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Evaluating the effect of live-streamed video from accident sites in maritime SAR using UAV

Analysis of control using the Contextual Control Model (COCOM)

Master's thesis in Maritime Management

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Gothenburg, Sweden 2022

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Acknowledgements

We would especially like to thank the Swedish Sea Rescue Society in Gothenburg for sacrificing their resources and personal time to contribute to this thesis. Without them, this thesis would not have been possible.

Further, we would like to thank our supervisor Fredrik Forsman for the continuous support and guidance throughout this thesis.

Lastly, we would like to thank the Eyes-On-Scene project team for the opportunity to pursue this research matter.

Abstract

Maritime search and rescue is an important part in the maritime industry that is regulated partly under the International Maritime Organization (IMO). In Sweden, maritime search and rescue is mainly organized by the Swedish Sea Rescue Society. Together with RISE, Chalmers Maritime Human Factors, Airpelago, Smartplanes, and Infotiv, the Swedish Sea Rescue Society have initiated the project Eyes-On-Scene (E-O-S) which is an Unmanned Aerial Vehicle (UAV) based support system that aims to support the responders in their search and rescue operations. The project is to be fully operational in 2023. To test whether a video from a maritime accident scene has an effect on the control of the responders, exercises have been conducted at three rescue stations in the Gothenburg area with a total number of 23 participants. Further, the study aimed to get the subject matters' opinions and suggestions for improvements on the system. At each station, two exercises were conducted, one with a video from the accident site and one without. The responders' actions and conversations in the rescue operations were recorded. Afterwards, the responders participated in a focus group discussion. The results were then analyzed based on the Contextual Control Model (COCOM) in order to determine whether a video from a maritime accident site has an effect on the level of control of the responders. The analysis shows that a video from an accident scene can increase the level of control among search and rescue responders. Finally, several suggestions have been given by the participants to aid the future work of the E-O-S project.

Key words: Search and Rescue, SAR, Unmanned Aerial Vehicle, UAV, Control, Contextual Control Model, COCOM

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Abbreviations

AIS	Automatic Identification System
COCOM	Contextual Control Model
ECDIS	Electronic Chart Display and Information System
E-O-S	Eyes-On-Scene
GT	Gross Tonnage
IPS	Information Processing System
JRCC	Joint Rescue Coordination Centre
Rakel	Internal communication system used by the Swedish Sea Rescue Society
SAR	Search And Rescue
S-O-R	Stimuli-Organism-Response
SSRS	Swedish Sea Rescue Society
UAV	Unmanned Aerial Vehicle
USV	Unmanned Surface Vehicle

1 Introduction

This chapter gives a short introduction to shipping and search and rescue operations. It describes the background and clarifies the aim of this thesis. Thereafter, the research questions and the limitations are declared.

1.1 Shipping and Maritime Accidents

The sea has always been an important element for humans, whether it was for food harvesting purposes like fishing, or for communication. The growing population and the increased trade in Europe prompted explorations and the discovery of the New World. Consequently, new trade and communication routes were established to Asia. In the 19th century, as interest in nature and the sea grew, the sea became popular for art and recreational purposes (Andersson et al., 2016).

Today, shipping is crucial for the world economy, delivering goods and passengers all over the world. More than 50 000 ships account for roughly 80 percent of world trade, carrying among other things raw materials, fuel, and consumer goods. The increase in cargo transported at sea together with the increased number and size of vessels led to the forming of the International Maritime Organization (Lim, 2017). It was created as the United Nations adopted a convention in 1948 to form an organization devoted solely to maritime affairs. The convention entered into force in 1958 and initially started to increase maritime safety. Today, IMO has facilitated the adoption of around 50 conventions and protocols together with more than 1000 codes and recommendations related to maritime safety, security, pollution prevention and other related matters (IMO, 2013).

In 1979, the International Convention on Maritime Search and Rescue (SAR) was adopted and entered into force in 1985. The purpose of this convention was to develop an international search and rescue plan that guarantees the rescue of persons in distress wherever an accident occurs. Although the rescuing of ships in distress was incorporated in tradition and international treaties, rescue operations were not covered by an international system. The ability to provide immediate and efficient assistance varied greatly depending on the area of the ship in distress. Therefore, the convention set out to coordinate the rescue of persons in distress by a SAR organization (IMO, n.d.).

In Sweden, maritime search and rescue is carried out by the Swedish Maritime Administration in cooperation with the Swedish Sea Rescue Society (SSRS), Coast Guard, Sea police and the military. These organizations have sea and air going resources that can assist in maritime search and rescue operations. The Swedish Sea Rescue Society with its 2300 volunteers owns and operates 260 rescue boats (designed for different purposes) along the coast of Sweden, while the Swedish Maritime Administration operates 7 helicopters for search and rescue operations. Normally, search and rescue operations are carried out by the SSRS with helicopter assistance from the Swedish Maritime Administration when necessary. The Coast Guard, police and military can assist when there is a need for more resources or if they are in the vicinity of the accident. (Sjöfartsverket, 2021; Sjöräddningssällskapet, n.d.).

In 2021, the Swedish Maritime Administration carried out 1,167 sea rescue operations and 1,221 in 2020. The majority of the sea rescues were leisure boats, and the emergencies varied from

engine breakdowns and groundings to rapid weather changes. The Swedish Sea Rescue Society is involved in approximately 90 percent of all sea rescues in Sweden. During 2021, they carried out 4,900 preventive calls, and 5,034 in 2020. Preventive calls are missions where there is no imminent danger to life and involve situations such as towing and/or helping with engine breakdowns and groundings (Sjöräddningssällskapet, 2022).

1.2 Background

The Swedish Sea Rescue Society is based on voluntary work and is a member society. The work of the SSRS includes providing information and knowledge to prevent accidents at sea as well as taking preventative actions to avoid an escalation of a situation. Further, their goal is to have effective operations that can aid persons in distress within 30 minutes from leaving the station. For this, they aim to provide all rescue stations with modern rescue crafts.

Figure 1 shows different kinds of rescue crafts in the SSRS along with their minimum and maximum manning requirements. There are 10 vessel classes under 20 GT and two above 20 GT. Each rescue unit must have a master, an engineer, and a radio operator. However, the positions can be combined, e.g., a master can also take the role of the radio operator and the engineer. Note, that a rescue unit must consist of at least two people to be operative except for the jet ski 'Rescuerunner', which can be operated by one person (Sjöräddningssällskapet, 2020).

Figure 1

Rescue Craft Classes With Minimum and Maximum Manning Requirements. Reprinted from Sjöräddningssällskapet (2020, p.29) with permission

Besättningsnumerär: Fartyg under 20 brutto:	Minimi	Max
 RESCUERUNNER	 *	
BÅT UNDER 6 m & 405 kW	 *	
BÅT 6-8 m UNDER 405 kW	 *	
 GUNNEL LARSON, 8m	 *	
ESKORTEN, 10 m	 *	
 RESCUE 90E, 11 m	 *	
 VICTORIA, 12/14 m	 *	
 HALLBERG RASSY, 15 m	 *	
 POSTKODLOTTERI, 11 m	 *	
 SVÄVARE	 *	
Fartyg över 20 brutto:		
 ODD FELLOW, 16 m	 *	
 RAUSING, 20 m	 *	

When a call is received from the Joint Rescue Coordination Center (JRCC), an alert is sent to the individual pagers of the responders. The on-call rescue skipper is then required to call and acknowledge the call to the JRCC by telephone and the responders are to head to the rescue station and prepare for departure (Sjöräddningssällskapet, 2022).

Since the SSRS responders work voluntarily, they must leave their work or home when receiving a distress call. The average time nationally for the responders to get underway is 12 minutes. From the time the responders get the alarm until they reach the accident site there are several tasks that need to be done. There is usually a minimum of preparation, like grabbing life jackets, before navigating to the site of the accident (Personal Communication, 10 Feb 2022 Fredrik Falkman).

In 2020, the Swedish Sea Rescue Society had 1408 blue light calls nationally, out of which the Gothenburg area received around 100 distress calls which involved a life-threatening situation. According to a member of the Swedish Sea Rescue Society, some distress calls can seem urgent and life threatening but turn out to be a minor emergency. It is hard to know what an accident will look like and in many cases the distress calls are different than described or expected (Personal Communication, 10 Feb 2022 Fredrik Falkman).

To assist rescue personnel, the Swedish Sea Rescue Society together with RISE, Chalmers Maritime Human Factors, Airpelago, Smartplanes, and Infotiv have initiated the project Eyes-On-Scene (E-O-S) which is a UAV support system for the Sea Rescue Society (funded by the Swedish Transport Administration). The E-O-S project started in 2021 and according to Airpelago (2021), it aims to “develop, test, and evaluate a system of small flying wing drones that can be remotely launched and operated during sea rescue shouts in order to give rescue boat crews and rescue coordinators early images from the scene of a maritime accident or incident”. The goal of the E-O-S project is to generate a live video from the scene of the accident that is accessible for the responders before they launch the rescue crafts. This means that planning, launching, and flying to the accident site needs to be done in less than 12 minutes (Airpelago, 2021).

The project involves an unmanned aerial vehicle (UAV) also called a drone which is an aircraft that can be remotely controlled by a pilot and does not require any personnel onboard. UAVs can be fitted with various equipment like cameras, missiles, or sensors to complete military or commercial missions. Since the 1970s, drones have developed significantly due to the advancements in the computer industry and become widely used in civilian and commercial use. Today, UAVs are a low-cost alternative that can complete tasks and missions without risking human lives (Alley-Young, 2020).

In the E-O-S project, the small wing drone is equipped with a camera which streams a live video-feed from the scene of the accident. Previous research shows that UAVs are not a new commodity in search and rescue operations, however, studies either examine different types of UAV suitable for search and rescue or deal with the usage of UAVs ashore.

Dol et al. (2015) have studied the different types of UAV and list advantages and disadvantages of the four different types of drones presented. According to Dol et al. (2015) fixed wing UAVs have poor maneuverability and require more space compared to other UAVs but have a long range and endurance instead. In time critical offshore and nearshore SAR operations, UAV technology has the potential to conduct rescue operations in a safer manner by reducing the human risks during operations in adverse weather conditions. It may help finding victims faster and in a safer way which ultimately saves more lives. Several practicable UAV-technologies have been developed by researchers around the world to save lives, in particular in off-and near shore SAR operations. (Dol et al., 2015).

Chen et al. (2021) have developed a system for UAV assisted search and rescue where the base station can be deployed at sea and powered by wind. The UAV can be launched when necessary and is charged at the base station. Chen et al. (2021) focus is on building a reliable UAV network system with information exchange to enhance information flow in SAR operations.

De Cubber et al. (2013) have analyzed robotic tools for search and rescue operations which include both land and sea-based SAR. According to their research, UAVs and USVs (Unmanned Surface Vehicles) can reduce the risk of rescue personnel and increase situational awareness. They propose different types of unmanned vehicles both aerial and ground-based for different types of operations. Generally, De Cubber et al. (2013) propose an unmanned surface vehicle for maritime SAR with small, unmanned rescue vessels that can carry equipment to the people in distress.

There are also several articles and reports of drones used in mountain search and rescue operations. Van Tilburg (2017) states possible benefits of UAV in search and rescue. The report exemplifies this with two cases where in one case, a dangerous night operation by rescue personnel could be prevented and in the other, inaccessible terrain could be cleared in a faster way. Van Tilburg (2017) adds possible benefits in searching, observing, and documenting missions but that they also could deliver equipment and establish means of communication (Van Tilburg, 2017).

Karaca et al. (2018) have also studied the use of drones in SAR operations but focus specifically on searching and locating the victims in mountain environment. This study compared the classical search pattern with a drone, assisted by a manned snowmobile technique. The results of this study show that the drone technique saved around 48 minutes compared to the classical search method.

Gay et al. (2019) have summarized a case report of a mountaineer that fell and slid down a slope while climbing in the Himalayas. After noticing that he was missing, other climbers launched a civilian drone to locate the missing climber in the suspected region where he fell. After finding him and confirming that he was alive, rescue operations were performed successfully. This case report shows the benefits of drones in harsh conditions near the human limits, where immense challenges are expected.

Gabbouj et al. (2020) studied the correlation between UAV flight altitude and detection probability of marine search and rescue using UAVs. The results show that there is a correlation between the altitude of the drone and the detection of people. At around 100m an accuracy drop was detected.

1.3 Aim and Objective

The aim of this thesis is to evaluate whether a live streamed video from a scene of a maritime accident can aid the responders' control of the situation. Further, this thesis, introduced to the E-O-S project via Chalmers Maritime Human Factors Department, aims to provide the project with useful ideas for improvement of their UAV system.

1.4 Research Questions

The research questions to be answered in this thesis are:

1. How does a video feed video from a scene of a maritime accident influence the level of control within a maritime search and rescue unit?
2. What are the subject matters' opinions on improvements on the UAV video feed project?

1.5 Limitations

This thesis is limited to the Swedish Sea Rescue Society and their area of operation. Furthermore, it will only evaluate whether live streamed video from an accident site influences the responders' level of control. An assessment on whether it is possible for the UAV to conduct such missions and the regulatory framework behind it will not be considered in this project. The exercises are limited to the Swedish Sea Rescue Society in the Gothenburg area where the E-O-S project is located. The joint cognitive system is limited to one rescue unit per station, and that includes the UAV as an information tool. Speculations of the participants on possible scenarios outside the scope of the exercises were not regarded in the analysis of control since they were hypothetical. These were however considered in the possible improvements for the E-O-S project. The feasibility of implementing the suggestions will however not be considered in this thesis.

2 Theoretical Framework

This paper uses the Contextual Control Model (COCOM) by Hollnagel and Woods (2005) to measure the level of control among search and rescue responders. The contextual control model along with cognitive systems engineering and their development will be introduced shortly in the following chapter.

Cognition involves the actions and conditions to achieve a state of knowledge. It includes conscious and unconscious actions such as perception, recognition, conception, and judgement to achieve this state. There are many interpretations of cognition that study cognition from different viewpoints. (Britannica, n.d.).

When psychology emerged as an independent field of study in the 19th century, researchers hoped to unravel the conscious mind by reporting inner experiences. This was called the introspective approach and was preferred by philosophers and among others Wilhelm Wundt. This approach was disrupted by John Watson who viewed psychology as the study of behavior rather than consciousness which he published in his behaviorist manifesto in 1913. As a consequence, the focus shifted to animal psychology and the conditioning of behavior trying to avoid all subjects related to mental processes and events. In the mid 20th century, the study of cognition was taken up by cognitive science that studied the inner processes of cognition and the 'cognition in the mind'. In this view, cognition was viewed independently of the context in which the human was situated which reduced the human cognition to a set of inputs and outputs. This became known as the standard view and was regarded as sufficient to understand human action. However, researchers began to understand increasingly that this view was insufficient to explain how humans coped with complex situations in the real world. Additionally, it was realized that the socio-technical aspect must be included in the study of cognition since humans rarely work alone but rather as part of a group or organization. This became known as 'cognition in the wild' which emphasized that humans cannot be studied in laboratories but must be studied in natural situations (Hollnagel & Woods, 2005; Hutchins, 1995).

Shipping is a high-risk industry where decisions need to be made in a rapidly changing environment. Therefore, situational awareness plays a critical role for the safe operation of vessels (Bychkovsky et al., 2022). Situational awareness is a model that was defined by Mica Endsley in

1995 as humans needed to cope with and make timely decisions in an increasingly complex and dynamic system. It shows that situational awareness is more than being attentive to different information. Situational awareness includes a higher level of understanding of the situation that can project future events depending on the operators' goals (Endlsey, 1995). However, the Situational Awareness Model is criticized by some researchers because it is challenging to measure and interpret situation awareness based on an articulated theory (Hollnagel & Woods, 2005).

2.1 Cognitive Systems Engineering

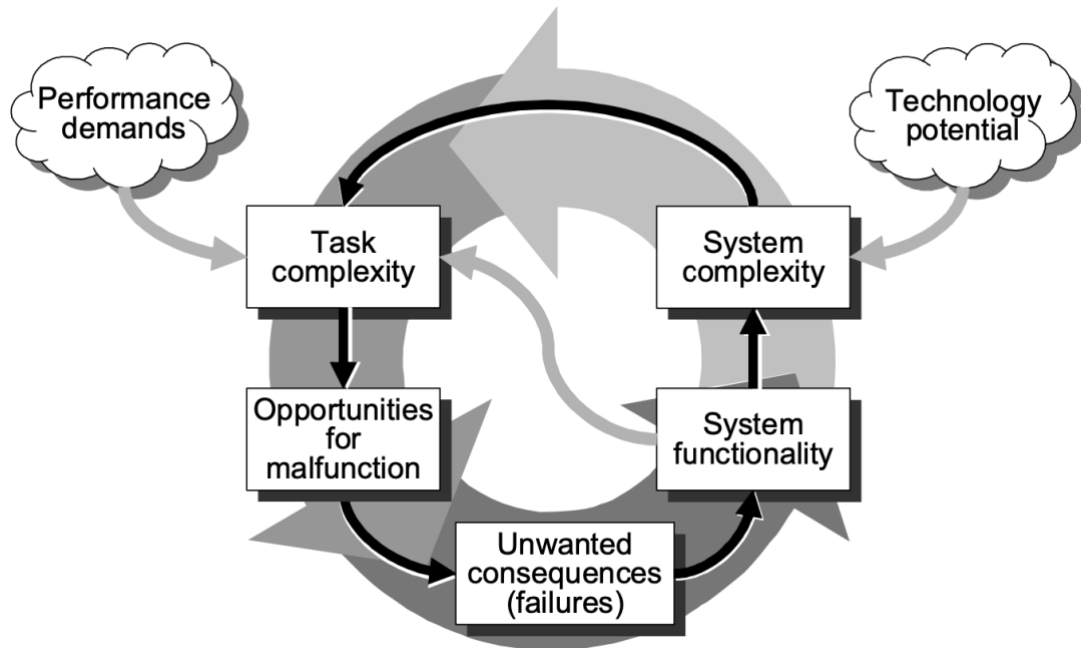
Cognitive systems engineering (CSE) is the study of human-machine systems that focuses on the cognitive function of the system compared to the traditional study of human-machine-systems that operate on the physical and physiological level (Hollnagel & Woods, 1983).

Generally, there were three driving forces for cognitive systems engineering. Due to the rise of technology in the 1930s and 1940s and the fast development of computers in the 1970s, computers became available to the public and revolutionized the way people worked. The change in the way of working meant that there was a need to study human-machine systems.

With technology developing, quality, flexibility, and production speed increased while costs could be reduced. Technology at the time aimed to decrease the workload of the worker while increasing the efficiency of production. However, this meant also that the systems became more complex which gave rise to a system that was prone to failures and malfunctions. This resulted in adaptation of the system to eliminate failures which ultimately led to an increase in the system's complexity. This is illustrated in figure 2, the self-reinforcing complexity cycle. The increased system complexity and emergence of failures in human-machine systems urged for a human-machine performance analysis. The self-reinforcing complexity cycle shows that human-machine systems depend on each other and must therefore be analyzed jointly. Further, it shows the importance of control and the influence of previous events to the context. Therefore, a model for analyzing performance was necessary which motivated the development of CSE (Hollnagel & Woods, 2005).

Figure 2

Self-Reinforcing Complexity Cycle. Reprinted from Hollnagel & Woods (2005, p.4) with permission



2.2 From S-O-R to COCOM

The basis of the Contextual Control Model (COCOM), also called the integrated view, evolved from the Stimulus-Organism-Response (S-O-R) model.

One of the most important paradigms in behaviorism is the S-O-R framework. This model regards humans as organisms that constantly react to stimuli. According to this model, external forces (stimuli) trigger processes inside the human mind which creates a response. It can be regarded as a black box where it is unknown what happens inside the human mind and only the inputs (stimuli) and outputs (responses) can be observed.

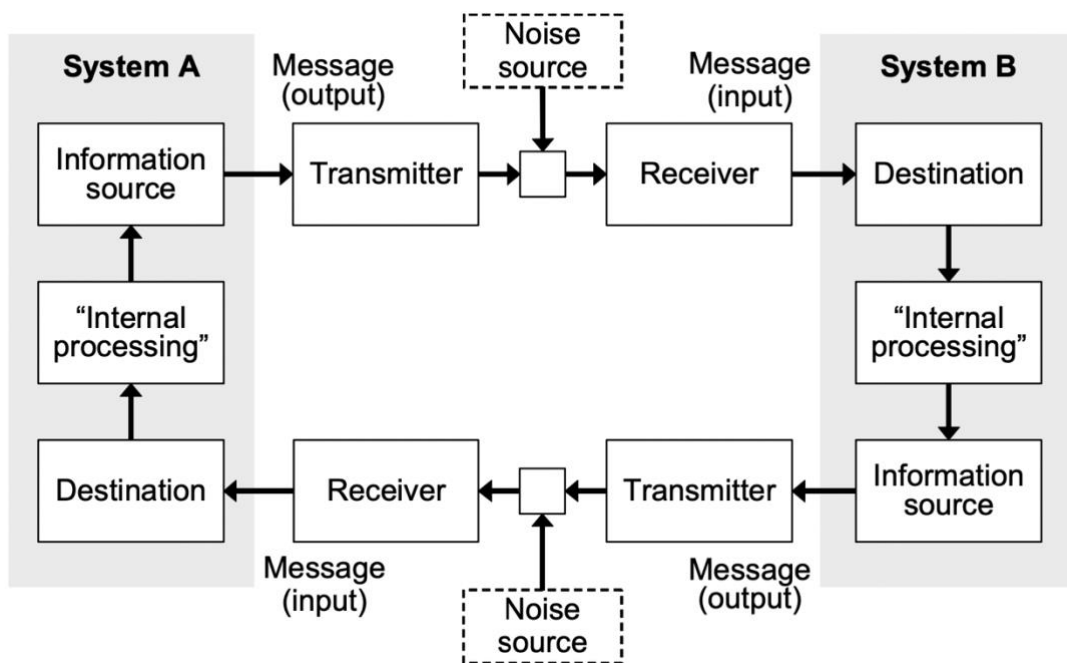
In computational psychology, the S-O-R paradigm can be compared to the human being as an information processing system (IPS). Computational psychology regards mental processes as specific mechanisms and mental states as a result of sensory input, motor behavior etc. This view, however, has been criticized by other researchers as being too simplistic and limiting the human to only being an IPS that reacts to inputs from the external world.

This can be illustrated by the extended Shannon-Weaver model, shown in figure 3, where a two-way communication is shown. In this model, one person (system) receives a signal or an input, processes it internally and creates an output to the other system which performs the same actions. The transmitter in figure 3 is the person's vocal system, and the receiver is the person's hearing system and brain.

The Shannon-Weaver model is suitable for describing the way communication works in terms of exchanging information, but it has been criticized for the insufficient ability to describe how two persons work together. This emphasizes that there is a need for a model that takes coagency into account and does not reduce a system to its mere interaction (Hollnagel & Woods, 2005).

Figure 3

The Extended Shannon Weaver Model. Reprinted from Hollnagel & Woods (2005, p.13) with permission



In the 1980s, the view that humans are information processing systems lost importance and a new model was introduced, called the cognitive viewpoint. This view considered cognition as active and not reactive, i.e., reactive in the sense that cognition is triggered by input or external stimulus. It acknowledged that several processes take place simultaneously in cognition and changed the view from internal mechanisms of performance to overall performance. The cognitive viewpoint also recognized that two systems or persons may have a different view of the world, different experiences, expectations, and knowledge. Further, the view that mental processes take place sequentially and starting with a stimulus was abandoned and the view that performance was cyclic, meaning that cognition neither has a starting point nor an ending was accepted. In the cognitive view, actions are a result of reoccurring evaluations and active information seeking in order make the best decision.

As technology advanced, researchers focused mainly on the interaction between humans and technology, not considering anything beyond that. Researchers regarded interaction between humans as a closed system where inputs are processed into outputs and communicated between

the human and the machine via an interface. It resembled the Shannon-Weaver paradigm in the way interaction between humans and machines was regarded. This classical human-machine view described interaction between humans and machines as the transfer of inputs and outputs. Moreover, it regarded both humans and machines as equal, separate entities, being information processing systems. The interaction between human and machines became the primary area of study while the overall performance of the system was partially ignored.

The classical view changed to the integrated view as the focus shifted from the interaction between the operator and the machine to a joint human-machine coagency. The fact that humans and machines are two separate systems does not mean that they are functionally separate. The integrated view, also called the contextual control model (COCOM) changed the focus from the individual cognition of human and machine to the cognition of the Joint Cognitive System (JCS). In this view, the interaction between humans and technology was less important than the overall performance of the system (Hollnagel & Woods, 2005).

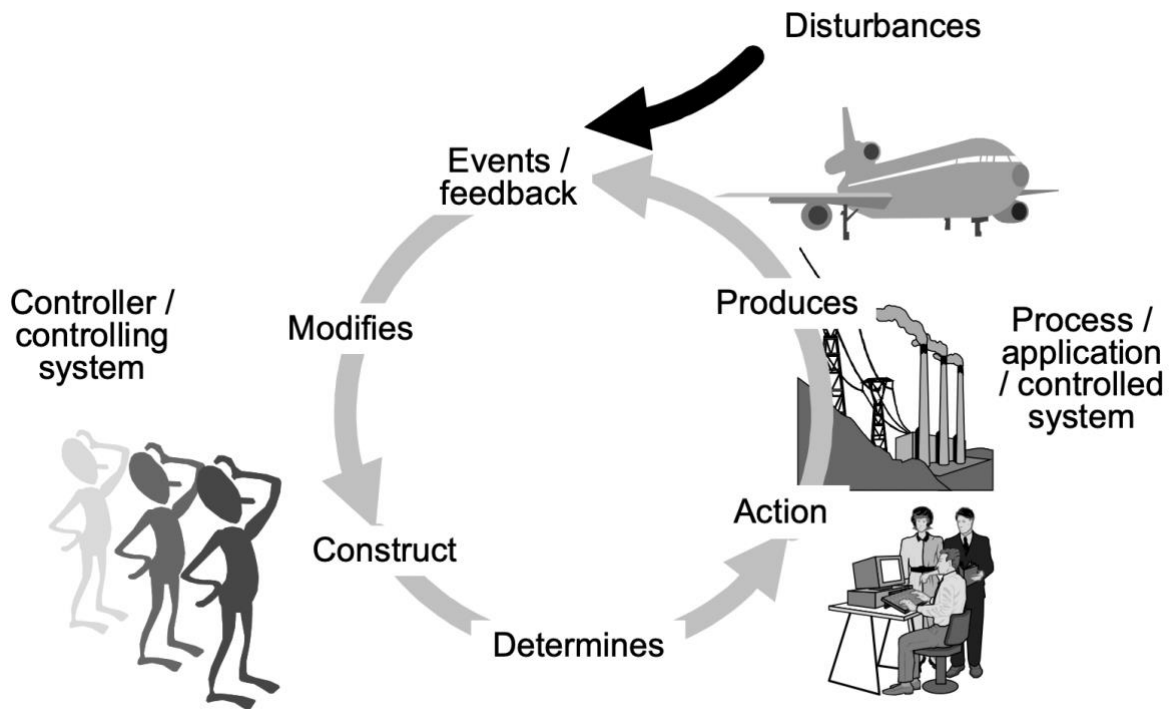
2.3 Contextual Control Model (COCOM)

The Contextual Control Model focuses on giving the necessary terms of controlled performance. This can be carried out by a human, a machine, a joint cognitive system (JCS), or an organization. Figure 4 illustrates a basic cyclical model of a joint cognitive system and how it remains in control. It highlights several important aspects of the COCOM model:

- Actions are seen collectively, meaning that actions are formed by previous actions and forecast future actions. Human behavior is a result of a series of interrelated actions and not a set of single actions.
- Because the cyclical model does not have a start or end, any representation of performance must include previous and expected events. Hence, it merges feedback and feedforward loops. In the feedback loop, the error is controlled, and in the feedforward loop, the cause is controlled. Further, its cyclical characteristic shows that actions are a result of previous actions and anticipated actions where previous and anticipated action feed back into the cycle as experience or knowledge.
- Operators are analyzed as a part of a whole and how they interact with the dynamic environment and other systems. It also focuses on the extent to which actions are dependent on each other.
- The context of the situation plays a direct role, and can influence the way operators handle, analyze, and choose actions in a situation. This means that operators can have different degrees of control of the situation
- The model is functional, meaning that internal processes are not regarded as important as overall performance (Hollnagel & Woods, 2005)

Figure 4

The Basic Cyclical Model (COCOM). Reprinted from Hollnagel & Woods (2005, p. 20) with permission



The Contextual Control Model focuses on the functions to describe performance and aims to be applicable to a variety of joint cognitive systems and is therefore minimalistic. Due to the minimalistic design of the model, it only has three parts, competence, control, and constructs.

Competence are the actions that are available to a JCS in a situation to solve a problem. The degree of competence depends on the detail of the analysis by the JCS. A JCS has certain limitations of actions in a situation. An action that is not available to the JCS, by lack of knowledge, training, or experience, cannot be executed by the JCS (Hollnagel & Woods, 2005; Palmqvist, 2010).

Control represents the level of performance of a JCS and the way in which competence is applied. The COCOM framework defines four levels of control that range from very little or zero control to full control. The four defined control modes ranging from smallest to highest level of control are scrambled, opportunistic, tactical, and strategic control. A JCS can jump between several levels of control depending on the situation and the level of performance and the chosen actions to handle a situation. Further, factors for defining a control mode are perceived time, decision alternatives, number of goals, information seeking etc. Hence, a JCS can lose or regain control of a situation based on defined characteristics of each control mode (Hollnagel & Woods, 2005).

Constructs can be characterized as how and what the system perceives and understands in the situation. It emphasizes that the system's perception is a reconstruction of the real situation. This perceived situation forms the system's basis of understanding, decisions, and actions in a situation.

An important part of the contextual control model is planning which actions should take place in the available time. The planning depends on the context of the situation, the knowledge and skills of the system, and the consequences of certain actions that are performed. Furthermore, forward planning and expectations on how the situation develops play an important role (Hollnagel & Woods, 2005).

2.4 Levels of Control

Hollnagel and Woods (2005) divide cognition into four different modes, the scrambled, opportunistic, tactical, and strategic. The strategic mode is the most efficient followed by the tactical and opportunistic modes, and the scrambled mode is the least efficient. These modes are defined by the perceived available time, the number of goals, evaluation of the outcome and the selection of actions. Normally, a system functions in the tactical and opportunistic control mode and switches between them depending on the situation and context. A system operates on the scrambled and strategic control mode only under certain circumstances and environments (Hollnagel & Woods, 2005). A summary of the main characteristics of each control can be seen in table 1.

The scrambled control mode is the lowest mode of control where actions are taken randomly and irrationally. These actions do not follow any plans and no assessment or reflection of the situation takes place, it is a trial-and-error type of action taking. The first alternative is chosen and there is little to no correlation between the actions and the situation. This control mode corresponds to having very little control of the situation and in the extreme case zero control. It is very inefficient, and a system may find itself in a vicious circle of failures before eventually succeeding.

The opportunistic control mode is the next higher mode where planning takes place on a higher level but is still limited due to either limited time, missing context, or knowledge of the situation. The opportunistic control is applied when the system's functioning is insufficient due to either lack of competence, abnormal environment, or dangerous working conditions. Actions are often inefficient, resulting in many failed attempts.

The tactical control mode can be considered a situation where known procedures or rules are applied. In this control mode, the time needed for the evaluation and action taking in a situation is less than the time available. Thorough and precise planning for future events does however not take place in this mode and is limited to ad hoc decisions and needs. Information seeking takes place in this control mode but is limited in the amount and sources. The tactical control mode is considered a normal control mode to a situation.

The strategic control mode can be considered the highest control mode where time is not limited, and goals can be pursued on a higher level. Time is abundant and the situation can be fully assessed, hence, actions can be compared thoroughly. The choice of action is therefore not influenced as much by the dominant features of the situation or the context but rather based on models and predictions (Hollnagel & Woods, 2005).

Table 1

Main Control Mode Characteristics. Reprinted from Hollnagel & Woods (2005, p.148) with permission

Control mode	Number of goals	Subjectively available time	Evaluation of outcome	Selection of action
Strategic	Several	Abundant	Elaborate	Based on models/predictions
Tactical	Several (limited)	Adequate	Detailed	Based on plans/experience
Opportunistic	One or two (competing)	Just adequate	Concrete	Based on habits/association
Scrambled	One	Inadequate	Rudimentary	Random

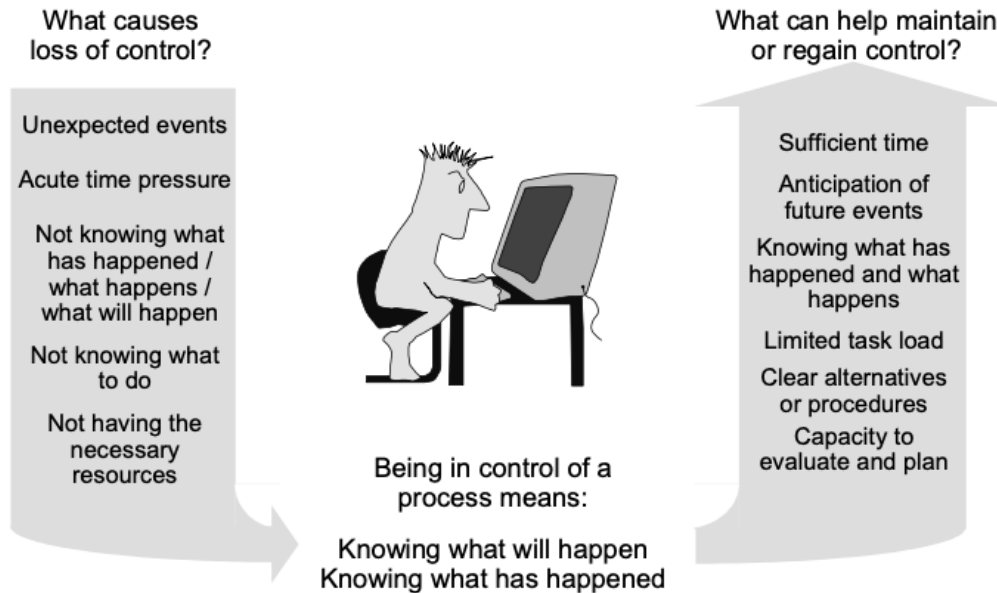
2.5 Loss of Control

As mentioned in the previous chapter, it is possible for joint cognitive systems to switch between the modes. When a system jumps to a lower control mode, it is regarded as losing control, and regaining control when a system jumps to a higher control mode. The determinants of control are shown in figure 5.

Unexpected events, insufficient time, insufficient resources, lack of knowledge and competence are reasons for losing control. Contrarily, if predictions can be made of future events, if the workload can be reduced, if there are clear procedures or alternatives, or if there is ability to evaluate and plan, control can be maintained or regained (Hollnagel & Niwa, 2001 ; Hollnagel & Woods, 2005).

Figure 5

Determinants of Control. Reprinted from Hollnagel & Woods (2005, p.75) with permission



Unexpected events have a large impact on the loss of control and are closely related to lack of time. The accuracy of predictions is determined by among others, available time, and if the predictions are inaccurate, the likelihood of unexpected events increases. Further, if unexpected events happen, it usually means that time must be devoted to the events since the operator needs to take in new information, understand it and consider the consequences. In dynamic environments time is always limited since processes and situations continue to develop even when the JCS is inactive. This means that there is limited time to plan, prepare, and execute actions. A system can cope with occasional unexpected events but if the frequency increases, the system will encounter problems and disturbances and will potentially lose control.

In addition to sufficient time, a system must have sufficient knowledge to recognize, identify and interpret incidents correctly. Without knowledge, sufficient time is irrelevant since the skills and knowledge to handle a situation are nonexistent. If people are responsible for a task which they have no or little knowledge about, the likelihood of losing control increases and consequentially the likelihood of accidents increases as well.

Control may also be lost when the system lacks readiness or preparedness. If an event occurs and the system does not know how to react and what to do, it is difficult to act appropriately, and actions will require additional time.

The last reason for a loss of control is a lack of resources. When a system lacks resources, the available actions are limited due to the limited resources. In a situation where resources are insufficient, the problem is often not the knowledge of what is happening. This can be compared to wildfires, where the expertise is available but the equipment to combat the fire are limited or insufficient (Hollnagel & Woods, 2005).

Figure 6

Temporal Relations at Work. Reprinted from Hollnagel & Woods (2005, p.169) with permission

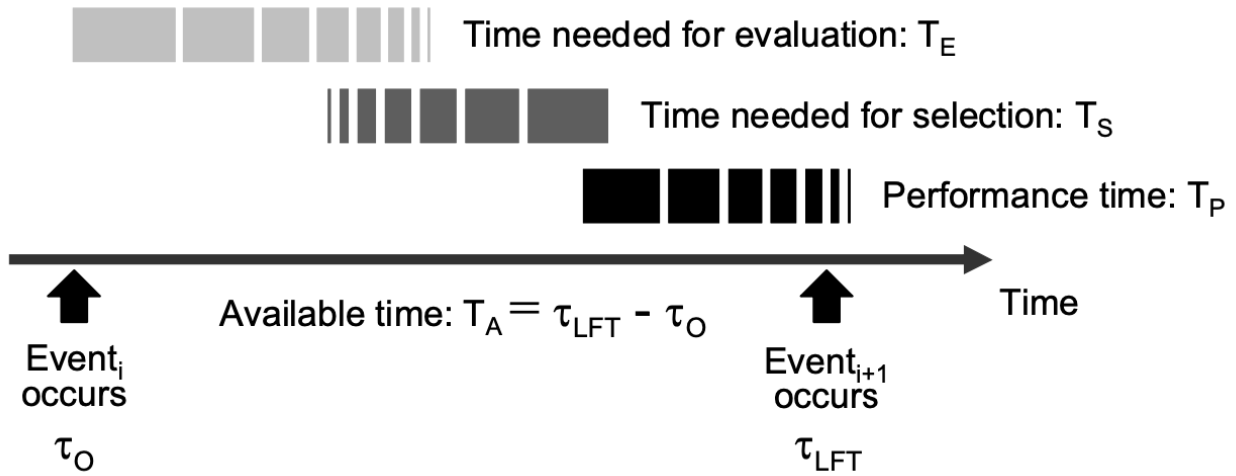


Figure 6 shows the relevance of time in the contextual control model. τ_O is the time when an action needs to be taken when an event occurs, or the operator realizes that something needs to be done. τ_{LFT} is the latest finishing time of that action in regard to τ_O . Hence, the available time to perform an action (T_A) is the time difference between τ_{LFT} and τ_O . T_E is the time that is needed to evaluate events and form an understanding of the situation. T_S is the time needed to select a suitable action and T_P is the time needed to perform an action. In figure 6, these are represented as bars that overlap since they often take place simultaneously, although event evaluation precedes action selection which in turn precedes execution of an action. The level of control depends on the time that a JCS needs to perform these tasks and the available time to do so. If a JCS completes event evaluation, action selection and performance of an action within the available time, the JCS operates on a higher control mode. Contrarily, if the tasks (T_E , T_S & T_P) require more time than the available time T_A the user operates on a lower control mode. This situation is shown in figure 6 where a new event occurs before T_P has been finished.

3 Method

In this study, a qualitative research method was chosen to answer the research questions with an abductive form of reasoning. According to Bryman (2012), abduction is “a form of reasoning with strong ties to induction that grounds social scientific accounts of social worlds in the perspectives and meanings of participants in those social worlds” (p.709). In abductive reasoning, the theoretical understanding of the context that is studied is grounded on the perspectives and world views of the participants. The results must reflect the views of the participants of the study and a social scientific account must be composed based on these views. The abductive reasoning resembles inductive reasoning in the approach; however, it differs in the way the results are presented since abductive reasoning must be based on the world views of the participants compared to inductive reasoning. To test whether a live video feed from the site of the accident is useful to maritime search and rescue personnel, exercises were performed with trained volunteers from the Swedish Sea Rescue Society in the Gothenburg area. This area was chosen due to the cooperation with the Eyes-on-Scene project which involved the Gothenburg area’s rescue stations. The proximity of the Gothenburg rescue stations was another reason to conduct the exercises with these stations. Due to the specific research area within search and rescue in the Gothenburg area, a non-probability sampling was used. The sample involved trained search and rescue personnel who participate in search and rescue operations.

To collect data, exercises were conducted at three rescue stations. At each station, two dummies were set out at sea at two different locations, simulating a person in a life-threatening situation. The simulated person in distress will from here on be referred to as dummy. One dummy was filmed and recorded using a drone which aimed to reenact the UAV which will be used in the future by the SSRS. A tag with contact information was attached to the dummies in case they would detach from their anchor.

3.1 Exercises

The exercises were conducted as a simulation prior to the launch of the E-O-S project since the full-scale operability was not completed at that stage. They were conducted at the rescue stations in the Gothenburg area. One station was located at the southern part, one was in the middle and the third was in the northern part of the Gothenburg area. In the following, these will be referred to as station A, station B and station C, where station A is the southern rescue station, station C is the northern rescue station and station B in between.

3.1.1 Preparing and Conducting the Exercises

Before conducting the exercises, preparations needed to take place to simulate a rescue call. At station A, the preparations were done one day prior to the exercises to account for time delays and other incidents. At the other stations, the equipment and dummies were prepared at the same day since there was more knowledge and experience from the days before regarding how much time it required. The resources that were needed for these exercises are listed below:

For preparations:

- Drone (DJI Mavic Pro)
- Dummies (as can be seen in figure 7) marked with contact information

- Anchor
- Ropes
- Rescue craft with master
- Camera mounts

For exercises:

- Rescue crews
- Rescue crafts
- Cameras
- Tablet with pre-recorded video

Figure 7

Dummies That Were Used in the Exercises.



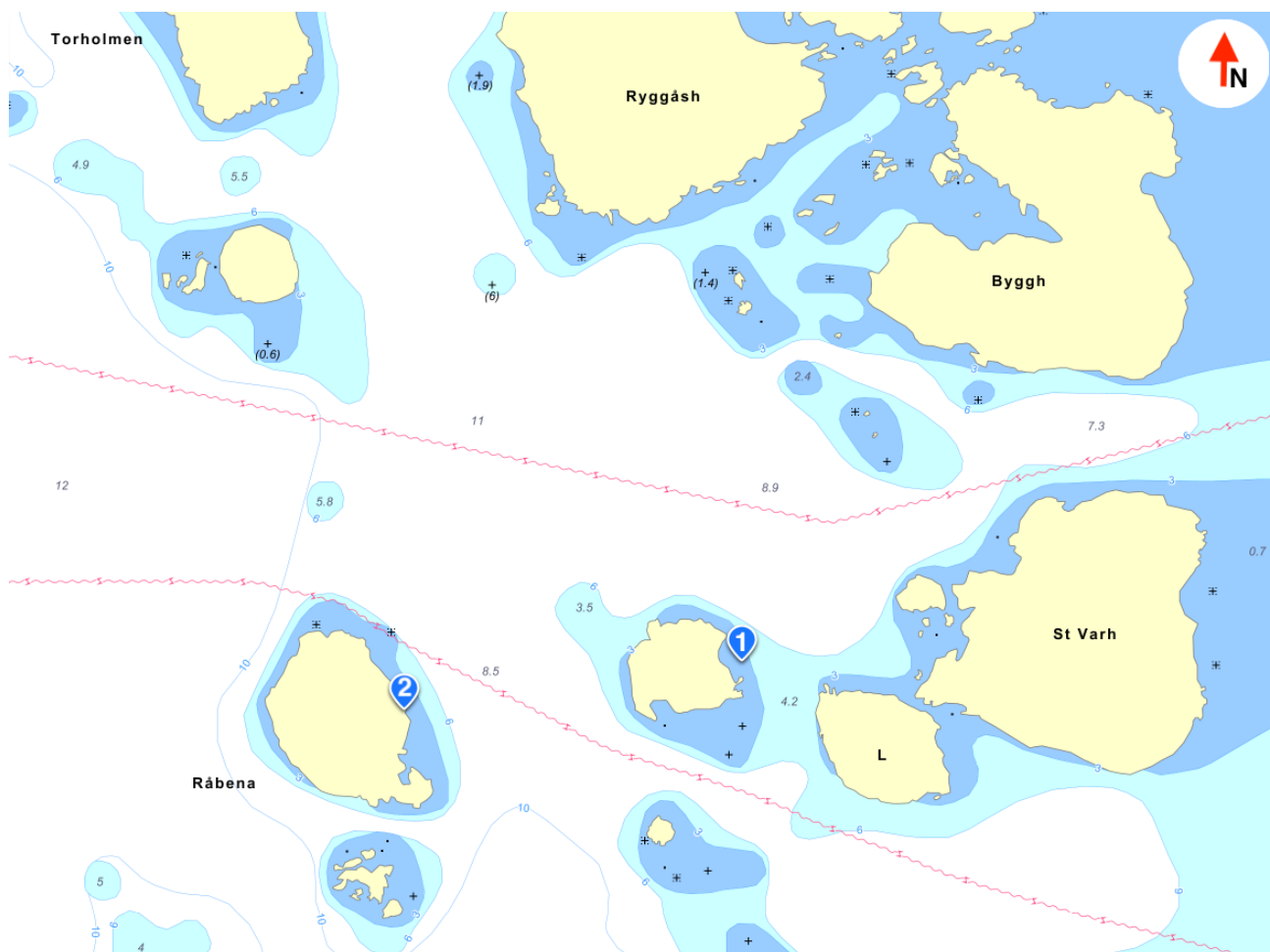
Note. The red dummy was used in the exercises without the video footage available and the yellow dummy was used in the exercise with the video footage available.

At station A, the exercise was set up and prepared one day prior to conducting the exercise to account for any deficiencies. This was done with the help of one of the masters at station A. The two dummies were marked with contact information and set out south of Stora Amundö. One was placed east of Råbena and tied to a large rock at the shoreline (see Figure 9). The other dummy was anchored in the water close to the shoreline west of Stora Varholmen (see figure 8 and 10). The latter was then filmed from another small island with the drone to get proper video footage of the scene. The dummy was filmed for around 8 minutes and a video loop was created to ensure that the video length suffices the whole rescue operation. Before looping the video, it was cut at a suitable frame so that it transitions smoothly.

The position of the dummies was reported to the Joint Rescue Coordinating Centre (JRCC) to avoid any misunderstandings and false alarms in case the dummies were mistaken for real persons. Preparations of the exercise took approximately 2 hours.

Figure 8

Position of Dummies at Station A, (1) Yellow Dummy, (2) Red Dummy. (Adapted from www.kartor.eniro.se with permission)



Note. The numbers (1) and (2) indicate the sequence of the exercises conducted at the station.

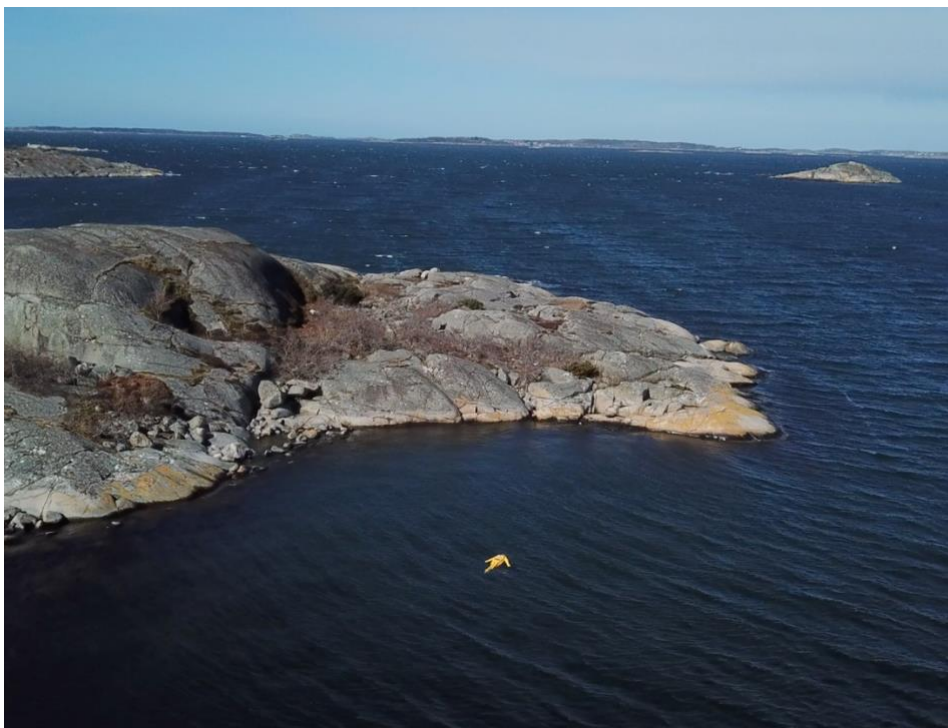
Figure 9

Picture of Dummy That Was Not Filmed.



Figure 10

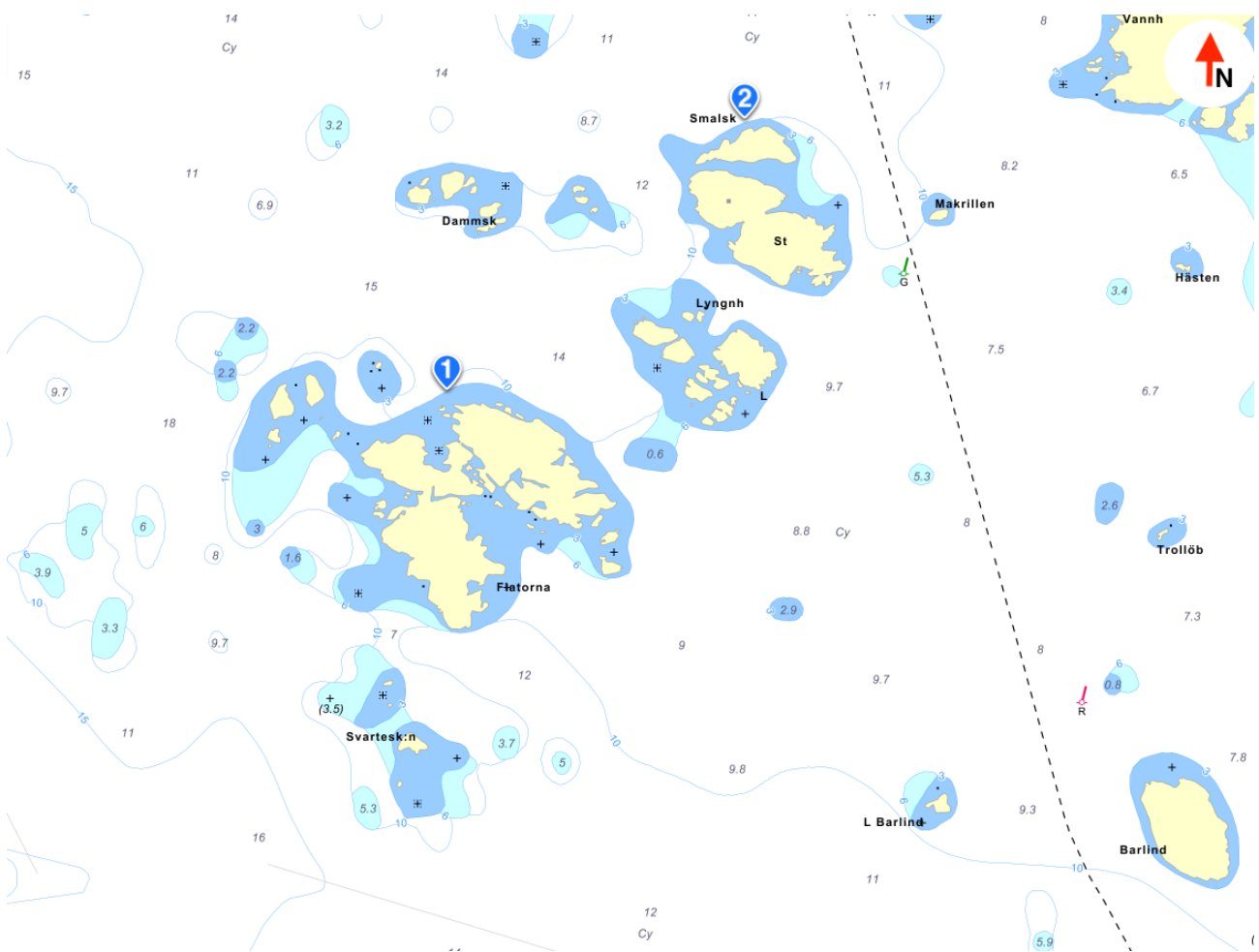
Drone Footage of Dummy at Station A, Cropped From Video.



At station B, preparations took place the same day as the exercise. Since the rescue station is manned by full-time responders, there was more time available to conduct the exercise. Preparations took place in the morning, and the exercise took place in the afternoon. The location of the dummies at station B was north of Flatorna for the exercise without the video and north of Smalskär for the exercise with the video as can be seen in figure 11 and 12.

Figure 11

Position of Dummies at Station B, (1) Red Dummy, (2) Yellow Dummy (Adapted from www.kartor.eniro.se with permission)



Note. The numbers (1) and (2) indicate the sequence of the exercises conducted at the station.

Figure 12

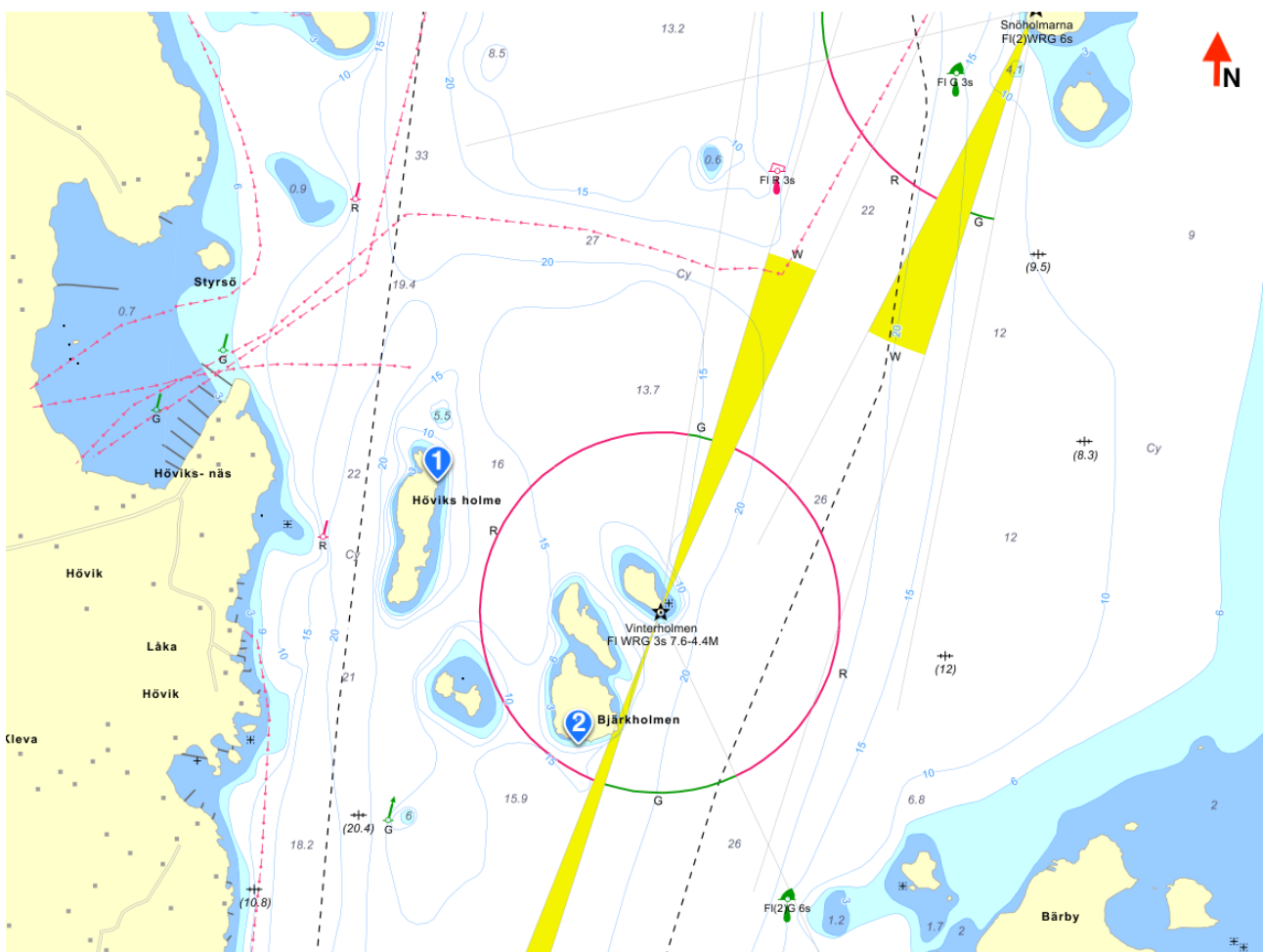
Drone Footage of Dummy at Station B, Cropped From video.



At station C, preparations took place the same day as the exercise. Since the responders of the SSRS are mostly volunteers, the exercise took place in the afternoon. For the preparations, the dummies were placed out at two different locations. The dummy that was filmed with a drone was placed south of Bjärkholmen, and the other dummy was placed northeast of Höviks Holme (see figure 13 and 14).

Figure 13

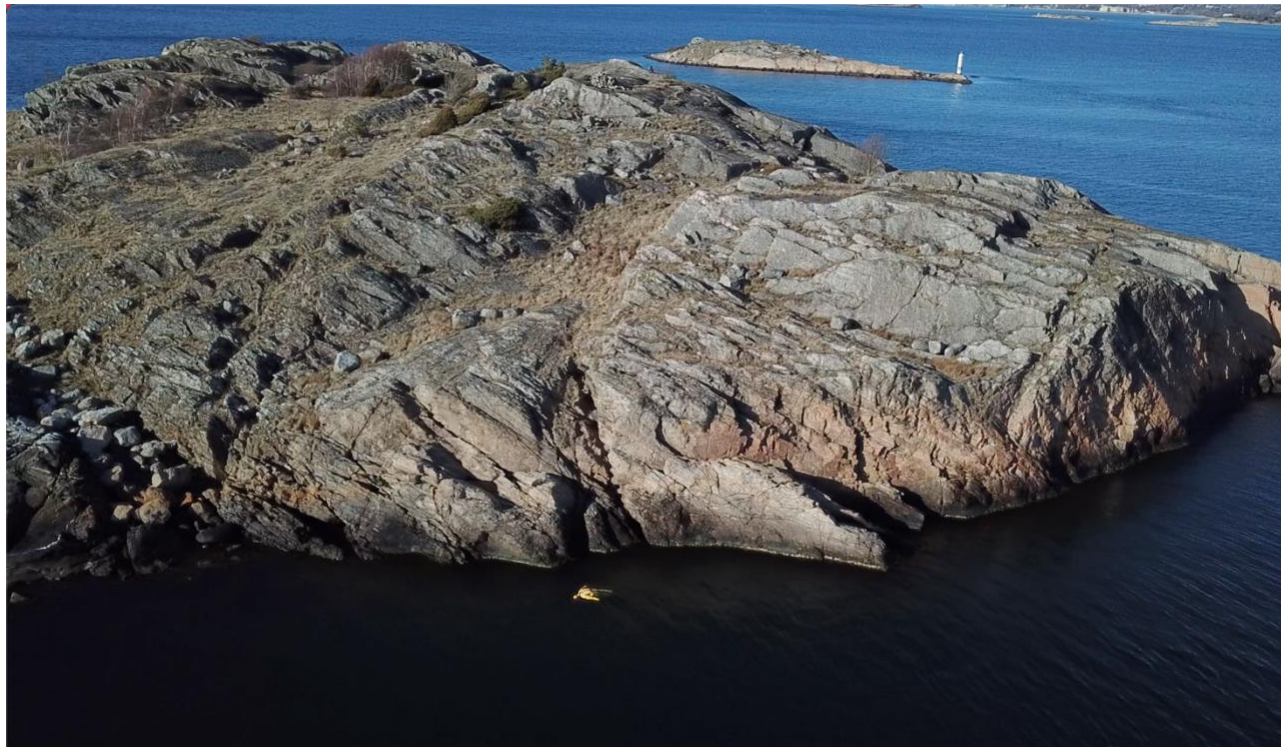
Position of Dummies at Station C, (1) Red Dummy, (2) Yellow Dummy (Adapted from www.kartor.eniro.se with permission)



Note. The numbers (1) and (2) indicate the sequence of the exercises conducted at the station.

Figure 14

Drone Footage of Dummy at Station C, Cropped From Video.



3.1.2 Execution of the Exercises

In the exercises, the sea rescue responders were gathered at the station. They were then informed about the study, and informed consent was given by the responders. They were asked to act as if the exercise was a real situation. The general setting of an exercise was that the rescue station receives a distress call that there is a kayaker in the water in distress. During the exercise, the volunteers responded to two similar cases at two different locations. In one of the cases, the responders had access to the usual resources available when responding to a distress call. In the other case, additionally, the pre-recorded video was shown to the responders on a tablet prior to launching the rescue crafts. The tablet could be taken on board the larger rescue crafts that have enclosed wheelhouses.

The responders were filmed from the moment the distress call was received until the end of the rescue operation. Cameras were used to capture behavior and voice recordings of the responders. These were handheld to capture the actions from receiving the distress call until the responders were in the rescue craft as well as installed in the wheelhouse of the larger rescue craft. One additional camera was fitted with a harness to the rescue craft's skipper. After completing both exercises, the responders were invited to a focus group discussion which was recorded as well and will be further explained in the next chapter.

At station A, the first distress call involved the exercise with the video footage available followed by the distress call without the video footage. At station B and station C, the participants first

responded to the distress call without video footage followed by the distress call with video footage available.

3.1.3 Recruitment of the Participants

The intention of the Eyes-On-Scene project is to provide better information to the search and rescue responders in the Swedish Search and Rescue Society. The project aims to be operational during 2022 in the Gothenburg area. Therefore, rescue stations in the Gothenburg area were chosen to get the same scenery as it would with the real UAV. First, an e-mail was sent to one of the contact persons in the SSRS with a description of the project and possible stations and locations where the exercises could be suitable. That contact person made requests to two rescue stations in the Gothenburg area. At a later stage, another e-mail was sent out to five rescue stations in the Gothenburg area (included the two that was contacted earlier) with a description and the aim of the project together with possible scenarios and requirements for the exercise. The request also included a plan on what needed to be done, i.e., preparing the locations/dummies, conducting the exercise, and having a focus group discussion. In this stage, it was already mentioned, that the exercises will be recorded but that the data will be held anonymous and confidential. Since the request went to the rescue stations' contact person, who forwarded it to the rescue crews to check whether there was any interest, the researchers were unable to make specific requests on experience and number of participants from each station. The aim was to get as many participants as possible from the SSRS and therefore, no limitations on the number was given. Finally, of the five rescue stations that were contacted, three stations agreed to participate.

The number of participants and which rescue crafts were used at each station can be seen in table 2. The rescue crafts are represented in classes, as shown in figure 1. The number of participants varied among the stations. One reason for this is that the work of the SSRS takes place on a voluntary basis, meaning, the participants needed to sacrifice a few hours of their free time to participate in this exercise.

Table 2

Number of Participants That Participated and the Types of Rescue Crafts Used at Each Station.

SSRS station	Number of participants	Rescue crafts
Station A	7	<ul style="list-style-type: none"> • Victoria 12m • Gunnel Larson 8m
Station B	5	<ul style="list-style-type: none"> • Victoria 14m
Station C	11	<ul style="list-style-type: none"> • Rescue 90E 11m • 2 x Gunnel Larson 8m

In total, 23 responders participated in the exercises from the three rescue stations. After the exercises, e-mails were sent out to the participants asking for demographic data. The data requested from the research team concerned age, gender, years of experience in the SSRS and the profession of the participants. Of the 23 participants, 15 (65%) responded to the e-mail. The

age ranged from 20 years to 73 years with an average age of 51,9 (median=53). The gender ratio was 11 male and 4 female participants which corresponds to 73,3% and 26,6% respectively. The experience ranged from less than one year/0,5 years to 25 years in the SSRS, corresponding to an average experience of 6,1 (median=5).

3.2 Focus Group Discussion

Upon completion of the two exercises in the field, the participants were asked to participate in a focus group discussion. A focus group discussion is an effective way of collecting qualitative data and is used to obtain an extensive range of thoughts and ideas about a research topic. As opposed to a traditional interview style, a focus group discussion's aim is to create an interactive discussion where the participants discuss their views of the research topic among each other. A focus group discussion is led by one or several moderators and consists of five to ten participants who are pre-selected. The participants who are invited to a focus group discussion should have similar experiences or common backgrounds, depending on the research topic. The topics and subjects should be limited to allow for thorough discussions of each issue. A focus group discussion aims to create a discussion between the participants where they share and discuss their views and opinions, which do not have to match. The participants do not need to come to a consensus on the topic. For this, the environment of a focus group needs to be permissive so that the participants feel comfortable to discuss issues and share their opinions and views of the research topic. The participants should not feel threatened and judged based on their thoughts and views but rather comfortable to share and discuss them with the other participants so that the researchers gain understanding of the research topic from the viewpoint of the participants (Hennink, 2014).

The participants were asked to write down their thoughts for 2 minutes prior to the start of the discussion. This was done so that everyone had time to reflect on the exercises and write their ideas, thoughts, and perception on paper without being influenced by other participants. After the 2 minutes, an open-ended question was asked: "What do you think?". The participants then had the opportunity to share their thoughts and opinions and discuss them with other participants. The discussions carried on with very little input from the moderators. Questions arose regarding the design of the UAV and were answered by the moderators to the best of their knowledge. It was highlighted that the participants should also include their opinions on design features that they think are important and should be included in the UAV system. Open ended questions were posed for the majority of the focus group discussion. After every participant had shared their opinions and ideas, the moderators continued with some closed questions to go into detail on specific issues that had not been raised in the discussion explicitly.

3.3 Thematic Coding and Analysis of the Data

After completing the focus group discussions, they were transcribed using the program Amberscript. Amberscript was chosen as it has the possibility to transcribe Swedish text. The audio files of the focus group discussions were imported into the program and the interview text was generated. Since the transcription had a considerable number of mistakes, the text file was corrected manually in Amberscript. This was done by listening to the audio file and correcting the text simultaneously. Using the rewind and fast-forwarding tool, the audio could be listened to several times in passages that were difficult to comprehend. After transcribing the interviews for the three rescue stations, the contents of the focus group discussions were coded. Coding is a

process in qualitative research where data is analyzed and fragmented into components which are then labeled (Bryman, 2012).

Bryman (2012) suggests reading through the transcription to see what the text is about without taking any notes or adding an interpretation. In this step, the text should be understood without analyzing it further. However, after finishing reading the transcription, key ideas or notes can be taken which are deemed important or significant. Then, the data should be read once more, and ideas and notes should be written down on the margin of the text about significant passages or observations. These notes can include keywords, similar responses or themes that are identified in the data. In this stage, the intention is to be imaginative and inventive, and therefore, the notes can be copious. This process is called coding and involves systematically marking in the text and indicating what the text is about. Subsequently, the codes should be reviewed by combining similar codes, removing unnecessary codes, and identifying associations of the data with theories from the literature. Lastly, general theoretical ideas are related to the data and the codes are interpreted and analyzed to add significance to the responses of the participants. The codes are used to find interconnections or relations in the qualitative data which is then connected to the research question (Bryman, 2012). The focus group discussions were analyzed and presented collectively to avoid repetitiveness since the results of the different stations were essentially identical. The participants' opinions and suggestions for improvement of the UAV system were derived from the suggestions that were mentioned during the focus group discussions.

3.4 Analysis of the Videos

The videos from the exercises from each rescue station were recorded on video cameras as mentioned under chapter 3.1.2. The actions and conversations of the participants were transcribed. The time frame of the transcriptions was chosen to be from the moment the responders casted off until they arrived at the dummy. Each exercise was then summarized shortly before the analysis of the videos. The research team then studied the level of control of the responders according to the COCOM framework. The transcriptions were analyzed by assigning the actions and conversations to the different determinants of control: *Acquiring information, knowing what has happened and what happens, capacity to evaluate and plan, reduced task load, time and clear alternatives and procedures* as well as *anticipation of future events* for the focus group discussion. The determinants of control were then selected as subheadings and the corresponding parts of the videos were described for both cases, i.e., with and without the video footage. The results of the videos from the exercises were then compared with each other and a control mode was assigned to each exercise from each station. A short result was then noted under each determinant of control. Rather than determining the control mode to small intervals of the operation, it was decided to assign a control mode to the search and rescue operation as a whole.

4 Results and Analysis

In the following chapter, the course of events of the exercises is described from casting off until arriving at the dummy. It is then followed by the assignment of the participants' actions and conversations to the different determinants of control. A short summary of the findings is presented at the end of each station's analysis. Then, the content of the focus group discussions is presented based on each determinant of control that cause a loss, maintaining, or regaining of control followed by a short summary of the results of the analysis. The results of both the videos and the focus group discussions are then presented, and finally the participants' suggestions on the improvement of the UAV system are summarized.

4.1 Video Results and Analysis – Station A

The following passages describe the general outline of the exercises at station A, after the responders received the distress calls. The approaches of the rescue craft and where they slowed down to start the lookout on scene can be seen in figure 15. In this paper, the time from when the craft slowed down and the rescue unit started their lookout until they spotted the dummy is defined as the 'search phase'.

4.1.1 Course of Events With UAV Video

Distress call: "Kayaker capsized south of Amundö, west Stora Varholmen".

The responders cast off and leave the berth. At this point, they know approximately where they should go. While navigating out from the port area the skipper and the navigator simulate radio traffic with JRCC and the two deckhands (hereafter named deckhand 'A' and 'B') look at the UAV video footage for a few seconds. Two minutes into the exercise the navigator informs the skipper about some surfers ahead. Right before leaving the port area the skipper asks the navigator if they have a little bit more of an understanding where they are going, upon which the navigator answers that he/she has it managed.

2 minutes and 45 seconds into the exercise the rescue craft exits the port area, and the skipper increases the speed. Deckhand A has the tablet with the video and looks at it, stands up and looks back and forth between the video footage and the ECDIS. After a while the skipper says that when they arrive, they will have a look at what is going on. He/she then continues with saying that they have the position, and he/she knows that the dummy is in the water. Deckhand A who has the video also says that the dummy is in the water, approximately 20 m out from the islet. Later, the skipper asks deckhand A (for the first time) how it's looking in the video to which the deckhand replies that the dummy is in the bay approximately 20 m from the shore. After this, deckhand A and the navigator discuss where on the ECDIS the dummy might be exactly and conclude that it is floating in the area inside the islet. The skipper asks for the depth at the location and the navigator says that it's 7,3 m and there is water all around the dummy but then adds that it depends on the exact position of the dummy because there is a 5 m shallow curve close by. 5 minutes and 45 seconds into the exercise the navigator informs the skipper of the depth of a strait they must pass

to reach the location. At 7 minutes 3 seconds the skipper instructs the navigator to be prepared to radio the other rescue craft (which currently is a bit behind them) when they arrive at the scene.

40 seconds later at 7 minutes 43 seconds the navigator instructs the skipper that they can start to slow down. The skipper slows down the rescue craft and instructs the two deckhands to start the lookout process on deck. The two deckhands leave the wheelhouse while the navigator calls the other rescue craft. 8 minutes and 7 seconds into the exercise the rescue craft is just drifting, and the skipper and navigator simulate radio traffic with JRCC. Deckhand A enters the wheelhouse again and together with the navigator they look at the video and discuss where the dummy should be. Deckhand A concludes that it should be over there and points out the window. At the same moment, 8 minutes and 56 seconds into the exercise, the skipper and the deckhand spot the dummy.

4.1.2 Course of Events Without UAV Video

Distress call: “Kayaker capsized south of Amundö, northeast of Råbena”.

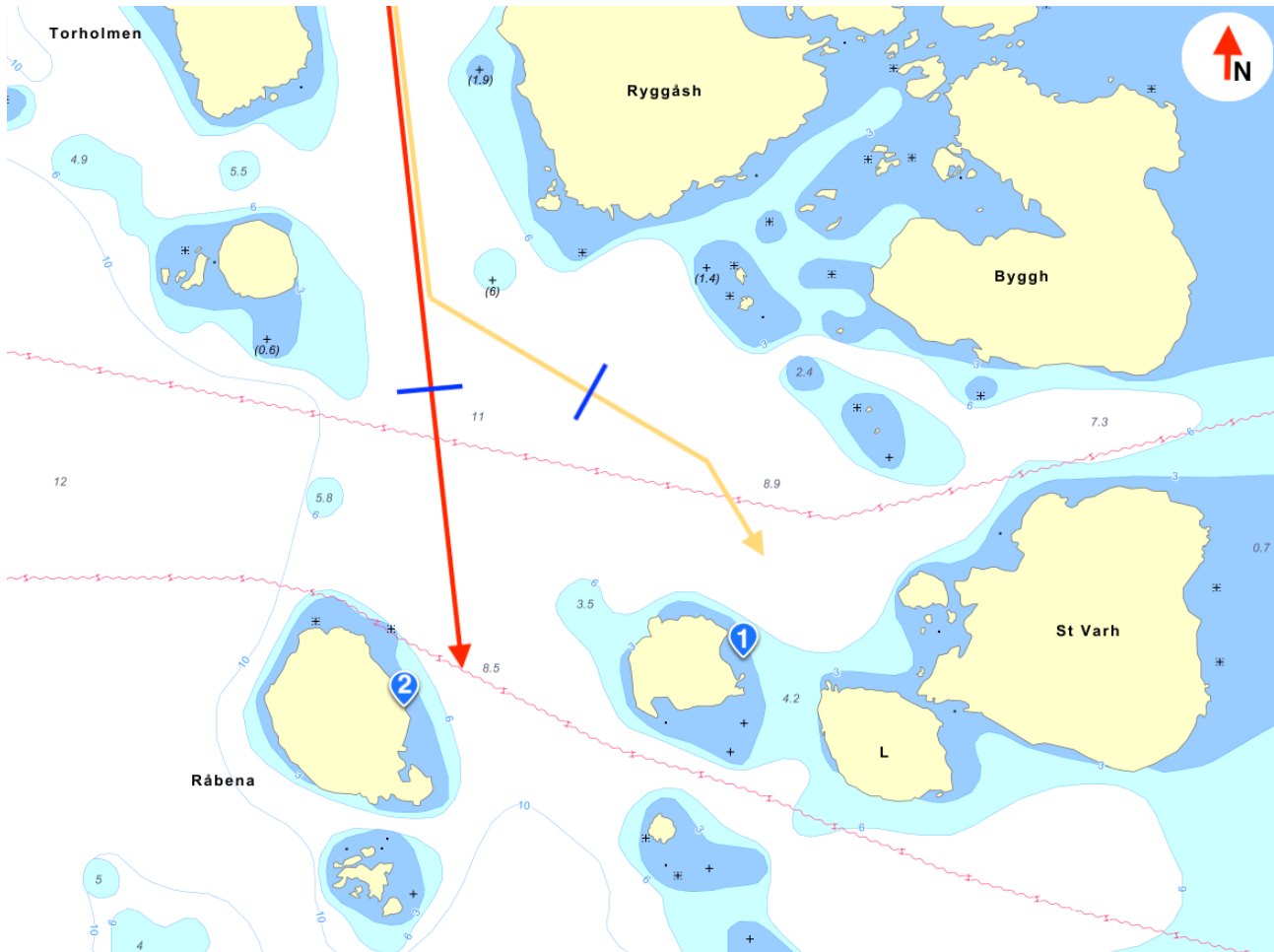
The responders cast off and leave the berth. The skipper and deckhand A simulate radio traffic with JRCC, while the navigator looks at the ECDIS. Later, the navigator repeats the position given in the distress call and asks if it was correct, which the rest of the crew confirm. Deckhand A then asks if they have a fix on the position (in the ECDIS). The navigator answers that he/she doesn't have it and continues to look at the ECDIS, trying to find the island Råbena. During this time, deckhand B locates Råbena on a chart app on a mobile phone and shows it to the navigator to which the navigator says that he/she might see the island better on the ECDIS after they have left the port area. The navigator continues by saying that he/she knows approximately where they are going and tells the driver to head for Långeskär. Deckhand A says that they were given the information that the accident site is east of Råbena which should be on the “inside” of the island. Shortly thereafter, the navigator locates the island Råbena on the ECDIS and says that they now have a position.

2 minutes and 37 seconds into the exercise the rescue craft leaves the port area, and the speed is increased. At 6 minutes 37 seconds deckhand A asks where on the ECDIS Råbena is, which is subsequently pointed out by the navigator. Deckhand A then points through the window and says: “There's Råbena”. This information is then relayed to the skipper. Deckhand A then asks for the water depth east of Råbena and the navigator responds that it is a bit shallow but does not know how far out the shallows stretches.

7 minutes and 41 seconds into the exercise, the skipper slows down. Deckhand B points at an island and asks whether that is Råbena, which is confirmed by the navigator. The two deckhands then proceed out on deck to start the lookout. Right before stepping out on deck the first deckhand and the skipper again simulate radio communication with JRCC. At 8 minutes 37 seconds deckhand A knocks on the window to indicate that they have spotted the dummy. The navigator says that it is too shallow for them to approach the dummy to which the skipper responds that he/she should call the other rescue craft (which has a smaller draft) to retrieve the dummy.

Figure 15

Approaches to Accident Scene, Station A. (Adapted from www.kartor.eniro.se with permission)



Note. Arrow tips indicate when the dummies were spotted. Blue lines indicates when the rescue craft slowed down. Yellow line = exercise with UAV. Red line = exercise without UAV.

4.1.3 Analysis of the Level of Control – Station A

In this section, the actions and conversations are categorized according to the determinants of control shown in figure 5. After the categorizing, the results are analyzed, and a control mode is assigned.

4.1.4 Acquiring Information

With UAV video: The responders analyzed the video. They knew from the information received in the distress call where they were (approximately) going, looked at the video and compared it with the chart in the ECDIS. At one instance, one responder asked about the depth at the location, which was answered by both the navigator looking at the ECDIS and the deckhand looking at the

video. The responders also analyzed the situation of the dummy. When they were at the scene one deckhand left his/her lookout position to consult the video again with the navigator to see where the dummy should be.

Without UAV video: The responders knew approximately where the accident site was. The responders spent more time on pinpointing the exact position, since they tried to locate the island Råbena. Eventually, one deckhand looked up the island on a mobile device which helped the responders in locating the island. When asked about the depth, the navigator could only acquire information from the ECDIS, however, he/she was not sure how far out the shallow area reached.

4.1.5 Knowing What Has Happened and What Happens

With UAV video: The responders could get more information regarding the position, where they were going and the exact location of the dummy in reference to the shore. The deckhand kept the other crewmembers informed on what could be seen in the video.

Without UAV video: The responders struggled to find the island Råbena. Compared to the other exercise, the main source of information was the ECDIS, and they had no means to compare the data received from the ECDIS. Regarding the depth, the navigator was not sure how far out the shallow area reached. Information regarding the condition, location or status of the dummy could not be attained in this case.

4.1.6 Capacity to Evaluate and Plan

In both exercises, the responders knew the approximate position.

With UAV video: The responders were able to assess the dummy to be on the inside of the small islet west of Stora Varholmen by comparing the ECDIS and the UAV video footage. This led to them checking the water depth on the ECDIS in that area, to see if it was possible to reach the dummy with their rescue craft.

Without UAV video: The responders discussed which route they should take to the accident site, which they did not do in the exercise with the UAV video.

4.1.7 Reduced Task Load

With UAV video: The responders concluded where the dummy was by analyzing the video footage. At the accident site one deckhand left his/her lookout position on deck and came back into the wheelhouse to study the video again with the navigator. After 10 seconds they figured out where to look for the yellow dummy and subsequently found it immediately. They had a longer search phase in this operation at 1 min 13 seconds compared to the search phase for the red dummy which was 56 seconds.

Without UAV video: The responders discussed more regarding the location of the dummy and the navigator needed more time to locate which island the distress call referred to in the ECDIS.

4.1.8 Time

Without UAV video: The responders struggled with finding the island Råbena and were engaged in this for a longer time. It is not certain whether it was because they did not have the video footage or whether it was due to operator error.

4.1.9 Clear Alternatives or Procedures

In both the exercise with and without the UAV the rescue team followed their procedures when they approached the scene. The skipper slowed down, the deckhands went out on deck to start the lookout, and the navigator contacted the smaller rescue craft to let them know that they were at the scene.

With UAV video: One difference in procedures between the exercise was that the skipper could consult the deckhand with the video about what could be seen. Another difference was at the scene the deckhand (who previously held the video footage) left his/her lookout station and came back into the wheelhouse after 50 seconds of visually trying to locate the dummy to re-evaluate the exact position of the dummy. By having another look at the footage with the navigator and consulting the ECDIS again they concluded that the dummy should be at a certain location and when they looked towards that position, they immediately saw it.

4.1.10 Analysis of the Results – Station A

The analysis of the exercise *with the UAV video* showed that the responders can consult the video as an extra source of information and compare it with the ECDIS to form a better understanding of the situation. They could find the exact position of the dummy, which resulted in the responders discussing less about the route to the accident area. Instead, they focused more on what they could see in the video, where the key take-away was the dummy's position in reference to the shore. They compared it to the ECDIS and concluded on their way to the accident site that the water was deep enough for their 12-m craft to retrieve the dummy. Ultimately, the search phase was 1 min 13 seconds in the exercise with the UAV video available, which is 17 seconds longer than the exercise without the video footage. However, having conducted lookout for a while without any results the video footage was consulted again and the environment in the video was compared with their surroundings at the scene to locate the dummy. This suggests that difficulties in finding an object can alternatively be reduced with the aid of an UAV video.

The analysis of the exercises showed that *without the UAV video*, the responders generally had a vaguer understanding of the situation. Because the exact position of the dummy is not known and information about the accident is limited, the ECDIS was their main source of information about the accident area, giving them an impression about the islands and the waters around them. This means that the responders cannot accurately analyze the situation until they have spotted the dummy. For example, in this exercise the 12-m rescue craft arrived at the scene before the 8-m craft. When they spotted the dummy, they saw that the water was too shallow for them to retrieve the dummy. Unlike in the exercise with the UAV video, where they could conclude in beforehand that the water was deep enough for them to reach the dummy.

In conclusion, the results from both exercises show that the responders operate on the opportunistic control mode. However, with the video the responders had more control while on the way to the accident scene, which indicates a higher level of control within the opportunistic control mode.

4.2 Video Results and Analysis – Station B

The following passages describe the general outline of the exercises at station B, after the responders received the distress calls. The approaches of the rescue craft and where they slowed down can be seen in figure 16.

4.2.1 Course of Events Without UAV Video

Distress call: “Kayaker capsized north of Flatorna”.

The responders cast off and leave the berth. The navigator looks at the ECDIS and confirms with the skipper that they are going to Flatorna.

Two minutes into the exercise the rescue craft leaves the port area, and the speed is increased. The navigator repeats the distress message “north of Flatorna” and discusses with the skipper how to go there. The navigator then repeats the distress message to the crew and adds that they do not have more information. At 3 minutes 30 seconds the navigator simulates radio traffic with JRCC with the research team, requesting more information regarding the clothing of the dummy and how long it has been in the water. The navigator takes notes of the received information. 6 minutes 50 seconds into the exercise the skipper informs the navigator of the approach plan, that they will approach from the south and move around the island anti-clockwise. Further, the skipper states that the speed will be reduced when approaching Flatorna because it is shallow, and because they will set out lookouts on deck. At 9 minutes 5 seconds the skipper points at a location in the ECDIS and shows the rest of the responders where he/she plans to slow down. One deckhand grabs a pair of binoculars and starts searching. Shortly thereafter, the navigator informs the crew that the dummy is wearing red clothing.

At 10 minutes 8 seconds, the skipper slows down. The deckhand with the binoculars informs the others that he/she will keep a lookout from the aft and instructs the other two deckhands to keep their lookout in the forward part of the rescue craft. Shortly after, at 10 minutes 30 seconds the deckhand holding the binoculars goes out on deck while the other two deckhands are getting ready and are talking with the navigator where to stand and where to look. At 10 minutes and 50 seconds the second deckhand goes out on deck and at 11 minutes 7 seconds the last deckhand leaves the wheelhouse. The navigator asks the skipper where the echo sounder is, which is shown by the skipper. The navigator then proceeds downstairs to the medical cabin to check the medical bag. After checking the bag, he/she returns and starts a lookout as well but from the inside of the wheelhouse. The skipper changes the display to north up mode and informs the navigator thereof. The navigator then simulates radio traffic again and states that they have arrived at Flatorna, started the search operation, and are going around the island in an anti-clockwise order.

At 14 minutes 54 seconds, the navigator spots the dummy, knocks on the window to get attention from the deckhands outside and points in the direction of the dummy. The navigator then assures

that the skipper has “control”. The skipper confirms this and says that they will follow the 3-meter shallow curve on the ECDIS and head directly towards the dummy when they arrive there. The navigator takes a note of the contact with a timestamp. The aft lookout grabs a boat hook while the navigator and the skipper discuss that the dummy probably has a low body temperature. The navigator then says that he/she will prepare the medical cabin.

4.2.2 Course of Events With UAV Video

Distress call: “Kayaker capsized north of Smalskär”.

The responders cast off and leave the berth. The navigator asks whether the dummy is drifting which is denied by the deckhand holding the video. The navigator simulates a radio call with JRCC with the research team and states that they are leaving station B and have visual contact by video with the kayaker in the water. Further the navigator asks whether they have an exact time when the alarm came in. The research team acting as JRCC states that the distress call came in about 7 minutes ago and the UAV was dispatched immediately.

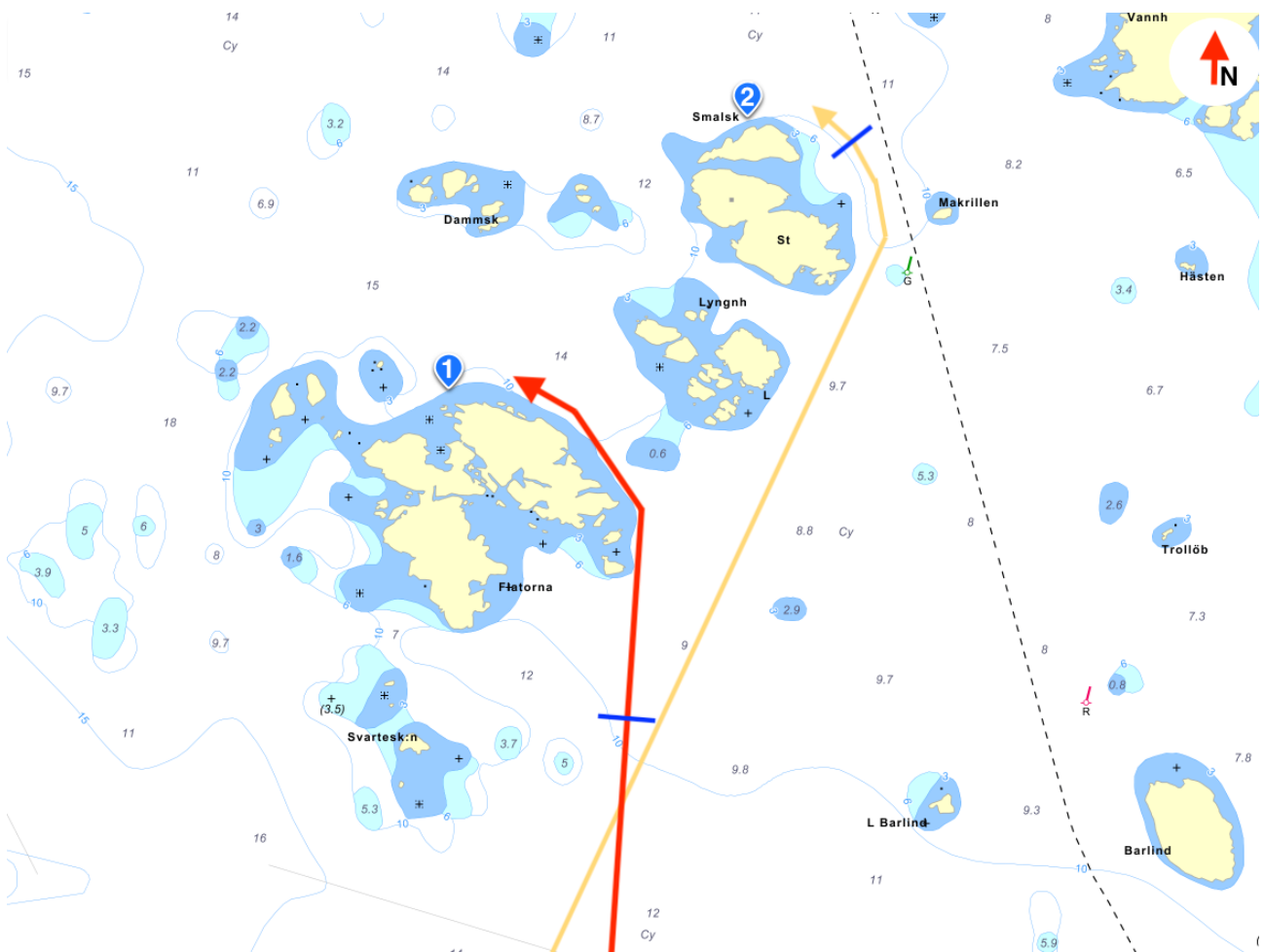
1 minute 20 seconds into the exercise the rescue craft leaves the port area. The skipper asks whether they are ready on deck which is confirmed. The skipper then increases the speed. While still on the radio with JRCC the navigator asks the deckhand holding the video if there is movement which is denied by the deckhand. Further, the deckhand states that the UAV has contact with the dummy and that it is floating on the water surface. The skipper mentions that he/she previously saw that it is the island with a green house on it which looks like Smalskär and then asks if they know which side of the island the dummy is on. The deckhand responds that it looks like the north side, and that it has relatively high cliffs. The skipper confirms: “North side Smalskär”. The deckhand corrects the statement and says that it looks like the northeast, which is subsequently confirmed by the skipper. At 4 minutes 22 seconds the skipper creates a plan for approaching the location from the east side of Smalskär. The responders make up a plan for preparations, delegation of tasks, what should be done and what to do with the dummy. The navigator and the skipper then discuss currents and the surrounding area. The navigator asks the deckhand with the video if they still have contact with the dummy. The deckhand responds that they do and that there is no movement and that the dummy is still at the same position. The skipper then points at the screen and says that it should be there if it is northeast of Smalskär. He/she then shows on the screen where they plan to go and how long they can maintain the speed before having to slow down, as to not create a swell at the location of the dummy. The navigator starts discussing resources after that and the skipper asks who plans to do what, who will take equipment and who will go out on deck to start preparing for receiving the dummy. Further, the skipper asks who will be wearing a one-hour survival suit and be ready to jump in the water. The navigator then asks one of the deckhands if he/she can put on the suit which the deckhand confirms. The deckhand proceeds downstairs to the medical cabin where there is space for changing into the suit. The navigator informs the deckhand that the suit is outside, and that he/she should wait until they have slowed down. The navigator then fetches the suit from outside and goes downstairs with the suit.

At 5 minutes 56 seconds the skipper informs the crew that they will approach the corner soon and that it will take about one minute until they arrive at the dummy. The navigator delegates responsibility to a deckhand when he/she is in the water. The skipper points outside and says that that’s Smalskär and slows down the rescue craft at 6 minutes 49 seconds. Six seconds later at 6

minutes and 55 seconds the skipper has visual contact with the dummy and shouts “Contact! Yellow!”. The navigator says “Yellow, 1 o’clock” and goes downstairs to change, while the deckhands go outside.

Figure 16

Approaches to Accident Scene, Station B. (Adapted from www.kartor.eniro.se with permission)



Note. Arrow tips indicate when the dummies were spotted. Blue lines indicates when the rescue craft slowed down. Red line = exercise without UAV. Yellow line = exercise with UAV.

4.2.3 Analysis of the Level of Control – Station B

In this section, the actions and conversations are categorized according to the determinants of control shown in figure 5. After the categorizing, the results are analyzed, and a control mode is assigned.

4.2.4 Acquiring Information

Without UAV video: The responders used the ECDIS to get information about the area where they were going. After leaving the port area the navigator simulated a call to the JRCC requesting more information about the person in distress (color of clothes, time since the distress call came in etc.). Finally, when they arrived at Flatorna and drove in shallower water the navigator asked the skipper to see the Echo sounder display to see how deep the water was.

With UAV video: By looking at the video, the responders gathered several pieces of information about the dummy, its clothing, position in the water in relation to the shore and they noted that there was no movement. After casting off the navigator asked the deckhand if the dummy can be seen drifting, and later simulated a call with JRCC asking at what time the distress call came in. On their way to the scene the skipper asked the deckhand if it is possible to see on which side of the islet the dummy was. The deckhand who has been looking at the video determined it to be the north side. The navigator also asked if there is still video contact with the dummy about halfway into the exercise.

4.2.5 Knowing What Has Happened and What Happens

Without UAV video: The responders had an approximate position, being north of Flatorna. They requested more information from JRCC, but the only information they provided was that the dummy had red clothing. The responders did not know much more and proceeded to the approximate position.

With UAV video: The responders got an approximate position from the distress call. They were able to directly see the color of the dummy's clothing. On their way to the accident site, the responders could narrow down the position to an almost exact position. The responders got the information north of Smalskär which they specified on their way out that it must be northeast of Smalskär by comparing the video with the ECDIS. They knew that the dummy was not moving and was floating at the water surface.

4.2.6 Capacity to Evaluate and Plan

Without UAV video: The responders knew an approximate position of the dummy and made up a plan on how to approach the location and where to slow down. The skipper planned to approach Flatorna from the south and move up the island anti-clockwise, meaning go around the west side of the island. The skipper slowed down the vessel and the responders started their lookout routine.

With UAV video: The responders determined the dummy to be northeast of Smalskär. They then planned the task delegation, preparations, equipment and how to pick up the dummy. They were able to pinpoint a more exact position of the dummy and plan where they needed to slow down to not create a swell at the location of the dummy. 58 seconds before the visual contact, the skipper said that they will soon go around the corner and that it is approximately 1 minute until they arrive.

4.2.7 Reduced Task Load

Without UAV video: The responders tried to acquire information from JRCC regarding the clothing, the status of the dummy and the time when the distress call came in. Further, the search phase in this operation was longer.

With UAV video: The responders had a visual image of the accident site and only requested the time from when the distress call came in. The search phase in this operation was only 6 seconds compared to 04:46 minutes without the video.

4.2.8 Time

As mentioned under chapter 4.2.7, the reduced task load resulted in the responders having more time available to focus on other tasks.

4.2.9 Clear Alternatives or Procedures

Without UAV video: The navigator took notes with timestamps of what has happened and what was known. The responders discussed the route, where they assumed the dummy would be and where they should slow down. They requested information from JRCC regarding the object and at what time the distress call came in. When they got closer to the dummy, they slowed down the rescue craft and the navigator checked the medical bag. The crew organized the search process with the deckhands being on deck and the skipper and navigator looking out from the wheelhouse. Each deckhand kept lookout in a different direction on deck. The skipper changed the mode on ECDIS to north up and informed the navigator of it. 4 minutes and 46 seconds after they slowed down, the navigator exclaimed visual constant with the dummy.

With UAV video: Like in the case without the video, the navigator took notes with timestamps in the exercise. They also communicated with JRCC but only requested the time when the distress call came in. The responders discussed the route, where they assumed the dummy to be and where they should slow down. They discussed preparations regarding task delegation, equipment and how to pick up the dummy. The skipper slowed down and 6 seconds later they made visual contact with the dummy.

4.2.10 Analysis of the Results – Station B

The analysis of the exercises showed that *without UAV video* the responders generally had a vaguer understanding of the situation and a less exact position. Consequently, the responders needed to slow down well in advance to search the area as can be seen in figure 16. They used the ECDIS as the main source of information from the anticipated location and tried to acquire more information from JRCC. The situation was analyzed when the responders reached the accident site. There were more discussions among the responders on a general level that are not specific to the situation. This indicates that the responders operate on the opportunistic control mode when the video footage is not available.

The analysis shows that the responders *with UAV video* available can consult the video as an extra source of information which can be compared and complements the information from the ECDIS.

The video supported the responders in assessing the condition of the dummy by getting visual contact. It shows that the responders know more about what happened and what is happening with the video footage available. This results in the responders being able to adjust the planning of resources according to the situation at hand. Further, the responders can reduce the amount of information requested from JRCC. They can pinpoint a more exact location which results in the responders being able to maintain speed for a longer time (see figure 16) and reduce the length of the search phase. It shows that the workload of the responders can be reduced which in turn increases the time to focus on other tasks. Lastly, the responders can give a more exact estimate on when they will arrive at the dummy.

Since the video footage reduces the task load, the responders have more time available to focus on other tasks which in turn increases their subjectively available time. Without the video, the responders must be open to and prepare for a wider range of possible scenarios. This means that they select their actions based on habits and association. The evaluation of the accident scene takes place when they arrive on scene. The video helps the responders in making a detailed evaluation of the outcome and can choose actions based on plans and experience rather than habits and association. This indicates that when having the video footage, the responders increase their level of control and operate on the tactical control mode.

4.3 Video Results and Analysis – Station C

The following passages describe the general outline of the exercises at station C after the responders received the distress calls. The approaches of the rescue craft and where they slowed down can be seen in figure 17.

4.3.1 Course of Events Without UAV Video

Distress call: “Kayaker capsized north of Bjärkholmen, east of Låka”.

The responders cast off and leave the berth. The skipper looks at a paper chart, while the navigator looks at the ECDIS. The navigator verifies the information about the position with the skipper and looks down at the ECDIS again. The skipper then repeats the information received by the distress call and hands the paper chart to the navigator. The skipper says that Låka is located on the island Tjörn while looking at the ECDIS together with the navigator. One deckhand joins their discussion and repeats the distress call: “North Bjärkholmen, east Låka”. The skipper looks up while the navigator proceeds to look at the paper chart. The deckhand points at station C on the chart and tells the navigator that it is from there they departed. While they are discussing the position the skipper switches between looking out and looking at the chart. The responders then find Låka and 2 minutes 52 seconds into the exercise, they have a rough position of the accident site. The navigator and the deckhand make up a plan on where they should go and discuss what way they should take there. This is then relayed to the skipper.

At 3 minutes 50 seconds the skipper tells the crew that the speed will be increased. One deckhand informs JRCC that they are going out for exercises. He/she finishes the call, and after a while that same deckhand asks the navigator whether they have found the islets. This is confirmed and the navigator shows the position to the deckhand on a paper chart. After that, the navigator points at the ECDIS and asks the skipper whether they are going on the inside of Branterna which the

skipper confirms. Shortly thereafter, the navigator asks for the position they received from the distress call. A deckhand repeats the information from the distress call and points at the paper chart. The responders then discuss what the actual words were from the distress call, whether it regarded one or two kayaks. They agree that they heard kayaks (plural) indicating that it involves two kayaks.

At 8 minutes and 12 seconds into the exercise, the skipper slows down and shows the others where Låka is. The navigator discusses what the best plan of approach would be and which way they should go. They agree that because the other rescue craft is going on the outside of islands, they will take the inside. The skipper then speeds up again and points out the window to show where Låka is. One deckhand calls the other vessel to inform them about their plan. The other vessel responds and says that they just spotted a life jacket, The exercise has now been going on for 11 minutes and 42 seconds. The deckhand instructs them to go closer and inspect it. The skipper slows down and the deckhand shows the skipper on the ECDIS where the life jacket was spotted. They make up a plan to cover the search area and, in that moment, the other rescue craft calls to inform them that the life jacket turned out to be the missing dummy. The deckhand instructs the other vessel to check the condition, what has happened and whether there are more persons missing. At this stage, the research team had to step in and explain that the exercise only regarded one person, to avoid the responders finding the other dummy. The skipper then speeds up, and heads for the other craft to assist with the retrieval of the dummy.

4.3.2 Course of Events With UAV Video

Distress call: "Kayaker capsized south of Bjärkholmen, east of Låka".

The responders cast off and leave the berth. The deckhands analyze the video while the navigator looks at the chart. One deckhand tells the skipper where to start heading while they check the details of the video. Two of the deckhands and the navigator start comparing the video with the chart and one deckhand mentions that it's south of Bjärkholmen. The other deckhand shows the video to the navigator and says that the object is on the backside of the island and is wearing yellow clothes. Further, the deckhand explains that at a certain angle, they can see an island with the lighthouse on it, and that it is therefore possible to see the direction in the video. The responders shortly thereafter pinpoint the location on the chart. The navigator shows the location to the skipper who then concludes that it is on the south side somewhere. The navigator confirms this. A deckhand calls the other vessel to inform them that they have analyzed the video and it is a person with yellow clothes, south of Bjärkholmen close to the steep shore and that they can see the lighthouse in the video.

2 minutes 45 seconds into the exercise the skipper increases the speed. They make a route plan, and the navigator analyzes the video and says that it is good to see the color of the person's clothing. The navigator and a deckhand make up a plan which way to take and conclude that they should go on the outside of Branten. They then discuss the name of a bridge they are passing under and after that the navigator points at the video and tells the skipper about the intended route. The skipper asks whether there are any other vessels in the vicinity which is denied by the navigator. The navigator mentions that it is good to have an image of the accident site because it is possible to see whether it is urgent or not. The skipper replies that everything is urgent when

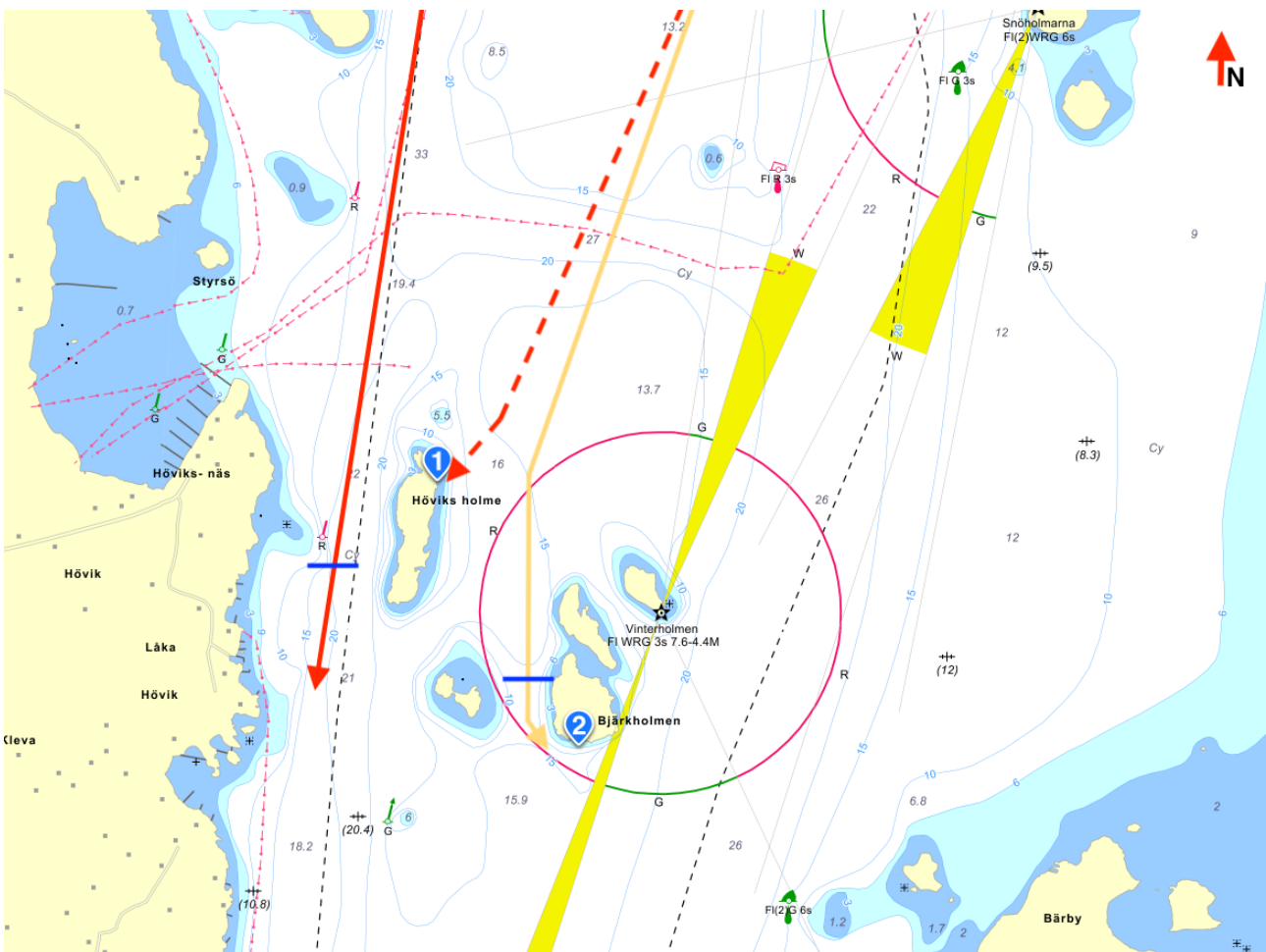
there are persons in the water. The navigator replies that that is true, but it is also possible to see whether others have arrived at the scene already.

One deckhand asks whether they are going in between the islets that are coming up ahead which the navigator confirms and explains what the plan is. The navigator points at the ECDIS and verifies the location of the dummy with that deckhand, and then says that he/she is certain that the dummy is there because of the lighthouse that can be seen in the background in the video. During this time, another deckhand grabs a pair of binoculars. Shortly after that, the navigator and the deckhand say that they should slow down in case the person has drifted.

9 minutes and 28 seconds into the exercise the skipper slows down and almost immediately, the navigator spots something in the water, which turns out to be a bird. A deckhand says that it should be around the following corner and at 9 minutes and 44 seconds the navigator spots the dummy. The crew makes up a plan on how to pick it up and agree to use a boat hook. One deckhand picks up the radio and informs the other vessel that they have found the person and that the other vessel should approach to assist if necessary.

Figure 17

Approaches to Accident Scene, Station C. (Adapted from www.kartor.eniro.se with permission)



Note. Arrow tips indicate when the dummies were spotted. Blue lines indicates when the rescue craft slowed down. Red line full (11-m craft) = exercise without UAV. Red line dotted (8-m craft) = exercise without UAV. Yellow line *full (11-m craft)* = exercise with UAV.

4.3.3 Analysis of the Level of Control – Station C

In this section, the actions and conversations are categorized according to the determinants of control shown in figure 5. After the categorizing, the results are analyzed, and a control mode is assigned.

4.3.4 Acquiring Information

Without UAV video: The responders searched for the location given in the distress call in the chart. The navigator looked at the ECDIS and a paper chart, and the skipper while driving switched between looking out and looking at the chart until they found the islands that were mentioned in the distress call. In this case, it was mainly the skipper and navigator who were trying to find the location. Throughout the operation, the responders repeated the location and asked each other if they have found it. At one point during the operation, the responders discussed whether the alarm regarded one or two kayakers. They agreed that it must have been two, when in fact it was only one.

With UAV video: The responders analyzed the video, looked at the chart, and compared the two images. The responders verified the location mentioned in the video with each other, however, this happened fewer times compared to the exercise without the video (2 times with the video compared to 5 times without the video).

4.3.5 Knowing What Has Happened and What Happens

Without UAV video: The responders had an approximate position that they tried to locate on the chart. They discussed the location of the information received in the distress call both in terms of the position and whether it involved one or two kayakers.

With UAV video: The responders knew an approximate position which they were able to pinpoint more exactly with the video. The video showed a lighthouse and a steep shoreline in the background which was recognized by the responders. The responders saw that the dummy was floating in the water and was wearing yellow clothes. They knew from experience that it was urgent because they saw that the person was in the water. When they approached the scene, they knew that the dummy would be around the corner that they were approaching.

4.3.6 Capacity to Evaluate and Plan

Without UAV video: After the responders had left the quay and were driving slowly inside the port area the navigator and skipper planned the route and where they should start the search. When they were searching at the accident area one of the other rescue crafts reported that they had

spotted a life jacket. A deckhand showed where the life jacket had been found and suggested a plan for searching the remaining area of the accident site. Shortly thereafter, the other rescue craft informed them that the life jacket they had seen was indeed the dummy.

With UAV video: The navigator and skipper planned which route to take. The navigator used the video to determine whether they should go on the east or west side of the island to approach the scene. The navigator asked the skipper to slow down before arriving at the southwest corner in case the dummy had drifted.

4.3.7 Reduced Task Load

Without UAV video: The responders discussed more regarding the location of the dummy and planned different search routes for the two rescue crafts. It was the 8-meter craft that found the red dummy. When they arrived at the scene, they reported that they had spotted a life jacket, and 40 seconds later informed the 11-meter rescue craft that what they had spotted was in fact the dummy.

With UAV video: The responders in the 11-meter craft did not discuss search patterns with the other rescue craft or among themselves. They analyzed the video and figured out the exact position of the dummy, which led to them going directly to the location. The search phase for the yellow dummy was 16 seconds.

4.3.8 Time

As mentioned under chapter 4.3.7, the reduced task load results in the responders having more time available to focus on other tasks.

4.3.9 Clear Alternatives or Procedures

Without UAV video: The responders discussed different routes to the accident site. They agreed that the 11-meter craft would search one side of the island and the 8-meter craft would search on the other. When approaching the scene, they followed procedure, slowed down and started the lookout process. As mentioned in chapter 4.3.6, they decided to search the remaining area of the accident site since they thought that they had only spotted a life jacket.

With UAV video: The responders agreed to go on the west side of Bjärkholmen to approach the accident site. When they approached the southwest corner, they slowed down the rescue craft and started the lookout process. They found the dummy 16 seconds after slowing down and agreed on picking up the dummy with the boat hook.

4.3.10 Analysis of the Results – Station C

The analysis of the exercises showed that *without UAV video* the responders generally have a vaguer understanding of the situation and a less exact position. This is shown by the rescue craft going past the island of where the dummy was located (figure 17) and continuing on the same course until the dummy was found by the other rescue craft. This indicates that without the video footage available the responders operate on the opportunistic control mode.

The analysis of the exercise showed that *with UAV video* the responders do not need to verify the position as often and can anticipate the position of the dummy more precisely. The responders know more about what has happened and what is happening at the site of the accident and have a clearer understanding of the situation. Discussions regarding search patterns and how and where to search can be reduced due to knowledge of the exact location. This reduces the workload which consequently creates more time for the responders to focus on other tasks. This also changes procedures in terms of planning the search for the missing person.

This indicates that by having the video footage the responders increase their level of control and operate on the tactical control mode.

4.3.11 Summary of the Analysis

As previously established in this chapter the responders can increase their level of control. At station A, the responders increased their level of control the least. Although the responders raised their level of control, they remained within the opportunistic control mode. At station B and station C, the responders increased their level of control and jumped from the opportunistic control mode to the tactical control mode. An overview of the stations and their control modes can be seen in Table 3.

Table 3

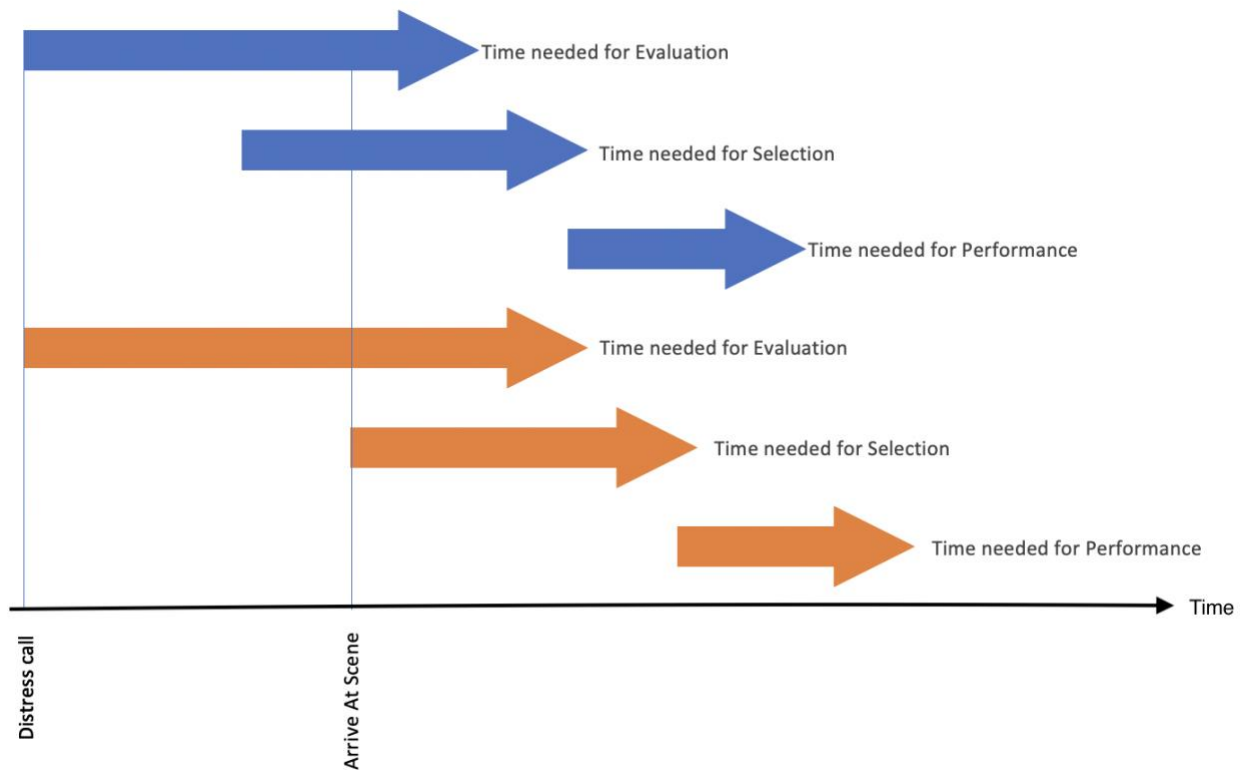
Control Modes Compared Between the Three Stations With and Without UAV Video Footage Available

Station	Control Mode Without UAV Footage	Control Mode with UAV Footage
A	Opportunistic	Opportunistic (higher)
B	Opportunistic	Tactical
C	Opportunistic	Tactical

At station B and station C, the video footage shortened the time to evaluate an event (T_E) and thereby shifted the time to select an action T_S to an earlier stage of the operation as can be seen in figure 18. With the video footage available the responders can evaluate the situation already before casting off and on the way to the accident site. This means that the time needed for evaluation of the scene can be shortened and the responders can already select an action based on the information they receive from the accident site. This implies that the responders are already more prepared when they arrive at the scene which reduces the overall time of the rescue operation. Without the video footage, the responders can only assume the circumstance and hence the time to evaluate the situation takes longer time compared to the case with a video available from the accident scene. The responders can select an appropriate action to handle the situation after they arrive at the scene.

Figure 18

Schematic Comparison Between the Temporal Relations With and Without the UAV Video Footage



Note. The blue arrows indicate the different times needed for the case with the video, and the orange arrows indicate the different times needed for the case without the video. This figure is only an illustration of the temporal relations between the two exercises and does not represent exact time values.

4.4 Analysis of the Focus Group Discussion

In this chapter the focus group discussions are analyzed based on the determinants of control.

4.4.1 Anticipation of Future Events

With the UAV video, the participants can observe the weather and sea state at the location of the dummy, which helps them to anticipate the drift of the person in the water. Resources, like an ambulance or a helicopter can be requested at an earlier stage since the condition of the individual can be seen.

The responders stated that it can be dangerous as well to have a video feed since there is a risk of reduced awareness of the environment if they focus too much on the video. For example, seeing

a person in distress in the video might create tunnel vision. This might result in them failing to see another person in the area and possibly running it over.

4.4.2 Knowing What Has Happened and What Happens

With the UAV video, the responders could determine the exact position of the accident, because with the help of their local knowledge, they could recognize islands and other landmarks in the vicinity of the location. The participants said that every time they respond to a distress call, they get a vague position, even if they receive GPS coordinates. This is due to the accident site drifting or things happening that they cannot see while they are on their way to the scene. At one station it was also mentioned that knowing the position and seeing the object could have a calming effect.

The responders also highlighted the benefit of getting a visual confirmation of what they were looking for from the video footage. There was already a lot more clarity about the operation in the start, and they could easier form a perception of the situation. This assessment regards the condition of the person in distress, what the person looks like (e.g., the color of their clothes), and any additional objects.

We try to stay as neutral as possible when we are leaving the quay. When we arrive at the scene, then we try to form an opinion. Then of course, when we have the camera, it will be easier because we will see if they are sitting on an islet and waving or if they are floating in the water.

Further, by having video footage of the object, the responders said they could better prepare mentally on the rescue operation. The participants expressed “You can prepare everything. For better or worse, but you know what to expect”.

Another rescuer stated that a lot of the things that were discussed in the exercise without the UAV video didn't come up in the exercise with the UAV footage, because the video had already provided this information.

4.4.3 Time

The responders mentioned at several instances the benefit of saving time when they had the UAV video footage available compared to when they didn't. “It saves time, hence, it saves lives”, the participants mentioned.

Overall, the responders perceived the operation to be faster with the video available. This is due to them being able to pinpoint the location of the person in distress more accurately. As a result, they were able to keep the maximum speed for a longer time since they could go straight to the scene of the accident.

In one instance, the video helped the responders in realizing that they were looking at the wrong island because they compared the video with reality. Therefore, it can be argued that more time is needed for the search phase of an operation when there is no video available.

The video footage also helped the responders in assessing the seabed of the accident site. If there are any shallow areas or rocks at the location of the object, they can be identified before approaching the scene which also increases the speed of the operation since they usually confirm the depth on site. Without the video footage, the responders needed to slow down earlier to search the area since they did not have an exact position and the area of uncertainty was larger.

The time from there, like the start of the search until we said, 'There is something, we go there', it was for sure 3-4 minutes if not more. And that is the difference between success and catastrophe, a time like that.

This highlights that the responders perceived the rescue operation to be faster and more effective with the video footage available. Furthermore, the participants stated that they perceived there to be no downtime in the case with the video footage available and that they could go straight to the position.

The need of resources can also be determined at an earlier stage since the responders can form an understanding of the situation before arriving at the scene. They stated: "With the UAV, you arrive with more understanding, and it makes you more prepared which in turn makes the operation faster". By having the video footage available, the participants can be more prepared regarding the equipment and what to bring from the station. The time saved by knowing what to bring is time they gain for rescuing the person.

4.4.4 Reduced Task Load

With the UAV footage the participants felt that it was easier to find the exact position of the dummy. The participant said that the search phase was almost non-existing, and they could go straight to the location. Additionally, they didn't need to discuss as much since many questions about the operation were already answered by the video. It was also easier to form an understanding of the situation at the scene since they have seen it in beforehand.

A closed question was asked whether the video feed itself drew attention from the navigational work and the task in general? All stations responded that if they are more than two on board it would not disturb the operation i.e., if the navigator and skipper look at the video, they could potentially lose focus from their own tasks. The information provided by the person looking at the video proved to be enough for the navigation team to know where to go.

4.4.5 Clear Alternatives or Procedures

The responders stated that the video footage supports their decision-making. The video footage combined with the responders' experience helps them seeing indications of what resources might be needed and choosing between alternatives that fit the situation best.

At one station, the responders explained that they deviated from their normal procedures by both going to the same location, when one rescue craft is supposed to search the remaining area.

4.4.6 Capacity to Evaluate and Plan

Normally, the responders generate a plan when they arrive at the scene of the accident, but with the UAV video they said that a plan of approach can be made before arriving to the scene. The responders thought it was useful that they could see the terrain on the scene where the dummy was laying e.g., the water depth, rocks, shallows, or any other objects hindering them from approaching the person in distress. They said that they are always thinking about the situation when they are approaching an accident scene, but with the UAV footage it is possible for them to assess the accident site and form an understanding beforehand. They continued explaining that because the areas are well known to them, knowing that the dummy was in the water was more important than knowing its exact position. The possibility to see what the accident scene looks like results in the responders being able to prepare equipment and delegate tasks before arriving at the scene. They know what they need to do when they arrive, whether it is jumping in the water or preparing a heaving line, and the responders are able to see the condition of the person in distress in the video. They explained that when they see that a person in the water that is not moving, they understand that the person might be hurt or hypothermic. Compared to not having video footage, resources can therefore be requested at an earlier stage since the responders know that the person in distress will need CPR equipment, and ambulance or helicopter evacuation.

4.4.7 Analysis of Control

The UAV video gives the responders an image of the accident site with up-to-date information regarding the object and its surroundings. This results in less unexpected events. It presents real time and predictive support that provides the responders with realistic expectations of what may happen. For example, the video shows the condition of the objects which aids the responders in evaluating the outcome and preparing for the rescue operation. This leads to them being able to decide between different alternatives and select the preferable action based on experience and evaluation. The video footage reduces the task load in terms of locating the person, by shortening the search phase. It also decreased the need to discuss the situation since many questions about the operation were already answered by the video, which increases time to focus on planning or other tasks.

This indicates that a video of the accident site can increase the level of control and shows that the responders can operate in the tactical control mode. This does not mean that a rescue unit automatically operates on the tactical control mode, but rather have the possibility to increase their level of control.

4.5 Subject Matters' Suggestions on Improvement of the UAV System

During the focus group discussions, several technical and communicational suggestions for the UAV were lifted by the participants. Although these do not influence the level of control of the JCS, the suggestions are included in this thesis since it is important information for the project group and the E-O-S project itself.

At station A, the responders were concerned that the video footage might take up precious time if they have to watch it before going out. The responders said that the video must not distract them too much, and that they should not need to stop and watch the video for several minutes before casting off.

The participants said that they would like the UAV to be equipped with an Automatic Identification System (AIS). In that way, it would be much easier to see the position of the accident site. If the UAV has an AIS, the position of the UAV would be shown directly on their ECDIS, eliminating the need to compare the video with the surroundings to pinpoint the exact position. Additionally, they stated that they did not know where north, south, east, or west was while analyzing the video. The responders concluded that a little chart image in the corner of the video with bearings would help them in assessing the situation. A scale in the video to estimate distances was also brought up as a potential benefit. Further, the responders mentioned that they want to be able to zoom in and out and freeze or pause the image in case they want to take a closer look at a certain frame. Because the UAV was circling the accident site, that circling motion hindered the responders in viewing the scene from certain angles for a longer time.

The ability of the UAV to be able to film accident sites in the dark was also lifted. The responders thought that it can potentially help them in rescue operations at night or in darkness.

The means of communication with the UAV operator was brought up as an issue to investigate. The responders want to be able to speak with the operator to make requests so that they can get a better understanding of the situation or order the operator to remove the UAV from the accident site (in case a helicopter is approaching). If the communication between all parties does not work properly, the risk increases that something is missed. One station regarded Rakel as the best way of communicating with the operator. They stated that they currently have some problems communicating with the ambulance helicopter since they do not operate on the same channel. According to another station, in case the JRCC also has access to the video, the communication should not take place via their internal communication channel Rakel, but rather VHF. This way, JRCC gets updated automatically by listening in on the communication between the responders and the operator.

Lastly, the responders mentioned that training and procedures are needed to implement the video footage in their operations in a safe way. Routines and priorities must be defined and/or adapted so that the video footage can be used safely.

5 Discussion

In this chapter, the overall approach and the results of this thesis are discussed. Chapter 5.1 discusses the approach to the research and the design of the study. It highlights possible improvements and sources of uncertainty regarding the design of the exercises. In chapter 5.2, the results are discussed and possible conditions that might have influenced the results are presented.

5.1 Discussion of the Method

Regarding the design of the study and the exercises, there are some aspects to highlight. The number of participants and rescue crafts varied throughout the stations. At station A, there were 7 participants and 2 rescue crafts, at station B, there were 5 participants and 1 rescue craft and at station C, there were 11 participants and 3 rescue crafts. The experience of the participants ranged between less than one year to 25 years, meaning some had far less knowledge about the routines, the equipment etc. It would have been beneficial to conduct the exercises with an equal number of participants and rescue crafts at each station, and smaller variance in experience would also be favorable. Although it is unclear whether these factors influenced the outcome of the exercises, setting the same preconditions would help in generating more valid results. However, the reason that these factors varied has its origin in the organizational structure of the SSRS and the recruitment of the participants. The participants were not chosen by the research team specifically, they rather signed up because they were interested in conducting the exercises. The communication did not take place between the researchers and the participants directly. The researchers were in contact with the stations' responsible persons who then relayed and forwarded the request to the individual participants. Coordinating and selecting participants prior to the exercises was not an option due to organizational and time limitations.

The focus group discussions were analyzed collectively as mentioned in chapter 3.2. This choice was taken since the results of the focus group discussions at the three stations were close to identical. Instead of including one chapter for each station for the focus group discussions, they were summarized in one chapter to avoid a high level of repetitions. This however, resulted in the data not being distinguishable between the stations and that the analysis takes place more generally.

Further, at station A and station B one participant went out together with the research team prior to the exercises to place out the dummies. This means that those participants knew where the dummies were located. The two participants were asked to not tell the other participants about the location and to act as if they didn't know. The research team chose to not exclude these participants for several reasons. Firstly, the researchers wanted to get as much insight from participants about the usage of UAV video footage as possible. Secondly, the number of responders was limited at these stations. This was especially the case at station B where the skipper assisted in placing out the dummies.

Regarding the dummies, they were dressed in bright red and yellow coveralls and floated with most of their body above the surface. In reality, there would only be a small part of a person's body floating above the surface, and with less noticeable clothing. However, both dummies were equally easy to detect.

After the coding of the data, the codes were analyzed according to the determinants of control and the control mode characteristics. The participants highlighted many areas and situations where the UAV system could be useful, as well as potential drawbacks. The participants speculated on many issues, and it was decided by the research team that those results should not be included in this study since these aspects were hypothetical. Instead, only the discussions that regarded the exercises and how the responders perceived it were included in this report.

The analysis of the participants was done from casting off to arriving at the dummy. The decision to have the cast off as the starting point was partially because there were different data sets between the stations, meaning, the researchers weren't able to capture reactions and moments at every station from when the distress call was given until they casted off (due to a limited number of available cameras). Mostly, it was because the participants were spread out and focused on tasks like donning gear, starting the boat, turning on instruments etc., and there was no data of significant relevance until they were all gathered in the rescue craft. The decision to have the arrival at the dummy as the end was because at station A, the responders let the other rescue craft pick up the dummy to train. At station B, the responders had to retrieve their handheld Rakel from the sea which they had lost while picking up the dummy. At station C, the other rescue craft located the dummy and the rescue craft being analyzed was not involved in the retrieval of the dummy. The arrival at the dummy was therefore defined as the ending point since there was no data of significant relevance after the arrival at the dummy and every station's participants reacted differently. Therefore, using the time from casting off until the responders arrived at the dummy was regarded as the most suitable starting and ending point.

At station A and C, the participants responded to the distress call with two, and three rescue units respectively. The tablet, however, could only be taken onboard the larger unit that had an enclosed wheelhouse, compared to the smaller unit that had an open maneuvering station. Although this study aims to analyze the control within one rescue unit, it is uncertain whether the availability of the video on the smaller rescue crafts would have made a difference in the operation and subsequently the control modes.

5.2 Discussion of the Results

This thesis presents a pilot study on the level of control among maritime search and rescue responders that have a live video feed available from an accident scene. Previous studies have shown that UAVs can support search and rescue personnel. These studies focused mainly on finding the simulated person in distress rather than studying the level of control among the responders. With the planned launch of the E-O-S project in 2023, this study presents an important basis on whether the usage of a UAV in maritime search and rescue is beneficial or not. The maritime search and rescue responders' suggestions on improvements also constitute an important result for the E-O-S project. Lastly, some aspects are discussed in this chapter that underline the need to interpret the results of this study with some care.

At station B and C, the search phase was much shorter with the UAV than at station A (A = 1 min 13 seconds, B = 6 seconds, and C = 16 seconds). The responders at station A had figured out the yellow dummy's approximate position, but unlike the other stations they decided to slow down much earlier. It also took them longer to spot the yellow dummy than the red dummy, counting from when they started the lookout on deck. It was, however, noticed from the recordings that the responders

had the sun directly in their eyes while looking towards the yellow dummy. This may have been the reason for the longer search phase and the reason for the deckhand leaving his/her lookout position on deck to consult the video again. Finally, even though the results from station A showed that the responders were slower to find the yellow dummy than the red dummy, the responders felt that the exercise with the UAV video was quicker.

In reality, the responders receive the distress calls on their mobile phones. This means that they can reaffirm the position. In the exercises, the responders were given the location verbally at the start of each exercise. This may have caused an additional task load on the responders.

At station A, the navigator switched roles with a deckhand in the second exercise. The research team was not aware that they had switched positions until they had already casted off, at which point the research team decided not to interfere. The deckhand who switched to the navigator seat was less experienced in the role which is a potential reason for the struggle with locating the island Råbena. To get more valid data, the roles should have been the same in both exercises. Therefore, the result of the responders needing more time to locate the island should be interpreted with caution.

The process of assigning different actions and content from the responders' statements to the different determinants of control was found not be as clear as initially thought. This was due to the actions and conversations fitting several determinants. Further, the result of categorizing an action or a statement to one determinant resulted in another determinant becoming relevant. This led to the boundary between the different categories to be less defined. The level of control was analyzed based on the responders' actions and conversations in the video. It is not possible to know what people feel or think during the operations and although the focus group discussion aimed to capture these feelings and thoughts, the evaluation of control remains a construct of the researchers.

Because the dummies were placed in the same area to make the exercises as similar as possible, the order of which the responders conducted these exercises might have affected the results. In the first exercise, the responders might have been less prepared, and subsequently would have needed more time to locate and familiarize themselves with the area. Both in the charts and visually at the scene. In the second exercise, it would have been easier to find the correct location in the charts, decide the optimal route, and recognize key islands at the scene since they had just been in that area. It was also noted that the dummies' placement could have affected how quickly they were spotted. If the position is reported to be on the north side of an island and the responders are approaching from the south, it may result in them slowing down earlier to search that island's shoreline to have that part of the area checked. The dummies were also placed differently in the water as can be seen in figure 9 and 10, where the red dummy was placed on the shoreline while the yellow dummy was 15 meters out from the shore. Similarly at station C, the red dummy was placed at the shoreline while the yellow dummy was placed in the sea approximately 5 meters from the shore. At station B, the red dummy was about 5 meters from the shore and the yellow dummy was placed about 20 meters from the shore. The placement of the dummies could potentially have made a difference in how easily they were spotted, which may somewhat limit these findings.

6 Conclusion and Further Research

The main purpose of this study was to evaluate whether a live streamed video from a scene of a maritime accident can aid the responders' level of control in the situation. By conducting exercises with and without video footage from the accident scene as well as focus group discussions at three different rescue stations in the Gothenburg area, the level of control among the search and rescue responders has been analyzed. Although the current study is based on a relatively small sample of participants, the findings suggest that the availability of a live video from a maritime accident scene can increase the level of control among maritime search and rescue responders.

The main findings of this study are:

- The video provides a new source of information that can be consulted to make decisions
- The video aids the responders in locating a more precise position of the person in distress
- The search phase can be shortened and hence, the object be found quicker
- Planning and preparing can be done more precisely and suitably for the situation
- The task load can be reduced, and responders can thereby focus on other tasks
- The responders can form a more exact understanding of the situation
- The responders can increase their level of control with the availability of a video from the accident site
- With the video from the accident site, two out of three rescue units jumped to a higher control mode and one station increased their level of control within the same control mode

The second purpose of this study was to gather the responders' opinions on how the E-O-S project should design the UAV system to fit the responders needs. Their suggestions were summarized from the three focus group discussions and the insight into their opinions and preferences will aid the developers in the project.

The E-O-S project involves a UAV that is recording the accident site and provides the responders with a live video feed. Further research should be carried out when the UAV system is operable to establish whether the results of this study can be confirmed and whether the UAV can increase the number of successful rescue operations.

During the focus group discussions, it became apparent that the UAV video influenced the responders' way of working. Therefore, studies on the effects live-streamed video have on the responders' awareness would be appropriate. It would also be relevant to study what effects live-streamed video has on the responders' stress level and mental well-being. Notably regarding situations where they can see situations unfold live in the video but are unable to affect the outcome. Lastly, this study was limited to the SSRS's rescue units and one object in the water at a time. A more complex study which includes more of the Swedish SAR system and uses multiple objects would be appropriate, as well as seeing how the SAR responders' routines and procedures are affected by integrating an UAV into their work.

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