Coagency of humans and artificial intelligence in sea rescue environments
A closer look at where artificial intelligence can help humans maintain and improve situational awareness in search and rescue operations

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Abstract

This paper aims to answer the question of how artificial intelligence could help humans maintain and/or improve situational awareness in search and rescue operations at sea, as well as where in such processes artificial intelligence could be incorporated to most efficiently compensate for human vulnerabilities and support human strengths. In order to answer this, a joint cognitive system perspective has been adopted whilst joining in search and rescue practice operations. These operations have been observed and persons participating in them have been interviewed, in order to gather insights about the process and the persons conducting it. The results from these insights coupled with experience with artificial intelligence and automation, show that artificial intelligence could help improve and/or maintain situational awareness by adopting functions which take up unnecessary time from man. According to the joint cognitive system view, these functions should never be solely performed by artificial intelligence however, but in coagency with man; allocated functions should overlap between man and machine. Suggestions have been given regarding which functions in particular an artificial intelligent agent could perform in terms of search and rescue and where these functions occur in the process. None of these suggestions are without man involvement, as they should not be. To summarise, these suggestions include; a UAV equipped with an infrared camera to search large areas quickly, a decision support system equipped with image recognition to analyse images gathered from the UAV, as well as a communication tool which allows for shared search patterns and hotspots between search and rescue units.

Keywords: joint cognitive system, artificial intelligence, automation, situational awareness, search and rescue, uav, public safety, human factors
Acknowledgement

I have been interested in artificial intelligence, rescue operations and how man can cooperate with technology, since the beginning of my studies in cognitive science three years ago. I began volunteering as a first aider at the Red Cross during this time and kept at it for two years during my time at university before having to leave to focus on this paper, my upcoming move from Linköping and bachelor’s graduation. During my time as a first aider I learnt many things regarding human cooperation in crisis, crisis management and of course how to conduct first aid. I never came into contact with much AI or technology however, other than the odd defibrillator, which is why the focus of this paper intrigues me to such a degree; it’s new and exciting for rescue operations!

Whilst working with Jesper Tordenlid at Combitech during one of my other courses at university, he spotted a sticker (one of many) I had on my computer from SSRS. He pointed to it and asked if I would be interested in working with them at Combitech on a project for sea rescue with UAVs and USVs, as my bachelor’s thesis. I looked into it and eventually said yes. I was later told that they had had an eye on me during that initial project and had been interested in seeing me back at Combitech all along, much to my surprise.

Thank you Jesper Tordenlid for seeing something in me during that project, pitching the thesis idea and being my supervisor through this. Your time, encouragement and help have truly been invaluable.

I would also like to thank my supervisor from university, Kenny Skagerlund, for meeting with me almost every week and putting up with my stress during this process. Thank you for reading, pushing and encouraging me.

Thank you also to everyone who gave their valuable time, either through interviews, long e-mail chains, proofreading, or just chit chatting with me over a cup of tea. Thank you all for showing and telling me what I did not know, for sharing with me inspiring stories and anecdotes, taking interest in what I had to say and confiding in me your own visions for the future. A special thanks to everyone working at Combitech in Linköping, in regard to this, for inviting me into their offices and letting me work on my paper in their vicinity and for their warmth during all interactions.

Lastly, I would like to thank my partner, friends and family for cheering me on and never hesitating to tell me how proud of me they are. Thank you all, it has kept me working hard.
To dad, for sailing and leaving me a sticker for my computer.

I hope you still had some for your boat Vindros.
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## Abbreviations

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<tr>
<td>AI</td>
<td>Artificial intelligence</td>
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<td>AIS</td>
<td>Automatic identification system</td>
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<td>COCOM</td>
<td>Contextual control model</td>
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<td>CSE</td>
<td>Cognitive system engineering</td>
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<td>DSS</td>
<td>Decision support system</td>
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<td>ECS</td>
<td>Electronic chart system</td>
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<td>HMI</td>
<td>Human machine interaction</td>
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<td>IR</td>
<td>Infra-red</td>
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<td>ISA</td>
<td>Individual situational awareness</td>
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<td>JCS</td>
<td>Joint cognitive system</td>
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<td>JRCC</td>
<td>Joint (aeronautical and maritime) rescue coordination centre</td>
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<td>MEDEVAC</td>
<td>Medical evacuation</td>
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<td>MSB</td>
<td>Swedish civil contingencies agency</td>
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<td>OSC</td>
<td>On scene coordinator</td>
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<td>SA</td>
<td>Situational awareness</td>
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<td>SAF</td>
<td>Swedish armed forces</td>
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<td>SAR</td>
<td>Search and rescue</td>
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<td>SCG</td>
<td>The Swedish coast guard</td>
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<td>SMA</td>
<td>Swedish maritime association</td>
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<td>SMC</td>
<td>Search and rescue mission coordinator</td>
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<td>SITREP</td>
<td>Situation report</td>
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<td>SRU</td>
<td>Search and rescue unit</td>
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<td>SSA</td>
<td>Shared situational awareness</td>
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<td>SSRS</td>
<td>Swedish sea rescue society</td>
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<td>STM</td>
<td>Sea traffic management</td>
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<tr>
<td>UAV</td>
<td>Unmanned aerial vehicle</td>
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<tr>
<td>USV</td>
<td>Unmanned surface vehicle</td>
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<tr>
<td>UxV</td>
<td>Unmanned x vehicle (USV or UAV)</td>
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<tr>
<td>Acronym</td>
<td>Description</td>
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<td>-----------------------------------------------------------------------------</td>
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<tr>
<td>WARA-PS</td>
<td>WASP research arena - public safety</td>
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<tr>
<td>WASP</td>
<td>Wallenberg Artificial Intelligence, Autonomous Systems and Software Program</td>
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“If the commander encounters someone in distress, he is obliged to provide any assistance that is possible and necessary to save the person in need, if this can be done without serious danger to his own ship or those on board.”

~ Maritime law 1994:1009 chapter 6 § 6
Introduction

Search and rescue (SAR) is a process where distress calls at sea are answered and people are saved. It is hence a very important and critical process and one which involves many units, organisations and persons. SAR is also very often carried out by people whose primary task lies elsewhere but are nonetheless called upon during crisis. This may be because they are stationed very close to the scene of the incident, or because they are onboard a ship which is the closest and deemed the fittest compared to the rest in the area to carry out a certain task. According to maritime law\(^1\), all commanders must be able to perform SAR and aid others in need of it at sea, why all commanders at sea should be ready to help whence called upon. The sea is vast, however and weather often does little to help in SAR operations. Waves can be high, fog may sweep over the area making search difficult with binoculars and currents may quickly carry men overboard further from the initial scene. It would seem that persons in distress are not really the only ones in need of help then; the SAR operation is not always simple for those conducting and performing it either.

Artificial intelligence (AI) seems to be on everyone’s lips today and companies are quick to incorporate it into their projects. The first thing that springs to mind when hearing about AI might be of cars that need no driver, software that operates your home powered by voice activation, or a voice in your phone that looks things up online for you. Many of these applications are fun, convenient and make life a little easier, but there are situations where the incorporation of AI could be critical. There might however also be times where AI inadvertently make tasks more difficult than they need to be. Such as when your phone mishears you and looks up something else, it would have been simpler to just search for what you wanted yourself. Consider AI in SAR operations. Could AI aid the operation for those performing it and if so; where and in what sense?

In rescue operations, it is of utmost importance that decisions are not only made fast, but thoroughly. Those performing the operation need to be at the scene of the incident as fast as possible in order to be able to provide help to those in need. The rescuers also need to be able to act quickly once they arrive at the scene. In order for rescuers to be able to do this, measures often need to be taken in advance.

AI has the capacity to extend the physical and cognitive attributes of man that are at times inadequate. For instance, AI can do arithmetics faster, move from point A to point B faster and analyse images more thoroughly using, for instance, heat detectors.\(^2\) This does not, however, necessarily mean that replacing man with AI in all instances is reasonable.

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Since some tasks seem more reasonably assigned to man and others to an AI, it is therefore of interest to clearly define when decisions and tasks ought to be dealt with by man and when by AI. This will in this paper be done by exploring how AI can assist humans in maintaining and/or improving situational awareness (SA), a measure of how well persons can discern relevant information from their surroundings and make predictions about the future.³

**Purpose**

The purpose of this thesis is to explore how AI can assist humans and systems in maintaining SA during a SAR operation and where AI is best implemented in a SAR system. While exploring this, a joint cognitive system (JCS) perspective will be adopted. The goal is to provide developers and users of the SAR system with insights and recommendations regarding the implementation of AI in SAR.

**Question formulation**

The questions to which this paper will try and provide answers are:
- How could AI help maintain and improve SA in SAR?
- Where in the SAR system could AI be incorporated to most efficiently compensate for human vulnerabilities and support human strengths?

**Delimitation**

This paper will be focusing on rescue operations at sea and the possible incorporation of AI in these processes. Whilst researching this area, many new topics and interesting aspects come to light, but some of these will not be gaining a focus in this particular paper. These limitations have mostly been chosen out of a lack of time and sometimes due to certain topics being too interesting and broad as they would require their own paper entirely. This paper will be focusing on;
- SAR operations at sea, as the WARA-PS project which Combitech is involved in regards this specific area of rescue operations
- the perspective of the user, for instance persons on the deck of SAR units (SRUs), control bridges/decks of ships
- JCS perspective, as it regards man and machine as one system, in contrast to human-machine interaction (HMI) perspectives, the JCS perspective also makes sure that man is not replaced by AI, but complemented
- AI, as it is a popular topic and one that requires the user-perspective to guide its incorporation in society so as to not create automation surprises or worsen performance of an already established process, AI in a rescue environment is also

especially interesting as AI in workshops on supervision may not be a controversial idea, as these are just supposed to build other machines for instance, but when AI all of a sudden is supposed to collaborate with man to save others, the idea and incorporation of AI may become more of a delicate matter

- SA, as a phenomenon to point to as to what the implementation of AI could result in

Whilst not focusing on, but possibly mentioning:

- limitations within UAVs and USVs and video-recording, such as laws and regulations
- the individual rescue of SAR, this paper does not investigate the specifics of for instance how first aid works, or if that could be automated in any way
- aspects of medical evacuation (MEDEVAC) or towing of SAR
- ethical dilemmas of including AI and automation within rescue operations
Background

The following paragraphs introduce a few different corporations and associations that have contributed to this paper. The section begins by describing the project assigned by Combitech and then follows with describing the term ‘search and rescue’.

WASP/WARA-PS

Wallenberg Artificial Intelligence, Autonomous Systems and Software Program (WASP) is a national initiative for strategic basic research, education and faculty recruitment within AI autonomous systems and program development. The ambition of the foundation is to contribute to Sweden having an internationally recognized and leading position in the designated areas.4

Within WASP; Combitech, SAAB, Ericsson, Axis Communications and the University of Linköping, have united in a project designated to develop a research area for autonomous SAR at sea. This research arena is called WARA-PS. The idea is to use USVs, UAVs and technical solutions which interact with each other and humans, in order to find and rescue those in need. The rescue system of WARA-PS includes UAVs, USVs, communication tools and management centres amongst others.5

Figure 1. USV and UAV from WARA-PS6

It is in relation to this project that this paper is written, why UAVs and USVs will be mentioned often throughout.

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5 ibid.
6 ibid. Photo: Thor Balkhed/LiU
Combitech

This paper is written in relation to Combitech, who is part of the WARA-PS project. Combitech is a consultant company with consultants with expertise in technical fields, defense and manufacturing, amongst others. The company is also a part of the defense and safety corporate group of Saab AB and is based in Scandinavia but also work internationally with their customers. As of today, there are almost 1900 qualified consultants working at Combitech in Sweden, Norway, Finland and Denmark.\(^7\)

Swedish Sea Rescue Society

The Swedish Sea Rescue Society (SSRS) is a non-profit organisation with 2300 volunteers and 71 rescue stations located around Sweden. SSRS is dependent on donations, testaments, memberships and gifts and members may receive assistance or rescue at sea and their membership contributes to others being able to receive the same from SSRS. The SSRS has 230 rescue boats around Sweden and participate in about 80% of all distress calls at sea.\(^8\)

Swedish Maritime Administration

The Swedish maritime administration (SMA) (sw. Sjöfartsverket) is in charge of availability, accessibility and safety at sea, on behalf of the Swedish government.\(^9\)

Search and Rescue

The SMA is responsible for round the clock SAR at sea, as well as MEDEVACs from larger ships. The responsibility covers Swedish sea-territory as well as inland lakes. The SMA also makes sure to localise aircrafts which have crashed or are believed to have crashed in their area of responsibility.\(^10\) SAR operations are conducted via the joint rescue coordination centre (JRCC) of Sweden which is run by the SMA.\(^11\)

SAR is however not a task that solely the SMA is responsible for, but the maritime law states that “if the commander [of any ship] encounters someone in distress, he is obliged to provide any assistance that is possible and necessary to save the person in need, if this can be done without serious danger to his own ship or those on board”.\(^12\) SAR includes

\(^10\) ibid.
\(^11\) ibid.
\(^12\) The Sea Act (1994).
conducting search operations, which could mean parallel search and deciding upon possible search areas, in order to rescue those in need.\(^{13}\)

**Joint Rescue Coordination Centre**

The national sea and aircraft guidance centre of Sweden is situated in Gothenburg and run by the SMA. The centre is located in the same building as the Swedish Coast Guard (SCG) (sw. *Kustbevakningen*) and the Swedish Armed Forces’ (SAF) sea surveillance centre, why the centre is called JRCC.\(^{14}\)

The JRCC is ready round the clock to receive distress calls and coordinate sea and air rescue missions. Distress calls include for instance need for towing and MEDEVACs. During larger accidents, the JRCC can call on further personnel, such as police and emergency services.\(^{15}\)

**SAR-OSC course**

The SAR-OSC course is held by the SMA at their simulator in Lindholmen in Gothenburg. People from various organisations that may at some point be part of a SAR operation, such as the SCG, the SAF and the SMA, may participate in the course. As put by the course administrator in an interview; “the incitament to participate in the course should be to learn about how other organisations work and in turn learn from that, as well as to expand the understanding of the role as an on-scene coordinator (OSC). Participants also learn more about how the communication with the JRCC works during an operation”.

The role as an OSC is assigned by the search and rescue mission coordinator (SMC), in this case the JRCC and often turns out to be the ship first at the scene or the ship most fit to take on that role. The JRCC asks the question whether the ship can take on the role as OSC and the ship may decline or agree to a temporary responsibility until another ship turns out to be more fit. The JRCC then, in that case, re-assigns the role to another ship. The OSC is supposed to coordinate the operation on scene by keeping a dialogue with the JRCC and other SRUs on scene. The OSC role is not always assigned for all operations, as its purpose is to unburden the JRCC and help the JRCC with on scene situational reports (SITREP).\(^{16}\)

**SAR-BASIC course**

The SAR-BASIC course is much like the SAR-OSC course, in the sense of who participates, but differentiates in the sense that it does not involve any OSC teachings. Participants would attend first this course, then a course called SAR-ADVANCED and lastly the SAR-OSC course, why

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\(^{14}\) *Sjöfartsvetet*. (n.d.).

\(^{15}\) ibid.

\(^{16}\) ibid. 13
participants of this course have yet to learn about the role of an OSC. The SAR-BASIC course is held at Arkö, outside of Norrköping, onboard ships unlike the SAR-OSC course which is held indoors in a simulator. Participants perform SAR operations from scenarios given to them over a span of a week and learn how to cooperate and implement techniques they have learned during the course.

To paraphrase the course administrator; “The courses are great because they are so unnatural in a way; you will never have one person from the SAF, one from the SCG and one from the police, on the same deck, in real life. Here you do have that, which means they can swap experiences with each other, understand the SAR system and see where their knowledge complements that of the other’s. Everyone is a puzzle piece and, in these settings, they are able to see where their particular piece fits in with the rest of the puzzle. Once on deck with other participants who have vastly different backgrounds, they are also able to shape their piece, to fit in with that of the rest’s. Everyone can contribute something different.”
Theory

The following paragraphs introduce the areas of study that will be mentioned throughout this paper. Different perspectives and critiques are presented from scholars in connection to this.

Cognitive system engineering

A cognitive system is a system where at least one part is human. This means that a cognitive system can be two humans working together, or one human and a computer.\textsuperscript{17}

Cognitive System Engineering (CSE) thinks of cognition as not only existing in the head. CSE is based on circular causality and studies within CSE begins by looking at empirical evidence, such as observations and looks at cognition being used in a context rather than theories about the mental processes that are thought to take place. Circular causality means that actions and responses are not produced in reaction to direct input, but rather depends on past events, current situation, as well as anticipation.\textsuperscript{18} A negative aspect of this could be that it is hard to find causality between a situation and a response. Since the causality is circular every response depends on so much, which could lead to a degree of uncertainty as to what specifically caused a certain event.\textsuperscript{19}

In CSE, focus lies on the system as a whole and its functions rather than which parts it is made of or how certain cognitive processes happen.\textsuperscript{20}

The focus of CSE is to investigate how a JCS can achieve its goals and maintain control in a dynamic and unpredictable environment. This leads on to how we can design a JCS so that it can maintain control in such a situation.\textsuperscript{21}

Classical human machine interaction

Interaction between a human and a machine, according to the classical human machine interaction (HMI) view, is the transmission or exchange of input and output. Humans and machines are described similarly in this view, each with a number of limited states. In interaction, the machine has a series of inputs and outputs, the human has a series of inputs and outputs and they communicate through for instance an interface. As seen in figure 2, the human and the machine interact through the interface, but previously the human was considered to be interacting with the interface, rather than through it.\textsuperscript{22}

\textsuperscript{18} ibid.
\textsuperscript{19} ibid.
\textsuperscript{20} ibid. page 19
\textsuperscript{21} ibid. 17
\textsuperscript{22} ibid.
As cognition was studied in the past, cognitive processes were thought to be possible to be studied on their own, usually as responses (output) to direct input. Yet, as Hollnagel and Woods describe; “[…] an observable action does not need to have an observable event as a cause; conversely, an observable event does not necessarily lead to an observable action.”

Eventually cognition began to be studied in a context with artifacts and other people, as it was realised that cognition was not solely responses and reactions to immediate input, but rather depended on where it was situated and who and what acted in that same environment. When this was the case, it was understood that cognition ought to be studied this way; in the wild, as so much of cognition depends on where it is situated and what it has to work with.

According to Hollnagel and Woods, it is also more important to look at “how the joint system performs rather than how the parts communicate.” When looking at HMI it is easy to see two parts; human and machine, and the interaction that subsequently takes place between the two. This creates a line between what actions are performed by which agent and eventually leads to actions being treated as discrete events belonging to one specific agent and events considered one by one. “While it is undeniable that we, as humans, are separate from machines, the physical separateness should not lead to a functional separateness”, Hollnagel and Woods argue. The physical separateness can clearly be seen in figure 2.

While actions are treated as discrete events, users are in this instance synonymous with single individuals, even though humans seldom work alone and independent of one another. The study of users’ actions also focuses on responses to immediate input and doesn’t

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26 ibid. 24
27 ibid. 25 page 17
29 ibid. page 19
consider humans’ actions to be for instance anticipatory. Responses and behaviours may also vary and depend on the environment and situation they are in and what factors play a part in that, but classical HMI does not consider this.\textsuperscript{30}

\textbf{Joint cognitive system}

CSE is the area of study which regards cognitive systems whereas the JCS is a model which aims to explain how CSE works and can be applied.\textsuperscript{31}

A JCS focuses on the system as a whole, rather than the parts of it. If a system contains humans and machines one might be quick to look at the human-machine interaction and in doing so put the human outside of that system, as someone who enters it, controls it and then leaves. But when taking on a JCS perspective it is important to look at the coagency of man and machine. It is also important to look at \textit{what} the system does and \textit{why} it does it rather than \textit{how} it does it. The focus hence lies on what the goals and functions of the JCS are and what the JCS does to achieve them.\textsuperscript{32}

The definition of what a cognitive system is has shifted over the years, but the definition used today is as follows; “a system that can modify its behaviour on the basis of experience so as to achieve specific anti-entropic ends.”\textsuperscript{33} Entropy in this context refers to the amount of disorder in a system and an anti-entropic system is therefore a system that can withstand any hardships and maintain order and control in a dynamic environment. Cognitive systems always have a purpose and a goal that they aim to achieve, and this goal is often the same as that of the human’s in that system.\textsuperscript{34}

\textbf{Contextual control model}

The contextual control model (COCOM) (see figure 3) is a reaction to the model shown in figure 2, with all its limitations as described in the HMI section, hence the COCOM tries to redefine how to study human-machine coagency.\textsuperscript{35}

\textsuperscript{31} ibid.
\textsuperscript{32} ibid.
\textsuperscript{33} ibid. 30, page 22
\textsuperscript{34} ibid. 30
\textsuperscript{35} ibid.
COCOM is a model which implies that actions are decided upon through the context and not as a sequential relation between solely previous actions. The three main parts of the model are; competence, control and construct (understanding). The competence of the JCS according to this model, are the possible actions or responses that the system can apply in a given situation. Control is the order of execution and how the competence is applied. The construct of the JCS, or the understanding, is the description of the situation being used to evaluate events and actions.

COCOM can be described and simplified as follows:
1. External events/disruptions affect another event
2. Event/feedback: something happens
3. The event modifies the current construct
4. An action is decided upon
5. An action is performed
6. This action creates an event
7. This event modifies the current construct

The model has now come full circle and continues to circulate with this new experience in mind.

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38 ibid.
39 ibid.
Automation and artificial intelligence

In the following sections, AI and automation will be defined and views on how to manage the implementation of automation presented.

**Artificial intelligence**

Artificial intelligence often regards mimicking or duplicating human thinking artificially, but with such a definition of AI, one must first define what human thinking entails. AI is not an easy area to define, as it has many different definitions and artificial thinking is only one of them.\(^{40}\) Figure 4 showcases eight definitions of AI, categorised into four separate boxes.

<table>
<thead>
<tr>
<th>Thinking Humanly</th>
<th>Thinking Rationally</th>
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<tr>
<td>“The exciting new effort to make computers think . . . machines with minds, in the full and literal sense.” (Haugeland, 1985)</td>
<td>“The study of mental faculties through the use of computational models.” (Charniak and McDermott, 1985)</td>
</tr>
<tr>
<td>“[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning . . .” (Bellman, 1978)</td>
<td>“The study of the computations that make it possible to perceive, reason, and act.” (Winston, 1992)</td>
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<tr>
<th>Acting Humanly</th>
<th>Acting Rationally</th>
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<tbody>
<tr>
<td>“The art of creating machines that perform functions that require intelligence when performed by people.” (Kurzweil, 1990)</td>
<td>“Computational Intelligence is the study of the design of intelligent agents.” (Poole et al., 1998)</td>
</tr>
<tr>
<td>“The study of how to make computers do things at which, at the moment, people are better.” (Rich and Knight, 1991)</td>
<td>“AI . . . is concerned with intelligent behavior in artifacts.” (Nilsson, 1998)</td>
</tr>
</tbody>
</table>

Figure 4. Definition of AI\(^{41}\)

Figure 4 shows eight definitions of AI, categorised into; acting humanly, acting rationally, thinking humanly and thinking rationally, all of which entail very similar aspects of AI characteristics. ‘Acting humanly’ is closely linked to the Turing test, a test which, if an AI passes, can be deemed has fooled people into believing it is in fact human. This test does not regard looks, but rather cognitive and mechanic ability. Functions which an AI must encompass in order to act human (in relation to the Turing test) are; computer vision, robotics, natural language processing, knowledge representation, automated reasoning and machine learning.\(^{42}\) ‘Thinking humanly’, regards cognitive science, i.e. the studying of how humans think and process information, here in order to mimic such functions in an AI. The study of cognitive science and AI are very closely linked for this very reason. ‘Thinking rationally’ involves logic and syllogism (deductive reasoning). Such reasoning can be described as “Socrates is a man; all men are mortal; therefore, Socrates is mortal” and are

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\(^{41}\) ibid.

\(^{42}\) ibid.
often called ‘laws of thought’. This ‘laws of thought’ approach, deems that anything that can be annotated logically, can be solved by an AI.\textsuperscript{43} The last box, ‘acting rationally’, regards logical reasoning and all of the characteristics needed to pass the Turing test, as well as autonomy, perception, adaptation, the pursuing and creating of goals, as well as persisting over a longer period of time. Studying AI with this approach involves a rational autonomous agent, a computer system which acts (rationally), but this approach allows for a wider perspective than solely ‘thinking rationally’ as not all logic can be inferenced and not all reasoning reaches solely one decision. Thinking rationally and acting rationally can differ, as it is easy to think correctly, but to act is another.\textsuperscript{44}

As we have learned from these four categories and eight definitions, AI involves many functions, abilities and characteristics. Few agree upon a clear distinction between AI and automation, however. In this paper I have decided upon a definition of automation in order to facilitate further referencing to automation and AI, even though there are several views on this distinction. In this paper, automation does not have to involve AI, but all AI involves a level of automation (see figure 5). Consider a sprinkler system for instance. Such technology is automated with for instance a timer, but it is not AI. But autonomy is involved in ‘acting rationally’, as well as ‘thinking humanly’, in conjunction to AI, as we saw from figure 4, so let’s review what automation is.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure5.png}
\caption{Automation and AI\textsuperscript{45}}
\end{figure}

\textsuperscript{43} Russell, S. J., & Norvig, P. (2016)
\textsuperscript{44} ibid.
\textsuperscript{45} ibid.
Automation

According to Parasuraman and Riley\textsuperscript{46}, automation is defined as the execution of a function, task or process, by a machine that previously was carried out by man. According to this definition, what is considered automation will change over time as more and more functions proceed from being executed by man, to being executed by a machine. The definition of automation according to the Oxford English Dictionary is “1. automatic control of the manufacture of a product through a number of successive stages; 2. the application of automatic control to any branch of industry or science; 3. by extension, the use of electronic or mechanical devices to replace human labor.”\textsuperscript{47} The third definition fits in with Parasuraman and Riley’s definition.

Previously, automation was thought of as simply mechanical devices carrying out one given task replacing manual labour, but today, we are able to automate human thinking using decision support systems (DSS) and algorithms\textsuperscript{48}, expanding the definition of automation further as human cognitive abilities can be replaced by artificial ‘cognitive’ abilities. Automation is closely linked to artificial intelligence today for that very possibility\textsuperscript{49}, why I use AI interchangeably with automation from this point onward in this paper. Note how I do not use automation interchangeably with AI though, as figure 5 shows that not all automation is AI.

Automation ironies

In work environments (systems) today AI and consequently automation, are increasingly replacing manual labour. But as tasks proceed from execution by man, to being executed by a machine, it is of importance to take notice of how the shift consequently does not replace and eliminate man from the system as a whole. As noted by Wickens et. al.; “automation has the capability both to compensate for human vulnerabilities and to better support and exploit human strengths.”\textsuperscript{50} As functions therefore are divided between man and machine, human-automation cooperation increasingly takes place and the introduction of automation does to a degree interfere with an ongoing process that man already has been familiarised to. The transition to automation therefore needs to be made gradually as to not interrupt that process.\textsuperscript{51} It is vital that man is a part of the feedback loop of the automated task. In a sense, part of the ‘cognitive’ functions of the machine and able to overlook which decisions are made by said machine and on what basis. This in order for man to be able to override

\textsuperscript{49} Russell, S. J., & Norvig, P. (2016)
any decisions that are made and replace the machine with manual labour when necessary, as a safety precaution. This can be done through a display for instance.\textsuperscript{52} If this is not done in any way and man is not part of the loop, automation ironies can arise\textsuperscript{53}, because “[...] the more advanced a control system is, (so) the more crucial may be the contribution of the human operator”.\textsuperscript{54}

Automation ironies regard issues that arise when one tries to optimise a system using automation. It can be argued that not everything can be automated and when it can’t, the scraps are left for man to perform. Meaning that even if the designer tries to eliminate man out of the system by automation, man is left with either the most difficult work or the easiest and most tedious. This is called the left-over principle.\textsuperscript{55} One such chore may be for man to solely monitor the automated function, to make sure that it is being performed as it should. And once it is not, take over that function and alleviate the machine. This opens up for another irony however, because if an operator is reduced to simply monitor, this person’s skills are not honed and practiced and therefore deteriorate; “efficient retrieval of knowledge from long-term memory depends on frequency of use”.\textsuperscript{56} Imagine then if this person is expected to be ready to take on any task of the machine’s from nowhere; this will not be an easy feat.\textsuperscript{57} Another irony which follows is; “if the job is 'deskilled' by being reduced to monitoring, this is difficult for the individuals involved to come to terms with. It also leads to the ironies of incongruous pay differentials, when the deskilled workers insist on a high pay level as the remaining symbol of a status which is no longer justified by the job content”.\textsuperscript{58}

The importance of a feedback loop, how man needs to be aware of all the inner workings of the machine in order to still be part of the system and to secure safety in the system, as well as hone their skills in theory, has been mentioned. There are however more precautions that can be made in order to avoid automation ironies. Automation does not eliminate man out of the system (or so it shouldn’t as we have learned), but merely shifts the role of man, human errors can therefore not be entirely avoided but merely their nature changes. In order to avoid automation ironies then, a JCS perspective needs to be adopted and function allocation considered for the implementation of automation. This should in terms of CSE be done with a goals-means function analysis\textsuperscript{59} which will be further explained later in this paper. This is called the complementarity principle.\textsuperscript{60}

\textsuperscript{52} Hollnagel, E., & Woods, D. A. (2005)
\textsuperscript{54} ibid.
\textsuperscript{56} ibid. 54
\textsuperscript{57} ibid.
\textsuperscript{58} ibid.
\textsuperscript{60} Hollnagel, E., & Woods, D. A. (2005)
**Level of automation**

As the role of man shifts during automation implementation, man’s role may vary depending on the level of automation and thereby the degree of man dependence and involvement.

There are many defined levels of automation, some have chosen to use a level of 1-10, others 1-5 and others 0-5, but they are very often similar and tend to describe the same kind of levels. These levels describe to what degree man is involved in the automatic processes, as automation being thought of as ‘without man’ is not that simple. Here I have chosen to adopt the 0-5 level definition as it has been described to me in interviews as well as seems to be the simplest of the three to use to explain and reference in connection to WARA-PS (see figure 6).

As seen in figure 6, it is here first at level 5 that automation does not include man. The only difference between level 4 and 5 is that man is included in the former, allowing for SA (through a display for instance, man is a part of the feedback loop) and the capability of man to intervene if noticing that the automatic process has chosen to do something which it shouldn’t. At level 5, man would not have been made aware of such an error, until too late.

Level 2 presents an interesting aspect, where a UxV, has to present man with which decisions it wishes to take, and man has to either give it the go ahead or intervene. But if man does not respond, should the vehicle simply wait forever? If so, then it has switched to a level 1. If the vehicle is supposed to wait, say for 3 minutes, for a response, should it at 3 minutes and 1

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second decide for itself what it should do? If so, then it has switched to a level 4.\textsuperscript{63} Claiming that something is autonomous could hence actually leave us with more questions than answers, because the level of autonomy and man involvement could vary greatly.

**Function allocation and the complementarity principle**

Speaking of degree of man involvement (level of automation) and principles of automation implementation such as the left-over principle and the complementarity principle\textsuperscript{64}, function allocation has long been an issue. Function allocation means choosing which parts of a system, which tasks, man should handle, and which can be left for a machine. Fitts list, is a list compiling what humans are better at and what machines are better at.\textsuperscript{65} This list was first presented in an article in 1951, which could indicate that the comparison has aspects that are outdated, but the authors of the article themselves humbly pointed out how that may very well be the case in the future.\textsuperscript{66} Many of the characteristics presented in the Fitts list (see figure 7) are however still very relevant today.\textsuperscript{67} The principle related to the Fitts list is called the compensatory principle. Which basically means that anything that man can’t do well should be automated and the tasks which man can do well should not.\textsuperscript{68}

<table>
<thead>
<tr>
<th>Humans appear to surpass present-day machines in respect to the following:</th>
<th>Present-day machines appear to surpass humans in respect to the following:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ability to detect a small amount of visual or acoustic energy</td>
<td>1. Ability to respond quickly to control signals and to apply great force smoothly and precisely</td>
</tr>
<tr>
<td>2. Ability to perceive patterns of light or sound</td>
<td>2. Ability to perform repetitive, routine tasks</td>
</tr>
<tr>
<td>3. Ability to improvise and use flexible procedures</td>
<td>3. Ability to store information briefly and then to erase it completely</td>
</tr>
<tr>
<td>4. Ability to store very large amounts of information for long periods and to recall relevant facts at the appropriate time</td>
<td>4. Ability to reason deductively, including computational ability</td>
</tr>
<tr>
<td>5. Ability to reason inductively</td>
<td>5. Ability to handle highly complex operations, i.e. to do many different things at once.</td>
</tr>
<tr>
<td>6. Ability to exercise judgment</td>
<td></td>
</tr>
</tbody>
</table>

Figure 7. The original Fitts list\textsuperscript{69}


\textsuperscript{64} Russell, S. J., & Norvig, P. (2016)


\textsuperscript{67} Sandom, C., Harvey, R. S., & Technology, I. O. (2009). *Human factors for engineers*. Institution of Engineering and Technology - IET. Chapter 6

\textsuperscript{68} Hollnagel, E., & Woods, D. A. (2005)

\textsuperscript{69} Fitts 51, Fitts, P. M. (Ed.). (1951)
According to the view of JCSs however, it is not as simple as just comparing attributes of man and machine one by one. We need to look at context and where these attributes take place and in conjunction with what other attributes and functions; functions and attributes are very seldom independent.\textsuperscript{70}

The Fitts list suggests that tasks should either be handled by man or be automated, but the JCS view argues that allocation of tasks should overlap between man and machine, for optimal control and safety.\textsuperscript{71} As mentioned in the CSE section of this paper, man can act on immediate ‘input’ but also acts on what may be, or what may have been\textsuperscript{72}, meaning that a direct replacing of man with machine, due to comparing man to a machine through solely ‘acting on input’, is faulty reasoning.\textsuperscript{73}

Man as part of the system is often deemed a bad idea, due to human factors, but according to the JCS perspective, man is an important adaptive and resourceful part of the system. Making the focus of automation implementation of a JCS more about coagency between man and machine, than simple function allocation attribute by attribute.\textsuperscript{74}

Function allocation is however of course needed in some sort of sense, in order to understand what we should actually automate in a system and for what purpose.\textsuperscript{75} The function allocation related to the Fitts list, makes \textit{a priori} judgements of tasks and functions in order to understand which should be assigned to man and which to a machine. In relation to the JCS perspective however, we instead define functions that are necessary for the JCS to maintain control based on its context. This is done with a goals-means analysis\textsuperscript{76}, which will be presented further in this paper. This is the complementarity principle, where man and machine cooperate with one another.\textsuperscript{77}

\textbf{Time and control}

Decision making that takes place in an environment that changes could at times be under time pressure. This means that the time aspect of making decisions needs to be considered explicitly.\textsuperscript{78} Time pressure can occur when the choice of action takes too long, or when the

\textsuperscript{70} Sandom, C., Harvey, R. S., & Technology, I. O. (2009). Chapter 6
\textsuperscript{71} ibid.
\textsuperscript{72} Hollnagel, E., & Woods, D. A. (2005)
\textsuperscript{73} ibid. 70
\textsuperscript{74} ibid.
\textsuperscript{75} ibid. 72
action takes too long to be performed (see figure 8). According to Kerstholt and Raaijmakers, time pressure increases when the control of the system decreases. In a dynamic environment then, multiple decisions need to be made and these decisions in turn have an effect on the system’s control.

When considering the COCOM (see figure 3), a model displaying how a system maintains control in a context, the system state or construct is defined as needing to be modified whenever an event takes place, but in certain situations such as during a fire extinguishing operation, or in this paper’s case; a rescue operation, the event is continuous. Unlike when for instance something in a process breaks and needs fixing, a fire can spread rapidly and a rescue operation can change drastically as a person in need’s health declines. This especially means that there is limited time for decisions to be made.

Figure 8 extends the COCOM (see figure 3) with the aspect of time in relation to control. Since the COCOM is based on circular causality, inserting time aspects means that time of one part of the cyclical model depends on and affects time of another. Time needed for event evaluation for instance, could be kept at a minimum by improving design of information presentation, as well as making sure only relevant information is shown. Time needed for selecting an action to be performed, could be decreased thanks to extensive training and prepared decisions (procedures) to be in place. Performance time could be reduced with

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79 Hollnagel, E., & Woods, D. A. (2005); ibid. 78
80 ibid. 78
81 ibid.
82 ibid.
83 ibid.
automation and employing extra staff and time available could be increased by making sure safety systems and systems that stall losing control are in place. Such systems could include an autopilot function allowing a human to focus entirely on the task of choosing an action rather than doing so while maintaining control as well. All of these time-values depend and affect one another, since if the time it takes to choose an action is larger than time available minus choice of action, the system has no time to perform said action and loses control.\textsuperscript{85}

How successful a system is at handling a dynamic situation is most often determined by its degree of SA.\textsuperscript{86}

**Situational awareness**

SA can be defined as the state of a person during a control assignment when needed to assess current construct and from that predict future states of the system. SA can be thought of in three levels\textsuperscript{87};

1. awareness of relevant factors in surroundings
2. interpretation of those factors
3. prediction of future states based on those factors

To further explain, SA regards the ability to discern relevant information from irrelevant information, understand the relevant information and with this predict and understand what might happen because of it. A classic example of SA is a control bridge of a ship.\textsuperscript{88} Here, it is important that everyone can apprehend relevant information, that that information is easily understood and accessed and that roles of every person involved in the system are clearly defined. SA is important on an individual level (individual situational awareness: ISA), but also generally (shared situational awareness: SSA).\textsuperscript{89} It is important that all individuals of a process are aware of what others are in charge of and what they need and what the individuals’ actions contribute to the whole, as well as understand what their own contributions are.\textsuperscript{90}

\textsuperscript{85} Hollnagel, E., & Woods, D. A. (2005)
\textsuperscript{87} ibid.
\textsuperscript{90} Danielsson, M. (2016); Berggren, P. (2016, 04)
Situational awareness and automation

SA is an interesting measure when dealing with the implementation of AI, in order to understand the reason for automating a particular function. We previously looked at the idea of automating what man is bad at (the Fitts list\footnote{Fitts 51, Fitts, P. M. (Ed.). (1951)}) and allocating functions in that way, but we also established that through the JCS view, we need to view man and machine as cooperative entities, coagency, a system and allocating functions based on how they help the system maintain control and achieve its goals.\footnote{Sandom, C., Harvey, R. S., & Technology, I. O. (2009). Chapter 6} In conjunction to this complementarity principle, SA can be a good measurement of level of control.\footnote{Danielsson, M. (2016)}

It has been suggested that a lack of SA is the culprit when certain automation ironies occur.\footnote{Wickens, C. D. (1992). Workload and situation awareness: An analogy of history and implications. \textit{Insight: The Visual Performance Technical Group Newsletter, 14}(4), 1-3; ibid. 89} A lack of utilising and practicing one’s skill is of course also to blame, but SA seems to also be an important factor.\footnote{ibid. 89}

According to one study, the greater the level of automation, the lesser the degree of SA (see figure 9).\footnote{ibid.} But automation is not all bad for SA, because according to another study, SA may actually be improved with automation.\footnote{Billings, C. E. (1991). Human-centered aircraft automation: A concept and guidelines. National Aeronautics and Space Administration, Ames Research Center.} SA may improve in conjunction with automation, if the automation provides integrated information and reduces manual work that is unnecessary.\footnote{Billings, C. E. (1991).}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure9.png}
\caption{Updated levels of autonomy figure}
\end{figure}

\footnotetext[91]{Fitts 51, Fitts, P. M. (Ed.). (1951)}
\footnotetext[92]{Sandom, C., Harvey, R. S., & Technology, I. O. (2009). Chapter 6}
\footnotetext[93]{Danielsson, M. (2016).}
\footnotetext[95]{ibid. 89}
\footnotetext[96]{ibid.}
\footnotetext[98]{Billings, C. E. (1991).}
Method

The method adopted in this paper has relied on the theory presented in this paper in order to ask relevant questions during interviews and in order to be aware of what to look for during observations to answer the research questions as adequately as possible. Namely;

- How could AI help maintain and improve SA in SAR?
- Where in the SAR system could AI be incorporated to most efficiently compensate for human vulnerabilities and support human strengths?

This part of the paper presents the methods used to conduct interviews and observations, as well as the method used for analysis of gathered data.

The overall approach

Researching the process of rescuing people at sea began with interviewing engineers related to the WARA-PS project about how they viewed that process, as well as what technology they believed was necessary in it. Adopting a JCS perspective as well as the cognitive ethnographic method meant that I viewed the SAR process and all its units as a system, where all technology and people in it had a function that contributed to maintaining the system’s goal. The JCS perspective allowed me to view this system as a whole, rather than what each specific part of it contributed and how it did so. While I did at times focus on certain aspects of the system, the focus lay more on how these contributed to the system in a wider sense rather than through any sort of depth.

After having interviewed a couple of people related to the WARA-PS project, interviews were held with people who were active in the process of rescuing people at sea. They too received, among other questions, the question of what technology they believed necessary in such a process.

Observations were then made at four separate locations; JRCC, SMA’s simulator at the University of Chalmers and Arkö on board ships, this in relation to two courses held by the SMA called SAR-OSC and SAR-BASIC. Observation was also conducted at the UAS forum conference in Linköping for emergency and rescue services and there managed to speak with persons who already use or in the future want to incorporate UAVs into their organisations.

After having conducted both interviews and observations, data was compiled into themes and knowledge about automation, JCS and SA was applied in order to give suggestions regarding automation implementation during sea rescue operations. Themes derived from data are presented and discussed in the discussion and analysis part of this paper, but original jottings will not be included besides the odd quote.
It is also worth mentioning that all quotations will in this paper be paraphrased as they were originally in Swedish and as irrelevant words, stammering, or hesitations have been removed. This should however not affect the results as according to the method used (cognitive ethnography and thematic analysis), what is being said is of interest rather than how it is being said.  

The following sections describe what the methodology of cognitive ethnography entail, how interviews and observations have been conducted, followed by how data gathered from these have been analysed and explain the method used for said analyses.

Cognitive ethnography

Cognitive ethnography was for a long time not an established methodology in qualitative research. Instead, solely ‘ethnography’, without any sense of cognition, was adopted. Ethnography’s main purpose is to look at first-hand empirical investigation through interviews, observations and participation, combined with theoretical interpretation of culture and social settings. Ethnographic fieldwork is hence very much interested in looking at anthropology and fieldwork often means spending time with new groups of people in their natural setting for an extended period of time, in order to observe and interpret their way of life.

Regarding this, notes are kept in conjunction to observations and interviews being made. The note taking is sometimes referred to as “jotting”, which implies that notes are to be taken fast and only capture; key words, phrases, dialogue and actions, almost like scribbles. These jottings aim to jolt the memory of the researcher once looking through the notes at a later stage. This helps the researcher write thorough accounts of what was experienced.

One source on ethnographic methodology suggests a six-step approach on how to jot down notes during ethnographic research:

1. Begin by jotting down key components of observed events or interactions. Some of these jottings may not be of independent importance, but rather aid the researcher in recollecting the full experience later.
2. Jot down concrete sensory details about observed scenes or interactions: kinetic, auditory and visual. This is so the researcher will be able to remember the feel of the experience. Visual jottings were however not made in correlation to observations in this paper as I instead brought my camera and took pictures to complement my jottings.

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101 ibid.
102 ibid. 99
3. Do not generalise or summarise experiences but try to avoid opinionated jottings. Notes should be of what was observed, or heard, without any of the researcher’s own ideas regarding what was said or observed.

4. Jot down dialogue, spoken words and phrases. This can be compared to that of step three, where jotting down actual phrases such as a sequence of swear words, rather than writing ‘person was angry’, can avoid summarised jottings.

5. Keep note of your own emotions such as sadness, happiness and anger related to experiences in a way that can be used to understand how persons being observed may feel. Making total assumptions about other’s emotions should not occur but be based on one’s own.

6. The final step in writing ethnographic fieldnotes is to jot down your own general impressions of an event. It is of course however very important to be able to distinguish between one’s own feelings and impressions and that of the persons’ being observed, when reading through the notes at a later stage.

Once notes have been taken and observations and interviews are finished, it is time to analyse gathered data through thematic analysis, the analysis method which will be presented further ahead in this paper.

The term ‘cognitive ethnography’ was first presented in an article titled ‘cognition in the wild’ and utilises much of the same methodology as ‘ethnography’ does, but with a twist. Cognitive ethnography aims at studying cognition in settings and contexts, rather than studying anthropology as ‘ethnography’ does. Cognitive ethnography looks at cognitive systems, such as bridges of ships (much like this paper does) and cockpits and studies the goals and functions of that system and how it achieves them. When applying this methodology, three distributions of cognition emerge:

1. cognition between social groups
2. cognition internally or externally
3. cognition over time; past, present, or future.

The third distribution of cognition relates very well to that of the COCOM model (see figure 3) previously mentioned in this paper, as they both describe how decisions are not solely based on immediate input, but may relate to lessons learned in the past, or due to analysis of the future through for instance SA.

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106 ibid.
Interviews

The interviews in this paper were either semi structured or completely informal. The interviews that were informal were conducted in relation to observations, for instance asking a participant why they performed a specific action at that particular moment or asking someone to explain the technology being used at that location. This is on par with Holtzblatt’s method of contextual inquiry\textsuperscript{109}, where interviews are conducted in relation to observations. According to Holtzblatt, the contextual interview should be guided by four principles;

- **Context** - While people are working, gather data in the workplace and focus on the activities they are doing
- **Partnership** - Collaborate with customers to understand their work; let them lead the interview by doing their work. Do not come with planned questions.
- **Interpretation** - Determine the meaning of the customer’s words and actions together by sharing your interpretations and letting them tune your meaning. When immersed in their real lives and real works, people will not let you misconstrue their lives.
- **Focus** - Steer the conversation to meaningful topics by paying attention to what falls within project scope and ignoring things that are outside of it. Let users know the focus so they can steer, too.\textsuperscript{110}

These principles guided the informal interviews that were conducted during observations.

Interviewing and observing in an environment and in a context that recipients are familiar with and where they perform what is being observed is a very well-established method. It is very closely linked to cognition in the wild and cognitive ethnography, the study of cognition in the wild.\textsuperscript{111} Cognition in the wild relates to cognition being studied in settings where cognitive tasks are naturally performed. Cognition has very often been studied in laboratory settings and much of what we know of cognition comes from these laboratory studies, but cognition in natural settings must be studied as well, as context matters.\textsuperscript{112}

Interviewing participants at location of observation and during observation, is also very closely linked to the JCS perspective adopted throughout this paper. The JCS perspective adopts cognition in the wild, situated and distributed cognition, or applied cognition, as the method of which to observe cognitive tasks.\textsuperscript{113}

Interviewing participants in the setting of where a product, in this case new technology or automation, will be used, is also recommended by other researchers within the


\textsuperscript{110} ibid.

\textsuperscript{111} Hutchins, E. (1995).

\textsuperscript{112} ibid.; Hollnagel, E., & Woods, D. A. (2005)

\textsuperscript{113} Hollnagel, E., & Woods, D. A. (2005)
field of user research, a method where users (or potential users) for a certain product are interviewed and observed in order to make sure the design of said product complies with the needs of the users.\textsuperscript{114} This method, user research, has in part been adopted as well, at least in terms of understanding user needs, but not in terms of actually designing a product for those needs.

The user has been particularly interesting during the writing of this paper, due to a possible implementation of automation needing to be user-centered; automation must not be implemented in a system for the sake of it\textsuperscript{115} but must aid the system in achieving its goal\textsuperscript{116}, complement man well\textsuperscript{117} and by complementing man well also need to have the necessary means for man to interact with, cooperate with and understand the automated task.\textsuperscript{118} All of this results in an interest to look at SAR actives’ needs, in part what they would need such automation to be able to do and in what segment of the system or process, but also in part if they would need automation in the system at all. Asking questions of this nature as participants conducted SAR scenarios, might have helped them apply the automation’s application in the system as the system’s processes unfolded.\textsuperscript{119}

Semi-structured interviews were not conducted in relation to observations, but during sit-down meetings and therefore required some questions to be prepared beforehand. These questions can be found translated in the appendix as attachment 1. Some questions came about during interviews as new information was learnt, or it was deemed on the spot that other questions were more appropriate for that specific recipient. A semi-structured interview is an interview that encourages the recipient to speak freely about topics and the interviewer only has a few questions prepared beforehand, allowing for questions to be added or removed as the interview progresses. Semi-structured interviews are often the choice for qualitative studies such as this paper.\textsuperscript{120}

All recipients were not interviewed at the same location, but many were interviewed in meeting rooms at Vita Huset in Linköping, the location of Combitech’s offices in Linköping (remember that informal contextual interviews were held at the various locations of observations), whilst others were interviewed at the UAS conference, or in Norrköping at the SMA’s headquarter. Interviews were recorded and some notes were taken during the interviews by the interviewer, a good idea according to other researchers\textsuperscript{121} and in line with

\textsuperscript{116} Hollnagel, E., & Woods, D. A. (2005)
\textsuperscript{117} ibid.
\textsuperscript{118} ibid.
\textsuperscript{119} ibid. 114
\textsuperscript{121} ibid. 114
the ethnographic method. The interviews held at Vita Huset with Combitech coworkers were kept private, behind closed doors, in order to make sure that recipients felt at ease expressing themselves and to speak freely regarding Combitech related matters without coworkers listening in. Semi-structured interviews that were not conducted at Vita Huset took place at the location of observation (but not during observation because then the interview was informal), i.e. at JRCC, the SMA’s simulator at Chalmers, or Arkö, where only people interested in the matter of SAR were positioned, deeming it an adequate level of privacy during interviews. Since persons who were at these observation locations were not affiliated with the same organisations (participants came from different backgrounds), it was also not deemed as important to keep interviews behind closed doors as at Combitech, where interviews were held with Combitech staff.

**Recruitment and ethics**

The plan was to recruit people to interview who had experience with rescue operations at sea, as well as technicians and engineers who created and designed products to be used for rescue at sea (WARA-PS researchers and developers). Whilst researching who would be a good fit, some pitched in their own name as a suggestion for recipient of interviews, whilst others were asked to participate as they were deemed an interesting person to interview on the matter. Persons related to WARA-PS were found through suggestions of people working at Combitech, or through my supervisor at Combitech who also happens to be the manager of WARA-PS. Persons active in SAR were found through observations during the SAR-courses. Leading up to the courses I kept contact with two persons at the SMA, one of which was in charge of the courses and later managed to also conduct an interview with these two in Norrköping at the SMA’s headquarter.

During the SAR courses I tried to be open with participants about how I wished to speak with them and observe them during their activities and how, if they at any point during the activities felt like I was in their way or disturbed with my questions, they should feel free to tell me so. I also informed them about how I was going to be taking pictures of scenes and activities during the courses, but that I would try to avoid taking any pictures of them as participants and how, if they at any point felt uncomfortable with the camera or with any pictures that I had taken, could come up to me afterwards and ask me to delete any pictures that they wanted gone. No participants asked me to delete any pictures and participants were often the first to initiate conversation with me during observations. An advantage, as they then knew what was of interest to me and could tell me things related to that which I did not

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This corresponds to the fourth principle of conducting contextual interviews presented by Holtzblatt.  

**Participants**

People who were interviewed included four rescue leaders from the Swedish JRCC, three employees at Combitech, a person from Saab AB working with the autonomous USV, a person from SSRS working with innovation and industrial design related to UAVs, two persons from the SMA, one administrator from the Swedish civil contingencies agency (MSB) (sw. myndigheten för samhällsskydd och beredskap), as well as a person conducting research at the University of Linköping regarding UAVs in rescue operations. This is not counting the participants that were informally interviewed in relation to observations, where there were perhaps around 30 people interviewed that were active in SAR operations. These participants came from the SCG, the SAF, the SMA, the police, or were stationed on ferries. A vast majority were men (two women out of all participants in total) and all around 25-45 years old. The person that was interviewed from Saab AB also had experience with the perspective of JCSs and could therefore provide insights not only in regard to the project of WARAP as a whole, but also to the perspective that has been adopted throughout this paper. Everyone interviewed, besides the two women from the SAR courses, were men, deeming this sample very homogenous. From what I’ve seen and gathered however, this seems to be quite a representable sample of maritime professions.

**Observations**

The two more major observations took place at two SAR courses conducted by the SMA, one in Gothenburg and one at Arkö. The courses included SAR-OSC and SAR-BASIC. The observation during the SAR-OSC course took place over a span of four days. During these days, a visit to JRCC was included, simulations of SAR-missions at the SMA’s simulator at the University of Chalmers and a few lectures about media communication amongst other topics from which I gained insight into the SAR process and the system. The focus of the observation was on the workings of the JRCC, as well as participants’ methods to complete SAR missions on deck. The observation at the SAR-BASIC course took place for one day, but both courses ran for one week. During the SAR-BASIC course, participants got on boats and headed out to simulate SAR scenarios, unlike the SAR-OSC course which was held at a simulator indoors. On the boat I was able to more realistically observe how participants searched using binoculars and verify or disprove any theories I had made regarding technology usage from the SAR-OSC course prior. I tagged along one boat with five persons.

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on board and was able to discuss with them how they viewed AI in SAR operations and conduct contextual informal interviews.

I will be showcasing some pictures during this part of the thesis, for a better understanding of what it is I have been observing. The pictures also work in a way as extracts from my jottings, since visual notes were not taken (step 2 of how to take ethnographic fieldnotes\textsuperscript{125}) but as scenes instead were photographed.

**Joint Rescue Coordination Centre**

At the JRCC I was able to meet and contextually and informally interview a few rescue leaders about their work and their vision for AI in SAR. This visit gave me insight into how the JRCC works together with SRUs in order to rescue those in need at sea and what they need of SRUs during such operations. The visit lasted a couple of hours and was made with participants of one of the SAR courses.

**SAR-OSC course**

The course took place over the span of five days, at Lindholmen in Gothenburg. I however participated only four days. The course was held at the University of Chalmers at the SMA’s simulator and this simulator consisted of about four decks and one control room. The former was supposed to be decks of ships and the control room was a simulated JRCC. The participants in the course were, during simulated scenarios, stationed on decks whereas persons responsible for the course were stationed at the simulated JRCC and could from there overlook the simulations whilst mimicking the responsibilities of the actual JRCC. The simulated JRCC had access to many screens. The screens corresponded to each active simulated deck. The top row (a total of six screens) showed what deck number one was seeing, row two deck two, et cetera. Whilst overlooking what the decks (SRUs) were seeing and doing, the simulated JRCC also had to act the part of JRCC and various other made up ships. It seemed that the simulated JRCC could communicate with SRUs much in the same fashion as the real JRCC would have been able to and when asking the ones responsible for the course if the simulator was realistic enough, they responded that they believed so.

\textsuperscript{125} Wolfinger, N. H. (2002, 04).
The simulated decks (see figure 10) and JRCC were located on one floor, in the same corridor, making it easy for me as an observer to move between units and allowing me to observe and hear things I otherwise wouldn’t have if only located on one deck (much like I would have been during a real SAR operation).

As the name of the course would imply, participants were taught the role of the OSC and took turns playing that role, often leaving me to observe from the deck of the OSC which of course left me with observations from the perspective of an OSC. This meant that I could overhear communications with the JRCC as well as with other SRUs.

**SAR-BASIC course**

The SAR-BASIC course was conducted at Arkö and I participated for one day despite the course running for an entire week. During this day I participated in a total of three scenarios on one boat with five participants of the course. I was able to conduct contextual informal interviews with these participants, as well as observe how they used electronic and physical nautical charts, searched with binoculars, communicated with the OSC and other SRUs, as well as carried out the SAR operation. During this course the role of the OSC was not assigned, but rather taken on by the one in charge of the course, leaving all boats with participants as SRUs, why my observations from this course were instead from the perspective of a SRU. This meant that I never heard the SRU I was on communicate with the JRCC for instance, but rather with the OSC.

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126 photographer: the author Johanna Seger
UAS conference

The UAS conference for emergency services was held at Frimurarehotellet in Linköping by UAS Forum Sweden. The conference lasted one day, between eight in the morning and four in the afternoon and included many presenters from different backgrounds; the police discussed UAVs within their organisation, the Swedish transport agency (sw. Transportstyrelsen) came to speak about laws and regulations regarding UAVs and MSB talked about UAVs within emergency services such as ambulances, to name a few. The day included short breaks and lunch, allowing time for semi-structured interviews, but a vast majority of the time was spent solely listening to presentations.

Analysis

Data from interviews were analysed through recordings and notes. The recordings helped put quotations into contexts as well as facilitate as exact paraphrasing as possible. Recordings of course also helped to remember all that was said. Interviews were analysed thematically, meaning that all interviews contained certain themes at times that were then grouped together under specific topics, allowing for different interviews to come together as a whole.

During observations, recordings were sometimes made in correlation to something being explained, for instance on the control deck, which is to be recommended according to the adopted methodology of this paper. Note-taking and photographs were however the primary form of data collection during observations. Upon analysing, observations, notes, photographs and recordings, were in a way also thematically analysed. This more in the way of where to put insights in this paper. Some of the data collection from observations were for

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127 photographer: the author Johanna Seger
instance solely my own thoughts and ideas on the matter, or strictly information about how the SAR system works, with drawings and photos to further describe that.

**Thematic analysis**

The primary method of analysis used in this paper is called thematic analysis, but often referred to as “developing a thematic narrative” in conjunction with ethnographic methodology.

From notes taken during interviews and observations, themes emerge and some of these are then organised into coherent stories in the form of flowing text. This method requires that only some aspects of the notes are selected and analysed in order to create an as accurate as possible representation of the settings that have been studied. According to one ethnographer; “the excerpts in an ethnographic story are not so much evidence for analytic points as they are the core of the story”, which correlates to how an ethnographer should not select themes and fieldnotes in order to argue points already made prior, but study notes in an open minded way, with no prior themes in mind. The act of writing out topics and themes is called coding.\(^{130}\)

Thematic analysis begins by looking at ones’ fieldnotes and explicitly writing out any themes found. In doing so many different themes will begin to emerge through these notes and one will have to think about how to tie these together. Once one or more general topics which encompasses and ties many of these themes together has been found, themes which do not fit in with these topics have to be removed. In doing so, the ethnographer purposefully ignores themes for the sake of the story, but must try and incorporate many different voices and perspectives into each theme.\(^{131}\) In disregarding certain themes however, some voices are excluded or not as distinct, whilst others are given a bigger platform to express themselves.\(^{132}\)

Above description of thematic analysis methodology can be put into six steps. Even though these steps are numbered and seem sequential, it is believed that the researcher should loop back and forth between them, in order to create coherence. The steps are as follows:\(^{133}\):

1. Data familiarisation, where a researcher or ethnographer will repeatedly look through or listen to, any fieldnotes or recordings in order to familiarise themselves with data gathered. During this process initial ideas or themes may emerge but it is essential that data is gone over repeatedly to not miss important nuances.

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\(^{130}\) Emerson, R. M., Fretz, R. I., & Shaw, L. L. (2014).

\(^{131}\) ibid.

\(^{132}\) ibid.

2. Initial coding generation, where a researcher will begin to code line-by-line. Having said that, that is regarding transcript, when interviews have been transcribed word for word. The interviews in this paper will not be transcribed, but rather listened to through recordings. Initial coding regarding recordings will be done on separate sheets of paper.

3. Theme searching based on step 2, where the researcher groups initial codings into categories. Some codings will correspond more to another coding than any of the rest, deeming these two to belonging under the same category. These categories are our themes.

4. Reviewing the themes, here the researcher reviews the selected themes and, if necessary, discards some of them. If one theme is better separated into two themes, this will be done, or if a theme is deemed weak, as initial codings do not seem to argue for that theme, this theme can be discarded or altered. It can be of importance to re-do step 2-3 when reviewing a theme, to see if the researcher lands the same conclusion again. If not, then that particular theme may be too weak.

5. Defining and labelling themes, where the researcher tries to make themes more precise and accurate. When doing so, themes or codings which were previously deemed too weak and hence discarded, may now be easier to fit into a more precise theme. The researcher must now look at selected themes and ask herself if she can say exactly what each theme represents and what it does not. It is also at this step where the researcher could ask others how they would define the themes, or if the themes are already perfectly defined as they are. This was, in this paper, done with one of my supervisors, which helped me further define the themes I had selected.

6. Writing the report, here the researcher begins to describe what she has done and present findings in conjunction to this. Whilst writing, the researcher may find new problems, or new ideas and need to alter the research question or the thematic analysis. In doing so, the writing of the report becomes its own step of the analysis and thoughts and ideas may emerge along with the emergence of the report.

Thematic analysis provides a broad perspective in coding and selecting themes, in comparison to other qualitative methods.134 This is why I have deemed it a perfect fit in connection with the system perspective that paints this entire paper. According to both the

JCS perspective, as well as the ethnographic methodology, it is the holistic approach which sets them apart from other perspectives.\textsuperscript{135}

**Goals-means analysis**

As described earlier in this paper, a goals-means analysis is conducted in order to help avoid automation ironies, according to the JCS view. This analysis begins by asking the questions “why”, “what” and “how” related to the JCS studied. The “why” answers what the goals of the system are and in the sense of what the system’s purpose is, whilst “what” answers what functions contribute to the achieving of these goals, i.e. the observable behaviour of the system. The question “how” answers how functions are achieved and provides details regarding how exactly this is done. This process is recursive, meaning that we ask these questions again, related to the answers we’ve received and as means of the first level becomes the goals of the second and so on.\textsuperscript{136}

Figure 12 showcases how a recursive goals-means analysis may look.

The answers that we receive from this analysis showcases the functions of the system that help the system maintain control and achieve its goals. It is these functions that ought to be allocated to man and machine.\textsuperscript{138} This method of analysis will be used to support any implementation suggestions of AI that this paper results in and to make sure that function allocation is conducted according to the complementarity principle.\textsuperscript{139}

\textsuperscript{138} ibid. 135
Results

In this part of the paper, data gathered from interviews and observations are presented thematically, meaning that quotations and observed behaviour that share general themes, are put under the same title (i.e. topic) corresponding to said themes. These are the results from the thematic analysis. The results of the goals-means analysis are also presented.

Positive opinions on UAVs transmitting initial but not continuous visual to control deck and management centre

What I found during the SAR courses was optimism regarding search with UAVs. Many deemed the UAV to be a good solution to receiving fast visuals from the scene of a distress call, whilst pointing out how it would not depend on height of waves like the SRUs do. A person from the SMA mentioned how you “on a small boat during 4-meter waves, have a difficult time finding anything at all at sea and if on a larger boat 30 meters up, have a difficult time seeing anything 30 meters ahead. In both cases UAVs would be a good idea.” For a UAV, waves do not matter, allowing them to quickly search large areas and report back what has or hasn’t been found.

During one of the courses, participants discussed disadvantages and advantages with helicopters during SAR. Some disadvantages with helicopters seemed to not be relevant for UAVs during said discussion. They mentioned how the sea surface came alive beneath a helicopter, making it harder to find anything below it and how helicopters were so loud that you couldn’t hear if anyone was calling for help, let alone speak to your coworkers. Many advantages that were discussed regarding helicopters however seemed to fit the UAV; fast search, lighting a scene in the dark and reaching were ships can’t.

One rescue leader at the JRCC had this to say regarding UAVs; “I often miss that first visual. You don’t really get how important that is. I mean, we’ve talked to people who call in who are very stressed out, the whole world is on fire sort of a thing. And so, we send out as many resources as we think they need based on that call. Once there at the scene we realise we’ve sent too much. If we’d had that visual earlier, we could have made better assessments. With that said, we are quite good at judging who it is we’re talking to and assume how well they’re depicting reality. But then there’s another problem, someone might be too calm and collected and first later in the call we are informed that they’re taking in water.” In an interview with the SSRS at another date, they too mentioned what this rescue leader had said; UAVs facilitating resource management with that fast visual feedback.

The Police, at the UAS conference, mentioned how a “continuous visual” was positive, because the perception of what has happened gained from a distress call is soon too old; “that was reality at that specific point, but indicators change, fires spread and waters
rise." They also mentioned how the expressed reality of the person in distress, may be affected by that person’s state of mind. If they’re stressed, it is difficult to judge how severe a situation actually is. “Pictures cannot lie”, the Police said, whilst discussing how a UAV could be equipped with an IR-camera in order to find anything in the water, before finishing with “we definitely believe in digitisation”. During another interview at the UAS conference, MSB also mentioned how pictures and videos “do not lie” and how it is difficult to understand the severity (or lack thereof) of a situation based on a call, without any complementary visuals.

During one of the SAR courses, one lecturer mentioned how you should “send the SITREP quickly, when you have time, that way you will not be asked of it when you’re too busy”. A SITREP is a situational report, which is required of the SRUs and is to be sent to the JRCC and/or the OSC.

Negative opinions on UAV continuous video transmission to management centres or control decks

“When the police first installed a camera that could share visuals with the JRCC, we didn’t like it. We became so caught up with what was currently happening that we forgot about the strategics. So, we paused that”, said a rescue leader at the JRCC when asked how they view the idea of video being transmitted to a screen from the scene. “That first visual from the first ship on scene is often enough, we don’t need or want long movies, we want to know how to dimension our resources. That first visual or SITREP is also very important for ship number two and three to receive, so they know what they’re getting themselves into. At sea, injuries or accidents are seldom as severe as those on land, such as car collisions, but when they are, it is important to be aware of that and for the first ship to be able to prepare ship number two that ‘it is worse than we had expected’”, said the same rescue leader at the JRCC.

At the UAS conference, MSB talked about how continuous video transmission could make the person watching in a way paralysed; “we’ve found it can be easy to get stuck there, to just sit and watch the video”. The SAF strongly agreed with MSB’s statement saying; “our staff should not receive continuous video, because then our staff does not move”.

During an interview with the SMA following the UAS conference, they too expressed negative opinions regarding continuous video transmission, “in Helsingborg they had video transmission from firetrucks to a management centre, but the centre quickly turned that screen off, because they were content with that initial visual. They might as well just have received a photo.” The SMA continued with “automating the analysis of visuals might be a good idea, also because man gets bored and tired easily.” The SMA expressed on several occasions that man and machine are good at different things, often referencing the usage of auto pilot in monotonous course-keeping tasks.
Communication as a tool to maintain SA

During one of the SAR courses that I attended a participant, after having conducted a SAR operation in the simulator, from the SAF mentioned this; “there should be a dedicated annotator role on the OSC. During this scenario there was one person on the radio, one by the nautical chart and everyone was jotting down what they heard and understood, but there should be someone taking notes on what we all know as a shared entity.” I noticed during my observations how many were jotting down things that at least one other person did not know, which could in a sense verify this statement.

During a conversation between the course administrator and a participant of one of the courses, it was discussed whether or not you could be certain that areas had been covered searchwise; “on the AIS you can see where units have gone, but were they only on their way to the scene, or did they actually search the areas they passed? And conversely, just because you’ve searched an area, does not mean you can be 100% sure you’ve covered it. Man could miss things when searching with binoculars.”

When observing the SAR-OSC course it was also found that their communication was sometimes lacking information and the necessary tools for shared SA among SRUs. Bear in mind that I mention/discern the SAR-OSC course here on purpose, because this was the course that allowed me to walk back and forth between decks, allowing for this particular observation that I am about to share to take place. When an OSC was communicating with other SRUs, they could communicate either with each other one and one, with the JRCC, or with all SRUs at the same time. Some information was therefore shared, an advantage for shared SA and some information was discussed solely among the crew onboard the OSC, whilst some information was only shared with some SRUs. Thanks to this particular course being held at the SMA’s simulator at Chalmers and not on real ships, I was able to walk between simulated ships and the simulated JRCC. What I found when moving between them, was that the JRCC had no idea why units were or weren’t acting a certain way. SRUs didn’t know why the OSC was taking so long to delegate roles to the units but were often inclined to not question the workings of the OSC and rather leave them to it and wait for orders.

When walking back to the OSC I found them deep in work and analysing and planning, as well as constructing how to say things once they reach out to the other SRUs. Hence, the OSC was working hard, but nor the JRCC or the SRUs were notified of the workings of the OSC’s collected mind, until they felt ready to share.

During observation I also noticed how participants used nautical charts in paper form, as well as digital ones. Upon questioning why they didn’t solely use the digital one, I was simply told they prefer using the paper format.
During an interview with the SMA in correlation to my discovery they said this; “the mouse pointer is very sensitive; mistakes are easily made. With pen and paper, it is much easier. If you zoom in for instance on an electronic chart system (ECS), you get a lot of details, when you zoom out however, these are lost. Also, if you zoom in and draw a search area for instance and then zoom out, your circle is now circling something else entirely.” At this point I questioned whether it was not solely a software issue, rather than the case of pen and paper being better. I asked the SMA, if they were handed a software that could do all of those things; you had rich details no matter the zoom level, you could draw on the map and the drawing was consistent with its coordinates, you could split screen (look at zoom in and out at the same time), have the screen laying down just like a paper chart, as well as share screen with other SRUs and the JRCC, if this software then would be used instead of pen and paper. They agreed that lacking software was the actual issue, not necessarily a case of pen and paper always being optimal. They also seemed positive to the idea of incorporating new, better suited, software on deck.

During the SAR-OSC course I spoke with a participant regarding the ECS and how I thought you should be able to share search patterns and search areas with other SRUs from that screen. He then told me about STM (sea traffic management), a concept that was born in 2011, where the main idea is to be able to not only see where other ships are, what kind of ships they are, where they’ve been, but also see where they are planning to go. The STM will hopefully soon also be able to share search patterns with SRUs.

During the SAR-BASIC course, the SMA was able to show me how the STM can be used today;

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140 Photographer: the author Johanna Seger
Figure 14c shows how you can send files of search patterns or search areas to other units. “It takes a while sometimes”, said the SMA, “it’s not so easy during high waves”. Figure 14b and 14d shows search patterns and search areas, they are marked using a tool which showcases how units should travel. This works fine for the search pattern, but for the search area it becomes an adapted solution by the user. The search pattern shown in figure 14b is available, readymade, in the STM and can be moved and made to fit the area where the user wants it positioned.

“The OSC has to keep notes of everything that is being said, everything that everyone is doing parallel and exactly what information has been verified” said a lecturer at the SAR-BASIC course. During a scenario at this course, it was long assumed that all persons that had initially gone missing had been found. The OSC counted six from their notes and a person on the scene counted to six also, meaning that one person was still missing as seven persons in total had gone missing. When the OSC and the person on scene however went through what they knew of each person, it seemed that the OSC’s and person at scene’s six persons together made seven, as they had each missed one the other had counted. Upon counting again however and trying to verify all persons carefully, only six were again verified. This meant that one person was still missing, after a total of 45 minutes.

142 Photographer: the author Johanna Seger
This person was soon found, cold, in the water. “It is better to clarify everything and be
eridiculously plain, as to avoid misunderstandings” said the lecturer when bringing up this
case later in the day, “what do we know and how certain are we about that?”. A participant
then said; “the thought process is usually there, someone just has to put it into action too”,
regarding having been uncertain during the counting but not expressing it.

During the SAR-OSC course, a lecturer asked the participants “where were the
hotspots? I mean, you have the search area defined, sure, but not all parts of it are equally
interesting. Had you defined these prior search? Or did you assume everyone agreed upon
which areas were most important?”. It turned out they hadn’t communicated this during or
prior search.

Thoughts on technology as a phenomenon in SAR

The general idea of technology in SAR seemed to be accepted amongst the ones I
interviewed and observed. One participant of the SAR-OSC course however mentioned how
“different technology is needed on different ships perhaps, because it looks different on all
our ships”, referring to how the participants of the course all had different backgrounds;
some were for instance captains on ferries, some came from the SAF and some from the SCG
or the SMA.

The course administrator mentioned how “the whole world is supposed to agree on a
certain communication technology, which means that the development is very slow. I mean,
China has to be able to communicate with us and we have to be able to communicate with
them and if anyone says no to a certain technology, then it halts the process. It becomes very
difficult to introduce new technology that way”, whilst explaining how there are many great
ideas and a lot of people active in SAR who agree with it and wishes to incorporate it, but if
anyone says no it won’t happen. A person from the SMA also mentioned how “even the AIS
was a controversial idea at first and took a while to incorporate, but eventually they did and
now it’s the standard. Look at STM, they are having that issue today. But I do think that will
become standard eventually too, within 10 years perhaps.”

During an interview the SMA also expressed positivity regarding automation; “there
are different levels of automation. Think for instance about an autopilot, who just keeps the
course. Humans are better at acting during crisis, not during monotonous tasks as humans
become bored and can’t focus. If the course is only supposed to be held, say during search,
then that could be automated, and it would allow for another human to actually search”.

Other UAV or USV implementations within SAR

When interviewing the SSRS, they spoke about a concept they are developing where
fixwings, a type of UAV, will be situated on shores and aid in drowning related SAR
operations.
When asked if they had thought about putting these fixwings with their contraption on ships, they said no; “we are currently only working on getting them on shores.”

During an interview with the SMA, they said this; “the IR-camera is great at sea, because there shouldn’t be anything warm in the water. You don’t need to have any analysis there, if the camera picks up any red where it shouldn’t then that’s enough information. Radar has had this function for a long time, that you choose an area and if the radar picks anything up then it should alert the captain. Something like that perhaps the drone could do, if equipped with an IR-camera? I mean, giving a task like that to humans is impossible, to say ‘just watch, don’t do anything, just let me know if anyone jumps off the ship or if you find anything in the water’. You can’t. They will act. If there’s a fire, they will be there with the handheld extinguisher. You can’t tell humans to solely supervise and not help. But you can tell a drone that.” During the same interview with the SMA they also mentioned, while on the topic of supervision, that drones could supervise indicators; “how much is a ship tilting? 3 degrees? If that number changes, then something has happened. We do not want that number to increase obviously, because then we can guess what will happen. Or if we are evacuating a ship, then we want to calculate how many we can evacuate per hour and then keep track of that number. These should be easy things to code, I definitely think UAVs could keep track of such indicators.”

Mapping the bottom of the sea was mentioned by the SMA as a possible application for the USV within WARA-PS, but mostly because I specifically asked them if they saw any application for it. They also mentioned how “UAVs are probably the one step ahead in terms of SAR. The autonomous USV is dependent on wave-technology, which is much more

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advanced and therefore more expensive. We are more interested in below surface vehicles for the mapping, as well as searching for someone who may no longer be alive, or overlook constructions.”

Goals-means analysis

In figure 17 the results of the goals-means analysis of the SAR JCS is presented. The analysis landed on two levels, as the succeeding third and fourth levels (see figure 16) are out of scope for this paper which has been mentioned in the delimitations section.

![Figure 16. Goals-means analysis for SAR](image)

The initial goal is to rescue persons in need of aid at sea and in order to do so rescuers need to first search for and find persons in distress.
This involves cooperation and coordination between SRUs, which adequate search and communication tools should facilitate. This particular goals-means analysis is simple, as it does not provide answers to what exactly is needed of said tools, but interviews and observations should be deemed to contribute with these specifics. As communication and search tools facilitate cooperation and coordination, they do also contribute to maintaining and/or improving SA as a result. Interviews, observation, goals-means analysis, the study of JCS, SA and the aspect of time and control should provide enough basis for implementation suggestions of AI, which will be presented in the analysis section of this paper.
Analysis

In this part of the paper, the results from observations and interviews will be more closely looked at and analysed. This section provides more of the author’s own thoughts and insights on the matter presented in the results section. Reflections are also presented regarding the results and their correlation to possible AI implementations in SAR.

Positive opinions on UAVs transmitting initial but not continuous visual to control deck and management centre

The persons I have interviewed are positive regarding UAVs transmitting visual imagery. They can be used for actual depiction of reality, without human factors such as stress, in turn accurate resource management and provide the important initial visual.

The lecturer from one of the SAR courses had something interesting to say which I didn’t expand on; “send the SITREP quickly, when you have time, that way you will not be asked of it when you’re too busy”. For a SRU to report back to the OSC or JRCC with a situational report, at least one person is taken out of working on the field as their job now is to provide the SITREP. This takes time from a person which could otherwise be out there helping in-field along with the rest or doing something else. If this SITREP job was given to a UAV for instance, at least one person would be alleviated and along with that, human factors would be avoided during SITREPS also.

Negative opinions on UAV continuous video transmission to management centres or control decks

In the results section, I write about how the police were positively inclined towards receiving continuous visuals, despite many others suggesting it would halt operations. An idea I have in mind, is allowing AI to analyse the continuous video transmission, rather than man doing so. This way, man would be able to view the first initial visual, something everyone seemed to agree on was a good idea, but then allow for AI to take over. If indicators change, such as degree of tilt, number of people overboard, or water level, the AI could report this and first then ask for man’s attention back. This would mean that man would not have to watch the transmission for the entire duration, but only when the initial visual has changed.

Communication as a tool to maintain SA

As mentioned in the results part of this paper, persons on deck used physical nautical charts. I questioned this as the deck was equipped with digital ones (ECS) as well as an AIS. Persons onboard the ship assigned the role of OSC were discussing amongst each other while SRUs
were waiting for orders and directives. Once they felt ready to share their plan, they had to communicate coordinates, mental images of parallel search tracks, as well as search areas, to the other SRUs. They had drawn circles and patterns on their physical nautical charts and were now trying to transfer this image to the other units, in spoken words. When walking back and forth between units during the SAR-OSC course, I noticed how much confusion often occurred regarding this. Coordinates were misheard and the formation of the search pattern misunderstood. After every simulated scenario, participants and the JRCC gathered in a classroom and discussed everyone’s overall performance. It was here that the JRCC could question the participants’ decisions and the OSC could question why units had misunderstood certain parts of directives. It was found that mental images were difficult to transfer in spoken words to others, as well as remember what pieces of information everyone had taken part in; some things were for instance only said to the JRCC and some only among the crew onboard the OSC. When speaking to participants and the ones responsible for the course, I suggested there should be a software program where units could share thoughts and mental images, so all units could take part in the plan as it was being formed. This could eliminate mishearing, misunderstanding and possibly encourage units to give suggestions and question the OSC, eliminating the potential fear of questioning authority personally.

While the members of the OSC were discussing amongst themselves, SRUs were often forgotten and left to wait for orders. The SRUs seldom took initiative and conducted their own search while waiting, but often simply waited. When observing the units who were left to wait, I heard them questioning the OSC. The crew among individual ships shared information and suggestions with each other on board on how to proceed, but never with other units. At one time, one SRU was left to wait for 40 minutes for orders from the OSC. The SRUs had sometimes picked up on information that it seemed that the OSC had forgotten or not heard. Because when the members of that SRU then were left to wait, they questioned whether the OSC had all of the information that they had, but the OSC was never questioned directly and the information that the OSC should have had was lost because it seemed they were assumed to already have it. Why SRUs didn’t question the OSC directly I cannot say, but when asking participants of this afterwards they simply said and I’m paraphrasing, “we thought they knew, and we were wondering why it took them so long when we knew what we knew”. I do however wonder whether it has something to do with culture and the idea of not questioning authority personally.

Remember the participant that said; “the thought process is usually there, someone just has to put it into action too”, regarding having been uncertain during the counting of missing persons but having not expressed it. I correlate this to the scenario I just mentioned, when one SRU was left to wait for 40 minutes. This SRU was also uncertain and had questions, but they weren’t expressed to anyone else but to those on the same deck. This is something I have come to witness several times during my observations. Many had smart
things to say, or significant uncertainties, that all should have been expressed, but ended up never being. “Decision making in groups is characterised by members of the group having a decently shared situational awareness of what is to be managed”\textsuperscript{144} (own translation); it is hence important that everyone has a decent idea of what everyone else is doing and in these cases, it would seem, what they are also thinking. Remember the part when the lecturer asked participants if they had decided upon where the hotspots were prior and they hadn’t? I’m just guessing now, but perhaps they had just assumed that they all already agreed, maybe they thought the hotspots were obvious. Let’s not forget however how; “It is better to clarify everything and be ridiculously plain, as to avoid misunderstandings” according to one of the lecturers. The take home message is to communicate as much relevant information as possible for the sake of SA and to not assume too much, but rather be explicitly clear about pretty much everything and ask questions when uncertain.

Could an extended STM help here? I presented in the results section how the STM works today in relation to SAR, but even though it has not yet been fully implemented, it already seems outdated in my opinion. The SMA had expressed how moving the mouse, clicking, zooming, circling areas, was difficult and just not as effective as using the physical chart, whilst at sea. This was the part when I wanted them to imagine a software which could do almost everything, they had expressed they wanted to be able to do and if this was something they would rather have instead. Upon being met with positive tones, I kept thinking about which technology would be best suited for their needs. When I had first described the technology, I included the fact that it could be made to lay down, the same way a physical chart does and to be used with a stylus. This would mimic the feel of a physical nautical chart, while providing additional benefits. Search areas, search patterns and hotspots could be shared either in real time, the same way two persons could be writing in the same google document at a time and see what the other is writing or chosen when to be sent. The prior, I believe would be a better option, when we refer to the SRU which had to wait for 40 minutes because the OSC was formulating their orders before sharing. Real time sharing seems to be the better option as to avoid delay and improve shared SA.

Another suggestion would be to use hololenses\textsuperscript{145}, but its effectiveness at sea, on a moving ship, I cannot make any judgements on. Perhaps to be used at the JRCC?

Custom figures

In figure 18, I have customised the COCOM model to fit with SAR. As we learned previously in this paper, the COCOM represents contextual control in a JCS. This means that each of the steps in the COCOM; evaluate event, plan procedure, etc, can be either by man or machine. When we add time, as an aspect to COCOM, we can quickly see where time can be saved and where it cannot, depending on the JCS. If we automate evaluation of an event for instance, the time it takes to evaluate is probably lessened, thereby allowing for more time to actually plan procedure and take action.\(^{146}\)

As we can see in figure 18, the model is never complete, but loops through all steps again and again. For each distress call, the loop begins with an incoming SAR assignment. The COCOM then loops through all steps and arrives at external feedback, which could be an acknowledgement of having done the right thing, or not, or simply video transmission from the field which could update the current understanding of the event. The system must then re-evaluate the event and steps are looped over again.

![Figure 18. COCOM SAR](image)

In figure 19, I have inserted possible AI implementations in the various steps of the COCOM SAR. These implementations are based on data gathered from interviews and observations.


\(^{147}\) ibid.
I refer to the levels of autonomy for two of the implementations (see figure 19), as these implementations are the most closely linked to what WARA-PS has to offer today and because I chose to define the levels in UxV terms previously. The two other implementations are not available from WARA-PS today, but still seem effective and interesting for users of SAR.

For the first step of the model, I have suggested to use a UAV equipped with an IR camera to provide feedback of the scene. This being of course not the absolute first step, as the first step is for an assignment to be given to SRUs by the SMC.

The second step utilises a DSS and image recognition, in order to analyse the feedback from the UAVs. This suggestion is in relation to interview recipients claiming that showing operators or fieldworkers videos, could halt their process, but also in relation to many describing how the first initial visual is essential. This would mean that operators or fieldworkers are presented with a summary of what the scene looks like and what it entails, along with a still image. The UAV continues to view the scene and the DSS analyses the images, but the persons on the receiving end only receive a new summary and still image if any indicators have changed since last.

The next step is to plan a procedure, something which is done today through communication with other SRUs. As learned from interviews and observations, everyone is at this stage taking notes of what they themselves know, but little information is shared. When information is shared however, this is done by communicating coordinates, images drawn on the physical nautical chart, or time stamps. I suggest a communication tool for this step, where SRUs can share their reality with that of the others in real time, in order to
maintain shared SA. A tool where they can draw search patterns, share bullet point information and circle hotspots. An idea would be to assign the role of annotator on the OSC, the same way the OSC is assigned, whose main role is to annotate all information gathered. Every other SRU then has their assigned annotator who makes sure the OSC annotator doesn’t miss anything. I believe this would allow for a greater shared SA, as well as avoid human factor issues in relation to not daring to question others. Being able to draw search patterns directly on an ECS with the help of a stylus and circle hotspots and visually share explicit common ground between units, would be of great benefit I believe. This should also reduce misunderstandings and eliminate mishearing. Real time sharing should also remove the issue of uncertainty and waiting too long to share. As STM seems to be able to do most of these things, even if I and users believe it can be improved, it would seem an extended STM is of benefit at this step.

The last step involves taking action. If this action involves searching, the UAV can search large areas quickly with the aid of its IR camera, this information is then put through DSS analysis and then presented to receiving persons and the loop continues.

This implementation suggestion (see figure 19) is closely linked to the goals-means analysis of the SAR system previously presented (see figure 17). The functions presented in this analysis are the functions which contribute to the SAR system maintaining control and as mentioned earlier, how successful a system is at maintaining control is most often determined by its degree of SA. In turn, these suggestions for implementations are hence based on the goals-means analysis which aims to avoid automation ironies and bares in mind which functions contribute to system control and as a result SA. The suggestions seen in figure 19 correlate strongly to that of ‘communication tools’ and ‘search tools’ in the goals-means analysis (see figure 17).

During the writing of this paper, the area I wanted to explore expanded greatly, as new organisations emerged, new theories and new technology. This is where I had to look at my delimitations and remind myself that not all was of interest for my paper, even if it was of interest for me personally. I then, with the suggestion of one of my supervisors, decided to create a mapping of my paper (see figure 20). This mapping began by asking ‘why?’, as in why am I writing this paper? What is the goal? The goal is to increase efficiency, make sure that right resources are allocated in right places and to research the implementation and usage of AI in SAR. The next step was to ask ‘who?’, as in who is involved in these goals? Organisations such as SSRS and the SMA, users such as SRUs and the JRCC and of course research and development; WARAP-PS. At this point introduction and background has been written. The next step was to ask ‘what?’, as in what are the needs of users? This became clear through interviews and observations as well as theoretical backgrounds; a need for

improving and maintaining SA, efficient time management and shared communication. In figure 20, I have connected an iceberg model to this question. This iceberg represents expressible needs (through interviews) and visible needs (through observation) as well as hidden needs, which are needs I have reached a conclusion on myself based on theoretical framework and research. From my studies at university I have learnt that users will often say they are content with a product, but through observation and upon questioning again, they do realise their product has flaws. This, from what I’ve gathered can be due to working with a product for an extensive time, that the user has gotten used to it and may not know what improvements are possible.

The last question I asked myself was ‘how?’, which brings us all the way here, to the conclusion part of the paper. How can we accommodate the needs of the users? This is where I found through expressible, visible and hidden needs, that a bird’s eye view was of interest, an interactive communication tool could be beneficial, and that analysis of images should be done by an AI.

Figure 20. Impact mapping\textsuperscript{150}

The reason that I am showing this mapping, is because I believe it displays to the reader how I have mapped by paper, why I have written about certain organisations and how interviews

\textsuperscript{150} Adzic, G. (2012). \textit{Impact mapping: Making a big impact with software products and projects}. Provoking Thoughts Limited.
and observations have been treated (the iceberg model). But also, because I believe this mapping is a nice conclusion to this paper, as it summarises where this paper began, as well as where it is currently ending.

**Question formulations answered**

To remind the reader, these have been my question formulations for this paper;
- How could AI help maintain and improve SA in SAR?
- Where in the SAR system could AI be incorporated to most efficiently compensate for human vulnerabilities and support human strengths?

Let’s review the first question. AI can help the SAR system maintain and improve SA by adopting functions which take unnecessary time from man. According to the Fitts list\(^{151}\) this should be done by automating tasks which man does not have superior attributes for, something which interview recipients have touched on several times. But through a JCS perspective, this should rather be done by looking at which functions help the system maintain control and in turn, how optimal each of these functions are performed either by man or machine. As we saw in the COCOM model\(^ {152}\), time can be saved if performing a task is automated for instance, leaving man to be able to entirely focus on analysis and planning.\(^ {153}\) Relate this to the levels of autonomy and thereby levels of man involvement; functions are seldom solely man or solely automated, but requires coagency.

The second question relates to the figures I showed previously, customising the COCOM model for SAR. In this model I have given a suggestion for every step of the process, but of course there are aspects of each and every one of these steps that have not been automated though my suggestions. ‘Action’ is not always exclusively searching for instance, lots of other work needs to be done simultaneously, but this is one aspect of the action step which can be automated. My recommendation is to test every one of my suggestions, measure the increased SA for each of them, test them independently as well as together and make a judgement of how many of these should co-exist.

As we learned when reviewing the Fitts list previously in this paper, it suggests which tasks should be handled by man and which by machines, but the JCS view argues that for optimal control and safety, tasks should overlap between man and machine\(^ {154}\), something which I have tried to keep in mind for my suggestions. As you will notice, no step of my COCOM model is level 5 of automation, man is always involved. Even when the DSS analysis shows persons what is has concluded, persons are also presented with a still image showcasing where conclusions have been drawn from to facilitate verification.

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\(^{151}\) Fitts, P. M. (1951).


\(^{154}\) Sandom, C., Harvey, R. S., & Technology, I. O. (2009) Chapter 6
Discussion

The following parts will be discussing different sections and topics of the thesis, their content and what conclusions can be drawn from them, as well as if any of them should have been treated differently.

Theory

When studying and reading about AI and automation and doing my best to define these terms for the reader, I found many different definitions and opinions on the matter. It would seem that their definitions are still not quite clear cut, which left me with having to choose definitions that were best suited for this paper. When speaking with friends regarding the definitions I had chosen, some did not agree with them and I do agree that they could be narrowed down or improved in some way or another, but I do believe they are sufficient enough for the purpose of this paper.

The theory of JCS and CSE seem to be theories which us studying cognitive science use frequently, but which are not used so much by engineers, at least from what I’ve experienced. For that very reason and since many persons working with WARAP-PS are engineers, I believe I made the right choice in choosing these theories. Because of this and my background in cognitive science, I believe and hope, I have contributed something else and new entirely to WARAP-PS which may be beneficial.

Method

Here i present reasons for adopting the method that I did, and critiques related to the method as well as try to critique my own implementation of it.

Cognitive ethnography and thematic analysis

According to the ethnographic method and thematic analysis, I should have entered into the research for this paper with a totally open mind. I did not however, because my thesis was from the start to explore how AI and automation could be implemented in the SAR system. I often, when speaking with friends and colleagues, would say “or explore if it should be implemented at all”, which one would think would indicate that I did go into this with an open mind. But had I ventured into that territory, more than I did and ended up with the conclusion that “no, AI and automation has no place in SAR”, then my essay would have become quite short and non-exploratory. The idea was more to see “how AI can become part of SAR” but without any forcefulness of course. To my satisfaction however, persons I interviewed were positive regarding the implementation of AI and automation and my observations left me with the same conclusion; AI and automation could have a place in SAR. I just feel like I need to disclose how I really wanted for AI to be able to be a part of SAR
prior to my interviews and observations and how this might have shaped anything that I’ve presented throughout this essay. I could have been more cautious or criticised AI and automation more, but I do believe that they are great tools when used for the right reason, at the right place and without replacing man completely (level 5 of autonomy); I’m partial for the main idea of them.

According to thematic analysis, some themes have to be removed and the ethnographer purposefully does so for the sake of the story. This can however be argued causes a bias, because I choose which themes I deem relevant and which I do not. This is where my partialness to AI and automation could become a problem. If twenty persons said they believe AI should be implemented in SAR and three said that they do not, I might choose to not include those three, for the sake of a positive narrative. I like to believe I have not done so and rather kept my results unbiased, but I cannot prove this to the reader without again, bias playing a part. When then presenting my results as “twenty persons were optimistic”, it would seem that 100% were optimistic, because I have removed the percentages which disagreed.

Another possible issue with thematic analysis as it has been implemented in this paper, is that I did not transcribe any interviews, but rather sound recorded them. This means that the reader is not given enough evidence as to where I produced my themes and topics from. It could be argued that the quotes I provide are enough, but this leaves us with the bias-issue again, as the reader is presented with handpicked quotes and not given the opportunity to listen to full interviews for the quotes’ context. It becomes very much of ‘I show what I want the reader to see’ and hide that which I do not. If the reader is presented with transcribed interviews, the reader may themselves review how I have reached the themes that I have and whether these seem forced or not. The reader cannot do this in my case, unless they of course contact me and ask for the recordings. I do not wish that I had done this differently however, because I made an active choice beforehand to not transcribe interviews. I chose not to due to time limitations and as a consequence of choosing to not transcribe, allowing for focus and time to lie elsewhere such as in a more extensive analysis.

The interviews were paraphrased and translated, something which is not an issue when it comes to thematic analysis, but when done with a transcript this becomes very transparent; the reader may see precisely how quotes have been altered, something which my readers cannot. Again, I chose not to transcribe due to time limitations.

Analysing interviews thematically helped me narrow down a narrative. With so much information gathered from many different sources, it was at first overwhelming. Thematic analysis helped me keep my mind on track and discern which information was of relevance and which was not, much like SA.

Cognitive ethnography utilises open ended questions and informal and semi-structured interviews. This allows for the researcher to receive extensive answers to aspects which the researcher may not even have considered. Had i asked for instance “do you believe UAVs could transmit videos and in doing so, be beneficial for SAR operations?”, instead of “do you see any potential areas needing improvement and if so, how would you improve these areas?”, the idea of a
UAV is mine and not theirs and my prior question is really asking them to fit this UAV into one of the SAR processes, perhaps forcefully. My latter question asks instead if they at all need any improvements and how they themselves believe processes can be improved. Perhaps that leaves me with an answer of a product I had not previously considered, why having utilised open ended questions in this paper avoids bias in that sense.

**Qualitative methods vs quantitative**

I have not been able to test the significance of my results as they are not quantitative but rather subjective thoughts and opinions. A way of quantifying such data can be to say ‘50% expressed…’ or ‘4 out of 30 people said…’. Something which is quite close to what I’ve done with my thematic analysis. Through my analysis I have selected themes which were reoccurring and or expressed by many. The only difference is they do not have a statistic connected to them. This could be argued is a disadvantage.

With my background in cognitive science, I believe I can contribute to WARA-PS with a user-perspective and a human centered approach which may otherwise not be as common. Related to this I believe that choosing a qualitative method was the right choice in hindsight. It was the users’ needs and thoughts and opinions which needed to be added, something which qualitative methodology does very well. Quantitative research contributes with numbers and statistics, more scientific according to some, but qualitative research can contribute with insights into the real lives of users and help understand their needs.

This paper has been very user-centered, with user research. The difference being that I haven’t actually created a product for the users, but rather conducted the pre-study which could help developers by providing insights into their product user’s lives and needs. These insights are not quantified, but that could in itself be positive. Not everyone active in maritime will agree with the users that I have interviewed or observed, but their thoughts and opinions might at least be a place to start.

This method of arriving at an interview or observation with an open mind, with the ability to improvise and interview and observe people in a familiar environment to them, is qualitative. The quantitative method prefers solely prepared interview questions, that every recipient is interviewed at the same exact location and with the same exact questions. This is for generalisation purposes. The qualitative method provides the researcher with a user *depth* and can for that very reason often not be generalised; interviews are not shallow, but very individual and exploratory. Generalisation is often a good idea, why many do not believe qualitative methods to be scientific enough, but for user-studies, it is the user, the individual, that we care about, why I do not believe generalisation to be necessary in these instances. This particular paper could have quantified SA however and compared the levels between users and situations, but not for generalisation purposes but rather as a measure of which part should be automated.
Interviews
Interviewing developers and then users and then presenting developers with the responses of the users, is an interesting technique because it allows for the perspective of what technology could be implemented provided by developers to be presented with the perspective of users claiming that the technology that developers aim to implement may not be of need at all. It is important to connect developers and users and present developers with the needs of the users. This is what the purpose of my interviews and in turn, this paper has been, which is why I chose to interview developers first, before users.

Observations
I haven’t described the scenarios which participants in the SAR courses operated on, which instructions they were given, or specifically what type of gear they brought with them. This is not a problem in relation to my choice of methodology, cognitive ethnography, but rather an issue when regarding replication possibilities. Something which qualitative methodology doesn’t find particularly problematic.155

The work in further context
Future papers in this area should investigate the ethics and cybersecurity of UAVs and USVs, for the very reason of me having chosen to not do so. It would also be interesting to see a suggestion of a JCS designed for shifts from low intensity to high intensity (a dynamic environment) and then test such a system, to see if improvements could be found when compared to today’s SAR system.

I have written a bit about ECS and physical nautical charts so far and Hutchins, in his article ‘cognition in the wild’, writes about nautical charts as artifacts.156 This is something which I didn’t venture into further as I have not described, explained, or used the theory of artifacts in this paper, but I do believe that future studies could definitely benefit from reading more about that.

What I found when reading about JCS and COCOM was that JCSs are very much about maintaining control in the event of external disturbances.157 Think for instance about an industrial facility where they oversee combustion of waste. If leaks were to occur or if the temperature of certain parts of the system were to rise over the recommended limit, this is an external disturbance, it’s an accident which shouldn’t happen. In such events, the system needs to reevaluate the situation, handle the accident and again reevaluate the current understanding of the system so that such accidents do not happen again.158 In the case of

SAR, accidents are in a way *supposed* to happen. To paraphrase a rescue leader of the JRCC; “We are like firefighters, if there are no fires, we are not needed”. I therefore believe it is important to clarify that there should be two separate kind of accidents when speaking about SAR systems. The first kind of accident is the one that we expect, the one where someone needs aid at sea. The second type of accident I’d like to define in this context is the one that is unpredictable and shouldn’t occur. Such an accident may be that the JRCC and OSC lose contact, or that the AIS system stops working; accidents that threaten the SAR system’s ability to complete its purpose; to handle the first kind of accident. When I began investigating SAR and consequently began writing this paper, I had in mind to research the difference between low intensity versus high intensity situations during SAR and where and when AI could come into picture during either. But as the rescue leader said; “we are like firefighters, if there are no fires, we are not needed”; there are no low intensity situations per se, either they (at the JRCC) are deep in work or not. It could be argued however that certain operations are more demanding than others, but nothing I looked more into.

Since SRUs also can be any boat or ship located around a scene of a distress call, it was difficult to fit tasks into low or high intensity situations here also; either they were for instance solely fishing, or traveling between Öland and Gotland, or involved in a SAR operation. Here it would also seem they were either included in SAR or not, again deeming SAR a high intensity situation as a whole, nothing divided into different intensities. For further studies, it would be interesting to go deeper into investigating if there are any processes within SAR that can be deemed more or less intense and investigate AI’s and automation’s place in conjunction with that. I have investigated AI’s and automation’s place when thinking about a JCS, SA and control and time, but an addition of thoughts regarding intensity’s impact on AI and automation implementation in SAR would still be quite interesting as well.

I would also like for future studies to try to measure SA in relation to SAR, in order to incorporate quantitative data and to be able to point to a measure which changes when automation is implemented and showcase to what degree it does. SA can be measured using for instance the situational awareness global assessment technique (SAGAT)\(^\text{159}\), subjective assessment by participants\(^\text{160}\), or the crew awareness rating scale (CARS).\(^\text{161}\)

In this paper, the focus of SAR has been on the actual finding of and searching for persons at sea. SAR includes first aid, towing and evacuation as well but as observations and interviews have not included these aspects of SAR, they have consequently not been included.

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\(^{160}\) Berggren, P. (2016, 04)

in this paper. Because of this, more focus has been on the UAV of WARA-PS, rather than the USV and possible implementations of the USV have hence not been found. The USV could most likely be implemented in towing and MEDEVACs of SAR, but these implementations have not been investigated further. For future studies, it would be of interest to focus on the aspects of SAR that this paper has not focused on (see goals-means analysis and delimitation).
References


Fitts, P. M. (1951). *Human engineering for an effective air-navigation and traffic-control system.* National Research Council, Division of Anthropology and Psychology, Committee on Aviation Psychology.


Appendix

Attachment 1. Prepared questions for semi-structured interviews

Potentiella respondenter:
utvecklare
wara-ps aktiva

(eng: Potential respondents:
developers
wara-ps actives)

- Hur samarbetar de olika systemen?
  (eng: How do the different systems work together?)

- Hur integrerad är människan idag?
  (eng: How integrated is man today?)

- Vilken vision finns för dessa farkoster i framtiden, vad är målet med de självkörande båtarna och drönarna vad gällande sjöräddning?
  (eng: What vision is there for these vessels in the future, what is the goal of the self-propelled boats and the drones as regards sea rescue?)

- Hur nära kontakt har ni idag med de organisationer som ska använda sig av dessa system i framtiden?
  (eng: How close contact do you have today with the organizations that will use these systems in the future?)

- År det endast USVn som är autonom?
  (eng: Is it only the USV that is autonomous?)

- Känner ni till andra områden där liknande teknik används idag, tex drönare i lavin?
  (eng: Do you know other areas where similar technology is used today, eg drones in avalanche?)

- Skickar UAVn ut USVn? År människor alltid på plats efterhand ändå?
  (eng: Does the UAV send the USV? Are people always in place afterwards anyway?)
• När ni idag utvecklar dessa system/farkoster, finns det några klara mål ni strävar mot?
  (eng: When you today develop these systems / crafts, are there any clear goals you strive for?)

Potentiella respondenter:
Personer i olika steg, larmcentral och på operativ nivå
SSRS
SAR aktiva

(eng: Potential respondents:
People in different stages, management centre and on operational level
SSRS
SAR actives)

• Hur ser händelseförloppet ut från larm till operation?
  (eng: How does the course of events look from alarm to mission?)

• Vad har du för roll?
  (eng: what is your role?)

  ○ Vid larm, vad är din uppgift?
    (eng: In case of alarm, what is your task?)

• Under vilka skeden tas beslut om vald operation?
  (eng: During which stages are decisions taken on the chosen operation?)

• Vem får fatta vilka beslut?
  (eng: Who can make what decisions?)

• Hur sker kommunikationen?
  (eng: How does the communication work?)

• Används drönare idag? Hur?
  (eng: Are UAVs used today? How?)
När en utryckning sker, har den operativa nivån mandat att fatta nya beslut själva om situationen tex ser annorlunda ut än man tänkt?
(eng: When an emergency occurs, does the operational level have the mandate to make new decisions themselves? if the situation, for example, looks different than you thought?)

På vilka kriterier fattas beslut idag? tex vilka resurser som behövs.
(eng: On what criteria are decisions made today? eg what resources are needed.)

Vilken information krävs för att kunna agera på rätt sätt?
(eng: What information is needed to act properly?)

Hur viktig är visuell information för att fatta rätt beslut?
(eng: How important is visual information to make the right decision?)

Vilka är inblandade från larm till operation?
(eng: Who are involved from alarm to operation?)

Finns det olika typer av beslut? mer eller mindre “automatiska”?
(eng: Are there different types of decisions? more or less "automatic"?)

Hur ser en sjöräddningssituation ut idag? Vilken teknik används i dagsläget?
(eng: What does a sea rescue situation look like today? Which technology is currently used?)

Tid, den parameter som kan mätas? Bara för att det tar 13 minuter och inte 15 betyder inte det att det är bättre, kan vara slarvigt. Hur mäter man att något gått bra/sämre?
(eng: Time, the parameter that can be measured? Just because it takes 13 minutes and not 15 does not mean that it is better, can be sloppy. How do you measure that something has gone well / worse?)

Kan du visa/återberätta hur en vanlig dag ser ut?
(eng: Can you show / retell how an ordinary day looks?)

Hur ser ledningscentralen ut, vad händer, när inget larm kommer in?
Hur ser ledningscentralen ut, vad händer, när larm kommer in?
(eng: How does the management center look, what happens when alarms come in?)

Vilken teknik använder ni i dagsläget? lågintensiv situation vs högintensiv?
(eng: What technology do you currently use? low-intensity situation vs high-intensity?)

Hur använder ni teknik idag? När och hur? Vad tillför tekniken?
(eng: How do you use technology today? When and how? What does the technology improve?)

Hur mycket AI har ni tänkt använda?
(eng: How much AI have you intended to use?)

Hur upplever du din SA under lågintensiv situation?
(eng: How do you experience your SA in a low-intensity situation?)

Hur upplever du din SA under högintensiv situation?
(eng: How do you experience your SA in a high-intensity situation?)

Ser du något behov av teknik?
(eng: Do you see any need for technology?)

Om du fick önska, hur skulle tekniken hjälpa dig i framtiden?
(eng: If you wanted it to, how would the technology help you in the future?)

Vad kan gå fel? När uppstår misstag vid övergång från lågintensiv situation vs högintensiv?
(eng: What can go wrong? When do mistakes occur when moving from a low-intensity situation to a high-intensity one?)

Vad är extra viktigt vid övergången?
(eng: What is particularly important during the transition?)

Vad skulle du behöva för att systemet skulle förbättras? Vad fattas idag?
(eng: What would you need for the system to improve? What is missing today?)

- Hur många larm får ni in?
  (eng: How many distress calls do you receive?)

- Hur mycket av din tid spenderar du åt förebyggande arbete?
  (eng: How much of your time do you spend on preventive work?)

- Hur mycket skulle du säga av din tid är lågintensiv/högintensiv?
  (eng: How much would you say of your time is low-intensity / high-intensity?)