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Høgskulen på Vestlandet

MASTER'S THESIS

The Use of SAGAT to Measure Situation Awareness on Nautical Science Students

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I confirm that the work is self-prepared and that references/source references to all sources used in the work are provided, cf. Regulation relating to academic studies and examinations at the Western Norway University of Applied Sciences (HVL), § 12-1.

Abstract

Objective: This study researched How well suited is Situation Awareness Global Assessment Technique as a method to measure situational awareness for students in Nautical Science? Where a case study was created to measure situation awareness (SA) with the use of SAGAT. The result of this study was done compared to previous research regarding SAGAT and SPAM to get an understanding of which of these methods is suitable to measure SA on Nautical Science students. SAGAT was then evaluated to see if this was a reliable method.

Participants: For this paper there were three students partaken in the created case.

Method: A qualitative case was created to understand how SAGAT is implemented in measuring SA. During the simulation there were three different freezes at random times with three different questionnaires. The created case was then conducted on the three students participating to get an estimate of what to expect when the simulation is running full scale.

Result: It was found that there are differences within the different Nautical Science classes. By discussing the results of the simulation with previous research performed with SAGAT and SPAM concluded with SAGAT being the most reliable method to measure SA on Nautical Science students during this simulation.

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We would like to thank Helle Asgjerd Oltedal for supervising this thesis, Western Norway University of Applied Science (HVL) for letting us borrow their simulation centre for us to construct and perform our SAGAT study. We would like to thank Vigleik Storesund for helping create the constructed case and help running the simulation. We would like to thank Sveinung Erland for giving us an estimate of the number of participants required to achieve a valid result.

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List of Abbreviations

AIBN	Accident Investigation Board Norway
AIS	Automatic identification system
CFQ	Cognitive failure questionnaire
CRM	Crew resource management
CVR	Cockpit voice recorder
DAIBN	Defence Accident Investigation Board Norway
DM	Decision making
DP	Dynamic positioning
ECDIS	Electronic chart display and information system
GDTA	Goal directed task analysis
LOA	Length over all
NASA TLX	NASA Task Load Index
NTS	Non-technical skills
NTSB	National Transportation Safety Board
NVC	Non verbal communication
OOW	Officer of the watch
OS	Own ship
SA	Situation awareness
SAGAT	Situation Awareness Global Assessment Technique
SARS	Three Situational Awareness Rating Scale
SPAM	Situation Present Assessment Method
TLX	Task load index
VTS	Vessel traffic services
WHO	World Health Organization
WM	Workload management
WSA	Work situation awareness

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1 Introduction

«'loss of SA', 'lack of SA' or 'poor SA' are now popular terms within accident investigations and have been identified as causal factors in all manner of incidents» (Salmon & Stanton, 2013, p. 1). Situation Awareness (SA) has been a topic for many years. Since the beginning SA has been developed to multiple definitions. Even though SA was developed and is most used in aviation, it's still highly relevant for the maritime domain. It is important to understand why SA is important and how to acquire good SA to make the voyage safer for the passenger and ship, SA is also the foundation for decision making (DM). (Endsley, 1990, p. 2). Here are two different examples where SA had an effect on the accident that occurred. HNoMS Helge Ingstads crew is showing the lack of SA while US Airways flight 1549 uses his knowledge and SA to make an unusual decision to save the passengers and crew.

1.1 Example where situation awareness affected the accident

Of the two different accidents mentioned underneath, situation awareness had an impact on the situation. The first accident where HNoMS Helge Ingstads crew had insufficient SA prior to the accident. The lack of SA managed to make the OOW take poor decisions, and therefore unavailable to take necessary actions to prevent the accident. On the other hand the pilot and second pilot onboard flight 1549 had sufficient SA where both knew how the plane operated. With their great knowledge about the plane they managed to focus on everything important prior to landing the plane on the Hudson River as safely as possible. Following this paper while studying these cases shows why we need to acquire SA HNoMS Helge Ingstad which was an accident that shouldn't have happened compared to Flight 1549 where everyone thought it would crash.

1.1.1 Helge Ingstad & Sola TS

HNoMS Helge Ingstad is a Norwegian frigate which collided with Sola TS in Hjeltefjord 8th november 2018. HNoMS Helge Ingstad was travelling with the speed of 17-18 knots towards south in Hjeltefjord. On the bridge prior to the accident HNoMS helge Ingstad had seven personnel on the bridge, the 'officer of the watch (OOW)' , the 'officer of the watch trainee', the 'officer of the watch assistant' , the 'officer of the watch assistant trainee' , and the bridge watch team consisting of two lookouts and a helmsman. (AIBN & DAIBN, 2019, p. 35). On the bridge there were many people, two of them being trained and the OOW sailed 8 months as OOW, prior 9 months with OOW training, and 3 months as navigation officer 1. (AIBN & DAIBN, 2019, p. 38). With OOW being new in the ranking, and training a new OOW up, while the assistant also is there training his trainee, there was a lot going on at that time. During her voyage they had put the automatic identification system (AIS) in a passive mode. That means that the AIS doesn't transmit the AIS data to other vessels, which means traffic nearby can't see HNoMS Helge Ingstad on their electronic chart display and information system (ECDIS). During her voyage south in Hjeltefjorden they informed Fedje vessel traffic services (VTS) about their entrance, and continued their voyage southbound. Sola TS then informed Fedje VTS about their departure from Sture terminal going northbound. During the voyage from the Sture terminal Sola TS was sailing with lanterns and deck lights, which is a violation of COLREG rule number 22 regarding lights while sailing. (Lloyd's register, 2009, rule 22, P. 34). Sola TS noticed a ship on the RADAR with a colliding course towards themselves. They quickly called Fedje VTS to inform them about the ship and to inform the oncoming ship to change the course to avoid collision. Even though Fedje VTS was informed of the entry from HNoMS Helge Ingstad, this was all forgotten when they first got the call. First after a while Fedje VTS then remembered that the ship in action was HNoMS Helge Ingstad. Fedje VTS informed HNoMS Helge Ingstad that they were on a collision course with Sola TS and ordered them to change course immediately. HNoMS Helge Ingstad thought they were closer to the shore and couldn't manoeuvre away. It ended with a collision where the frigate suffered extensive damage on the starboard side and capsized while Sola TS received minor damage. (AIBN & DAIBN, 2019, pp. 5-28).

Accident Investigation Board Norway (AIBN) and Defence Accident Investigation Board Norway (DAIBN) investigated this accident. In their report it is clear that the crew on HNoMS Helge Ingstad didn't know their surroundings. Both Fedje VTS and Sola TS tried to contact HNoMS Helge Ingstad to deviate from their course and avoid the collision. Sola TS was unable to deviate due to the size of the vessel, it would take too long for the vessel to manoeuvre enough to avoid the collision. There are a lot of factors that could be done differently to avoid the accident. Firstly by limiting the employees onboard the bridge to make it easier for the OOW to have his focus on the navigation. With more people on the bridge makes it easier to get distracted from the main task at hand. Safely navigate the vessel to shore. Aalvik et al. did a study on communication between VTS and vessels and found that communication could be better and possibly avoid the collision. (Aalvik et al., 2021).

1.1.2 US Airways Flight 1549

US Airways flight 1549 experienced a bird strike in 2009. This resulted in the bird strike which led to the loss of both engines on their Airbus Industrie A320-214. US Airways flight 1549 departed from LaGuardia Airport only minutes before hitting the birds. At 15:27 the captain Chesley Sullenberger III informed the first officer of the flight Jeffrey Bruce Skiles about the birds. A second later the bird impacts are heard on the cockpit voice recorder (CVR). At the position of the bird impact the flight was 2,818 feet (858.9 m) above ground. After the impact they noticed both engines rolling back, indicating that they lost thrust in both engines. They immediately tried restarting both engines without any luck, and the captain took control over the flight. At this point they went through important parts of checklists, one of them being the quick reference handbook. At this point the captain and first officer were gathering information over the situation (SA) to figure out the rescue process (decision making (DM)). After the engine dual failure checklist and Mayday procedures were completed the LaGuardia Airport ordered the flight to return. The captain was informed that a runway at LaGuardia Airport and Teterboro Airport was cleared for the emergency landing. After quick thinking the captain figured out that neither of the options was possible to reach. The captain and first officer discussed the possibilities they had in front of them. The final verdict will always land on the captain. He then decided that their best approach was to land on the Hudson River. Prior to the landing both engines were tried restarting and the officers were in direct contact with the LaGuardia Airports air traffic controller. After the landing in Hudson River the passengers and crew were quickly evacuated from the flight. (NTSB, 2010, pp. 1-5).

The reason for why this accident is relevant for this paper is because of the situation that the officers experienced compared with HNoMS Helge Ingstads crew had lack of situational awareness. Within a short amount of time the pilot managed to gain SA and do a DM process to safely land the aeroplane without casualties. The National Transportation Safety Board (NTSB) carried out simulations to figure out if the flight could land on LaGuardia Airport or Teterboro Airport. During the NTSB investigation they found out that the flight could land on both LaGuardia Airport and on Teterboro Airport. In the beginning of their investigation all their testing implied that humans could make a decision within seconds. Here they ordered the cockpit to retrieve instantly after the bird strike back to LaGuardia Airport, without time to process the insident. By immediately letting the pilots change the course after the bird strike, the investigation removes the decision making process captain and first officer went through prior to taking actions. Following through the investigation after a 35 seconds added for the human DM, no flight managed to land on either LaGuardia Airport or Teterboro Airport.. (NTSB, 2010, pp. 49-50), (ARMS, 2016, 00:00-09:54).

1.2 What is Situation Awareness?

The concept of SA has been around since World War 1 where the definition then focused on gaining knowledge over your enemy before the enemy gains knowledge about you. (Stanton et al., 2001, p. 1). From that time the definition of SA has changed. The concept of the more modern definition of SA was developed in aviation. (Schömig & Metz, 2013, p. 45). The simplest way to describe SA is: "knowing what is going on around you". (Endsley, 2000b, p. 2). Today the model Endsley created of SA in 1995 is the most cited definition of SA. (van Dijk et al., 2011). The definition is: «the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future" (Endsley, 1988)» (Endsley, 1999, p. 258). As seen above in 1.1.1 and 1.1.2 both of these incidents were influenced by SA in one way or another. HNoMS Helge Ingstad showed the lack of SA when they didn't observe Sola TS and didn't know their exact position, and with the lack of instruments limits the (OOW) to make decisions. SA is the ability to understand, comprehend and the ability to predict the future. To be able to do so, experience and all available technology available on the bridge is necessary. Where in the case of HNoMS Helge Ingstad most of the instruments were turned off. While on the other hand on flight 1549 the captain understood fairly quickly with his experience on the aeroplane that he wouldn't make it back to the airport safely. The quick DM from his part managed to land safely on the Hudson river.

SA is a part of the cognitive skill (Sneddon et al, 2013, p. 80) that means there are a lot of factors that can have an effect on the officers SA. Cognitive skills are the skills that require the human mind to work (Liu, 2003, p. 253) in other words every skill that requires thinking. According to (Endsley, 2013, p. 88) SA helps the person to create a foundation to their DM process. Therefore to make a good decision it is important to have a good SA.

According to Endsley Kirkpatrick researched that SA is an important skill to acquire due to it being an essential element to both success and failure. (Endsley, 1990, p. 3). For a fighter pilot to survive he needs a plan for his actions. He also needs control over his plane, as well as the enemies. If the fighter pilot loses his SA at any time during his mission his decisions will be poor. Othen in a fight til causes loss of life. This is also important for the maritime industry to know about your surroundings. As seen in chapter 1.1.1 HNoMS Helgfe Ingstad didn't have proper SA and therefore couldn't manoeuvre properly to safety. In chapter 1.1.2 where the captain has proper control over his surroundings and his aeroplane he manages to bring everyone to safety even though he needs to land the aeroplane in the Hudson river. SA is needed for everyone who does a job (Endsley, 2000b, p. 6). A big reason for this is every job requires the person to make a decision, and due to SA being the foundation to DM (Endsley, 1990, p. 2).

There are many possible ways to gather SA, where some of the information is important for the situation, while other isn't important. SA can for example be collected through technical displays. Usually the officer of the watch (OOW) will have the possibility to decide what the displays should show. This makes it easier for the OOW to always keep track of the information he or she means is the most relevant. One thing to keep in mind is that this will only affect the SA if there is a human that can perceive the given information. Other methods to gather SA are viewing and listening to your surroundings, sensors are also valuable SA gatherers if its setup correctly.

1.3 Definitions of the Research Area

In high risk industries SA has been analysed among the workers to create a safer work environment. By having the possibility to understand how the experienced personnel understands perception of the element, comprehension of the environment and prediction of the future are allowing the researchers to understand where each participant is in each field and what needs to be done to improve this. This research paper will use a premade case to understand how SAGAT operates and its validity. This will make it possible to use the improved version of this case to understand how the students evolve their ability to acquire SA.

1.3.1 Research Question

"How well suited is Situation Awareness Global Assessment Technique as a method to measure situational awareness for students in Nautical Science?"

To answer this research question, this paper will go in depth in different methods to measure situation awareness. By comparing the different methods found in this paper, discuss these methods, and see if SAGAT is best suited for this case, and suggest changes for the case if necessary.

1.3.2 Limitations

The original design of this project was created to measure SA on students in nautical science. The main goal of the planned design was to investigate the different understanding of SA within the different classes (1st year, 2nd year and 3rd year). While running this project we received only three participants that were interested in participating, making this an invalid attempt. Therefore, We changed our research question to be «How well suited is Situation Awareness Global Assessment Technique as a method to measure situational awareness for students in Nautical Science?».

2 State of the Art

A systematic literature search has been done in order to find relevant information regarding situation awareness and decision making. For the following chapter you can find the relevant literature search in appendix A.

Maritime shipping is contributing to around 90% of the global trade (Sharma et al., 2019, p.1). «Chauvin et al. (2013) studied investigation reports and found that 85% of collisions were caused by unsafe acts related to decision-making.» (Wahl & Kongsvik, 2018). Wahl and Kongsvik focused their studies on crew resource management (CRM) and the Non-technical skills (NTS) that needed to be improved. Previous studies regarding the definition of NTS are performed by Fjeld et al. «Five NTS were identified: situation awareness (SA), decision-making (DM), workload management (WM), communication and leadership.» (Fjeld et al., 2018, p. 475). Maritime shipping is also considered a high risk industry. Taking into consideration that marine shipping and marine traffic in general is considered a high risk industry. (Sharma et al., 2019). Therefore the SA methods used in other domains could be transferred over to the maritime domain.

2.1 Situation Awareness (SA)

SA has been defined by multiple people during the years. In World War I SA was identified by Oswald Boelke. The concept of SA was to get the most amount of information over the enemy. As indicated below.

> «According to Gilson (1995), the concept of situational awareness was identified during World War I by Oswald Boelke who realised 'the importance of gaining an awareness of the enemy before the enemy gained a similar awareness, and devised method of accomplishing this.'» (Stanton Et al., 2001 p. 1).

Since World War I the concept of SA has changed. In the beginning SA dealt mostly with getting knowledge over your enemy before the enemy got knowledge over you. The leader who had the most information had a better advantage in planning the next steps in attack/defence. The concept also included that it was important to have a method to accomplish this. Since this time the concept of SA has changed into being able to fit in every day work. SA is especially relevant for high risk professions such as aviation, maritime industry and the medical professions. Below are several definitions made for SA that are used today.

> «Situational awareness is the conscious dynamic reflection on the situation by an individual. It provides dynamic orientation to the situation, the opportunity to reflect not only the past, present and future, but the potential features of the situation. The dynamic reflection contains logical-conceptual, imaginative, conscious and unconscious components which enables individuals to develop mental models of external events (Bedny and Meister, 1999).» (Stanton Et al., 2001 p. 3).

«Situational awareness is the invariant in the agent-environment system that generates the momentary knowledge and behaviour required to attain the goals specified by an arbiter of performance in the environment (Smith and Hancock, 1995).» (Stanton Et al., 2001 p. 3). These two definitions alongside Endsley have the most commonly used definitions of SA at this time. Something to take into consideration before choosing the definition is that each of the definitions has their own main point SA is centred around.

«The most commonly used and widely cited theory of SA is the three-level model of SA proposed by Endsley (1995b). (van Dijk et al., 2011). The theory that Endsley created regarding SA is: «the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future" (Endsley, 1988)» (Endsley, 1999, p. 258). This definition is also relevant today. (Husjord, 2016, p. 1157) & (Wahl & Kongsvik, 2018, p. 385) both of these sources have used Endsley's definition in their research focusing their research in the maritime industry. Due to this definition being widely used today, in the aviation, health sector and maritime industry, this definition will be used in this research paper.

Endsley's definition of SA is divided into three different categories of SA. Also called three 'levels' of SA. The levels are (1) perception, (2) recognition, and (3) anticipation. These three levels have been interpreted by multiple researchers. One of the interpretation is done by Malcom et al. «(1) understanding of the single discrete elements in a situation ("perception"),

(2) comprehending the way those elements interact ("recognition"), and (3) ability to anticipate developments in a situation ("anticipation")» (Malcom et al., 2020, p. 1031). Another interpretation of this definition is: «(1) perception of the environment and the elements in the situation; (2) interpretation of information, which is used to form a comprehensive mental image of the situation; and (3) projection of the information into the future» (Fjeld et al., 2018, p. 479).

As mentioned earlier in the introduction, SA affected both the crew onboard HNoMS Helge Ingstad and Flight 1549. The differences between these two incidents are that Flight 1549 had the experience that was needed to fully understand the situation they were in. The captain was an experienced captain that a total of 19 663 flight hours where 8 930 of these hours were as a pilot in command. The A320 flight that he flew with on the day of the accident was a known aircraft with 4 765 hours flown. (NTSB, 2010, p. 7). The first officer was also an experienced pilot. He had a total of 15 643 flight hours. Where 8 977 of these hours was as a second command. (NTSB, 2010, p. 8). The crew onboard HNoMS Helge Ingstad on the other hand the OOW had sailed a total of 8 months as OOW, with 9 months of training and 3 months experience as a 1. Navigation officer. (AIBN & DAIBN, 2019, p. 38). What first was supposed to be a normal voyage in Hjeltefjorden ended up with two ships colliding. During an interview with Sullenberger he said that he couldn't have had a better second pilot. Together with both experiences they were able to work together with non verbal communication to each other. (Inc., 2019, 5:30-6:15).

2.1.1 Automation

«‹Automation is being implemented in a variety of systems in an effort to improve performance and overcome high operator workload.» (Endsley, 1995, p. 365). Focusing on automation is important due to today's society they are doing research on self driving vessels. «The interest of academia on automated marine vessels is also rapidly increasing.» (Gu et al., 2021, p. 1707). The process to automate everything is to improve system reliability and performance by removing human factors from the equation. This could be done by either limiting the amount of work making this a semi automated work task or shifting the human to monitor the work task rather than performing it. Research previously done shows that with automation crew caused accidents are being reduced in the aviation industry. After the automation the human tasks have changed from doing everything, to now only monitor the automated tasks. Before starting to automate different work tasks there were statistically more accidents caused by human factors. (Endsley, 1995, p. 365). Some other reasons why crew made accidents have been reduced with the automation process can also be the aeroplanes age, improvements on the systems also. (Endsley, 1995, p. 365). While there were more accidents, the accidents that occurred were usually smaller types of accidents, the consequences were significantly less. After starting the automation of work tasks there were statistically less accidents now. An example of this is the ground proximity warning that was introduced. (Endsley, 1995, p. 365). The downside of the fewer accidents now is the few accidents that occur have higher consequences than previously. According to Endsley's study «An increase in the complexity level of the system and, correspondingly, an increased propensity for catastrophic failures has been associated with the incorporation of automation (Wickens, 1992; Wiener, 1985).» (Endsley, 1995, p. 365-366) For example a dynamic positioning (DP) task is to maintain the position and heading for a vessel. If the DP system fails it is the DP operator's responsibility to manually steer the vessel in position so the mission can be aborted safely. Here the knowledge and skill for the DP operator is important to regain control of the vessel in a short amount of time to prevent an accident. Therefore enough training to use automated operations such as DP and other systems is important. (Sanchez-Varela et al., 2021). While operators are monitoring displays they have a problem by detecting automation failure, and to retake manually control to prevent an accident. During Endsley's research she finds out a problem by automating systems is A problem identified by Endsley while she researched automation «can be directly attributed to lower levels of operators situation awareness». (Endsley, 1995, p. 366).

With the use of Endsley's definition above in section 2.1 there are 3 levels of SA. According to SA level 1 'perception' is to perceive critical data. By the use of automatic identification of critical data, important for the (OOW) while navigating it is easy for the OOW to forget about the importance of the identified data. In this case loss of SA level 1. RADAR and ECDIS can both plot information on nearby vessels automatically. If your vessel is in an area with a lot of traffic it can be hard to comprehend which vessel is which RADAR plot. If you would manually activate the plots you would also have a view of where the vessel is from the beginning, and therefore easier to gain important information from the vessel. If the information is given automatically and the OOW isn't monitoring it properly he can have a harder time to comprehend all information within a limited time. If you have a hard time to comprehend the given information you will also have a hard time to understand the future 'anticipation' as known as SA level 3.(Endsley, 1995, pp. 365-367).

2.1.2 Why is Situation Awareness important?

SA is the precursor for the DM process. According to Endsley it is one of the main precursors for operators to make a good decision. (Endsley, 2000b, pp. 4-5). Looking back on HNoMS Helge Ingstad and US Airways Flight 1549 shows two different aspects of SA. Flight 1549 managed to land the aircraft on the Hudson River without any casualties. The captain had to make his decisions quick. When it comes back to HNoMS Helge Ingstad created an accident that never should have happened based on their understanding of the environment. According to Endsley SA can be conceived as the internal model for the operator's surroundings at any time. (Endsley, 1990, p. 5). Endsley focused her research in aviation, but this is still reliable for other high risk domains. Being OOW on board a vessel still has to make important decisions. Some quicker than others. By understanding the environment we are facing helps us to quicker and most often the best choice possible. As mentioned previously SA is the foundation for decision making. This can be done in all fields such as aviation, maritime and driving etc. A high level of SA is important for an effective DM process, and it is therefore important to maintain the high level of SA at all times. (Endsley & Connors, 2008, p. 2).

Even though every task is starting to be automatic compared to previously done manually such as manoeuvring a vessel. Today you can choose to let the vessel steer automatically on your planned course, or you can set a course the autopilot can steer on. Prior every manoeuvre was done manually by steering the wheel. This causes the OOW to be more observant of everything that happens, and give orders to change course, instead of managing the vessel to be on the right course all the time. SA is still important for operators because the automation can still malfunction and it's the operators responsibility to take over the task. (Endsley, 1995, p. 369).

2.1.3 Why is Situation Awareness Important to Measure?

As mentioned previously SA is an important part of the decision making. By being able to measure SA in a controlled environment the researchers are able to understand where the students need more awareness. As seen in section 1.1.1 the crew onboard HNoMS Helge ingstad's lack of understanding of their surroundings caused the vessel to crash into Sola TS.

Therefore, when we are able to measure SA on the personnel responsible onboard the vessels it is possible to identify the strengths and weaknesses of the navigators. This could help improve the safety if it is possible to see some common factors on the officers. The same can be performed on students. This could be done during a controlled simulation where the researchers want to evaluate the knowledge of the students by gathering information about their SA.

There are multiple ways that can measure SA. According to Endsley SAGAT is one of the most used methods to measure SA. (Endsley, 2021, p. 126). With this method you freeze the situation that they partake in, and give them a questionnaire the participants can partake in. This method makes it possible to ask questions regarding 'perception', 'comprehension' and projection' during all stops. (Endsley, 2021, p. 142). While other well used methods such as SPAM, where researchers ask probe questions to the participants. It is important to know that prior to asking the questions all participants need to answer yes to being ready for a question. (Endsley, 2021, p. 141).

2.2 Decision Making (DM)

Decisions are made constantly through the day. These decisions could be as small as choosing what to wear for the day, or harder decisions deciding how to complete the work task for the day. Some of the decisions we are facing are limited by a timeframe. This means that the people in charge need to understand the situation and take actions based on their understanding. An example of a decision made by a short time frame was when Flight 1549 needed to take the necessary actions to land the aircraft. After the aircraftthe aircraft collided with the birds the investigation board gave the pilots 35 seconds delay to identify the problem and make a safe landing (DM process). In total the captain had 208 seconds from the birdstrike to the aircraft was landed in the Hudson River. (ARMS, 2016, 03:10-03:35). The more knowledge you have regarding the decision the easier it will be. In the instance for the crew onboard HNoMS Helge Ingstad they had a very good time frame for the DM process. Even with the time frame they had prior to the accident their SA was poor, this led to the OOW not taking the necessary actions to avoid the collision. Therefore, with a good SA the choices we take will have a better chance of succeeding. «Situation awareness (SA) is a central orginizing construct that forms a key foundation for human decision making in a wide variety of dynamic and challenging environments from aviation to driving to command and control to space operations.» (Endsley, 2013, p. 88)

According to Lunenburg there are 6 steps to the DM process. This is shown in figure 1. In his research he focuses on decisions made in school administrations. It is the same process for every decision made during the day. The difference is that some decisions are more complex than others. The first step is to identify the problem. An example for this could be figuring out what you want to study. Continuing to the next phase, gathering information. What do I want to study? Which universities provide the course? And do I see myself working in this field in the near future? Gathering all possible information regarding the different universities and courses to further take into consideration. After the problem has been identified and collected relevant information the next step is to evaluate the problem. What are the pros and cons for each option? After the evaluation the decision can be made. And then further implement the necessary implementations to finalise the decision. Last part of his DM process is to evaluate the decision's effectiveness. (Lunenburg, 2010, pp. 3-7).

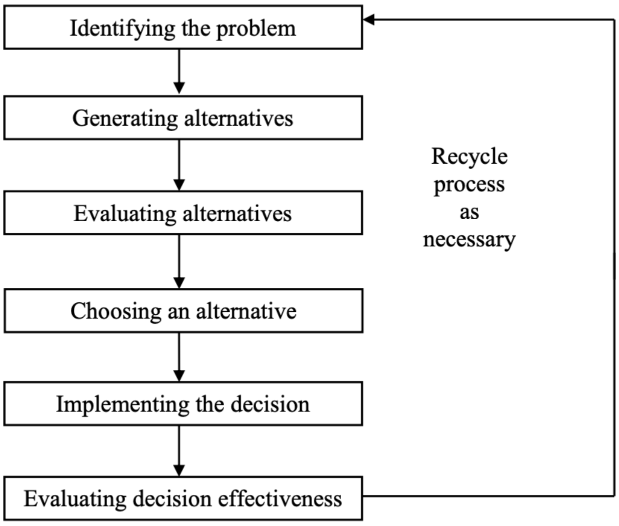


Figure 1 Decision making process (Lunenburg, 2010, p. 3).

Fülöp researched DM methods where he found a statement from R. Harris that stated in 1980 that to make a decision you require multiple options to choose. Harris also finds that the first problem in the DM process is to identify as many solutions to your problem and find out the best solution to complete your goal. Further in Fülöp's research he comes up with 8 different steps to make the DM process possible. These steps are as follows: 'define the problem', 'determine requirements', 'establish goals', 'identify alternatives', 'define criteria', 'select a decision making tool', 'evaluate alternatives against criteria' and 'validate solutions against problem statement'. (Fülöp, 2005, pp. 1-3). Fülöp's understanding of DM is in compliance with the understanding of Lunenburg in figure 1. Lundenberg is focusing his definitions on problems while Fülöp is focusing the definition on possibilities or 'goals' as he described it.

It is easy to misunderstand Endsley's 3rd level of situation awareness to be decision making. Hoffman et al makes it clear that there is a difference between SA and DM. «It is important to recognize that SA is not decision making nor is decision making encompassed within the three-level framework. But arguably SA will influence, in part, decision making where good SA can subsequently contribute to better decision making.» (Huffman et al., 2022, p. 1). Endsley's 3rd level of SA is to anticipate what happens in the near future as explained previously, while DM is to figure out what needs to be done based on a problem.

«As decision-making is a cognitive skill, it is affected by many of the same factors as situation awareness, namely stress, fatigue, noise, distraction and interruption.» (Flin et al., 2008, p. 57). Cognitive is thinking or being conscious. (Cambridge Dictionary, nd). That means cognitive skills are everything that you need to use your brain to find out. Further in chapter 2.4 the research will look deeper into what factors, and how they can affect cognitive skills.

2.3 Communication

> «Communication is a major part of good teamwork (Nivea et al., 1978) and is fundamental to workplace efficiency and safety. Communication is the exchange of information, feedback or response, ideas and feelings. It provides knowledge, institutes relationships, establishes predictable behaviour patterns, maintains attention to the task, and is a management tool (Kani and Palmer, 1993)» (Flin et al., 2008, p. 69).

Teamwork requires good communication to function. Flin et al. further explains that in order to explain good communication he divides communication into four components. The components mentioned are what, how, why, and who. To maintain good communication all four components must be understood. What is the information communicated between the parties? How will the communication provide the information? Why is the information needed? Who is the receiver of the information? (Flin et al., 2008, p. 69). By understanding these four components it is easier for the team to maintain good communication. Communication can be seen as a two way system. If the receiver doesn't receive the right understanding of the message, the communication is poor.

A good example of communication between a team is on Flight 1549. All actions that were taken after the bird strike appeared was communicated between the two officers. They immediately declared an emergency and were in contact with LaGuardia air traffic controllers informing them about their plan. It is also clear from the beginning that the captain is in charge of the aircraft when he first says «my aircraft» (NTSB, 2010, pp. 2). According to Aalvik et al. communication between HNoMS Helge Ingstad, Sola TS and Fedje VTS failed in certain areas. Moments before the accident happened, Fedje VTS stopped communicating. At this point HNoMS Helge Ingstad and Sola TS had started communicating with each other. The reason for why Fedje VTS stopped communicating was to avoid interfering and interrupting HNoMS Helge Ingstad and Sola TS in the last minutes before the collision. At this point Fedje VTS could still give recommendations to solve the situation but chose to not do it to avoid distractions for the crew. (Aalvik et al., 2021, p. 28-29).

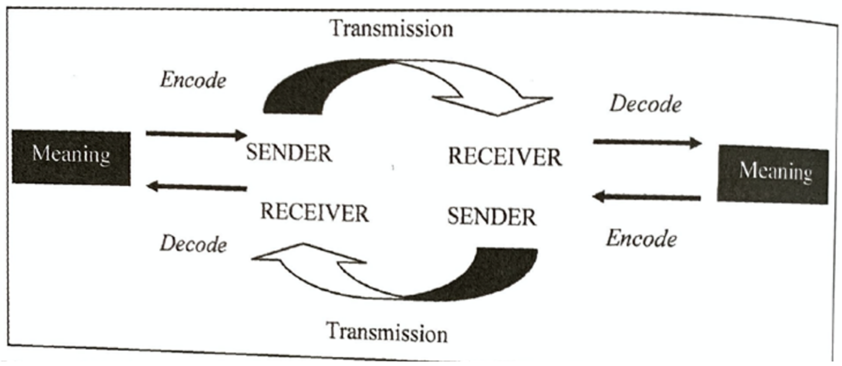


Figure 2 Simplified model of two-way communication (Flin et al., 2008, p. 72).

Figure 2 is a model of communication between two sides. After the message is sent, the receiver needs to decode the received message. And it is first when both messages are aligning together it is possible to perform good communication. In order to communicate between each other and decode/encode the message to be understandable for each other the questions mentioned above are relevant. What, how, why and who. (Flin et al., 2008, p. 69-72).

Communication is the exchange of information. The information is exchanged through verbal or nonverbal communication (NVC) methods between two or more people. (Peltokorpi & Hood, 2018, p. 645). NVC includes facial expressions, gesture, and vocal tone (Colegrove & Havighurst, 2016, p. 574). Further research done on NVC is performed by Metaxas & Zhang who researched facial landmarks in their study to identify NVC within verbal communication. Their research came along with the following NVC methods: 'smiling', 'nodding', 'facial expression' (such as eyebrow, mouth, eyes, etc.), 'hand gestures' & 'how you walk'. (Metaxas & Zhang, 2013, pp. 421-428). An example of why NVC is important to know is when a leisure boat or a raft is broken or damaged. They would wave both their arms up and down to signal to people in sight that they need help. For some people this could be indicated as a nice gesture of being welcoming and saying hi to the people around.

2.4 Factors that affect SA & DM (cognitive skills)

As previously mentioned in chapter 2.2 cognitive skills are skills that require thinking or a conscious mental progress.(Cambridge Dictionary, nd). Flin et al. finds multiple factors that influence the cognitive process. The most common factors according to Flin et al. are stress, fatigue, noise, distraction and interruption.

2.4.1 Stress

«Stress is described as a sense of being overwhelmed, worried, destroyed, pressured, exhausted, and lethargic. Therefore, stress can influence people of every age, sex, race, and situation can result in both physical and psychological health» (Shahsavarani et al., 2015, p. 233). This is one of the definitions Shahsavarani et al. found during their studies about stress and it was defined by the American Psychiatric Association (2014). Being stressed or being overwhelmed causes a lot of distractions that could affect SA and DM. Flin et al. describes when being stressed it is easy to get tunnel vision. When you tunnel vision you only focus on one or a small part of your surroundings, and forget about everything else. This means that stress could result in lack of intel on your surroundings and cause lack of SA, which again could end up affecting the DM process. (Flin et al., 2008, p. 57-58). World Health Organization (WHO) describes stress as: «any type of change that causes physical, emotional or psychological strain.» (WHO, 2021).

«However, high levels of stress could result in biological, psychological, and social problems and even serious harms to people» (Shahsavarani et al., 2015, p. 230). During Shahsavarani et al. 's research about stress that can be caused by either a good experience or a bad experience. (Shahsavarani et al., 2015, p. 233). «Stress is a sense of emotional tension caused by several life events. For example, worrying about something, being under pressure, and facing significant challenges are causes of stress» (Attar, 2022, 209). According to McEwen stress can cause imbalance of neural circuitry. This affects cognitive skills. He follows his research and locating that stress can alter the expression to the person in stress. (McEwen, 2015, p. 50).

Captain Sullenberger reacted like a normal human being when he felt the plane operated differently. When both engines started shutting down he was aware of the life threatening stress he was feeling. He could feel the pulse raising and the tunnel vision arrived. (Inc., 2019, 2:00). Sullenberger got three thoughts into his head and managed to control his stress levels. He saw this incident as a problem that he needed to solve. Sullenberger shifted his focus to the parameters that were important to face and left out the rest. (Inc. 2019, 1:30-3:30). Meaning that his experience as a pilot helped him work through his stress levels and maintain good control over his aircraft.

2.4.2 Fatigue

High risk industries that are operating 24 hours a day with seven days a week do require long hours of shift work. Unlike machinery who can work for hours upon hours and month after month with small or none amount of maintenance. Humans are different, Humans can only work for so long before being affected by fatigue. (Flin et al., 2008, p. 191). A broad definition of fatigue is stated to be «subjective experience of someone who is obliged to continue working beyond the point at which they feel confident at performing a task efficiently (Smith et al., 2001)» (Ahktar & Utne, 2012, p. 2). People affected by fatigue are lacking rest. That means that the people affected by fatigue have a harder time focusing on their work. The tiredness and lack of focus are affecting their judgement, and have the possibility to reduce their level of SA. If the fatigue has gotten to the point of affecting SA the person affected by fatigue faces the possibility of making the wrong decision. If the DM process isn’t done correctly, it could affect the whole work plan and create unnecessary risk for the ship and crew or company.

2.4.3 Noise

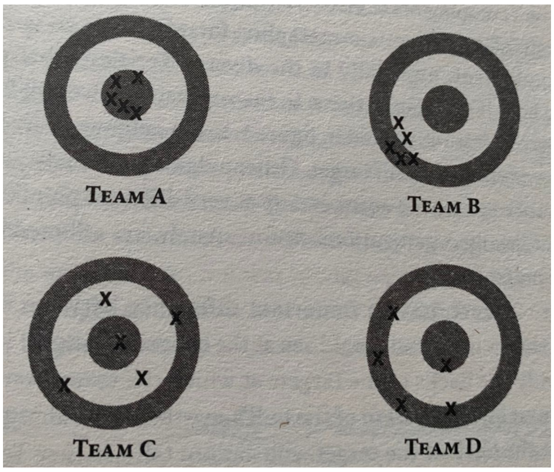


Figure 3 Picture of noise and bias (Kahneman et al., 2021, p. 3).

Figure 3 is an illustrated example of noise and bias. In this example they use four teams with five people in each team. Each team is given one rifle to share. Everyone shoots one shot each at the target with the same rifle, and optimally should all hit the middle of the target. Team A manages to shoot closely around the bullseye and is therefore not impacted by either noise or bias. Team B is clustered around the same area outside the bullseye, therefore they are affected by bias. Now it is possible to predict generally the area the next shot would be. This reason could be that the sight was set incorrectly, or damaged. Team C every shot is scattered from each other. This is noise. Here you can't predict where the next shot would be. The reasoning for this is difficult to know, the only answers we get is the shooters are bad at the shooting. This could be from distractions from outside or bad practice but it is impossible to know. Team D is both biassed and noisy. It would be hard to predict the next shot, other than the left side of the target, and most likely a little lower on the target. This can be due to slightly inaccurate sight and bad aim or outside distractions. (Kahneman et al., 2021, pp. 3-5).

Kahneman and Sibony defined noise and bias during an interview with McKinsey. Bias is as Kahneman stated the 'average error in judgement'. Sibony states that noise is where the researcher wants the same result from each participant, but the results are widely different. That means as the example of Team C shots are shattered all over the target. In court it means when one type of crime is giving multiple different sentences. Bias is an error in human judgement where you can keep expecting the same error to be roughly the same every time outside of the bullseye seen in team B. (McKinsey, 2021).

2.4.4 Distractions

«definition of distraction as an event that causes a break in attention and a concurrent orientation to a secondary task» (Mentis et al., 2015, p. 1714). Mentis et al. further interpret this definition to where you take a break from your original activity, to do a secondary activity. (Mentis et al., 2015, p. 1714). As Mentis et al. states, distractions are secondary activities that takes over primary tasks. On board HNoMS Helge Ingstad there were 2 trainees, one for the OOW and one for the OOW assistant. (AIBN & DAIBN, 2019, p. 35). With these trainees onboard they could be distracted by teaching them up with everything that is important. This secondary task could overtake some of the time where the OOW needed to collect SA. Sullenberger on the other hand knew exactly what he needed to do, due to his experience with the aircraft, he took only the necessary actions that needed to be done to be able to land. When doing these actions he understood that a lot of the checklists were not as important and ignored them. By doing this he kept distractions to a minimum and did every primary task that needed to be done. (Inc., 2019, 03:00-05:00).

2.4.5 Interpretation

> «People have several limitations, one of them being their working memory saturation. In addition, their level of familiarity with various types of situation makes the situation awareness process more or less easy to perform. This depends on the mental model that they have developed.» (Boy, 2020, p. 1).

Boy further explained the definition of interpretation to the citation above that since every person's background, experience and so on are different. Meaning that two people put into the same situation could understand their surroundings differently. (Boy, 2020, p. 1). Having a bridge team working together on the voyage makes it important to communicate together. Without communication people could interpret their situation differently. If an accident occurs the less experienced employee might sense the incident as a 'mayday' while the more experienced employee who has more experience than the first employee might see the incident as a 'pan-pan'. The reason for this is that the more experienced employee might see different solutions than the less experienced one.

Interpretation had an impact on Flight 1549. The reason for this is because other captains or second pilots could have a different opinion on how to solve this problem. Sullenberger and Jeffrey Bruce Skiles worked together. They were able to communicate wordlessly (Inc., 2019, 5:30-5:53). Sullenberger was in charge during the rescue process but Jeffrey Bruce Skiles was ready to intervene to check his performance. (Inc., 2019, 6:10-6:20). Another example of Sullenberger and Jeffrey Bruce Skiles working together is right before the impact Sullenberger asked a simple question. “Got any ideas?” And by asking this simple question both of them understood that Sullenberger had done everything he could to try and save this flight. So are there any other actions you can think of we should take to help succeed. And Jeffrey Bruce Skiles answer was simply “actually not.” (Inc., 2019, 8:45-9:25). By making these comments to each other they both knew that they had done everything they could to try to save this flight.

3 Methods to measure Situation Awareness (SA)

A new literature search was conducted to find more information regarding SAGAT and SPAM. This was due to changes in the original research question. The original research question was "How do Nautical Science students comprehend situation awareness depending on their grade?" This research question changed to "How well suited is Situation Awareness Global Assessment Technique as a method to measure situational awareness for students in Nautical Science?" The new literature search is located in Appendix B. The new literature search made it possible to get a better understanding on how SA has been measured on students in the last decade.

«The direct measurement of SA provides a great insight into how operators piece together the vast array of available information to form a coherent observational picture.» (Endsley, 2000b, p. 17). This is to understand how the participants in the study are operating. While measuring SA the researchers gain information about the mind of the participants to understand how they analyse the "picture" in front of them. Today there are many different methods that are used to measure SA, where some of them are mentioned underneath. In this paper, Endsley's definition of SA is used as seen in chapter 2.1, stating: «the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future" (Endsley, 1988)» (Endsley, 1999, p. 258). Since this is the definition of SA that has been in focus for this paper, it was necessary to locate a suitable method for Endsley's definition to measure SA.

3.1 Simulation

Simulation is a controlled environment where damages on physical objects or humans are removed. Therefore, to measure SA simulations are often used. When Endsley conducted her PhD. She performed this through simulations studying SA. During her PhD paper she focused her studies on fighter pilots in a war situation. To evaluate SA during the simulations Endsley used Situation Awareness Global Assessment Technique (SAGAT). (Endsley, 1990). By implementing Goal Directed Task Analysis (GDTA) helps the researchers to understand all the elements that the participants can meet. GDTA will be explained further in 3.1.1

3.1.1 Goal Directed Task Analysis (GDTA)

A GDTA is conducted to get all necessary information to complete the main goal. First a main goal is located. For the case in Appendix C the main goal is to navigate safely through Karmsund. To be able to complete the main goal, it is then sectioned up to smaller goals or subgoals. Each of these subgoals are goals that need to be completed to be able to complete the main goal. For example, to be able to navigate safely through Karmsund here are some of the following subgoals that need to be located. 'Create and follow the planned route to the best ability', 'Get familiar with important landmarks', 'Locate oncoming traffic and navigate from there' and 'Understand the dangers that are located below the water surface'. When all the subgoals are obtained the next step is then to identify which important decisions that are needed to make to complete these goals. The last step of GDTA is to use all the information to execute the decisions to make the best decisions possible. (Sharma et al., 2019, P. 747). All information needed to be able to make the decision is called situation awareness. (Endsley, 2000a, p. 148). With a good GDTA the researchers know what information that is important to know during a given situation. Then the researchers can perform a questionnaire based on the findings in the GDTA. The different stages of a GDTA are located in Figure 4.

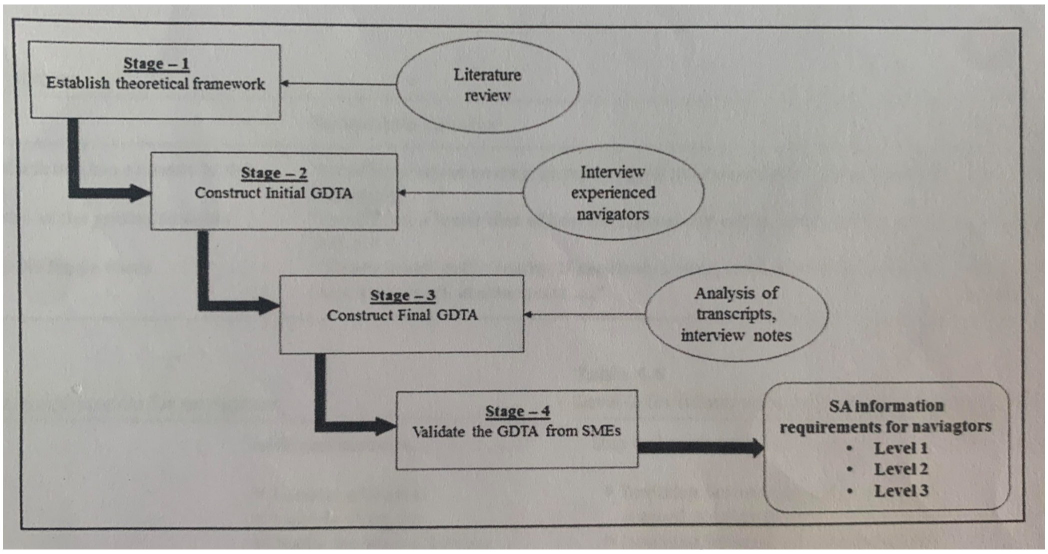


Figure 4 Stages to conduct GDTA (Sharma et al., 2019, p. 748).

3.2 Situation Awareness Global Assessment Technique (SAGAT)

«SAGAT is one of the earliest and most widely used measures of SA» (Endsley, 2021, p. 126). The most common method to measure SA is either SAGAT or SART. (Falkland & Wiggins, 2019, p. 25), (Strybel et al., 2016, p. 31) & (Joffe & Wiggins, 2020, p. 1). Here is SAGAT, a simulation based method while SART is a questionnaire used to measure SA. SART will be described later in chapter 3.4.4. This simulation is done by having a scenario running, where the simulation is paused and screens are blacked out. It is important that the freeze happens at random times so the person in the simulation can't memorise everything prior to the freeze. After the simulation is frozen and the screen is blacked out, the person receives a questionnaire relevant for their current situation. For SAGAT to be an unbiased research method they need to give the queries at random times during the simulation. (Endsley, 2021, pp. 126-127). During Endsley's research on SAGAT she found two previous studies that used small sample sizes (questions) in their studies. This resulted in a lower sensitivity for the research compared to larger sample sizes. Endsley then performed research regarding SAGAT as a method to measure SA. This study ended up with a recommendation of 30 - 60 samples per query while using SAGAT. (Endsley, 2000a, p. 167).

One of Endsley's concerns regarding SAGAT was the effect of the freezes in her PhD. She was worried that these freezes would change the results of the simulation compared to if the freezes didn't occur. Therefore this hypothesis was tested. Endsley performed research on the effect of the threat of a simulation freeze on pilot performance. (Endsley, 1990, p. 98). There were a total of 90 simulations with three different ways the simulation could occur. 1/3 of the simulations the participants were told that Endsley was researching the performance of the case. Another 1/3 of the simulations the participants were told that there might occur stops in the simulation while it didn't. The last 1/3 of the trials the participants were told that there might occur stops where they did occur. The performance of the case was studied in all scenarios. These conditions mentioned were performed at random. (Endsley, 1990, p. 100). Endsley concluded the study with «using a simulation freeze method to collect data on situation awareness is not intrusive on pilot performance.» (Endsley, 1990, p. 105).

Table 1 was a result of the new literature research where in total 5 of the 11 articles were regarding SAGAT. Table 1 presents the aim of the study, together with the number of participants and the total number of questions used. This data will be used to understand how SAGAT has been implemented on studies regarding students in the last decade.

Aim of Study	Participants	Number of questions per questionnaire	Source
«Determine if providing paramedics with a targeted educational approach, including aspects from CRM such as sterile cockpit and Endsley's model for SA, can improve overall SA during emergency calls.»	10	31	(Hunter et al., 2022)
«Determine if paramedic students are situationally aware during clinical high-fidelity situations»	12	20	(hunter et al., 2021)
«Investigate the extent to which cue utilisation and situational awareness contribute to learning a simplified, simulated rail control task incorporating an implicit pattern of train movements»	55	6 (2 for each SA level)	(Joffe & Wiggins, 2020)
«examine the role of cross-task cue utilisation in the acquisition of situational awareness during the initial stages of learning to operate an air traffic control simulation»	68	9 (3 each SA level)	(Falkland & Wiggins, 2019)
«test the effect on participants' subjective preferences and objective task performance»	16	X	(Wu et al., 2016)

Table 1 listed how many participants / questions asked during each SAGAT survey retrieved from the second literature search in Appendix B

The participant number in each paper varies a lot. The fewest number of participants in our research was found to be 10 from both (Strybel et al., 2016) who used SPAM and (hunter et al., 2022) who used SAGAT. To the largest number of participants being 68 participating, where 8 were removed due to various reasons (Falkland & Wiggins, 2019). To get a reliable answer for measurement we were recommended by Sveinung Erland who has a PhD. in statistics that to receive a valid result we should aim up towards 30 students, where we would like to get 10 students from each class of Nautical Science at Western Norway University of Applied Science. Other researchers show that it would be possible to measure SA with fewer students. But since the original research question was to compare SA with different classes we would require more students.

SAGAT questionnaires vary a lot from case to case. One example is from the study of Hunter et al. from paramedics where they implemented a random number of freezes from 1 to 3 in each study. These stops wouldn't last more than 1 minute where all unanswered questions were labelled as wrong. For each freeze they provided questionnaires with 31 questions each regarding all three levels of SA.(Hunter et al., 2022, p. 3). In a different study performed by Hunter et al. used a questionnaire pool of 20 questions where they had two different case studies. (Hunter et al., 2021, p. 4). A study done on air traffic control by Joffe & Wiggins used a smaller questionnaire size compared to the other researchers. They decided to have 2 different questions for each level of SA. (Joffe & Wiggin, 2020, p. 3). While Falkland & Wiggins decided to develop 3 different questions for each level of SA. These questions were set to be answered two times. One in a calm situation and one in a more stressful situation. (Falkland & Wiggins, 2019, p. 27). Wu et al. created a questionnaire for the participants to notice which alarms were triggered and the importance of the alarms. During the project they implemented two freezes with the questionnaires regarding the alarms. At the end of the study Wu et al. used a NASA-TLX questionnaire to fill out. (Wu et al., 2026, p. 46). NASA-TLX will be described further in section 3.4.5.

SAGAT's domain is big, some of the most common use of SAGAT is from 'aviation', 'air traffic controller', 'driving', 'military', 'medical', 'process control', 'robotics', 'train driving', 'maritime', 'maintenance' etc. (Endsley, 2021, p. 131). SAGAT is mostly combined together with simulator tasks. There are also some occasions where SAGAT is used in live exercise where the questions have been provided during natural breaks for the participants in their assignment. (Guille & French, 2003, p. 452-453). Research done by Endsley shows that 73 of 152 studies done using SAGAT were done on experienced personnel. While 29 of the studies were done on students. (Endsley, 2021, p. 132).

Experience will affect the SA on the participants. (Shahsavarani et al., 2015, p. 233). This is also seen in Flight 1549 where the experienced pilots managed to land the aircraft. For the participants on the other hand, experience such as having experience from the simulation prior to the project. Many of the researchers mentioned in Table 1 are giving the participants time to familiarise themself with the situation they are facing. Whether this is by learning the controllers or the necessary actions for the project. Endsley on the other hand recommends the researchers to be open with detailed instructions on how the method should take place. The reason for this is that it is only possible to implement the act of surprise once for each participant. Therefore Endsley recommends that the participants run through a training trial with 3-5 training queries to get used to the SAGAT method. (Endsley, 2000a, p. 166).

3.2.1 How other researchers implemented SAGAT into their studies:

Falkland and Wiggins did have in total three different stops during their simulation. During each stop they implemented a questionnaire with 9 questions at each freeze. 3 questions for each level of SA. The questionnaire started with 3 questions regarding SA level 1 then moved to 3 questions for level 2 and then ended the questionnaire with 3 questions for level 3. The students were given 10 minutes in the beginning of the simulation to familiarise with the situation to ensure that they understood the situation. After the familiarisation was done each stop followed by an interval of five minutes until the simulation was done within 20 minutes. (Falkland & Wiggins, 2019 p. 27).

For the beginning of the study they had a 1 minute period where there were no trains appearing on the simulation. After this one minute there came a lower task that demanded their attention. When this lower task was done the simulation was stopped and the first questionnaire was given. This stop lasted for 3 minutes. Following the first SAGAT freese the higher demand tasks began. This followed by a new SAGAT freeze and the NASA-TLX questionnaire was again given to the participants after each freeze. After the simulation was completed each participant was interviewed regarding whether or not they detected implicit patterns of the movements for the trains. (Joffe & Wiggins, 2020, p. 5).

Hunter et al. used 12 students in their study. Each simulation ran for 15 minutes. The students were divided into two days where the case changed for the following day. Day 1 focused on severe septic shock, while day 2 was a patient suffering from anaphylactic reaction. Upon completion of the simulation the students were located to a secure location to follow up on questions to assess their level of SA., with then a video debriefing. Each question for the SAGAT questionnaire was either correct or incorrect. (Hunter et al., 2021, p. 3). This simulation used only 1 questionnaire after the simulation was complete. The reason for why this was a SAGAT method was because the students were taken away from the location while answering the questions.

SAGAT was also used to measure SA for paramedics during 911 calls. This was done by randomising the number of freezes for each 911 call between 1 and 3. During these freezes the researcher could ask each participant queries from the SAGAT related to each scene and/or the patient. No stop lasted longer than 60 seconds. After this first session of SAGAT, all participants were lectured on Crew Resource Management (CRM), which focused on sterile cockpit and situational awareness. After the lesson of CRM was completed another SAGAT simulation was done, this was done in the same order as the first SAGAT simulation. (Hunter et al., 2022, p. 3-4). Here SAGAT was used to measure SA on students participants prior to attending CRM training and after. This to identify whether or not CRM training improved the participants SA.

Wu et al studied the validation of the alarm bar. For their study they looked at the time needed to discover abnormality. This was done by starting a stopwatch when the alarm occurred, and stopping the time when the participant pressed the “alarm detected” button. After the alarm was detected a new screen was shown, where it shows a hierarchy selection. At this point each participant can show the importance of each alarm that is shown on the screen during the simulation. At the end of the scenario they were given a SAGAT questionnaire to fill out. After two scenarios were run a NASA-TLX questionnaire was also presented to each participant. All participants received a 15 minute training time where they could get knowledge with the experiment platform. (Wu et al., 2016, p. 46).

3.2.2 Advantages & disadvantages with SAGAT:

SAGAT has been proven that it can provide a high degree of validity, sensitivity and reliability when it is used to measure SA. SAGAT has good sensitivity because of broad questionnaires where it can cover a large amount of SA. (Endsley, 2000a, p. 160). By having the possibility to have a large variety of questions is allowing the possibility to ask questions regarding all the wanted elements of each freeze found in the GDTA. Endsley’s study found out that fighter pilots who were able to report enemy aircrafts via SAGAT were three times more likely to kill the target in the simulation (Endsley, 2000a, p. 161).

SAGAT also has long concerns regarding the participants ability to measure from memory rather than SA. To limit the possibility of remembering every answer, the SAGAT query should be delivered at random times. This is due to the participants' possibility to prepare for each stop if the stops are following a pattern. By randomising the stops makes it harder for the participants to memorise the important information where they actually need to know the information at any given time.

The SAGAT method is an instrument that is usually custom designed for the given simulation the students are participating in. (Falkland & Wiggins, 2019, p. 27). The reason for why SAGAT can be used as a custom design for any given situation is that there aren't strict lines in where the freezes can occur. Keeping the number of freezes and timespan between the reasonable times. Otherwise the freezes are flexible to fit most of the cases that need to measure SA.

Some concerns regarding the freezing moments of SAGAT is that it might impact the participants performance of the assignment. (Endsley, 2000a, p. 161). Endsley performed a study to test this theory in her PhD. This study was done by using 5 different teams of 6 participants in each team to run multiple simulations. Each simulation had a duration of 30 seconds, 1 minute and 2 minutes where the number of freezes varied between 1 and 3. Each team participated two different times for all nine different scenarios. In the end the 5 teams participated also 6 times where no stop occurred. In the end Endsley compared the results together to see for differences in each scenario. The result of this project was that there were close to no differences between each scenario meaning that the freezes Endsley used in this study didn’t affect the outcome of the case. (Endsley, 1990, p. 91-93).

3.3 Situation Present Assessment Method (SPAM)

SPAM is a simulator based SA measurement where the queries are given to the person being researched while he/she is performing in the simulation. This means while the person is in the simulation the researcher gives queries verbally to the person in the simulation. During the simulation the person can accept the query or delay it for when the workload is smaller. It is also possible for the person to give the answer to the query whenever they feel like it within a given timeframe. Therefore, it is possible to look for the answer prior to answering. Since SPAM gives the questions during the simulation itself it can be debated that this form can be seen as a secondary workload task. (Endsley, 2021, pp. 127-128).

Aim of the Study	**Participants**	**Number of questions each questionnaire**	**Source**
«Dissect the conflict resolution process across conflict geometries performed by male and female ATCOs»	22	6	(Trapsilawati et al., 2022)
Compared existing text-based query method with a new graphic-based method in a simulation	10	12 per scenario	(Strybel et al., 2016)
«investigated whether the presence of SPAM probe questions using Bacon & Strybel's optimised administration technique, would negatively impact ATCo performance, workload, and SA with a larger sample size of students, including those who participated in Silva et al.'s study»	54	X	(Keeler et al., 2015)
«examine the possibility of the intrusiveness of the online-probe technique to an operator's SA»	12	6 probe questions	(Bacon & Strybel, 2013)

Table 2 listed how many participants / questions asked during each SPAM survey retrieved from the second literature search in Appendix B.

Questions regarding SPAM tend to be smaller than the questionnaires performed with SAGAT. The average number of questions per scenario is 8 questions out of the articles where the number of questions were included. The questions performed with spam usually followed a pattern in how often they were introduced to the participants. The first question was for example presented after three minutes followed by a new question every three minutes, where if the probe question wasn't responded to after a minute it was removed. (Strybel et al., 2016, P. 33). This method of performing the questions was a common factor in all articles regarding SPAM.

This could make the participants expecting the next question when it is close to come visible for the participants. This can make the participants 'study up' for the questions beforehand. Rather than answering it from memory or looking it up when the question is brought up. Another challenge that we are facing with implementing SPAM is that it is hard to ask questions in the middle of the critical parts of the scenario. The participants can choose to answer the question at a later time within the given timeframe. If the participants chooses to not answer the question or the timer is up, the question is marked as wrong.

Spam was mainly studied in the domains: ‘aviation‘, ‘air traffic control’, ‘driving’, ‘military’, ‘process control’ and ‘submarine management’. (Endsley, 2021, p. 133). Together with SAGAT, SPAM is also mostly used together with simulations. She also found out that 16 out of 26 studies done using SPAM as a method were done on experienced personnel, while the rest 10 studies were done on students. (Endsley, 2021, p. 134).

(Keeler et al., 2015, p. 3001) did research to figure out if SPAM questions affected the performance on air traffic controller workload and SA. They started with an eight week training program to get familiarised and learn to use NextGen technologies. After the eight weeks of training they received a midterm exam they needed to pass prior to starting the actual study. After the midterm exam participants received an 18 minute training time before the real scenario was started. The goal for this research was to investigate whether the presence of SPAM probe questions using Bacon & Strybel’s optimised administration technique, would negatively impact ATCo performance, workload, and SA with a larger sample size of students. This study resulted in that with the larger number of participants their results are consistent with the results found in Bacon & Strybel. (Keeler et al., 2015, p. 3003). Meaning that the number of participants shouldn’t affect SPAM.

3.3.1 How the researchers implemented SPAM into their studies:

Strybel et al. assessed SA in three different scenarios with a text-based method and three scenarios with the graphic-based method. Each scenario was 40 minutes long. The density of the air traffic during the scenarios varies from 12-16 aircraft in each sector. For the first scenario the participants received a ‘ready for question’ prompt with an audio alert in their headset. When the participants answered ready they received the question where they could answer ‘yes’ or ‘no’. For the graphic based method the ready prompt also appeared while the question itself was presented with the participants current traffic shown on the display. To answer this prompt question the participants needed to touch the symbol of the correct aircraft. For both scenarios the first question was presented after three minutes, and followed with a total of 12 questions asked (8 regarding SA) for each scenario. (Strybel, 2016, p. 33).

Prior to executing the project done by Keeler et al. they did a 8 week learning process to get familiar with the utilisation of NextGen. Following this 8 weeks learning period the students had a midterm exam to test their air traffic management skills. During the testing all participants received 18 minutes to warm up and get familiar with the different scenarios. Every scenario that the participants ran through lasted for 40 minutes each. Each scenario lasted for 3 minutes until a "ready" prompt appeared on a screen with an audio alert given to the participants headset. For each ready prompt the participants had 1 minute to answer the prompt. All participants were instructed to accept the prompt if they were capable of reading the question and manage each task at the same time. Participants who were unable to answer the question received a new prompt after 2 minutes. The researchers collected information about the question whether it was right or wrong alongside the time it took before the question was answered. (Keeler et al., 2015, p. 3000-3001).

The research performed by Bacon & Strybel used 12 students either graduated or enrolled from the Aviation Sciences Program at Mount San Antonio College. Each scenario the students performed went on for 30 minutes. Participants ran one training scenario and six 30 minute sessions in one day. Between each session a break of minimum 10 minutes was given. The students were briefed beforehand on what to look for and what to do if something occurred. The participants were responsible for all standard Air Traffic Controller tasks during the scenarios. The students were given a "Ready for Question" only to be pressed when he/she was able to answer the question. The question was given via audio in the headset. The "ready" prompt was live for 2 minutes before it got withdrawn. After the end of each scenario a SART questionnaire and NASA-TLX questionnaire was given. (Bacon & Strybel, 2013, P. 92-92).

The research performed by Trapsilawati et al. had the participants trained to use the ATC (Air Traffic Controller) simulator. Then the participants were given several conflict scenarios where each participant needed 70% to go through to the next part of the study. During the main simulation case the participants were briefed and supposed to handle ATC activities. During this case the participants were getting 6 questions. Where they needed to acknowledge that they were ready to answer. Both the ready for question and main question got removed after one minute. This session lasted for a duration of 1 hour. (Trapsilawati, et al., 2022, p. 539).

3.3.2 Advantages & disadvantages with SPAM

SPAM questions are given in real time during the scenario either verbally or on a screen. Before the prompt question is asked the participants are given a ready for question to indicate for the researcher that he/she in fact is ready for the question. If the participant however isn't ready he/she is allowed to ignore the ready for question to signal that he/she needs to wait or discard the question totally. SPAM questions will also correspond to past, present and future for the situation. (Endsley, 2021, p. 127-128). There have been studies done using SPAM in live exercise and microworlds as well as in simulation. (Endsley, 2021, p. 133). On the downside with this method to perform SPAM questions, the researcher has usually added a timeframe to answer both the ready for question as well as the prompt question. If the participant doesn't have time to answer this even though he already knows it it will be marked as wrong.

Since SPAM requires participants to answer questions in the middle of their assignment it can be debated whether or not this is considered a secondary work task. This could affect the participants to shift their focus from their main task over to the question. By shifting their focus away from the goal could affect the results of the study. (Endsley, 2021, p. 141).

Another issue that is concerning SPAM is that the participants get a ready for question. This means that the probe questions can only be asked when the participants are ready for the question. This also gives the participants the possibility to study up before answering the questions. (Endsley, 2021, p. 127-128). Therefore, it is really important that it is considered that the question is more advanced so the participants can't find the answers easily. It has been proven that SPAM provides an unbiased estimate of the participants SA. (Endsley, 2021, p. 130).

A disadvantage of following a pattern with asking questions at a given interval could make the participants expect the next question right before the probe question is asked. This can make the participants "study up" for the questions beforehand. Rather than answering it from memory or looking it up when the question is brought up.

Another challenge that we are facing with implementing SPAM is that it is hard to ask questions in the most critical point of the case. This is because the participants can wait to answer the probe question, or refuse to answer it during the high workload times. Therefore, by giving the participants a minute to respond to the question in a location that wouldn't affect the navigation during the time of answering.

3.4 Questionnaires

3.4.1 Cognitive failure questionnaire (CFQ)

The cognitive failure questionnaire was created by (Broadbent et al., 1982) to measure minor everyday errors. The aim for this questionnaire was to make mistakes that the majority of the people make often or occasionally. During the creation of CFQ they also created a questionnaire that the person can answer for other people. For example on a bridge if you would ask the OOW the CFQ, you can also send him an CFQ for others that he can answer how often he notices when other people make the mistakes. (Broadbent et al., 1982). Figure 5 shows the cognitive failure questionnaire.

	Very often	Quite often	Occasionally	Very rarely	Never
1. Do you read something and find you haven't been thinking about it and must read it again?	4	3	2	1	0
2. Do you find you forget why you went from one part of the house to the other?	4	3	2	1	0
3. Do you fail to notice signposts on the road?	4	3	2	1	0
4. Do you find you confuse right and left when giving directions?	4	3	2	1	0
5. Do you bump into people?	4	3	2	1	0
6. Do you find you forget whether you've turned off a light or a fire or locked the door?	4	3	2	1	0
7. Do you fail to listen to people's names when you are meeting them?	4	3	2	1	0
8. Do you say something and realize afterwards that it might be taken as insulting?	4	3	2	1	0
9. Do you fail to hear people speaking to you when you are doing something else?	4	3	2	1	0
10. Do you lose your temper and regret it?	4	3	2	1	0
11. Do you leave important letters unanswered for days?	4	3	2	1	0
12. Do you find you forget which way to turn on a road					
13. Do you fail to see what you want in a supermarket (although it's there)?	4	3	2	1	0
14. Do you find yourself suddenly wondering whether you've used a word correctly?	4	3	2	1	0
15. Do you have trouble making up your mind?	4	3	2	1	0
16. Do you find you forget appointments?	4	3	2	1	0
17. Do you forget where you put something like a newspaper or a book?	4	3	2	1	0
18. Do you find you accidentally throw away the thing you want and keep what you meant to throw away – as in the example of throwing away the matchbox and putting the used match in your pocket?	4	3	2	1	0
19. Do you daydream when you ought to be listening to something?	4	3	2	1	0
20. Do you find you forget people's names?	4	3	2	1	0
21. Do you start doing one thing at home and get distracted into doing something else (unintentionally)?	4	3	2	1	0
22. Do you find you can't quite remember something although it's 'on the tip of your tongue'?	4	3	2	1	0
23. Do you find you forget what you came to the shops to buy?	4	3	2	1	0
24. Do you drop things?	4	3	2	1	0
25. Do you find you can't think of anything to say?	4	3	2	1	0

Figure 5 Cognitive failure questionnaire (Broadbent et al., 1982, p. 15).

3.4.2 The work situation awareness (WSA) scale

WSA scale was invented by (Sneddon et al., 2013) with the inspiration from the CFQ.

This research method focuses on everyday attention. As you can see in figure 6 this questionnaire doesn't cover any work specific questions. WSA scale is aimed for measuring awareness in the drilling work environment. (Sneddon et al., 2013, p. 81). To further research

WSA they also used questionnaires such as: 'the fatigue scale', 'the sleep disruption scale', 'offshore stress scales' and 'offshore safety questionnaire'. (Sneddon et al., 2013, p. 83). All these methods can be used to measure WSA.

(Circle one number on each line)	Very often	Quite often	Occasionally	Very rarely	Never
I often daydream during work	0	1	2	3	4
I am easily distracted by background noise	0	1	2	3	4
I find it easy to remember work instructions	0	1	2	3	4
My work area is often cluttered or disorganised	0	1	2	3	4
I am easily distracted by my thoughts or feelings	0	1	2	3	4
I think ahead of my work to plan for different possible outcomes	0	1	2	3	4
I ensure I know most rig activities that are ongoing so I can 'keep an eye' on things	0	1	2	3	4
I find it difficult to pay attention to someone, even if I am being spoken to directly	0	1	2	3	4
I become bored with my work quickly	0	1	2	3	4
I find it difficult to concentrate for long periods of time	0	1	2	3	4
I am easily distracted by visual stimulation (e.g., movement)	0	1	2	3	4
I often find I have carried out work on 'auto-pilot', without being aware of it	0	1	2	3	4
I take note of objects/events on the rig even if they are not immediately related to my work	0	1	2	3	4
I find it easy to keep track of everything that is going on around me	0	1	2	3	4
I have trouble getting back into work after an interruption	0	1	2	3	4
I am not able to keep my mind focused on work and it has a tendency to 'wander'	0	1	2	3	4
When I finish reading or being told instructions, I often have to re-read them or ask for them to be repeated as I don't remember them	0	1	2	3	4
I often speak or act without thinking	0	1	2	3	4
I have difficulty paying close attention to details, which often results in careless errors	0	1	2	3	4
I 'tune out' during routine work, or when work is boring	0	1	2	3	4

Figure 6 The work situation awareness scale (Sneddon et al., 2013, p. 87).

3.4.3 Situation Awareness Rating Scale (SARS)

Situational Awareness Rating Scale (SARS) was developed to measure pilots performance in a fighter environment. These instruments measured SA from three different perspectives. Supervisor, peers and self report. (Waag & Houck, 1994, p. 13). This method was created because in general three types of performance rating have been used where the most common type is supervisory ratings followed by peer ratings and self ratings. (Waag & Houck, 1994, p. 14). Waag & Houck struggled to select one approach since the literature doesn't suggest one to be the best. For this reason it was decided to develop SARS to gather data on the three types of performance rating. (Waag & Houck, 1994, p. 14).

3.4.4 Situation Awareness Rating Technique (SART)

SART was developed as a method to measure the pilots SA. This is a questionnaire that is given after the situation is completed for the participants to answer. This focuses on 10 dimensions "familiarity of the situation, focussing of attention, information quantity, information quality, instability of the situation, concentration of attention, complexity of the situation, variability of the situation, arousal, and spare mental capacity." (Salmon et al., 2006, p. 233). According to

(Falkland & Wiggins, 2019, p. 25) This method has been used in the following areas: military aviation, air traffic control, military operations and process control. The figure 7 below is taken from the SART technique. The number 1 is a low grading while 7 is a high grading for each question.

SITUATION AWARENESS RATING TECHNIQUE (SART; Taylor, 1990)

Instability of Situation
How changeable is the situation? Is the situation highly unstable and likely to change suddenly (High) or is it very stable and straightforward (Low)?

1 2 3 4 5 6 7

Complexity of Situation
How complicated is the situation? Is it complex with many interrelated components (High) or is it simple and straightforward (Low)?

1 2 3 4 5 6 7

Variability of Situation
How many variables are changing within the situation? Are there a large number of factors varying (High) or are there very few variables changing (Low)?

1 2 3 4 5 6 7

Arousal
How aroused are you in the situation? Are you alert and ready for activity (High) or do you have a low degree of alertness (Low)?

1 2 3 4 5 6 7

Concentration of Attention
How much are you concentrating on the situation? Are you concentrating on many aspects of the situation (High) or focussed on only one (Low)?

1 2 3 4 5 6 7

Division of Attention
How much is your attention divided in the situation? Are you concentrating on many aspects of the situation (High) or focussed on only one (Low)?

1 2 3 4 5 6 7

Spare Mental Capacity
How much mental capacity do you have to spare in the situation? Do you have sufficient to attend to many variables (High) or nothing to spare at all (Low)?

1 2 3 4 5 6 7

Information Quantity
How much information have you gained about the situation? Have you received and understood a great deal of knowledge (High) or very little (Low)?

1 2 3 4 5 6 7

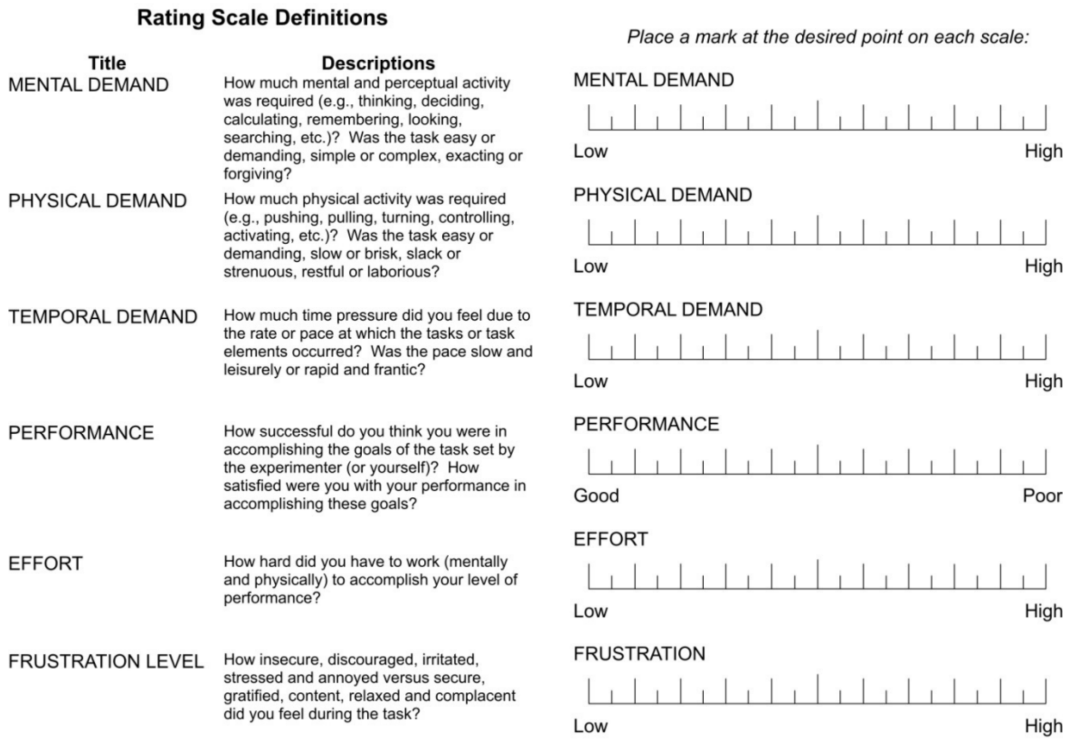
Familiarity with Situation
How familiar are you with the situation? Do you have a great deal of relevant experience (High) or is it a new situation (Low)?

1 2 3 4 5 6 7

Figure 7 SART questionnaire (SESAR, 2012).

3.4.5 NASA Task Load Index (TLX)

NASA-TLX is used to measure the mental workload for an individual performing specific tasks. It measures the mental workload through six different dimensions such as : ‘mental demand’, ‘physical demand’, 'temporal demand’, ‘effort’, ‘performance’ and ‘frustration level’. (Digital Healthcare Research, 2006). There have been multiple different kinds of NASA-TLX constructed. The first one was the paper NASA-TLX which is found in figure 8. Afterwards a electronic version of the NASA-TLX was created, which is the same version as the paper, only it is provided electronically. Random NASA-TLX is the same kind of dimensions, but they are asked in different orders than the original version. (Trujillo, 2011, p. 6).



Rating Scale Definitions

Title	Descriptions
MENTAL DEMAND	How much mental and perceptual activity was required (e.g., thinking, deciding, calculating, remembering, looking, searching, etc.)? Was the task easy or demanding, simple or complex, exacting or forgiving?
PHYSICAL DEMAND	How much physical activity was required (e.g., pushing, pulling, turning, controlling, activating, etc.)? Was the task easy or demanding, slow or brisk, slack or strenuous, restful or laborious?
TEMPORAL DEMAND	How much time pressure did you feel due to the rate or pace at which the tasks or task elements occurred? Was the pace slow and leisurely or rapid and frantic?
PERFORMANCE	How successful do you think you were in accomplishing the goals of the task set by the experimenter (or yourself)? How satisfied were you with your performance in accomplishing these goals?
EFFORT	How hard did you have to work (mentally and physically) to accomplish your level of performance?
FRUSTRATION LEVEL	How insecure, discouraged, irritated, stressed and annoyed versus secure, gratified, content, relaxed and complacent did you feel during the task?

Place a mark at the desired point on each scale:

MENTAL DEMAND
Low High

PHYSICAL DEMAND
Low High

TEMPORAL DEMAND
Low High

PERFORMANCE
Good Poor

EFFORT
Low High

FRUSTRATION
Low High

Figure 8 Paper NASA-TLX (Trujillo, 2011, p. 7).

4 Method

The method used in this research project was SAGAT, this research was inspired by Endsley's PhD. (Endsley, 1990). With the first literature research string located in appendix A we found that SAGAT is still one of the most used methods to measure SA. Therefore we constructed a realistic scenario to perform a SAGAT experiment to measure SA on students within nautical science. The constructed case is located in appendix C. Location used for the project is Western Norway University of Applied Sciences, where all simulations were constructed and performed. The case was constructed with the help of Vigleik Storesund, who has former experience as a captain. After the scenario was created, a questionnaire was constructed with the help of a premade GDTA regarding maritime navigation (Sharma et al., 2019), and some tips from Vigleik on important aspects of navigation.

4.1 Execution of the exercise

As previously mentioned it was performed a test run of this exercise with the students willingly to partake in this study. From this test run it is possible to see that there is a difference with the students SA. The picture shown in figure 9, 10 and 11 is from an testrun performed by the researchers. This means that these figures are from the researchers performing the same exact scenario. The figures are giving an indication on roughly where their positioning should be. During the testing of the case only three students were available and willing to partake in this study. Meaning that the results retrieved from this project isn't reliable. The results will be used to discuss "how well suited is Situation Awareness Global Assessment Technique as a method to measure situational awareness for students in Nautical Science?" It will also discuss possible changes to improve this project for later studies.

To begin with all ship parameters, and technical equipment will have the same start settings on the equipment. The students will be briefed quickly regarding this exercise. The participants will be informed about the freezes that will occur during the session. They will also be recommended to answer every question on each SAGAT query even if they don't know the answer. As Endsley states it is better for students to guess the answer than answer blank. (Endsley, 2000a, p. 166). They will receive short information on the planned route, what type of assignment this is and that there will occur stops during this simulation. After a short introduction of the assignment all participants will need to sign the participants consent form as seen in appendix D. The students will then be taken into the simulation where they will have 2-3 minutes to make their wanted changes on the ECDIS and RADAR.

4.1.1 First freeze

The first stop will occur after 4 minutes and 30 seconds. This will give the students a few minutes to get familiar with their surroundings. During approximately the first 5 and a half minutes, the planned course and speed was preset to the wanted speed. This was done to make the participants familiar with the situation going on around them and to make the participants approach the critical parts at approximately the same time. The main goal during the first freeze is to see if the students notice important landmarks and the usage of lanterns. Inspirations for questions are located in Figure 13, 14 and 15 in section 4.2. The first freeze can be located in Figure 9. Where the own ship is located with a red circle around it. As you can see in the figure, there is no reason to change their course unnecessarily. At this point the workload for the navigation is considered low. The questionnaire used during this freeze is located in Appendix F.

During the first 4 minutes and 30 seconds participants will have Meløyfjord arriving from behind. This vessel is easy to notice both on ECDIS and RADAR. They will also pass two vessels. One of the vessels is a passenger vessel that is passed in the beginning. Selskjer is a smaller fishing vessel, harder to locate visually but available RADAR (not on the ECDIS). Visible on port side is a vessel called Edda Flora, the vessel is showing lanterns that tells the participants the vessel has poor manoeuvrability. After 3 minutes the first VHF message arrives on channel 19. This informs the participants about a vessel leaving Haugesund port going southbound. During the entire time they have a premade passage plan that gives them directions and planned speed to follow.

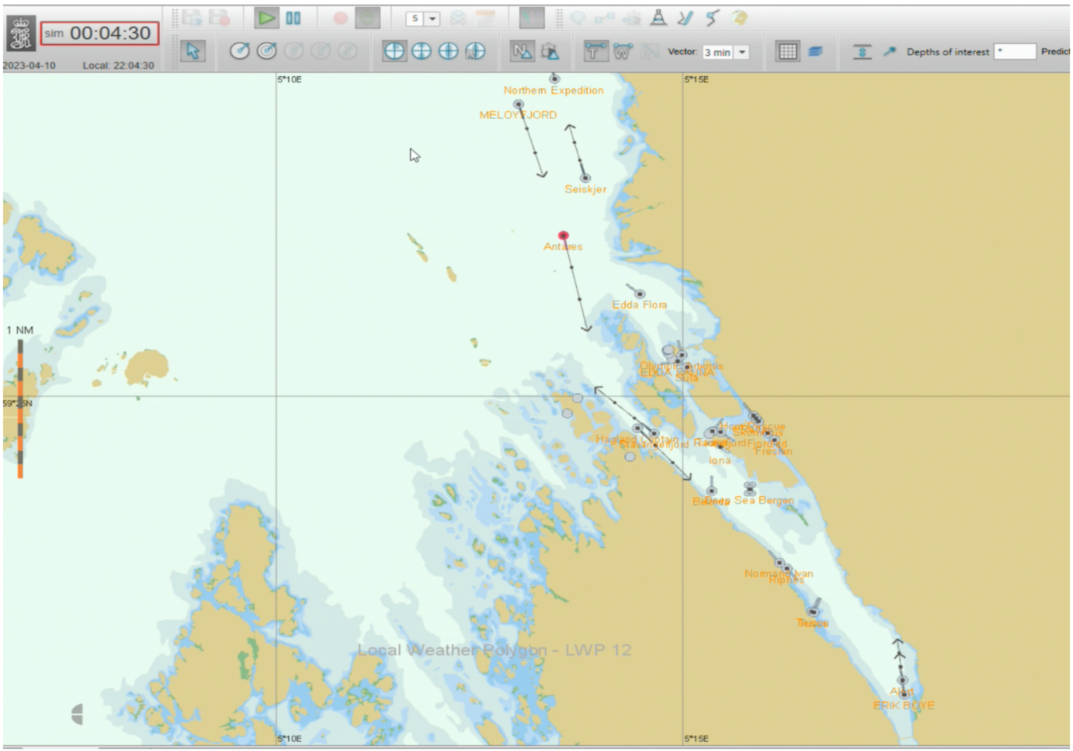


Figure 9 First freeze of the SAGAT simulation.

4.1.2 Second freeze

The second freeze is determined to appear after 8 minutes and 30 seconds. Endsley mentioned in (Endsley, 2000a, p. 167) that when performing SAGAT measures of SA it is important to make freezes in both stressful and non stressful situations. As seen in figure 10, OS is meeting Stavangerfjord at a critical point during the simulation. If the participants don't follow the planned course or speed this situation would be more critical. During the second freeze the students need to make sure that they can pass Stavanger Fjord at a safe distance, and enter Karmsund without grounding. The questionnaire used for the second freeze is located in Appendix G.

Between first freese and second freeze the students need to lower their speed in order to sail at a safe speed. They also need to make sure that they manoeuvre the vessel correctly to access Karmsund in a safe manner, while they also can prevent collision with Stavanger Fjord. During this session the second VHF message is given on channel 16. This informs the participants about a floating container that is located 1 nm south of Karmøy bridge.

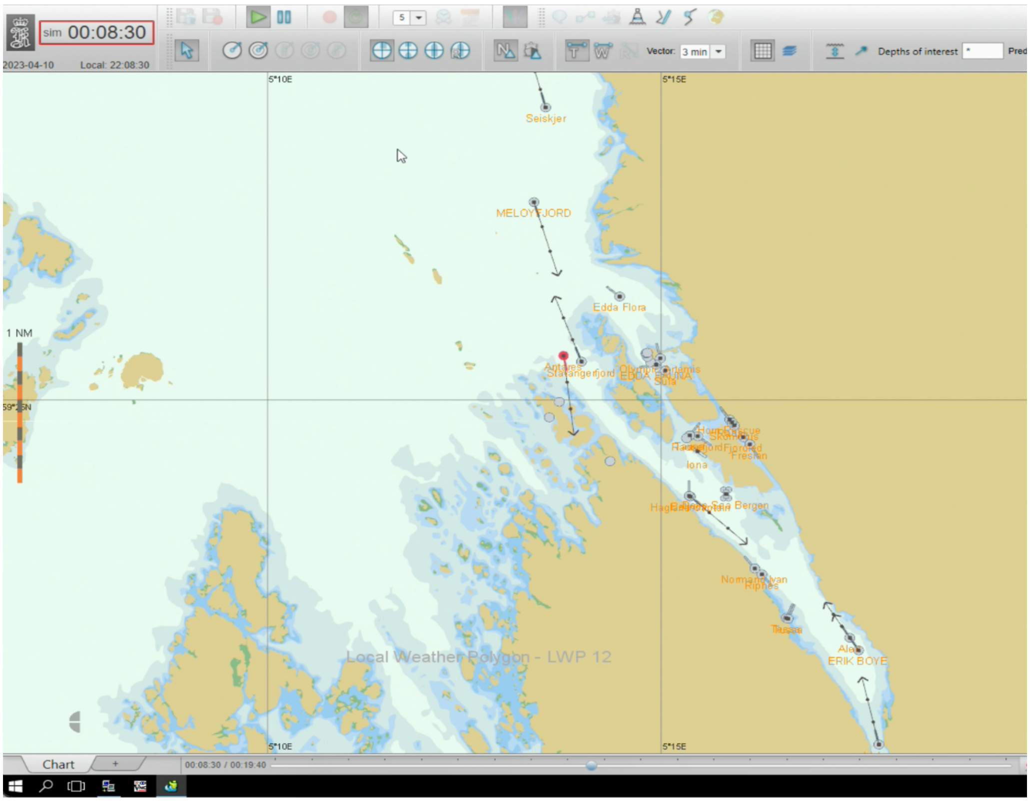


Figure 10 Second freeze during the SAGAT simulation.

4.1.3 Third Freeze

The third and final freeze occurs when the simulation is finished after 17 minutes. One of the goals during this freeze is to understand if the participants can remember "old" information that was given earlier during the simulation. Between freeze 1 and 2 a message was received about a floating container. Questions regarding this container were asked both during the second and third freeze. The reason for why this was asked at both stops was to see if the students remember previous messages and to see if they manage to understand the location of this message. In Figure 11 the OS has passed Haugesund and is approaching two different vessels. One tug with a tow over 200 metres. Therefore, "Sjøfartsreglene" was placed on the bridge within sight and range of the participants so there was a possibility to investigate the lanterns in this book.

During the last session of the SAGAT simulation the participants continue to travel south in Karmsundet, where they have some time to locate a tug with lanterns showing it is tugging a load with over 200 metre line. If the participants are following the planned course they will also locate Volga, the vessel that informed about the floating container. The session will end before the participants will pass both vessels. After the third freeze is done and questionnaire is answered, the participants were given an explanation of what the original project was created for.

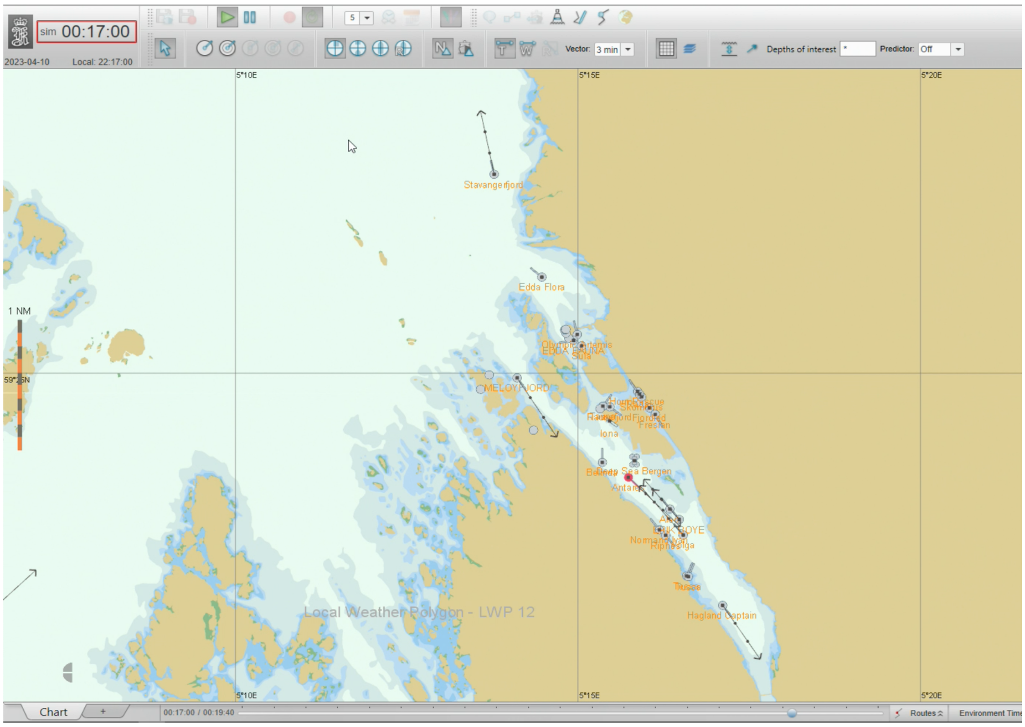


Figure 11 Third and final freeze during the SAGAT simulation.

4.2 Construction of the Questionnaire

The questionnaire used during this SAGAT method is based on a goal directed task analysis (GDTA) done by (Sharma et al., 2019) together with a discussion with the former captain Vigleik Storesund regarding his knowledge of what's important to include for navigators. The questionnaire pool used for this research project is listed in appendix E. According to Vigleik Storesund these are the important parts to gain knowledge about. OS, course (including current course, next course, and time to next turn), speed, draft, length over all (LOA). Information about other vessels were course, speed, and lanterns. Technical information regarding RADAR, ECDIS such as vector length and range. As well as important landmarks and weather conditions. For the VHF communication name of the vessel, direction, position of the message, and the relevance for this voyage. Figure 12 is a description for each level of SA. Figure 13, 14 and 15 are according to Sharma et al. important requirements for acquiring good SA for each level. Taking inspiration from both the previous Captain and (Sharma et al., 2019) our questionnaire pool can be located in appendix E. Which will be used to create three different questionnaires one for each freeze, appendix F, G and H.

Levels of SA and classification.

Level	Definition	Excerpt from interview	Identification of element
Level 1	Perception of information elements in the environment	"Usually the officer on duty, he reports speed in knots, course and some relevant information….."	Speed and Course
Level 2	Comprehension of the present situation	"I would get a better idea of how the currents are acting in the direction that….."	Impact of tidal stream
Level 3	Projection of the future status	"If there is any traffic nearby. If somebody's going to come or if I'm going to meet some vessel at some point….."	Projected movement of own ship/ targets

Figure 12 Level of SA and classification (Sharma, et al., 2019, p. 749).

Level-1 SA information requirements for navigators.

Ship status

- Position
- Speed
- Gyro heading
- Magnetic heading
- Under keel clearance

Equipment status

- Operational status of
  - o Navigation system – GPS, ECDIS, Radar, Automatic Identification System (AIS) data.
  - o Radio system – VHF/MF.
  - o Steering system
  - o Communication channels – Portable radios, PA systems.
  - o Fire and safety equipment
  - o Signal lights
  - o Deck equipment
  - o Engine controls

Route plan

- Planned route
- Distance to waypoints
- Planned speed for each leg
- Air draft

Traffic and obstacles

- Location of targets
- Number of targets
- Traffic Separation Scheme (TSS) to be followed
- Vessel Traffic Service (VTS) communication frequency
- VTS standing instructions
- Location of navigational hazards
- Anchorage areas
- Location of shoals, under water rocks
- Density of traffic

Weather

- Conditions
  - o Visibility
  - o Temperature
  - o Sea temperature
- Wind
  - o Speed
  - o Direction
- Current or tidal stream
  - o Speed
  - o Direction
  - o Range of tides

Figure 13 Level 1 SA information requirements for navigators (Sharma, et al., 2019, p. 749).

Level-2 SA information requirements for navigators.

Ship and equipment

- Deviation between current position and planned position (XTE)
- Deviation between current heading and planned heading
- Deviation between minimum required Under Keel Clearance (UKC) and current UKC
- Validity of - Position, speed, heading and other indicators
- Risk level of system related emergencies

Route
- Deviation between current speed and planned speed
- Deviation between planned course and course made good
- Current separation between own ship and other ships
- Current distance to nearest obstacles

Impact of

- Traffic conditions
- Ship maneoveres
- Ship performance
- Alteration of course
- Alteration of speed
- Weather conditions
- Wind speed
- Tidal streams

Emergencies
- Confidence level in alarms
- Available sea room
- Available manpower
- Applicable checklist
- Available time limit
- Fire-fighting system settings
- VTS communication frequency

Figure 14 Level 2 SA information requirements for navigators (Sharma, et al., 2019, p. 749).

Level-3 SA information requirements for navigators.

Traffic and route

- Projected position of own ship
- Projected movement of targets
- Projected relative separation
- Projected traffic congestion
- ETA to waypoints

Meteorological data

- Projected weather conditions
- Projected visibility
- Projected wind speed
- Projected currents or tidal streams

Figure 15 Level 3 SA information requirements for navigators (Sharma, et al., 2019, p. 749).

4.3 Collection of Participants

For the originally planned research project it was necessary to find volunteers to partake in this project. A discussion was done with Sveinung Erland. He has a PhD in statistics and recommended us to aim for around 30 students to get a reliable result. To get participants in this project we arrived at Western Norway University of Applied Science to meet physically in the classes of Nautical Science students. This to introduce the project for the students. During the meetings in the classrooms we got the feeling that there were multiple students that were interested in the project. The following week we got in contact with the program coordinator for Nautical Science. A message got posted on Canvas for all Nautical Science students informing about this project. During this time a message on Facebook was created for all the students to read about this project. The final attempt to collect participants was by meeting up at the simulator centre when the students finished their classes at the simulator centre. In total this resulted in three voluntary students wanting to partake in this study.

4.4 Limitations

The first plan was to research how the SA is evolving compared to the Nautical Science study. The necessary number of participants were around 30 students. Therefore, was it necessary to do some changes. The study shifted focus from focusing on their level of SA to the method used to measure SA. Since there were only three students available the project became a qualitative research where the case study will be used to understand SAGAT as a method.

The simulation centre was following the school's schedule. This meant that during the day the simulation centre was occupied. Since the simulator was occupied most of the day, the participants had to go through the case during the evening. This made it hard for the students that have a part time job after school. Planning the run became challenging to be able to include as many as possible. To make the simulation run it was necessary to have participants available at that time, have experienced personnel who can run the simulations and available simulations.

4.5 Ethical Issues

It is important that all participants are participating voluntarily. The students were informed prior to joining this project that it was voluntary and anonymous. This was held anonymous by dividing the test results from the participant consent form. While analysing the results from the questionnaire was kept in a secure location out of reach from other students. The Participant consent form was kept in an enclosed folder to prevent people from seeing them and located at a secure location away from the questionnaire results. The questionnaire and participants' consent form will be destroyed when the project is handed in and graded.

5 Results

All correct answers are given 1 point to each question. If the participants are close within the answers they are given 0.5 points for example marking the vessel, but directions isn't where it should be but approximately. If questions are regarding the course we accept 3° as the correct answer, while up to 5° are given 0.5 points. Three students participated in this project following the result underneath. Out of the three students two of them had previous knowledge from working on the sea, while one didn't. It is important to notice that the last question for each questionnaire gives a total of 4 points if all vessels are marked correctly. This will affect the results in SA level 2.

All three students are in different grades of Nautical Science. Student #1 is the second year of a Nautical Science bachelor degree. Student #1 has no prior experience working at sea. Student #2 is in the first year of Nautical Science with integrated Practice. He has experience working at sea. Student #3 is a third year student from Nautical Science, with previous experience working in sea.

5.1 Freeze one

Questionnaire 1	Student #1	Student #2	Student #3
What is your current speed?	1	-	1
What is the next planned speed?	1	-	-
What's your current planned course?	1	-	1
What's your next planned course?	1	-	1
Where is the closest vessel located according to your own ship heading? (N being your heading)	1/2	1/2	-
What is the current wind direction?	1/2	-	1/2
Are there any vessels observed in the near proximity that have a different navigational state than power driven vessels underway?	1	1	1
If so, which vessel?	1	-	1

If yes, what kind of lanterns do the vessel use?	-	-	1
Will any of the vessels around you have a collision course if no action is taken in the near future?	1	1	1
Which letter or symbol did the racon send out on the RADAR?	1	-	1
What light characteristic does the racon send out?	-	1/2	1
What VHF radio channel are you listening to? (DW = Dual Watch)	-	1	1
What is your current vector length on the ECDIS?	1	-	1
What are your current range settings on the RADAR?	1	1	-
What are your current range settings on the ECDIS?	-	1	1
What is the ETA for the next waypoint?	-	-	-
Mark the ships around you with a radius of approximately 1.0nm. Given your own ship in the centre.	3/4	2/4	3/4
Total	**14/21**	**7/21**	**15.5/21**

Table 3 Result of questionnaire 1.

Freeze 1	SA Level 1	SA level 2	SA level 3	Total SA freeze 1
Student #1	7/11	4/6	3/4	14/21
Student #2	3.5/11	2.5/6	1/4	7/21
Student #3	8.5/11	5/6	2/4	15.5/21

Table 4 SA level on first questionnaire.

The results of freeze 1 are shown in table 3 and 4. Table 3 shows how each participant responded to the first questionnaire. In table 4 shows the total score of SA regarding each level of SA. While looking into table 4, there are noticeable differences regarding SA between the three students The further into the studies the participants get the more knowledge they have regarding the navigation. Looking into the last question in table 3 the participants were supposed to mark the ships around their position. They had all good control over the ship's that are in sight or have been in sight of the participants. Meaning that the ships that are going northbound past their own position are marked. But the ship that is located approximately 1 nautical mile behind isn’t located by the participants. This ship was also visible on ECDIS and RADAR from the beginning of the simulation. Student #2 was also missing Edda Flora. All participants noticed that Edda Flora didn’t use the normal lanterns, but only student #3 understood the meaning of the lanterns.

5.2 Freeze two

Questionnaire 2	Student #1	Student #2	Student #3
Did you notice if any of the four lighthouses was defective?	1	1	-
What direction is the vessel leaving port travelling towards?	1	-	1
What VHF channel did you receive information regarding the vessel leaving port?	1	1	1
What VHF channel did you receive information regarding floating containers?	1	1	1
Is your ship deviating from the Off track limit? If so, which direction?	1	1	1
What is your current under keel clearance?	-	-	1
What is the difference between your current speed compared to the planned speed?	1	-	1
Will the floating container be relevant for your planned course during the next 5 minutes?	1	-	1
What is your planned speed for this leg?	1	-	-
What is your current vector length on the ECDIS?	1	1	1
What are your current range settings on RADAR?	1	1	1
What are your current range settings on the ECDIS?	1	-	1
Are there any new vessels observed in the near proximity that have a different navigational state than power driven vessels underway?	-	1	1
What is the ETA for the next waypoint?	-	-	1/2

Mark the ships around you with a radius of approximately 1.0nm. Given your own ship in the centre.	2/4	2/4	3/4
Total	**12/18**	**9/18**	**14.5/18**

Table 5 Result of questionnaire 2.

Freeze 2	**SA Level 1**	**SA level 2**	**SA level 3**	**Total SA freeze 2**
Student #1	3/5	8/11	1/2	12/18
Student #2	2/5	7/11	0/2	9/18
Student #3	4/5	9/11	1.5/2	14.5/18

Table 6 SA level on second questionnaire.

The participants have either improved or maintained their SA. Student #2 and Student # 3 has improved their SA. Where student 1 is maintaining his understanding with the same percentage of the questions right as in questionnaire 1. As seen in the last question in table 5 the students are during this location also struggling to mark the ship from behind. The results collected in table 5 & 6 is that it is following the expected hypothesis that the students will increase their SA alongside their bachelor degree.

5.3 Freeze three

Questionnaire 3	Student #1	Student #2	Student #3
What direction would you most lightly expect the container drifting toward? given wind as the only influence	1/2	1	1
Where was the drifting container first located?	1	-	1
What does the lantern on the tug mean?	1/2	1	1
If you registered any current, what direction?	1	-	1
At what time was the floating object first observed?	1	-	-
Which ship sent the securite message for the floating container?	1/2	1	1
Do you have a crossing course with the Tug Alert?	1	1	1

Do you have a crossing course with Volga?	1	1	1
What is your current vector length on the ECDIS?	1/2	1	1
What are your current range settings on RADAR?	1	1	1
What are your current range settings on the ECDIS?	1	1	1
Is your ship deviating from the Off track limit? If so, which direction?	1	1	1
If you're deviating from the course, how much are you deviating from the off track limits?	1	1	1
Are there any new vessels observed in the near proximity that have a different navigational state than power driven vessels underway?	-	1	1
What is the ETA for the next waypoint?	1/2	1	1
Are there any vessels that would have a collision course with you if no actions were performed?	1	-	1
Quickly mention what is important to take into consideration if the simulation continues?	1	1	1
Mark the ships around you with a radius of approximately 1.0nm. Given your own ship in the centre.	3/4	3/4	4/4
Total	**16.5/21**	**16/21**	**20/21**

Table 7 Result of questionnaire 3.

Freeze 3	SA Level 1	SA level 2	SA level 3	Total SA freeze 3
Student #1	4/5	10/13	2.5/3	16.5/21
Student #2	4/5	10/13	2/3	16/21
Student #3	4/5	13/13	3/3	20/21

Table 8 SA level on third questionnaire.

In table 7 & 8 the students are still increasing their SA. This is regarding all three students. The participants had a good understanding of the oncoming traffic in front of their own ship. The ship that previously followed own ship was at this position out of range. The reason for why

2/3 students got 3/4 points at this stop was because these students didn't mark the stationary ships. The students that previously have had experience working on the sea did have an understanding of the tug towing a ship of 200 metres or more. While all of the participants noticed that this vessel was towing.

5.4 Summarise

Total result	SA Level 1	SA level 2	SA level 3	Total SA
Student #1	14/21	22/30	6.5/9	39.5/60
Student #2	9.5/21	19.5/30	3/9	32/60
Student #3	16.5/21	27/30	6.5/9	50/60

Table 9 Total level of SA in each level.

During this small test run of the created case it is noticeable that there are differences between the classes. Common factor during the entire session is that the students have control over vessels in front of their own vessel, while they struggle to notice or forget vessels behind. As seen in table 9 at the total acquired SA there are noticeable differences between the three participants. Surprisingly the increase of SA during the three stops indicates that the participant became more observant about their surroundings. Where participants have received ½ points is when the participants are in the general area, but it isn't close enough to give them a full score.

6 Discussion

Many different measurements have been constructed to measure SA. In chapter 3 is it possible to read about the two of the most used methods for measuring SA in a simulation based research. This chapter will be discussed based on the results found in chapter 5 compared to previous research found in chapter 2 and 3. The result of this discussion will help to answer the research question: "How well suited is Situation Awareness Global Assessment Technique as a method to measure situational awareness for students in Nautical Science?" After the research question is answered, possible changes for this project will be listed to further improve the validity of the original case study.

As mentioned previously this research paper was supposed to be a research regarding Nautical Science students SA. This got changed where the case study is used to test the SAGAT as the method. By using the results and findings regarding SAGAT and the case study, it will be possible to create a new research project where this case study will be taken full scale with possible improvements for the original case. Table 4, 6 and 8 shows that all the participants have a positive graph in the increase of SA during the three freezes. An indication for this can be that the students are put in a new situation they never tried before. Stress stated in section 2.4.1 talks about stress being a factor that might affect SA. To better measure SA on the students Endsley recommends that three to five different test stops makes the participants familiarised with the SAGAT as a method. (Endsley, 2000a, p. 166). By implementing this test freese in the simulation it is possible to reduce stress or nerves among the participants. The test freezes also helps the participants to get familiarised with the environment they are navigating in together with the implemented freezes. Other researchers had also implemented 10 minutes to get familiarised with the case. (Falkland & Wiggins, 2019 p. 27).

As mentioned in 2.4.2 Fatigue could be involved by the students. The case was held in the evening after school was done for the day. This means that the student could face a full day of school before joining this project. The timeframe for when this project occurred was also poorly executed. This occurred when the 3rd year students were at the end of their Bachelor thesis and the other students were just prior to the examination. Having this performed in this time period could have the possibility to have students studying hard before the exams or bachelor. Making the possibility of fatigue higher than if this study was performed at a different time. Looking into the results from Table 9 Where all participants had a good understanding of most of the elements. It seems like fatigue isn't affecting the participants.

Distractions on board the bridge can become a problem. This is seen in chapter 1.1.1 for HNoMS Helge Ingstad. This is because HNoMS Helge Ingstad had a lot of personnel onboard the bridge who could distract the OOW. To limit the distractions for this case study it was decided to use one student at the time. By only having one student at the time limits the distractions for both the participants and the researchers. If the researchers have multiple students to focus on will make it hard to observe all the questionnaires within the timeframe. For the participants on the other hand, there will not be any distractions of having other students competing in getting the best results or chatting together while on the bridge. The pilots on board Flight 1549 had a lot of non verbal communication. (Inc., 2019). By removing the possibility of non verbal communication between the participants. This is because the researchers can't understand the nonverbal communication between the participants. The partner in a potential duo will also make a huge difference because if the partners have worked together a lot they should do it better. One of the researchers was also present in the room. This was to make sure everything went as it should regarding the questionnaires and VHF messages. Having more students participating at the same time would mean that the researcher needs to relocate between all rooms and distract the participants.

Communication is a method used to give or receive information from others. (Flin et al., 2008, p. 69). To measure how much information the participants received from communication, two different VHF messages were used. One was constructed as an information message, where the other was constructed as a sécurité message. By the use of these two messages and questions from the questionnaire, we could see if participants managed to gain the important message received. Studies done by Aalvik et al. found that where communication isn't adequate accidents might happen. (Aalvik et al., 2021). SAGAT has been proven to also work for measurement of team SA, where the questionnaire is delivered to all people. (Endsley, 2021, p. 143). If the participants are able to remember the location of the container will it possibly be easier for them to avoid this. Two of the participants manage to locate the exact position of where the container was first spotted. The last participant misheard the direction of the message. Where two of the participants noticed the direction of the ship leaving port while one didn't as seen in table 5.

The number of participants varies a lot during the SAGAT studies. For this project only three participants were able to partake in the exercise. The average participants for studies that used SAGAT as a method previously is 31 participants as seen in Table 1. The average number of participants regarding SPAM as the method is 22 participants. This is aligning with the number of participants that Sveinung Erland suggested to use in this project. He suggested around 30 students divided into the different classes to be able to get a reliable result. Therefore, to perform this study in a full scale with reliable results it is recommended to use around 30 students. However if the researchers only want to research one group, the number of participants can be reduced. As seen in (Hunter et al., 2021) where the number of participants were 12. This study was focusing on students as one group compared to this study.

A questionnaire pool of 44 questions was created to measure SA during the case study. These questions contain important information found in (Sharma et al., 2019), and recommendations from Vigleik. 14 questions for level 1, 23 questions for level 2 and 7 questions regarding SA level 3. This questionnaire pool can be located in appendix E. According to (Endsley, 2000a, p. 167) you should aim for 30-60 samplings per query. Due to the possibility for large samplings of questions for each freeze SAGAT can direct questions that hit all levels of SA, 'perception', 'comprehension' and 'projection'. (Endsley, 2021, p. 142). For the example found for the second literature search, the number of questions asked on each SAGAT study varied a lot. The highest number were 31 questions for each questionnaire (Hunter et al., 2021) , while the lowest was 6 (Joffe & Wiggins, 2020), where the average questions asked each freeze according to table 1 is 16 questions. Comparing this with SPAM, where the average number of questions asked each scenario according to table 2 is 8 questions. SAGAT has the possibility to have a much larger variety of questions since the articles regarding SAGAT have larger queries. By adding more questions to the questionnaires with SAGAT it is possible to study SA on a wider level by using questions from all aspects of the navigation.

Endsley has done a lot of research regarding SPAM and SAGAT. In her studies she found that SAGAT is more sensitive compared to SPAM. By being sensitive she means that SAGAT are able to receive more exact answers regarding SA. In previous studies it has been found that SPAM are more sensitive than SAGAT. But this has later been proven wrong (Endsley, 2021, p. 133). SPAM provides questions during the simulation, where they can ask one question at the time and the participants are able to choose whether or not to answer it. Due to this they will not be able to answer such a broad set of questions. During each scenario while they still have time to look up the information prior to giving out the answer, they have the possibility to wait before answering. For example in (Bacon & Strybel, 2013, P. 92-92) a study using SPAM gives each participant the possibility to have two minutes to answer every question. By having a larger questionnaire pool SAGAT is less biassed compared to SPAM. (Endsley, 2021, p. 127).

SAGAT is supposed to blackout the instruments and screens while the simulation is frozen. This became a problem where the screens in the simulator centre couldn't black these screens out. The first solution was to remove the participants into a new room. The challenges with this is that it will take valuable time to move the participants. During this time they can forget some of the collected data. The second solution was to use a partition wall. This was placed in the back of the simulation room. Behind the partition wall the student had a table, a pen and a light to answer the questionnaires. The partition wall was approximately 1.6 metre tall. Therefore, if the participants wanted, it was possible to look over this wall. This was solved by having one of the researchers stay in the room. Then he could collect necessary data from the equipment and overlook the participants so they don't look over the wall. By having the participants in the room the whole time makes the time from the freezes starting to the time where participants are answering questions much shorter. Possibly making them remember more important information. Endsley tested if the duration for the freezes would affect the study. Up to two minutes she found out that it didn't. (Endsley, 1990, p.93). Therefore, by shortening the stops to the shortest possible so the freezes wouldn't affect the participants.

Multiple articles are combining SAGAT or SPAM questionnaire together with a NASA-TLX or SART questionnaire. These two questionnaires are described in section 3.4.4 & section 3.4.5. Joffe & Wiggins goal with implementing NASA-TLX as a "manipulation check between the periods of lower and higher task demand during the simulated rail control task" (Joffe & Wiggins, 2020, p. 4). By implementing different questionnaires that have already been used in the different areas, will give a new way to compare the different data. Here NASA-TLX measures the workload in 6 different dimensions, being: 'Mental demand', 'physical demand', 'temporal demand', 'performance', 'effort' and 'frustration level' (Trujillo, 2011, p. 7). This can be used to compare the different dimensions measured within the same domain with other studies. By possibly adding NASA-TLX at the end of the case will give the researcher an understanding of how challenging the constructed case is. This questionnaire allows the participants to make their own analysis of the case where the researchers can see if the majority thought it was challenging or not. These questionnaires will help the researcher to understand if a new case is needed because the original case was too challenging or too easy.

SPAM is mostly used for driving and in aviation according to (Endsley, 2021, p. 134). During the second literature search found in appendix B all SPAM articles were studied in the aviation sector, either for air traffic controllers or air traffic management. «The situation present assessment method (SPAM; Durso and Dattel, 2004) is potentially suited to the submarine control room because it measures SA in real-time without freezing task operations» (Loft et al., 2013, p. 35). During (Loft et al, 2013) study found that since SAGAT freezes the simulations it will disrupt the operator from his original task, and limits his/hers work in the submarine control room. «Temporarily removing access to the display would lead to operators' mental picture of the situation being quickly lost» (Loft et al., 2013, p. 35), and therefore chose SPAM. From their understanding people who have a higher understanding of SA will know where to look for the wanted information, and therefore answer every query quicker. (Loft et al., 2013, p. 35). For operations, for example air traffic controller, submarine control room they need to be able to look up information sufficiently within a short amount of time. Therefore this method is well suited for work tasks that require operators to look up information on a screen. In the maritime industry this could for example be used efficiently while measuring SA on vessel traffic service operators. Due to this case being constructed to measure officers of the watch SA, they have an overview of everything that happens within a range of their own vessel.

After analysing both SAGAT and SPAM we will recommend to still measure SA with SAGAT on this case study. The reason for this is because SAGAT has been flexible in the previous case studies. Spam on the other hand has had the most of the studies performed in the ATC. This means that it has usually been used for cases where observation is important. Even though an important part of navigation is observing, it is still necessary to make decisions quickly. SAGAT is also seen as more sensitive than SPAM where it is possible to cover a larger area of questions. This means that SPAM is really suited for cases where it is important to locate different information on for example a control room. Therefore, SAGAT is still the recommended method to use in this case study. The next question to get an understanding for is if SAGAT is a reliable method for this case study.

SAGAT is as stated earlier one of the most widely used methods to measure SA on participants. (Endsley, 2021, p. 126). From previous studies it has also been proven to be reliable, sensitive and valid (Endsley, 2000a, p. 160). In this constructed case SAGAT is found to be a sensitive method, due to the various questions that can be asked. The result in table 9 shows that there is a significant difference compared to the grade the participants are studying. Therefore this method is able to discover these differences in the participants. With a full scale SAGAT case study For this constructed case with the recommended changes, will be well suited for the use of SAGAT.

6.1 Recommended changes for the constructed case

We constructed a realistic simulation after reading a lot of different articles regarding measurement on SA. After our last literature research we found 11 articles that used both SAGAT and SPAM, those are found in chapter 3. After the new literature research we found some parts where we could improve the project, to receive a better result. Many of the SAGAT articles included some time in the beginning to get to know the system prior to starting the actual project. For example in (Falkland & Wiggins, 2019, p. 27) they gave each participant 10 minutes to get familiar with the system, prior to starting the project. Since this was done in multiple different articles, and is reliant with the state of the art found for the usage of SAGAT, we would like to start further away from the actions where the participants can get roughly 10 minutes navigating with the vessel. At this point they would experience a little how the vessel will respond to different commands, and get a little more familiarised with the simulation that they are attending on.

In the first 10 training minutes we would also like to add a stop in the middle where the students can attend a smaller test version of an example SAGAT method. Following the first stop we would let them go through and stop the simulation again where they should begin and do another SAGAT query. This is due to then the participants can get familiarised with both SAGAT queries and the vessel being used for the assignment. After the training phase would stop, all participants should roughly be at the same position, but if there are people that decide to change the speed/course the simulation would be reset so everyone can start at the same position, where toe starting position is at the constructed case.

There are some changes that are wanted to do on the second questionnaire. This stop has the fewest questions regarding SA level 3. This stop is also at the most critical parts. Adding questions such as the next planned course and next planned speed at this location will give an indication if the participants are able to focus on all the important aspects to acquire good SA. Having information about the next planned course before the course is supposed to be changed will help the participants to be ready at the given location. They will also know exactly where the route is planned where it isn't necessary to make an estimate. By making an estimate for what degrees to turn to, it could end up being too much turn or too less where it will be harder to stay out of the shallow waters.

Prior to start the assignment the participants were informed regarding freezes that would occur during the exercise. They received no information on when or why we needed those stops, but they received information on where they should go and answer the query. A different way to reduce their stress level could be giving them more information on what their task is for the duration of the exercise. When the participants receive information prior to starting the simulation, it would be more realistic. This is due to whenever OOW switches they goes through a list that both people agree on. This information can be speed, course etc.

Stress could be a factor that affects the SA on the participants. Therefore a change in the constructed case to help reduce stress is to implement test trials of SAGAT. (Endsley, 2000a, p. 166). By implementing these training trials prior to starting the actual assignment the stress factor of being in a new citation is reduced. This can be a factor of why SA increased for every student found in table 3, 4 and 5. To make the change in this study found in appendix C, the own ship would be placed further north in Haugesund. A possible way to construct this is to make two different scenarios where the first starts further up, where the participant can get familiarised with their own ship, and give them an example on how SAGAT queries work. By running this test version we would remove other traffic that is relevant for the constructed case, and after the test run is completed launch the case where all participants can start on the same starting point again. But the difference here is the participants are familiarised with their own vessel and how SAGAT queries are answered. For the result found in appendix B, some participants had trial tests such as (Bacon & Strybel, 2013, P. 92-92) did a test run for the SPAM method, while the effect of doing it in SAGAT remains the same. SAGAT papers usually implemented practice time prior to starting the freeze.

SAGAT articles have a common factor where they usually give the participants a maximum time to answer each query. For the constructed case in this paper we gave the participants needed time to answer the query. Due to this the participants can spend more time than what (Endsley, 1990) tested to have no impact with up to 2 minutes freezes. This has also been impacted in other papers, such as (Joffe & Wiggins, 2020, p. 5) who implemented 3 minute freezes, and (Hunter et al., 2022, p. 3-4) implemented freezes up to maximum 60 seconds. This helps the participants get fast back to the simulation. By implementing a given maximum time on answering questions makes it easier for the researchers to analyse questions where the participants can't spend 1 minute just pondering over the same question. Therefore we would like to implement a maximum time frame of maximum three minutes.

6.2 Future Research

During chapter 6 discussion, it was found that SAGAT is a reliable method to use for measuring SA on nautical science students. By performing a well constructed GDTA it is proven that SAGAT has potential to be used in many different domains. This includes the constructed case on nautical students. It is therefore recommended to continue this case study in a later stage with a full stage research. This has the possibility to help to understand where the teaching is lacking and where to improve if the questionnaire is constructed properly relative to a proper GDTA.

SAGAT is a flexible method that can adapt into different domains, and can also study team situation awareness (Endsley, 2021, p. 143). This can also be done on students with the same created case located in appendix C. For this to be possible you can have two students on the bridge in the same case. By making one of the students in charge of the exercise simulating an OOW. By running them through the same case, with a new constructed questionnaire to measure their team SA. By measuring team SA it is also possible to research how students are working in a team.

Further research regarding comparing SAGAT and SPAM during the same case study is recommended. This to get an understanding by using two different methods will help understand the participants SA or if this will ruin the validity of the case.

7 Conclusion

Situation awareness has been studied for a long time where it is the precursor to the decision making process (Endsley, 2000b, p. 4-5). SA has been discussed regarding accidents where it is due to SA being one causal factor in all manners of incidents. (Salmon & Stanton, 2013, p. 1). By increasing SA, the DM process can be optimised to make better and faster decisions. This research paper has studied: "How well suited is Situation Awareness Global Assessment Technique as a method to measure situational awareness for students in Nautical Science?" A case study was conducted where SAGAT was used to measure SA on Nautical Science students from Western Norway University of Applied Science. After analysing previous studies regarding SAGAT and SPAM and comparing this to the result it has been determined that SAGAT was the optimal method. Since SAGAT was the best method out of these two it was necessary research if this method is reliable.

SATAT has been used in many domains and is very flexible to the wanted domain. There were a few changes to the constructed case in appendix C that would make SAGAT even more reliable. Therefore, by implementing the recommended changes SAGAT is found to be a suitable method to measure SA on Nautical Science students.

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Appendix A

The first literature search string is located below. This is based on the results found in chapter 2.

Date	Database	Advanced search	Results
08.03.23	ScienceDirect	"situation awareness" AND (marine OR Maritime OR ship OR vessel OR sea OR navigation) NOT (Autonom OR autonomous)	258
08.03.23	ScienceDirect	Title, abstract, keywords:"situation awareness" AND (marine OR Maritime OR ship OR vessel OR sea OR navigation OR offshore) NOT autonomous	108
08.03.23	ScienceDirect	NOT ("team communication")Year:2013-2023Title, abstract, keywords:"situation awareness" AND (marine OR Maritime OR vessel OR navigation OR offshore) NOT (autonomous OR automation OR maintenance)	89
08.03.23	ScienceDirect	NOT ("team communication" OR "eye tracking" OR "virtual reality" OR Surveillance)Year:2013-2023Title, abstract, keywords:"situation awareness" AND (Maritime OR navigation OR offshore) NOT (autonomous OR automation OR maintenance OR military)	50
08.03.23	ScienceDirect	NOT ("team communication" OR "eye tracking" OR "virtual reality" OR Surveillance)Year:2013-2023Title, abstract, keywords:"situation awareness" AND (Maritime OR navigation OR offshore) NOT (autonomous OR automation OR maintenance OR military OR drill)Title:“International Journal of Human-Computer Studies” OR “Accident Analysis & Prevention” OR “Energy Research & Social Science” OR “Expert Systems with Applications” OR “Procedia Manufacturing” OR “Safety Science” OR “Ocean Engineering”	22
08.03.23	ScienceDirect	Year:2013-2023Title, abstract, keywords:"situation awareness" AND (Maritime OR navigation OR offshore) AND (questionnaire OR simulator OR simulation OR survey) NOT Autonomous	12
12.03.23	ScienceDirect	Search descriptionYear:2013-2023Title, abstract, keywords:"situation awareness" AND (maritime OR ship OR vessel OR marine OR sea)Title:NOT autonomous	10

Table 10 First litterature search..

Year	Author(s)	Title
2015	Sandhåland, H., Oltedal, H. & Eid, J.	Situation awareness in bridge operations - A study of collisions between attendant vessels and offshore facilities in the North Sea
2016	Nordström, J., Goerlandt, F., Sarsama, J., Leppänen, P., Nissilä, M., Ruponen, P., Lübcke, T. & Sonninen, S.	Vessel TRIAGE: A method for assessing and communicating the safety status of vessels in maritime distress situations
2017	Sandhåland, H., Oltedal, H., Hystand, S. W. & Eid, J.	Effects of leadership style and psychological job demands on situation awareness and the willingness to take a risk: A survey of selected offshore vessels
2017	Sætrevik, B. & Hystad, S. W.	Situation awareness as a determinant for unsafe actions and subjective risk assessment on offshore attendant vessels
2017	Cordon, J. R., Mestre, J. M. & Walliser, J.	Human factors in seafaring: The role of situation awareness
2018	Grabowski, M., Rowen, A. & Rancy, J. P.	Evaluation of wearable immersive augmented reality technology in safety-critical systems
2019	Sharma, A., Salman, N. & Ernsten, J.	Situation awareness information requirements for maritime navigation: A goal directed task analysis
2020	Huang, Y., Chen, L., Chen, P., Negenborn, R. R. & van Gelder, P. H. A. J. M.	Ship collision avoidance methods: State-of -the-art
2020	Andreassen, N., Borch, O. J. & Sydnes, A. K.	Information and emergency response coordination
2020	Lahtinen, J., Valdes Banda, O. A., Kujala, P & Hirdaris, S.	Remote piloting in an intelligent fairway - A paradigm for future pilotage

Table 11 Result of the first literature search.

Appendix B

This literature search was constructed to find further information regarding the methods used to measure SA in a simulation based on students.

Date	Database	Advanced Search	Results
13.03.23	ScienceDirect	Search descriptionSAGAT OR SPAMYear:2013-2023Title, abstract, keywords:"Situation Awareness"	165
13.03.23	ScienceDirect	Search descriptionSAGAT OR SPAMYear:2013-2023Title, abstract, keywords:"Situation Awareness" AND Student	27
13.03.23	ScienceDirect	Search descriptionSAGAT OR SPAMYear:2013-2023Title, abstract, keywords:"Situation Awareness" AND student NOT nurse NOT nursing	15

Table 12 Second literature search.

These 15 articles were studied further, where the abstraction and research question was analysed. Out of these 15 documents 11 were relevant for this case study. The remaining 4 were found to not be relevant for this study. The 11 articles relevant for this study are located below.

Year	Title	Author(s)
2013	Assessment of the validity and intrusiveness of online-probe questions for situation awareness in a simulated air-traffic-management task with student air-traffic controllers	Bacon, L. P. & Strybel, T. Z.
2015	May I interrupt? The effect of SPAM probe questions on air traffic controller performance	Keeler, J., Battiste, H., Hallet, E. C., Roberts, Z., Winter, A., Sanches, K., Strybel, T. Z., & Vu, K. P. L.
2016	Validation of "alarm bar" alternative interface for digital control panel design: A preliminary experimental study	Vu, X., Yuan, X., Li, Z., Song, F. & Sang, W.
2016	A Comparison of Methods For Assessing Situation Awareness in Current Day and Future Air Traffic Management Operations: Graphic-Based vs Text-Based Online Probe Systems	Strybel, T. Z., Chiappe, D., Vu, K. P. L., Miramontes, A., Battiste, H. & Battiste, V.
2018	Selecting trainee pilots: Predictive validity of the WOMBAT situational T awareness pilot selection test	Caponecchia, C., Zheng, W. Y. & Regan, M. A.
2019	Cross-task cue utilisation and situational awareness in simulated air traffic T control	Falkland, E. C. & Wiggins, M. W.
2019	Situational awareness measurement in a simulation-based training framework for offshore well control operations	Raza, M. A., Salehi, S., Ghasal, S., Ybarra, V. T., Naqvi, S. A. M., Cokely, E. T. & Teodoriu, C.
2020	Cross-task cue utilisation and situational awareness in learning to manage a simulated rail control task	Joffe, A. D. & Wiggins, M. W.
2021	Do paramedic students have situational awareness during high-fidelity simulation? A mixed-methods pilot study	Hunter, J., Porter, M., Phillips, A., Evans-Brave, & Williams, B.
2022	Investigating traffic and controller factors in spatial multitasking: The context of air traffic conflict resolution	Trapsilawati, F., Prastiwi, P. B., Vista, Y., Myesha, Z., Herliansya, M. K. & Wijayanto, T.
2022	Can a targeted educational approach improve situational awareness in paramedicine during 911 emergency calls?	Hunter, J., Porter, M., Cody, P. & Williams, B.

Table 13 Result on second literature search.

Appendix C

Below is a detailed construction of the case that was used. Why the vessels were chosen, and location for where the vessels were.

Construction of the Case

The purpose of the simulation performed is to test the students SA. Therefore, one of the challenges we were facing is to create a realistic simulation that could occur at the sea. To create a realistic case we got help from a previous Captain Vigleik Storesund. The first decision we're facing was to determine the ship to use during the simulation.

In this case study there were in total three different vessels that were up to debate to use for the students. The first vessel was a vessel called Ellen Knutsen. This vessel is used by the nautical science students, meaning that they are familiar with how this ship operates.This is a vessel with a length of 141 metre long and sailing in ballast loading condition. The top speed of this ship is 14kn. The advantages for using this vessel was that since the top speed of this vessel is only 14kn the navigators have more time to evaluate their decisions before they are made. A downside for this vessel is that it is a really long vessel. So for the 1st year students it could be hard if they weren't experienced with this vessel from before.

The second ship that was tested was a smaller tanker called Bow Master of 100 m with a top speed of 14 kn. The students have to some sorts tested this vessel before, but not as much as Ellen Knutsen. The advantages of using Bow Master as its own ship is that it was much smaller than Ellen Knutsen. When testing this vessel we experienced gaining approximately the same view over our surroundings as we did with Ellen Knutsen. The disadvantage was that this ship was sailing in fully loaded conditions, meaning that it felt like this was much harder to navigate even though it was a smaller ship. Due to the added weight in the cargo the vessel took a longer time to reach with every manoeuvre that was made. Therefore, this vessel was not used in this study.

The last vessel tested is a high speed vessel from the navy. That vessel was approximately 50 metres long and had a top speed of 32 knots. The advantages to use this vessel is that the vessel can manoeuvre very easily with the small hull size and the fast speed. The disadvantage for using this vessel was focus on the surroundings, here we used a lot higher speed which made it harder to see your surroundings as well as previously done with Ellen Knutsen or Bow Master. This vessel is not either used in the nautical science study, while it have been used for students that have met up some afternoon to use the simulator then. The vessel wasn't chosen due to it being hard to follow your surroundings, and the vessel hasn't been used in the curriculum for the nautical science degree.

The decided ship was Ellen Knutsen. The length over all is 141.5m, with a beam of 23.0m, depth fore at 4.06m and depth aft 5.95m. The reason for choosing this vessel was because of the prior cases this vessel was used. Out of the two product tankers it is the vessel that felt easiest to manoeuvre in the given area. The location was selected to Haugesund because of the location of the university. This is a location that at least some students have tried during their bachelor degree depending on which year they are in. It is also an area where the students should be familiar with. The entrance to Haugesund does have a radar beacon to locate during the voyage. This gives the students more elements to focus on while sailing. The date decided is set to be 10th april 2023 due to this date being close to the time the students will partake in the simulation. The time of day is 22:00 which makes it possible to locate lanterns in the simulator because of the darker scene during the simulation.

SA will be measured by using the students' knowledge from lanterns, the students capability to use technical equipment, their understanding of their own and other ships, and how they manage to comprehend messages given over the VHF. The reason for why these aspects are chosen to be the focus point during the SAGAT simulation is because these elements are part of the education system for the Nautical Science Bachelor degree. Therefore, by analysing the results from these aspects it will be possible to understand how the impact of the education is and how prior experience will influence the students thinking and DM process. A possible landmark to identify on the RADAR is a radar beacon that transpond the letter 'T' in morse code. On the radar screen it shows a long line indicating the letter T. This landmark helps the officer to get a reference point for locating their positioning.

Fishing Vessels

The first vessel of importance is a small fishing vessel located in front of your own ship (OS) sailing north. The reason for why a small fishing vessel was used is because these vessels don't have AIS on board. Meaning that this fishing vessel needs to be plotted manually. This vessel isn't interfering with the planned route. The important part to notice is International Regulations for Preventing Collisions at Sea rule 18. Responsibilities between vessels. This rule states that a power driven vessel like the OS shall keep out of the way of fishing vessels among other vessels. Except if rule number 9, 10 and 13 is applied. These three rules are regarding narrow channels, Traffic separation schemes, and overtaking. (Lloyd’s Register, 2009, p. 30).

Another fishing vessel has planned a trip towards Haugesund and is travelling approximately the same speed and course located north of OS. This vessel won't either interfere with the passage plan for OS but it is according to the former captain Vigleik Storesund important to know possible vessels that may overtake OS leading to the OS needs to keep his course and speed. With this fishing vessel we can identify if the students are capable of getting an overview of their surroundings even if the target is located behind their vessel. This fishing vessel is visible on both RADAR and AIS. This vessel is important to use due to the persons SA and DM regarding if the vessel is overtaking you or not.

Edda Flora

Edda Flora is a vessel that we used to see if the students have any knowledge of what the lanterns mean and this can be predicted to their future. This vessel shows lanterns that the vessel has poor manoeuvrability, this means that all other vessels need to yield for this vessel. This vessel is visible from the beginning of the simulation and is during the entirety of the simulation laying still in one position. Here the students can either locate the vessel on ECDIS to see that the vessel is laying still, RADAR or visual. Since this vessel isn’t able to manoeuvre well, it is important that the students can identify this and take the necessary precautions if necessary. If this vessel was moving the OS would need to steer away from this vessel. Since Edda Flora is located to the port side this vessel is supposed to deviate from their course if they are on collision course. In this case the students would have to interfere with their course if they’re on collision course.

Stavangerfjord

Stavangerfjord is a passenger ferry that is sailing northbound in Karmsund. This passenger ferry will meet OS at the most critical point during this voyage if the students remain with the starting speed at approximately 14knt’s. But after the first turn the speed is planned into 10knt’s. When the students reduce their speed Stavangerfjord will be passed the critical point when they meet. Another aspect used to understand the students SA is to understand their navigation. Do they stick to the planned route, do they deviate from the planned speed / Course? By adding this ship it will give indications if the students manage to keep their attention on multiple parameters and comprehend all the information they're gathering at the given time.

Tug

During the later part of the simulation the students will also locate a tug. This tug is shown both on the AIS that is telling them that they are towing a vessel. The tug is currently towing a vessel at 6 knots going northbound in the Karmsundet, which the students will meet at the end of the simulation. If the students have the knowledge about its lantern they can find information that the tug is towing a vessel over 200 metres behind itself. This is important information to the OS to figure out how they should manoeuvre around the vessel. For SA it is important because while towing a vessel with a longer line it needs more space to manoeuvre safely compared to shorter lines. If the students don't know the meaning of the lanterns in use there is a Norwegian book called 'sjøveisreglene' to help the students understand the lanterns. This book is translated from the International Regulations for Preventing Collisions at Sea, with the Norwegian distinctive rules.

Volga

The last vessel that the students are going to come across is Volga. This vessel is drifting after the tugboat and is also heading north in Karmsundet. If the simulation were to continue this vessel would interfere with the planned passage plan, therefore the students need to be able to plan out a possible route correction to move past this vessel. With this vessel we would also be able to measure if they can recognise a possible threat towards their sailing route. The simulation is planned to stop prior to passing Volga. This vessel is important to use to see if the students SA can identify that Volga is getting too close to the planned path, and can therefore predict the future and find a possible deviation safe from Volga.

Other vessels

Common during a voyage there are areas where there are a lot of types of vessels around you. Therefore, there is also a vessel that is passing OS in the beginning of the voyage to indicate if the student can identify that this vessel is no longer important. Since its passing and the vessel is continuing north towards Bergen they won't have to know much about this vessel. With discussion with Vigleik Storesund he informed us that this vessel doesn't require much attention. There will also be a cruise ship that is moored alongside the pier of Haugesund. On the cruise ship there are no lanterns indicating that the vessel is moored to the pier.

Communication

A VHF message would be heard over the radio letting OS know there is a floating container spotted 0.5 nm south of Karmøy bridge. This message will be read to see if the students can comprehend all the information that is affecting their route. This will be given during the most critical part of the simulation to simulate a hectic workload. The message sent is according to the IMO Standard Marine Communication Phrases (SMCP) standards (sjøfartsdirektoratet, 2014, pp 78 & 250) & (UK Hydrographic Office, 2019, p. 113). The message is as follows:

“Securite securite securite
All ships all ships all ships
This is 273350780 Volga Callsign: UBHJ2
One container observed adrift in the vicinity 1 nm south of Karmøy bridge at 22:07 local time.”

Another message that's being read to the students during the first five minutes is regarding the ship Belinda which is a Norwegian vessel. Therefore since this is in the norwegian waters the message will be spoken in norwegian. A translation of the message will follow below.

“B: Kvitsøy VTS dette er Belinda
Ber om tillatelse for å seile fra Haugesund havn retning Stavanger
K: Belinda dette er Kvitsøy VTS
Det er mottatt dere kan starte seilasen”

“B: Kvitsøy VTS this is Belinda
Asking for permission to leave Haugesund port direction Stavanger
K: Belinda this is Kvitsøy VTS
Its received you can start your voyage”

Appendix D

Appendix D shows the participant consent form given to the students prior to starting the assignment.

Participants Consent form

This is a consent form for a master degree in Maritime Operations regarding two students for the use of a simulator exercise. This exercise was created by Jarle Alvik and Rolf Aalvik with the help of Vigleik Storesund as technical help. By consenting to this form you are consenting to the following:

This exercise is voluntary and the participants can leave the project without any reasons at any point during the exercise. The data collected during the exercise will be removed from the project and shredded.

All data is anonymous during this project. Meaning that personal information is not going to be used in this project. The Participant Consent form is the only time the signature and name is necessary. The pile of Participant Consent form will be located on a secure position and shredded after the master thesis is submitted and graded. This will not at any point be located together with the collected data.

To keep the results of this study reliable you are unable to discuss this exercise with any students. The reason for this is because this could affect the new student to go into this simulation knowing what we are looking into.

All collected data from this project will be shredded after the project is submitted and graded. The submission is at 02.06.23 and will be shredded when the results are back.

If you have any questions regarding the project you can contact us at either of these following methods

Jarle Aalvik jarleaa@hotmail.no 99371488
Rolf Aalvik rolfaa@hotmail.no 99371457

____

Full name

____

Signature Date Place

Appendix E

In appendix E all questions asked during the entirety of the SAGAT are collected into one questionnaire pool. From this questionnaire pool questions are selected at each given stop in the simulation. To prevent students from memorising the questions at each of the stops, none of the questionnaires are the same. Appendix E will be used to compare the results for after the simulation to understand what the students pay attention to regarding level 1, 2, and 3 of SA.

SA level 1

What is your current speed?

What is your current planned course?

What is your current under keel clearance?

What is your current vector length on the ECDIS?

What are your current range settings on RADAR?

What are your current range settings on the ECDIS?

What is your planned speed for this leg?

Where is the closest vessel located according to your own ship heading? (North being your heading)

N NE E SE S SW W NW

What is the current wind direction?

What VHF radio channel are you listening to? (DW = Dual Watch)

16 17DW 17 19DW 21DW

At what time was the floating object first observed?

Which ship sent the securite message for the floating container?

Are there any vessels observed in the near proximity that have a different navigational state than power driven vessels underway?

Did you notice any current?

SA level 2

Is your ship deviating from the Off track limit? If so, which direction?

NO Port Starboard

If you're deviating from the course, how much are you deviating from the off track limits?

What does the lantern on the tug mean?

What is the difference between your current speed compared to the planned speed?

Which letter did the radio beacon send out on the RADAR?

What light characteristic does the radio beacon send out?

3 short 3 long (1 long 1 short 1 long) (1 short 1 long 1 short)

Where was the drifting container first spotted?

What direction is the vessel leaving port travelling towards?

North South

If you registered any current, what direction?

N NE E SE S SW W NW

Mark the ships around you with a radius of approximately 1.0nm. Given your own ship in the centre.

Draw roughly the direction of the vessels heading.

Did you notice if any of the four lighthouses was defective?

YES NO

Are there any vessels observed in the near proximity that have a different navigational state than power driven vessels underway?

Yes No

If so, which vessel?

Meløyfjord Northern Expedition Edda Flora Stavanger Fjord No

At any stage, were you uncertain about either the reliability or the relevance of the information you had available?

Yes No

Was there any stage during the decision making process in which you found it difficult to process and integrate the information available?

Yes No

If yes, which situation?

What VHF channel did you receive information regarding the vessel leaving port?

16 19 21 17

What VHF channel did you receive information regarding the floating container?

16 19 21 17

If yes, what kind of lanterns do the vessel use?

What direction would you most lightly expect the container drifting toward? given wind as the only influence

N NE E SE S SW W NW

Do you have a crossing course with the tug Alert?

Yes No

Do you have a crossing course with Volga?

Yes No

SA level 3

What's the next planned course?

What’s the next planned speed?

Will the floating container be relevant for your planned course during the next 5 minutes?

Yes No

Will any of the vessels around you have a collision course if no action is taken in the near future?

What is the ETA for the next waypoint?

If any, which vessel would have a collision course with your own vessel if no action is taken during the next 2 minutes?

Quickly mention what is important to take into consideration if the simulation continues?

Appendix F

In appendix F is the questionnaire that is asked during the first freeze in the SAGAT simulation.

First questionnaire

What is your current year during this study?

☐Nautical Science year 1 ☐Nautical Science year 2 ☐Nautical Science Year 3

Have you had previous experience working on the sea?

☐Yes ☐No

Do you have previous experience on the bridge Antares?

☐Yes ☐No

What is your current speed?

What is the next planned speed?

What's your current planned course?

What's your next planned course?

Where is the closest vessel located according to your own ship heading? (N being your heading)

☐N ☐NE ☐E ☐SE ☐S ☐SW
☐W ☐NW

What is the current wind direction?

☐N ☐NE ☐E ☐SE ☐S ☐SW
☐W ☐NW

Are there any vessels observed in the near proximity that have a different navigational state than power driven vessels underway?

☐Yes ☐No

If so, which vessel?

☐Meløyfjord ☐Northern Expedition ☐Edda Flora ☐No

If yes, what kind of lanterns do the vessel use?

Will any of the vessels around you have a collision course if no action is taken in the near future?

☐Yes ☐No

Which letter or symbol did the racon send out on the RADAR?

What light characteristic does the racon send out?

☐3 short ☐3 long ☐1 long ☐1 short ☐(1 short 1 long 1 short)

What VHF radio channel are you listening to? (DW = Dual Watch)

☐16 ☐17DW ☐17 ☐19DW ☐21DW

What is your current vector length on the ECDIS?

What are your current range settings on the RADAR?

What are your current range settings on the ECDIS?

What is the ETA for the next waypoint?

Mark the ships around you with a radius of approximately 1.0nm. Given your own ship in the centre.

Draw roughly the direction of the vessels heading.

Δ

Appendix G

In appendix G is the questionnaire that is asked during the second freeze in the SAGAT simulation.

Second questionnaire

What is your current year during this study?

☐Nautical Science year 1 ☐Nautical Science year 2 ☐Nautical Science Year 3

Have you had previous experience working on the sea?

☐Yes ☐No

Do you have previous experience on the bridge Antares?

☐Yes ☐No

Did you notice if any of the four lighthouses was defective?

☐YES ☐NO

What direction is the vessel leaving port travelling towards?

☐Northbound ☐Southbound

What VHF channel did you receive information regarding the vessel leaving port?

☐16 ☐19 ☐21 ☐17

What VHF channel did you receive information regarding floating containers?

☐16 ☐19 ☐21 ☐17

Is your ship deviating from the Off track limit? If so, which direction?

☐NO ☐Port ☐Starboard

What is your current under keel clearance?

What is the difference between your current speed compared to the planned speed?

Will the floating container be relevant for your planned course during the next 5 minutes?

☐Yes ☐No

What is your planned speed for this leg?

What is your current vector length on the ECDIS?

What are your current range settings on RADAR?

What are your current range settings on the ECDIS?

Are there any new vessels observed in the near proximity that have a different navigational state than power driven vessels underway?

☐Yes ☐No

What is the ETA for the next waypoint?

Mark the ships around you with a radius of approximately 1.0nm. Given your own ship in the centre.

Draw roughly the direction of the vessels heading.

Δ

Appendix H

In appendix H is the questionnaire that is asked during the third freeze in the SAGAT simulation.

Third questionnaire

What is your current year during this study?

☐Nautical Science year 1 ☐Nautical Science year 2 ☐Nautical Science Year 3

Have you had previous experience working on the sea?

☐Yes ☐No

Do you have previous experience on the bridge Antares?

☐Yes ☐No

What direction would you most lightly expect the container drifting toward? given wind as the only influence?

☐N ☐NE ☐E ☐SE ☐S ☐SW
☐W ☐NW

Where was the drifting container first located?

What does the lantern on the tug mean?

If you registered any current, what direction?

☐N ☐NE ☐E ☐SE ☐S ☐SW
☐W ☐NW

At what time was the floating object first observed?

Which ship sent the securite message for the floating container?

Do you have a crossing course with the Tug Alert?

☐Yes ☐No

Do you have a crossing course with Volga?

☐Yes ☐No

What is your current vector length on the ECDIS?

What are your current range settings on RADAR?

What are your current range settings on the ECDIS?

Is your ship deviating from the Off track limit? If so, which direction?

☐NO ☐Port ☐Starboard

If you're deviating from the course, how much are you deviating from the off track limits?

Are there any new vessels observed in the near proximity that have a different navigational state than power driven vessels underway?

☐Yes ☐No

What is the ETA for the next waypoint?

Are there any vessels that would have a collision course with you if no actions were performed?

Quickly mention what is important to take into consideration if the simulation continues?

At any stage, were you uncertain about either the reliability or the relevance of the information you had available?

☐Yes ☐No

Was there any stage during the decision making process in which you found it difficult to process and integrate the information available?

☐Yes ☐No

If yes, which situation?

After your own opinion do you think these stops affected your decision making process?

Mark the ships around you with a radius of approximately 1.0nm. Given your own ship in the centre.

Draw roughly the direction of the vessels heading.

Δ