purpose to develop good mobile, desktop and web design (Shneiderman, 1997).

26% of the challenges are linked to strive for consistency, 17% for both offer informative feedback and prevent errors, 9% for all reduce short term memory load, support user in control, permit easy reversal of actions, and design dialogs to yield closure. 4% were linked to seek universal usability.

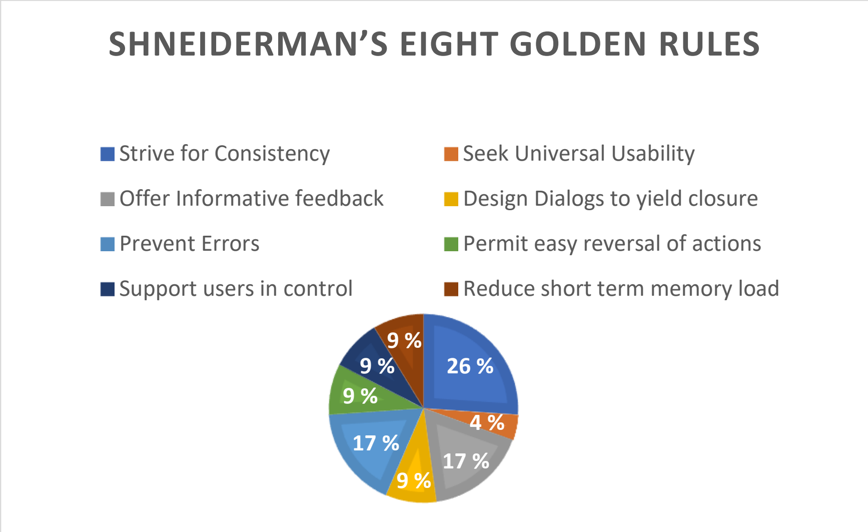

Figure 4.0.4 Shneiderman´s Eight Golden Rules

Designing for SA

These principles were considerate relevant because of the goal to guide through how to design for SA, and is based on SA demons.

All together 41% of the challenges can be linked to the designing for SA principle organize information around goals. 16% were connected to present level 2 information directly, 10% support global SA, 9% use information filtering carefully, and 6% to provide assistance for level 3 SA, Support trade-offs between goal-driven and data-driven processing, make critical cues for schema activation salient, and take advantage of parallel processing capabilities.

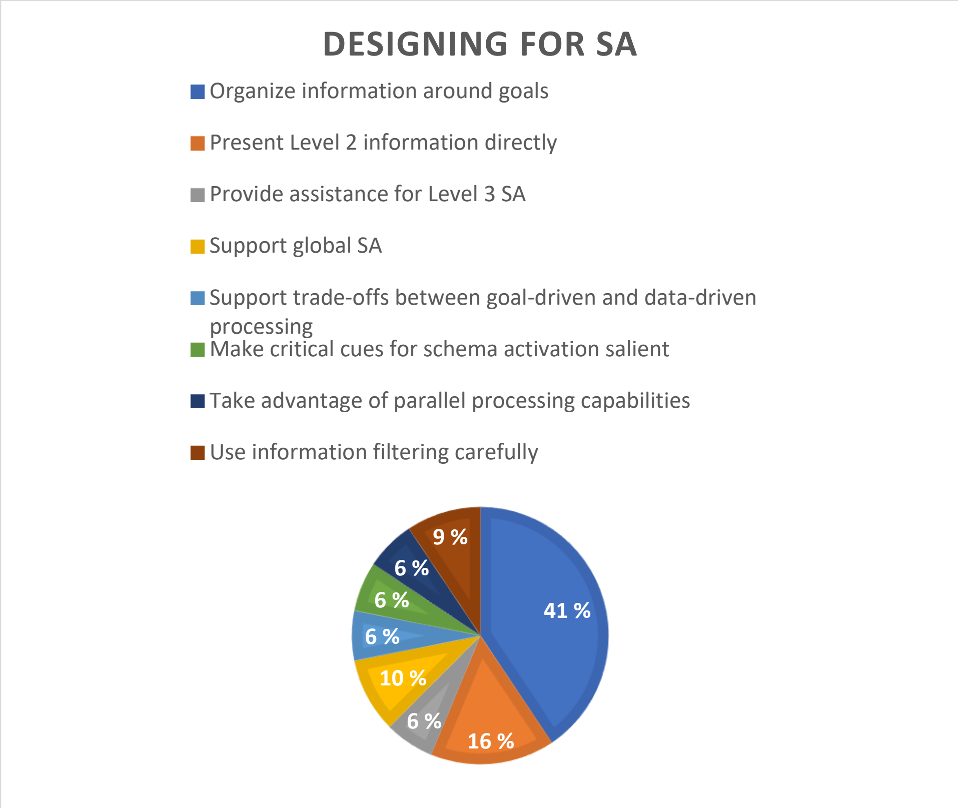

Figure 4.0.5 Designing for SA

WCAG

WCAG 1.3.3 Sensory Characteristics, 1.4.2 Use of Colour, 1.4.4 Resize text, and 3.3.2 Labels or instructions were used once each during the pilot, observations and interviews.

5.0 Discussion

This chapter presents the discussion of the results of this study on barriers in emergency management information systems, and how universal design can mitigate these barriers. The chapter will start by discussing the results from the previous chapter with suggestions on improvements. Further discussion on how these findings agree with previous research, and discussion on how universal design other design principles can contribute on mitigate these barriers.

5.1 Discussions of the findings

This section is discussing the findings and how the challenges found are having an impact on different aspects. There are some suggestions on what can be done and how this should be prioritized based on impact, how much time and money are required, and the criticality.

Table 0.1 Priority table

HIGH	MEDIUM	LOW

5.1.1 Workspace

The organization of the desktop seems to be random, and little considered and contributed to an increased number of movements. This apparently little considerate organization was a big surprise based on how little effort is needed to fix the challenge compared to the impact this has on the operators.

Table 0.2 Suggestion for organization of workspace

What: Organization of workspace		
Stakeholder: Manager, purchaser, system owner		
User Impact: HIGH	Improvement: EASY	Criticality
Requirement Specification: Organize software and hardware based on criticality, physical and mental capacity, information provided.		
Priority: HIGH This requires little time and money. Most equipment is already at the desk. It is important to analyse and carefully plan the organization, and this will be very beneficial for the operators.		

5.1.2 Training

Training can be divided into two parts, training for new operators and training for maintenance. This is divided into two sections:

New operators

New operators find it hard to learn the systems because of complexity together with the confusion that occurs when multiple operators are involved with the training, and these operators are choosing different ways of navigation. Less complicated systems and navigation with more familiar interface design is also in this challenge a very good solution. However, developing a good routine on how the new operator should use the systems can reduce the confusion the operators are meeting. Flexible use is easier to learn when the foundation is good.

Table 0.3 Suggestion on training for new operators

What: Training of new operators		
Stakeholder: New operators, Manager, System owners		
User Impact: HIGH	Improvement: MEDIUM	Criticality: MEDIUM
Requirement Specification: Develop a systematic training program with one efficient routine on how to reach a concrete goal.		
Priority: HIGH This should have a high priority because systematic and improved training routine has a high impact on the users, it is not time demanding or expensive to develop or implement, and it can reduce the time of the training period and the new operator can feel less frustration.		

Maintenance

The systems are not intuitive, the operators are not sure what is self-explanatory, and they must train to maintain the knowledge on how to use features. One operator told it was impossible continue in the job because of lack of frequency, and knowledge within the system was the challenge, not the being an operator itself. Changing focus between multiple displays is also trained. Achieving level 3 SA, projection needs experience. A reduction in complexity and presenting critical data in an interface will make it easier for less experienced operators to change the focus and achieve projection. This can be an overview showing automatic alarms, phone calls, ongoing incidents, and activity on the emergency network. This will provide a set of information that is good to know at any time. Having this information displayed where the operator can see and hear with no efforts will also reduce requirements regarding level of mental capacity and attention tunnelling.

Table 0.4 Suggestion on implementation of Overview display

What: Developing an overview interface		
Stakeholder: Developer, designer, decision makers		
User Impact: HIGH	Improvement: MEDIUM	Criticality: HIGH
Requirement Specification: Display providing on overview to support global SA, taking advantage of parallel processing with visual and auditory presentation. Provide projection for future events like status on resources. Provide information on active alarms and warning signals. Use colours, icons, and text efficient. Blinking must be used carefully!		
Priority: HIGH This is a more complicated feature that will need more time and money to develop. But the advantage can be beneficial, especially for less experience operators, or in situations where there are many accidents at the same time. It is important to carefully analyse the criticality of selected information, this is a delicate balance.		

5.1.3 Warnings

Missing salience

Salience should be presented in a way that it is easy to percept. Parallel processing is beneficial, and it is very important that information is not lost. This challenge is related to the idea on developing an overview interface and should be integrated in the requirement specifications. Missing salience can be very critical and must be taken seriously. That is why SA errors must be mitigated and critical alarms highlighted.

Pop-up windows

Pop-up windows should only appear when this is necessary, like in situations where the operator is about to make an error or guidance must be provided. Pop-ups occurs when the operator are receiving a call and is opening an incident, this is described under position and search, and when the automatic alarm Detec Next is interfering and pops up over the assignment the operator is working on. This feature should be integrated and specified in an overview interface instead of as a pop-up window. This window will reduce SA and disturb the operator, and this can be critical when the operator is in an emergency call.

5.1.4 Position

Search

Searching for the position must be more agile. There are today technologies that support this:

- Auto correction
- Auto complete
- Exact or nearby location with use of base stations

There are no reasons why the search engine should be sensitive to spelling mistakes when map solutions like Google maps are supporting this. This is the most critical information the operators are receiving, and is a big stressor.

Table 0.5 Suggestion on improving the search engine

What: Improvement of search engine		
Stakeholder: Developers		
User Impact: HIGH	Improvement: HIGH	Criticality: HIGH
Requirement Specialization: The search engine should support Auto correction, auto complete, and location provided by nearby base stations.		
Priority: HIGH		

This is the most critical challenge and a stressor that are removing SA when the position is not clear. It should be invested enough time and money to improve or develop the search engine.

Open incident

One of the responders said that his team opened an incident with a work around; instead of opening an incident by using the auto selected address, this was closed, and they started from scratch. This pop-up window should be removed since this is not in use by the operators. Instead, a new or improved search engine can provide a more correct position. The home address is coming as an addition to that.

5.1.5 Software

There are some functionalities and inconveniences in the systems that should be rectified.

Integration of interview forms

The interview forms are today on paper or a PDF. This is the template they are following when interviewing callers based on accident type. Integration of this form seems to be beneficial. It the reduces the time the operator is using on writing all information into the system, they can check of type of information, they are sure that all information is clearly receive, it helps operators that are slow writers, and it can reduce mental capacity with less multitasking.

Table 0.6 Suggestion on integrating interview forms

What: Integration of forms

Stakeholder: Designers, developers, decision makers		
User Impact: HIGH	Improvement: MEDIUM	Criticality: MEDIUM
Requirement Specification: Implementation of interview forms into the system to replace PDF and paper versions. This should replace information fields where it is an advantage for the user to check of instead of writing the information.		
Priority: HIGH This will be positive for the user and will reduce time and mental capacity during an interview. This should not require much time and money to develop. It is not a critical feature, but can be can be improved with great advantage.		

Obligatory fields

There are no information explaining which fields are mandatory or not. If such box is not filled out, the operator is not informed before the enter button is pressed. This should be a quick fix that can cause a lot of frustration.

Table 0.7 Suggestion on informing about mandatory text fields

What: Inform about mandatory text fields		
Stakeholder: Designer, developer		
User Impact: HIGH	Improvement: LOW	Criticality: MEDIUM
Requirement Specification: Mark boxes that are mandatory so that the user easely can see what is mandatory or not.		
Priority: HIGH This requires little time and money and can cause frustration. This is the reason for the high priority.		

Separate incidents

It is hard to separate incidents, especially when there are many accidents at the same time, many callers, and a high level of stress. It is hard to separate because all incidents are just listed up with no design features showing type of accident and other relevant information. No written information is separating them, and each incident must be opened and checked. A solution to separate these incidents can be with use of colours, icons and written information, and reduce stress, time, and mental capacity.

Table 0.8 Suggestion on separating incidents

What: Separate incidents		
Stakeholder: Designer, developers		
User Impact: HIGH	Improvement: MEDIUM	Criticality: MEDIUM
Requirement Specification: Improvement of design to help the user to separate objects in a list of incidents. This can be done with use of colours, icons and written information, to support visual perception.		
Priority: HIGH This challenge can be improved by small design implementations. This will be positive for the user especially in stressful situations. It will have a medium on time and money consumption. This is not a critical feature, but will improve situational awareness.		

5.1.6 Summary

The suggestions are based on the observations and interviews, the most critical challenges. They can be divided into technical, situational, environmental and design factors.

Technical

- New and improved search engine
- Developing an Overview Interface
- Integrate interview forms

Design

- Inform about mandatory text fields
- Separate incidents

Environment

- Organization of Workspace

Situation

- Training Program

5.2 Discussion of the literature

Previous mentioned research says most paper relevant to UD of ICT in Emergency Management is focusing on the public, compared to other stakeholders like first responders and control room personnel, and only 6% research focuses on operators (Gjøsæter et al., 2020). This research is investigating what the barriers that hinder control room operators to achieve SA when use of EMIS. This is a contribution to further research to understand SA in operators, and how UD of ICT can mitigate these barriers. Another research claims that UD of ICT for Emergency Management together with Situational Disability also is an unexplored area and should include control room operators (Gjøsæter et al., 2019). This research is investigating what barriers the operators are meeting in stressful situation and how operators are experiencing situational disabilities in stressful situations.

Radianti et al. (2021) say future research should investigate:

> *"1) the causes of human-errors when technology is involved and contributes to human-errors, 2) the key technological challenges that need to be addressed, 3) design of technology to reduce human-errors and enhance SA, 4) user-oriented information presentation and the technology design that support user interactions through different modalities and devices"*, Radianti et al. (2021).

This research wants to contribute on answering these questions based on the findings. The findings shows that 44% is caused by technology and 39% is caused by HCI. Only 14% is directly caused by human factors and 3% the situation. The challenges that are considered to be caused by human factor are involving training and maintenance, and the SA demon being complexity creep. It is possible to say that the reason for problems regarding human factors is the complexity of the system, and if the system is more intuitive, it would be easier to learn the systems, but also maintain how to use certain features in rare situations. The systems should also require a low level of mental capacity which is a human factor. This is also linked to complexity creep, and further will cause attention tunnelling, and stress and anxiety. This study shows that most errors or challenges caused by human factors occurs because of the organization and design of the systems.

44% of the challenges the operators met was caused by technology, and 39% was caused by HCI, meaning that technology was in somehow involved in 83% of the challenges. Radianti et al. (2021) findings showed that humans are to blame in most SA errors, and technology is less mentioned in the discussion of understanding SA demons. When a human-error occurs while using a system, it is probably because the system is not helping the user to reach the goal. Why is it hard for the operator to fine the address? The feedback from the operators where clear, it is hard to use the search engine, and it does not provide them any help. The home address pops up when someone is calling, but what they could need was their position. When this necessary information is hard to provide, the operator is getting stressed, a feeling that will follow them into the interview, and can lead to misinterpretation or lost of other important information.

As suggested, an overview interface can contribute on increasing SA. There are no solutions that are supporting global SA today. If the workspace is better organized, and an overview interface is showing current information, it will be easier for the operator to understand where to focus, when there is information over a large area. This is also a concrete suggestion on how interaction with the systems can be supported by using other divices.

Information about mandatory text fields in the interface and a design that makes it easier to separate the incidents are concrete design solutions that should be implemented. By using the 7 principles of universal design and Shneiderman´s 8 golden rules when analysing the findings showed that SA could be improved by stiving for consistency, and support simple and intuitive use.

5.3 Discussion of design principles

This research is based on four design principles and guidelines:

- The 7 principles of Universal Design, for environment, product, and communication design
- Shneiderman´s 8 Golden Rules, for development of mobile, desktop, and web design

- Designing for Situational Awareness, designing for better SA
- WCAG, for accessible content

These design principles were chosen because the each one of them different areas relevant for control rooms and because they could complete each other. None of them are alone covering all design and functionality aspects, but most of the challenges could be supported by one or more design principles. An alarm challenge at Sykehuspartner where the alarms were delayed, false, or needed human confirmation could not be covered by any of the principles. The same regarding outdated information displayed in street view map where the house where exchanged, which could lead to decision making based on wrong information. Common for these challenges were unreliable information and was caused by missing updates or lagging, which is technical problems that should be fixed by operation and network teams. An interface design fix for these challenges could have been an implementation of information telling when this data was last updated, or visibility of system status. This can relate related to the designing for SA principal support global SA, data-driven processing (Endsley & Jones, 2004).

Other design principles considered was Jakob Nilsen´s 10 Usability Heuristics for User Interface Design. The overlap between Nilsen´s Heuristics and the other selected principles made it unnecessary to use this in addition, also to keep it simple.

5.4 Limitations

The limitation of this study is the limited number of observations and interviews, with three observations and six responders. As qualitative research with observation and interviews used as methodology, the answers were subjective and based on the operators' own experiences. There was not collected any quantitative data to support what the operators were sharing. Operators from the emergency centrals 110 fire and 113 AMK were interviewed, but no one from 112 police.

Inside the 110 centrals there are not allowed to bring technical devices like mobile phone and PC. All information were written with pen and paper, and no documentations like picture were taken. It is easier to evaluate interfaces when images are provided. So, all data is collected with use of human memory, and this can create bias.

6.0 Conclusion

The purpose of this research was to contribute to further investigation of barriers in EMIS that are hindering SA. Previous research has increasingly been focused on other stakeholders like the public, volunteers and government agencies, and this research aim to look at control rooms and the operators using EMIS. Human factors have been considered to be the blame of most SA errors, but this study shows that the main factor is technology, and additionally HCI, where it is reasonable to say that it is the technological part that is preventing the operator to perceive and understand the information. The complexity of EMIS and misplaced salience were causing stress and anxiety and are all sources to SA errors.

By using design principles, some concrete suggestions were made:

- New and improved search engine
- Developing an Overview Interface
- Integrate interview forms
- Inform about mandatory text fields
- Separate incidents
- Organization of Workspace
- Training Program

These suggestions can all mitigate one or more barriers

6.1 Future work

UD of EMIS is a little investigated area. Most literature and research have been related to other research fields and disability groups, while this UD of EMIS is about addressing situational disabilities what barriers this may cause in stressful. This research had a main focus on control room operators at 110 with two representatives from AMK. Further research could include the police, and on system interaction during triple alerts. Future work could also include specific design sketches and prototypes on a suggested interface and user testing. Other disciplinaries within ICT could contributed with research on technical solutions on data collection that can give the operators more information without oral communication.

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Appendices

Appendix 1: Consent Form

Vil du delta i forskningsprosjektet

” Evaluering av Universal Utforming i Beredskapssystemer”?

Dette er et spørsmål til deg om å delta i et forskningsprosjekt hvor formålet er å finne eventuelle barrierer i beredskapssystemer. I dette skrivet gir vi deg informasjon om målene for prosjektet og hva deltakelse vil innebære for deg.

Formål

Dette er en masteroppgave i Applied Computer and Information Technology (ACIT) med spesialisering innen Universal Design (universell utforming) ved Oslo Metropolitan University. Prosjektet startet i januar 2022 og skal leveres mai 2023.

Formålet med masterprosjektet er å avdekke eventuelle barrierer i beredskapssystemene som hindrer situasjonsbevissthet eller skaper situasjonsbetinget funksjonsnedsettelse hos operatørene. Videre vil det bli sett på hvordan universell utforming kan bidra med å forhindre slike barrierer. Prosjektet gjennomføres ved bruk av kvalitativ metodikk, herunder observasjon og semistrukturert intervju.

Hvem er ansvarlig for forskningsprosjektet?

Oslo Metropolitan University

Hvorfor får du spørsmål om å delta?

Utvalgte deltakere for intervju er plukket ut ved hjelp fra leder ved operatørens arbeidsplass der det tidligere har blitt foretatt observasjon av arbeidsmiljø, samt bruk av programvare og maskinvare.

Hva innebærer det for deg å delta?

I dette prosjektet vil jeg benytte semistrukturert intervju, som betyr at jeg vil stille spørsmål rundt forhåndsdefinerte temaer, der det vil være mulig for deg som deltaker å svare åpent på spørsmål, og for meg å komme med oppfølgingsspørsmål. Dette skal føles som en samtale, og du står fritt til å svare eller å gå videre i intervjuet hvis det er noe du ikke ønsker å dele.

Deltakelse i prosjektet innebærer å stille til intervju som vil vare i rundt 30 minutter, der det stilles spørsmål om dine erfaringer og opplevelser av rutiner og bruk av arbeidsverktøy ved din arbeidsplass. Jeg vil ta lydopptak og notater fra intervjuet.

Det er frivillig å delta

Det er frivillig å delta i prosjektet. Hvis du velger å delta, kan du når som helst trekke samtykket tilbake uten å oppgi noen grunn. Alle dine personopplysninger vil da bli slettet. Det vil ikke ha noen negative konsekvenser for deg hvis du ikke vil delta eller senere velger å trekke deg.

Ditt personvern – hvordan vi oppbevarer og bruker dine opplysninger

Vi vil bare bruke opplysningene om deg til formålene vi har fortalt om i dette skrivet. Vi behandler opplysningene konfidensielt og i samsvar med personvernregelverket.

Student Marit Skårsmoen og hennes veiledere ved Oslo Met vil ha tilgang til personopplysningene fra intervjuet. Navn og kontaktopplysningene dine vil bli erstattet med en kode som lagres i separat liste adskilt fra øvrig data. Du som deltaker vil ikke kunne gjenkjennes i den endelige oppgaven som publiseres.

Hva skjer med personopplysningene dine når forskningsprosjektet avsluttes?

Prosjektet vil etter planen avsluttes når masteroppgaven blir godkjent, rundt 15.juni 2023. Etter prosjektslutt vil datamaterialet med dine personopplysninger anonymiseres eller slettes. Disse personopplysningene er inkludert lydopptak.

Hva gir oss rett til å behandle personopplysninger om deg?
Vi behandler opplysninger om deg basert på ditt samtykke.

På oppdrag fra Oslo Metropolitan University har Personverntjenester vurdert at behandlingen av personopplysninger i dette prosjektet er i samsvar med personvernregelverket.

Dine rettigheter
Så lenge du kan identifiseres i datamaterialet, har du rett til:

- innsyn i hvilke opplysninger vi behandler om deg, og å få utlevert en kopi av opplysningene
- å få rettet opplysninger om deg som er feil eller misvisende
- å få slettet personopplysninger om deg
- å sende klage til Datatilsynet om behandlingen av dine personopplysninger

Hvis du har spørsmål til studien, eller ønsker å vite mer om eller benytte deg av dine rettigheter, ta kontakt med:

Oslo Metropolitan University ved
Marit Skårsmoen (student), epost: s180328@oslomet.no
Terje Gjøsæter (førsteamanuensis), epost: tergjo@oslomet.no
Weiqin Chen (professor), epost: weiche@oslomet.no

Personvernombudet ved OsloMet: Ingrid S. Jacobsen,
epost: personvernombud@oslomet.no.

Hvis du har spørsmål knyttet til Personverntjenester sin vurdering av prosjektet, kan du ta kontakt med:

- Personverntjenester på epost (personverntjenester@sikt.no) eller på telefon: 53 21 15 00.

Med vennlig hilsen

Terje Gjøsæter og Weiqin Chen (Forskere/veiledere)

Marit Skårsmoen

Samtykkeerklæring

Jeg har mottatt og forstått informasjon om prosjektet *[sett inn tittel]*, og har fått anledning til å stille spørsmål. Jeg samtykker til:

☐ å delta i intervju
☐ å delta i «Evaluering av Universal Utforming i Beredskapssystemer»

Jeg samtykker til at mine opplysninger behandles frem til prosjektet er avsluttet

----
(Signert av prosjektdeltaker, dato)

Appendix 2: Observation guide

Observasjonsguide

Hovedkategorier

1. **Hardware**

Skjermer

Annet utstyr

2. **Software**

Antall prgrammer

Skjermbilder

Støy på skjermene

- Lys
- Blinking
- Visuelt

Lyder

Farger

Kart

- Farger
- Ikoner

Oppdateringer

- Innføring
- Endringer
- Crash/freeze

Samhandling sw + hw

Systemene + database/server

3. **Human**

Mennesker (operatørene)

- Bakgrunn
- Erfaring
- Digital kunnskap

Hva er de fornøyd/misfornøyd med

4. SA demons og barrierer

Se etter SA demons

- Overload
- Memory

Språkbarrierer

Samtaler under stress

5. Universal Design

UD-Perspective

Skjermer

Software

- Farger
- Font
- Contrast

Web accessibility prinsiples

- Four principles

6. HCI

Demonstrasjon

Opplæring/Trening

Stressnivå

Multitasking

Navigasjon i programmene

Betydning av ulike signaler

7. 110-sentralen

Området de dekker

Workflow:

- Trippelvarsling
- Eskalering
- Trafikk

Samhandling med andre nødetater

Nødløsning: rutine/flyt

Appendix 3: Interview guide

Intervjuguiden

Formål med intervju

Formålet med intervjuet er å finne eventuelle barrierer i beredskapssystemene operatørene som blir intervjuet bruker til daglig på sin sentral.

Metode

Semi-strukturert intervju

Metode for datainnsamling

Lydopptak, notater med penn og papir.

Informasjonsskriv sendes til deltaker i god tid før intervjuet slik at deltakeren har hatt tid til å sette seg inn i rettigheter og prosjektets formål. Samtykkeskjema med signatur leveres før intervjuet starter

Tid

20-30 minutter per deltaker

Tema og spørsmål

Hardware og Software

- Kan du fortelle litt om hvordan arbeidsplassen din er tilrettelagt for deg i dag med skjermer, mus og tastatur, hodetelefoner?
- Jeg har observert at dere må bruke to tastatur og minst to mus; Hvordan opplever du arbeidsflyten når du må jobbe på dobbelt utstyr?

- Kan du fortelle om kjennskapen du har til programmene dere bruker på din sentral i dag?
- Hvor mye av arbeidsflyten på dagens systemer føler du er opplært og opptrent, kontra hvor intuitiv og selvforklarende du føler systemene er?
- Hva synes du om systemene dere bruker i dag?

Menneskelig

- Hva slags faglig bakgrunn og erfaring hadde du før du startet i jobben du har i dag?
- Hvor lang tid tok det for deg for å bli en trygg og erfaren operatør? Og hvordan opplevde du veien dit?
- Hvordan vil du beskrive din digitale kompetanse?

Menneske – maskin – interaksjon (MMI) og universell utforming (UU)

- Hvordan er arbeidsflyten mellom deg, dine kolleger og systemene dere bruker daglig?
- Hva kunne vært enklere med tanke på god arbeidsflyt?
- Er det oppgaver du mener du bruker unødvendig mye tid på å utføre?

- Hva synes du om bruk av farger, kontraster og skriftstørrelse i de ulike systemene?
- Er det innhold i programmene du har vanskeligheter med å oppfatte?
- Brukes det ikoner og andre symboler som kan være vanskelig å forstå?

Situational Awarness (SA) demons og barrierer

- Er det noe teknisk på din arbeidsplass i dag du tenker er en direkte barriere?
- Kan du tenke på situasjoner der programmene hjelper deg til å huske mye informasjon på en gang, og motsatt; gjør det vanskeligere?
- Kan du beskrive situasjoner der programmene:
  Burde være til større hjelp, hindrer deg i å fortsette til neste oppgave, krevd mye av deg i en hektisk situasjon?

Lokale ulikheter

- Kan du beskrive bemanningen hos dere i forhold til antall mennesker i deres distrikt til enhver tid, og antall kritiske hendelser dere får samtaler på i løpet av en dag?
- Er det lokale ulikheter mellom din arbeidsplass og andre tilsvarene sentralen du vet om?
- Og kan du her tenke gjennom fordeler og ulemper du/dere har på nåværende sentral?

Appendix 4: List of figures and tables

The list of figures and tables are interactive, but the numbering of the tables and figures formats back to some strange system, and after trying to fix this problem three times, I have no choice but to share the list.

Chapter 2, tables

Chapter 2. Figures

Chapter 3, tables

Chapter 4, tables

Chapter 4, Figures

Chapter 5, tables