University of South-Eastern Norway

AIS Visual Communication

The next step

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Abstract

The purpose of AIS Visual Communication is to improve and simplify the user interface of ECDIS by displaying information about navigational status from AIS with lantern symbols on the screen. Telko AS, the company behind TECDIS, developed new software that displays lanterns in the AIS symbols, for use in this research project.

The software was installed on a desktop navigation simulator at the University of South-Eastern Norway (USN). An experiment was developed to investigate whether the new user interfaces could contribute to improved situational awareness and reduced workload compared to the current user interfaces.

The university's nautical students from 2nd and 3rd grade were invited to participate in the experiment. The experiment used the well-known methods Situation Awareness Global Assessment Technique (SAGAT) and National Aeronautics and Space Administration Task Load Index (NASA TLX). In addition, interviews were conducted with all participants. The results of the experiments led to a clear conclusion.

Keywords: *Visual Communication, Situation Awareness, Workload, Safe navigation.*

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1 Introduction

Automatic Identification System (AIS) originated as an anti-collision aid for ships. Vessels with AIS equipment onboard transmit and exchange information such as their identity, position, speed and course over frequencies on the VHF band. Vessel Traffic Service (VTS) centres also use AIS to keep track of the vessels within its areas of responsibility. In a not too distant future, it may also become an essential aid for navigators who monitor a group of autonomous ships from shore control centres.

Today the navigator get the AIS information on the screen in the form of a triangular symbol. If navigators want to know more about the object's navigational status, they can "track" it, and they get the information displayed outside the radar image, or they can on some models right-click the object, and get a menu selection, which they can click into further. Besides, there is a separate AIS terminal on the bridge. In the real world, the ships communicate this information through its lanterns and its day signals. These signals defined by *"Regulations for preventing collisions at sea (Rules of the Road at Sea)"* short named Colreg are universal; they have the same design and meaning in all the worlds languages (Johansen, 2017).

The idea of using lantern configurations on the AIS symbols was conceived by the author during an exercise on a navigation simulator in autumn 2015 with very demanding conditions and reduced visibility. It came in a vision as a result of a high workload and a high degree of frustration. Shortly after the simulator exercise, the author created a simple illustration in Excel that visualised the idea in the form of a radar image with AIS symbols with lantern configurations for different navigation statuses. The illustration that showed the idea was presented to students and experienced navigators to get feedback on what they thought of this. What happened when they saw the illustration was not as expected, they said nothing about the use of lanterns in the AIS symbol; however, they instead began to analyse the situation they saw in the radar image. Only on direct questions about the use of lanterns, they noticed this new aspect of the symbol. The author thought this was very exciting and interesting. After some time, it became clear that this should be the research topic in the authors Bachelor thesis.

This Master's thesis, which is a continuation of the research from the author's Bachelor thesis, is about how AIS information, with the primary emphasis on how navigational status, is presented under sailing in the ECDIS displays and ARPA radar, on a vessel with integrated bridge systems. (Johansen, 2017).

The previous Bachelor thesis aimed to investigate whether the use of visual communication can improve information from AIS on ships with integrated bridge systems. In this context, visual communication involves placing lantern configurations, for navigation status, on the AIS symbol. The question posed through a questionnaire was whether the navigators thought the idea of lantern configurations on the AIS symbol could lead to better situational awareness, reduced mental workload and increased navigational safety. Presentation of information and the navigator's ability to interpret received information is the central theme of this thesis on AIS and the use of visual communication.

This type of visual communication, in addition to what we already have today, might be a safety enhancement, of how AIS information; is presented, communicated, and implemented into the navigation. Visualisation of a ship's relative size shown in the right scale related to the radar's "range" in narrow waters and reduced visibility, is something that may also be beneficial in the same matter. The latter is already available in ECDIS. Other important matters are the use of colours on the AIS symbols. What will be investigated is whether the use of lantern configurations on the AIS symbol, limited to the predefined signals set by IMO, will give the individual navigator the opportunity to intuitively and at once, get a better overview and a better awareness of what situation he or she are surrounded by, at any given time.

After seeing the results and feedback completing the previous research project, a good picture of what Norwegian navigators think about the use of symbols for the dissemination of information and about the idea, "AIS Visual Communication" has emerged. The majority of the population, which represented Norwegian navigators in the study, answered a clear yes that they believed this could be a beneficial aid. The author found that this was an idea that might have great potential moreover, that it was essential to develop it further with a prototype and with more thorough research using simulator tests to find out whether this new way of presenting information with symbols really could be a better and safer way to communicate relevant and vital information.

This thesis intends to disclose whether the use of "AIS Visual Communication" as previously described can cause navigators to experience reduced workload and increased awareness of their surroundings under challenging conditions while sailing moreover, whether this new way of presenting information might contribute to increased navigational safety. In order to answer the research questions, this project proceeded to the next step in the development of "AIS Visual Communication”. An experiment, using a functional prototype program developed in collaboration with Telko AS for their version of ECDIS called TECDIS, were performed on a desktop navigation simulator. Technical expertise at the University of South-Eastern Norway (USN) installed the program.

1.1 **Research questions**

Contrary to the first project questioning what the respondents thought about the idea of AIS visual communication, this project aims to find out whether the use of lanterns in the AIS symbol, actually will lead to increased situational awareness and reduced workload, and whether this will lead to increased navigational safety or not.

The research questions are:

Will the use of “AIS Visual Communication” lead to;

1. Increased situational awareness?
2. Reduced workload levels?
3. Increased navigational safety?

2 Theory

This chapter consists of three main parts. The first part includes a literature review of various aspects of AIS on ships and the results from previous research on AIS Visual Communication. In the second part, the author presents technical and regulatory conditions and the design and development of the new AIS symbols with lanterns. In the latter part, the author will show the most relevant literature on situation awareness and workload that is important to this thesis.

2.1 AIS technology and its limitations.

In international traffic, it is a requirement that all passenger ships carry AIS. In domestic traffic, passenger ships of 300 gross tonnage or more and passenger vessels with a gross tonnage of 150 or more when capable of achieving a speed above 20 knots shall carry AIS. Cargo Ships whit a gross tonnage larger than 300, mobile units and fishing vessels longer than 15 meters shall all have AIS installed. The requirements for AIS do not apply to cargo ships with gross tonnage below 500 in the trading areas 1 and 2. It is also a requirement that AIS must be in operation at all times. Except when there is a danger to the vessel's safety. These requirements are all regarding class A-AIS (NMA, 2012, 2014).

AIS provides information about the vessel's identification, position, course and speed, as well as destination, estimated time of arrival, navigation status and other information (Kjerstad, 2010). It can provide this information from ships to ships or from ships to shore. AIS transponders exchanges information over two VHF frequencies using the "Self-Organized Time Division Multiple Access" (SOTDMA), this requires a common timing source and is why AIS relies on Global Navigation Satellite System (GNSS) (IMO, 1998, 2001; ITU, 2014; Selivanova, 2016). Therefore, the loss of GNSS will affect not only the vessel's reported position but also the synchronisation of data between AIS transponders. Besides class A-AIS which transmits and receives messages, there are class B-AIS for leisure and other use which usually only receives messages, and the latter comes in two types B-SO and B-CS. B-SO is transmitted using SOTDMA and B-CS which use “Carrier Sense” TDMA. B-CS equipment is usually less expensive and less capable than B-SO equipment (USCG, 2018). Although AIS transponders primarily use GNSS for slot timing, they can still work with a base station for synchronisation. However, as long as they rely on the GNSS position, errors or omissions in the GNSS service will render AIS unusable. An alternative and redundant source of Position, Navigation and Timing (PNT) may be e-Loran (Grant et al., 2009).

The GNSS systems today consist of the US "GPS" which has been operational since 1995. From 2011, the Russian GNSS system "GLONASS" has also been operational. We also have the EU's "Galileo" and China's "BeiDou". The latter two are not operational yet. Using a multi-constellation GNSS receiver, one will be able to utilise several of the systems because they use UTC for their system time and because they have virtually the same coordinate systems (Sulen, 2016). Several independent GNSS systems and the use of multi-constellation receivers will provide a more robust and redundant system in the future. However, it will not eliminate the vulnerability of the systems. The weakest link in this is the signal strength, the signals are weak, and signals at different frequencies can interfere with each other and create problems for calculating position. Atmospheric disturbances, antenna errors, the icing on antennas, or antenna cable failure can cause positional errors or loss of GNSS signal, which may result in poor satellite geometry and increased values in Horizontal Dilution of Precision (HDOP), which means positional margin of error in the horizontal level (IMO, 1998; Kjerstad, 2010; Sulen, 2016). The weak signal strength also makes the system vulnerable to deliberate manipulation through so-called jamming and spoofing, or misleading position (Glomsvoll, 2016; Grant et al., 2009; Kjerstad, 2010). Recent discoveries show that LED lights may disturb the VHF signal and cause a reduced range of the VHF (USCG, 2019).

AIS is not a perfect tool. It produces information based on sensors, from GNSS, log and gyro (Kjerstad, 2010, 2012). Some of the information transmitted must be manually entered. The recipient of the information has no way of controlling the integrity of this information or sensors from which the information comes. AIS information must be double-checked against information from other sources, such as the ARPA radar (Kjerstad, 2012; Stitt, 2004).

Today, AIS is not directly subject to Colreg and is only considered an aid. Colreg rule 5, on the other hand, clearly states that we should avoid collisions with all available aids. AIS is such an aid (Nyhamn, 2017; Stitt, 2004).

There are several navigation status options for use in dynamic messages, some of which indicate privileged status, while others do not. These options cover most situations where Colreg specify lantern configurations and day signals (Stitt, 2004; USCG, 2017). The biggest problem associated with the navigational status transmission is that it is optional and must be manually entered (Kjerstad, 2010; Stitt, 2004). In addition to oversight, this can open up the possibility of deliberate misappropriation of privileged navigational status (Salinas et al., 2012).

AIS has the potential in itself to be a useful aid if appropriately used. Nevertheless, the reality is that in many cases, the information given is directly misleading; this is especially dangerous if AIS information is to be trusted under, critical conditions when visibility and radar detection capability is limited (Bailey, 2005). If AIS is to be a useful tool for making decisions on the bridge, regarding navigation, the main focus area must be linked to proper installation, integration with other navigation equipment and the accuracy of manual data fed into the system (Transport Canada, 2016), presentation of information and the bridge team's ability to interpret received information. (Harati-Mokhtari et al., 2007).

2.2 AIS Visual Communication. Previous research.

The previous research project examined whether using visual communication improves information from AIS on ships with integrated bridge systems. In order to answer the research questions, first, it scrutinised what relationship the navigators had to the system as it is today and what experiences they had made so far. In order to assess the answers they gave about the idea AIS Visual Communication, it was the essential first try to get a picture of the level of knowledge they had, concerning Global Navigation Satellite Systems (GNSS) in general, and to GNSS-based tools (Johansen, 2017).

They were presented with an idea, visualising information, in addition to how the information is displayed today. There was, therefore, no basis for directly asking questions whether this would lead to increased situational awareness and increased safety. On the other hand, it was appropriate to ask the question of what the respondents thought about what visual communication could lead to by reduced workload, improved situational awareness and what they thought it would possibly result in regarding increased navigational safety (Johansen, 2017).

Based on a literature review, a quantitative survey was prepared, which intended to investigate the population of Norwegian navigators. The study was three folded, where the first part emphasised on clarifying population demographic data, in the second part the focus was on which experiences and views the navigators had about GNSS in general and about AIS as a GNSS based aid. In the third part, it examined what opinions and views they had on the idea of AIS Visual Communication. It analysed workload conditions using a modified version of the NASA TLX method (Johansen, 2017).

The survey, distributed to a few Norwegian shipping companies and presented publicly through the Facebook pages of the Norwegian Maritime Authority (NMA) and the Norwegian Maritime Officers' Association (NMOA), revealed some exciting findings of navigators' knowledge of GNSS and GNSS based aids, and it led to a definite conclusion regarding the use of Visual Communication (Johansen, 2017).

The demographic part of the survey was subject to categorical questions about the respondents; this was important in order to get the best possible picture of the participants' background and level of experience. There was no possibility of checking who answered the survey. Some control criteria were introduced, which led to respondents who, by their answers, showed that they did not belong to the target group, were thanked politely out of the survey (Johansen, 2017).

The respondents divided into age groups; 18–29, 30–39, 40–49, 50–59 and 60+. Professions: Student / Cadet, Third mate, Second mate, Chief mate, Captain, Pilot and Teacher in Nautical science. Certificates of Competency: Deck Officer Class 1, 2, 3, 4, 5 and not relevant. Experience as a Navigator: Less than 1, 1-4, 5-9, 10-14, 15-19, 20-24 and 25 + years. Experience with AIS: Less than ten years or more than ten years. The distribution included men and women (Johansen, 2017).

The survey took place in the period from March 16th to April 10th, 2017. Very few shipping companies responded on the request to distribute the survey to their navigators. In those cases where they did, very few navigators responded to the survey. It was from the posts, the NMA and the NMOA had on their Facebook pages the survey received a response. Another effect was that different Facebook groups directly related to the industry shared the posts. This sharing gave a further response. After a thorough review of all response data, the author removed respondents with incomplete response forms. Some respondents, who had completed the survey in their entirety, were eliminated. In the question batteries they had ticked off, as an example; 0% load, on all NASA TLX variables. Four hundred forty-one respondents answered the survey. After a thorough review, there were finally 200 respondents left for the analyses, from a population set at 6000 according to figures from the NMOA. An online calculator for confidence calculations was used (Aksnes, 2017). A 95% confidence level has a margin of error of 6.8% (Johansen, 2017).

Based on the navigators' demographic data, it appears that the survey received a reasonable and representative sample from the population of Norwegian navigators. It provided a good starting point for further assessments of the experiences they had developed until now with GNSS and GNSS-based tools (Johansen, 2017).

Regarding the respondents experience with AIS until today, the second part of the survey gave a clear picture of what experiences the navigators had made so far. About two-thirds of the respondents had experienced a loss of the GNSS signal and changed HDOP values (Kjerstad, 2010). However, one-third claimed they had not experienced a loss of signal or experienced altered HDOP values. When it comes to controlling the system position against bearings, optical or radar, to determine the accuracy of the GNSS position, two-third said they practise this; while one-third said they do not. Another way to monitor the quality of the position from GNSS is to use the "Coast Contour" function in radar. It requires that they have a "chart" radar, and here about one-third replied that they use this aid. Controlling AIS against other sources of information is vital (Kjerstad, 2012; Stitt, 2004), one way to do this is to activate an ARPA plot in the radar that is beneath an AIS symbol, with speed and course vector, and compare them to examine the accuracy of received AIS information. Here, 83.5%, (95% CI [77.8, 89.2]) replied that they did this regularly (Johansen, 2017).

The survey revealed a finding that gives cause for concern. When asked whether the navigators had routines for manually updating the dead reckoning in ECDIS with bearings from radar, and using the "position fix" for loss of GNSS signal, a full 38%, (95% CI [35.4, 40.6]) replied that this was not necessary because ECDIS automatically updates the position. Eighteen per cent, (95% CI [16.8, 19.2]) answered that they did not know if this was common practice (Johansen, 2017). The ECDIS indeed continues to calculate the position after the loss of the GNSS signal, but only based on input from course and speed. It does not include wind and current in the calculations, and it will eventually lead to deviations in the stated position relative to the real position. This deviation also applies when using a Doppler log (Kjerstad, 2010).

One source of constant irritation and error is that the vessels forget to update the navigation status or other information that requires manual entry. When asked whether the navigators have forgotten to update their navigation status, most admit that they have done it a rare time, but on the question of whether they have experienced that others have done so, almost everyone answered that they had experienced it many times. The same repeats itself in the question of deliberately incorrect use of the navigation status "Not under command" (NUC). Here 84%, (95% CI [78.3, 89.7]) answered that they had not done it themselves, but at the same time, 47%, (95% CI [43.8, 50.2]) claimed that they had seen others had done it (Johansen, 2017).

In the AIS system, navigators have the opportunity to send messages directly or as "broadcast". Instant messaging can present problems by, for example, agreements to manoeuvre in violation of Colreg, either because the recipient does not see the message, or that other nearby vessels are not aware of these agreements (Kjerstad, 2010). When asked how they made such agreements, 91%, (95% CI [84.8, 97.2]) replied that they did so over the VHF radio. Other aspects of using AIS are the symbols itself and how it interacts with other radar information. The author asked respondents if they had previously ignored radar echoes because they had focused on the AIS symbols, and asked if they had made wrong decisions due to incorrect AIS information from other vessels. Here the emphasis was on the answers "no" and "a rare time" which indicates that this is not a widespread problem. Something that can indicate what the navigators think about the GNSS system's reliability and robustness is to see how many think there is a need for a redundant system for GNSS, such as e-Loran. Here, only 29%, (95% CI [27, 31]) answered yes, correspondingly, the same amount did not know, and 42%, (95% CI [39.1, 44.8]) replied that they did not think there was a need for redundancy with alternative systems (Johansen, 2017).

The third part of the survey asked questions about the idea of "AIS Visual Communication". There was a high expectation to the use of NASA TLX as a tool to reveal what navigators had of mind, of whether the use of visual communication would entail any changes in perceived workload. Unfortunately, many respondents expressed that they thought this was difficult to relate to, and it was a significant dropout in the survey from part two to part three, some of the reason might be these difficulties. In retrospective, it seems that the NASA TLX tool was not appropriate in this survey. The respondents did not relate to the real workload in the survey. Instead, it asked them to imagine workload based on previous experiences, set above two identical situations in a radar image where one had regular AIS symbols, and the other had symbols with lanterns. The results indicated that the use of lanterns in the AIS symbols led to lower subjectively experienced workloads. However, because so many of the respondents stated that they had great difficulty imagine the workload, the results must be taken with a pinch of salt. In order to get valid data using the NASA TLX model, it seems that a proper test under a controlled environment on a simulator would be more appropriate (Johansen, 2017).

After reviewing the second part of the survey, a picture emerged. Revealing that around two-thirds of the population of Norwegian navigators have a good understanding of how the systems work and about the system's inherent weaknesses, but it may indicate that the remaining third has a slightly weak and deficient level of knowledge, concerning GNSS and GNSS based aids. With these results as background, we can look at the results of the latest questions in the survey that dealt with the use of visual communication (Johansen, 2017).

The last part of the survey consisted of categorical questions concerning "AIS Visual Communication". They answered what the navigator's thoughts about whether using lanterns on the AIS symbols will be a useful aid or not. All questions were cross-tabulated against the category age groups. 55% (95% CI [51.3, 58.7]) thought it would be a useful aid for vessel clearance. 64,5% (95% CI [60.1, 68.9]) thought it would make it easier to remember to update their navigation status. On the question of whether they thought this would lead to increased navigational safety, 58.5%, (95% CI [54.5, 62.5]) answered yes (Johansen, 2017).

Something that must be present in order for the safety to increase, regarding accidents and near-accidents in connection with the risk of collision, is that the navigators must get a tool that helps them to increase their awareness of the situation during the voyage (Johansen, 2017).

69,5% (95% CI [64.8, 74.2]) believed that lanterns on the AIS symbols would be such a tool. Other factors that are important when using symbols as a source of information are with which colours to use for displaying them. Colreg defines the lantern configurations. The standard S-52 defines several of the conditions for ECDIS (IHO, 2010). What this survey looked at is whether the navigators prefer bright and clear colours to the AIS symbol as opposed to muted colour usage at the same brightness. 81% (95% CI [75.5, 86.5]) responded that they prefer a bright and clear colour. Another aspect of AIS is the relationship between class A-AIS and B-AIS, the latter being for boats below a certain size that are not required by IMO to carry AIS. Yachts and small crafts often use B-AIS. The most significant difference between these is how frequent they update their position (Johansen, 2017).

Example; For a Class A ship exceeding 14 knots, the position is updated every 2 seconds, for a Class B vessel correspondingly to every 30 seconds, this creates uncertainty. Besides, Class A vessels have the opportunity to use a function called "Hide all class B-AIS". This opportunity can lead to class B vessels relying on false safety when they think they are observed by the merchant's vessels due to their class B- AIS. (Kjerstad, 2010). One way to separate the AIS symbols might be to introduce different colours to the symbols. By direct questioning, this in the survey, 65%, (95% CI [60.6, 69.4]) answered that they thought this would make sense (Johansen, 2017).

In a newer ECDIS, we can now see the outline of our own and others' vessels under a certain "range". This outlining can be an excellent tool to understand the situation one sail into, during reduced visibility or absence of visibility, or when entering ports. The survey questioned whether this would be beneficial and whether this is a function we should have on the radar. To this question, 84%, (95% CI [78.3, 89.7]) answered yes (Johansen, 2017).

2.3 **Legal and technical prerequisites for designing AIS symbols with lanterns.**

This section covers how Colreg defines navigational status, how the AIS system works, and what standards apply.

2.3.1 Navigational status. AIS vs Colreg.

Before we can go into the actual design of the new AIS symbols, we first need to look at the limitations of an AIS transponder regarding what we can send according to predetermined choices of information. The focus here is on the signals that can help the navigator to make the right choices for a safe and smooth sailing under challenging conditions. Obtaining an overview of other vessels' navigational status, quickly and efficiently, in addition to their course and speed is essential in this context.

To be able to develop new software for the ECDIS and ARPA radar that displays activated AIS symbols with lanterns can this only be done by utilising the signals on the receiving side. For this project, there are signals from the dynamic and static messages that are of interest. The message signalled must also correlate with lantern configurations defined in Colreg.

The AIS information transmitted by a ship comes in three different types, static, dynamic and voyage related. Static information consists of the ships Maritime Mobile Service Identity (MMSI), call sign and name, IMO number, length, beam, type of ship and the antennas location. Dynamic information consists of the ships position, course over ground (COG), speed over ground (SOG), heading and navigational status. Apart from navigational status, the information updates automatically from the ship sensors connected to AIS. Voyage-related information consists of the ships draft, type of cargo, destination, estimated time of arrival (ETA), and a route plan with waypoints which must be entered by hand (IMO, 2001).

A navigator must be aware of the navigational status of the surrounding vessels, and the reason is defined in Colreg (1975) rule 18, *Responsibility between vessels*. A vessel underway using engines shall keep away from vessels, which are not under command, have restricted manoeuvrability, fishing vessels and vessels sailing. A vessel underway sailing must make way for vessels, which are not under command, have restricted manoeuvrability and vessels engaged in fishing. A vessel fishing on its route shall, to the extent possible keep away from vessels, which are not under command, and vessels, which have restricted manoeuvrability. All vessels, except those that are not under command or with limited ability to manoeuvre, should, if the circumstances permits, avoid preventing the safe passage of a vessel limited by its draft. Vessels obstructed by their draft must navigate with particular care and take full account of the conditions that arise. In addition to traditional vessels, rule 18 also tells us how seaplanes and "wing in ground effect vessels" (WIG) shall relate to other vessels. In general, they shall keep clear of all vessels and avoid impeding or obstructing their voyage. Under circumstances where there is a risk of collision, they should follow rule 18, a WIG vessel operating on the surface shall apply the rules as a vessel underway using engines (Boissier, 2013, pp. 80–82). We get exceptions from Rule 18 when the rules 9, narrow channels. 10, traffic separation schemes and 13, overtaking, require something else. These are complex rules that all navigators are familiar with and trained to use. Excerpts from these rules are rendered here to show how important it is for navigators to be aware of their surroundings and to have an overview of other vessel's navigational status.

2.3.2 AIS Reporting Intervals

The different messages are valid for varying periods and need different update intervals. Static information updates every 6 minutes or when altered or amended. Information from dynamic messages is dependent on speed and course alteration according to table 2-1. Report intervals for Class B-AIS, are subject to own requirements, table 2-2 (ITU, 2014).

Table 2-1: Class A reporting intervals (ITU, 2014)

Ship`s dynamic conditions	Nominal Reporting Interval
Ship at anchor or moored and not moving faster than 3 knots.	3 min.
Ship at anchor or moored and moving faster than 3 knots	10 s.
Speed 0-14 knots	10 s.
Speed 0-14 knots and changing course	3 1/3 s.
Speed 14-23 knots	6 s.
Speed 14-23 knots and changing course	2 s.
Speed > 23 knots	2 s.
Speed > 23 knots and changing course	2 s.

Table 2-2: Class B-SO reporting intervals (ITU, 2014)

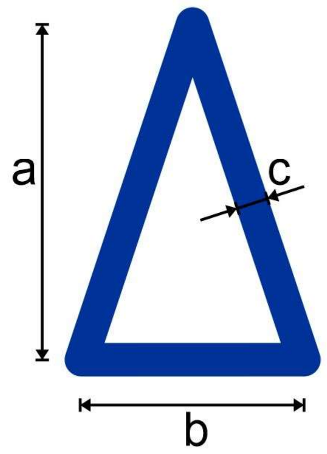
Mobile equipment's dynamic conditions	Nominal RI	Increased RI
Shipborne mobile equipment, not moving faster than 2 knots.	3 min.	3 min.
Speed 2-14 knots.	30 s.	30 s.
Speed 14-23 knots.	15 s.	30 s.
Speed > 23 knots	5 s.	15 s.

Class B AIS transmitted with SOTDMA shall report at "Increased Reporting Interval" when the last four consecutive frames in the SOTDMA system each have less than 50% free capacity and shall not return to "Normal Reporting Interval" until there is at least 65% free capacity in the system (ITU, 2014). This means that vessels with class B-SO updates its position less frequently at a higher speed when there is much traffic in the area. Class B-CS transmits with intervals similarly to B-SO in increased report intervals.

2.3.3 The S-52 standard for symbols in ECDIS

This standard applies to all symbols used in ECDIS. In integrated bridge systems, the same symbols are displayed in the ARPA radar. Below table, 2-3 describes the requirements for designing the activated AIS symbol according to the S-52 standard. There are other requirements to symbols that are not activated, they appear smaller and symbols that signals alarm situations, which appear slightly increased in size and in the colour red (IHO, 2008). This thesis will focus on the activated symbol. In ECDIS and ARPA radar the use of colour on the symbols are defined and predetermined and may be selected from colour palettes according to the individual's preferences.

Table 2-3: Active AIS target according to S-52 (IHO, 2008)

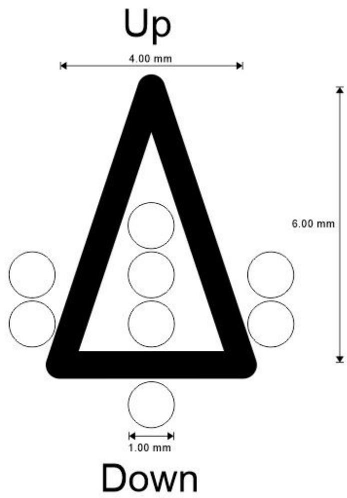
Description	Symbol design
Called by CSP etc.: CSP VESSEL02 Symbol Colours: RESBL a. Height of Bounding Box: 6.00 mm b. Width of Bounding Box: 4.00 mm c. Line weight 0.6 mm Pivot Point Column: 2.00 Pivot Point Row: 6.00 Point diameter 0.6 mm References: IMO Guidelines for the presentation of navigation-related Symbols, terms and abbreviations SN/Circ.243 15.December 2004. IEC 62288, Ed.1	 a b c *Figure 2-1: The author's illustration of an active AIS target.*

2.4 **Design of the new AIS symbol with lanterns.**

This section describes the construction design of the AIS symbol with lanterns. It is the foundation for all the new symbols. It explains the simplification and the choice of design for symbols based on dynamic messages, symbols based on dynamic messages combined with static messages and symbols based on static messages alone.

Table 2-4 below shows the basic design of the new symbols. The S-52 standard defines the AIS symbol. The author have defined the bow end of the triangle as up. Figure: 2-2 in Table 2-4 illustrates the lanterns' location. They have a diameter of 1 mm and an outline of 0.1 mm.

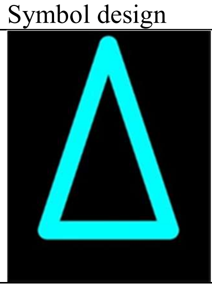
Table 2-4: Construction design for AIS symbol with lanterns

Description	Symbol design
Based on the shape and dimensions of CSP VESSEL02 AIS symbol: Height of Bounding Box: 6.00 mm Width of Bounding Box: 4.00 mm Line weight: 0.6 mm Lanterns: Diameter: 1.00 mm Outline: 0.1 mm Orientation for reading lanterns: Bow side of the symbol is up. Stern side is down.	 *Figure 2-2: AIS with lanterns.*

2.4.1 Symbols based on dynamic messages.

Dynamic messages contain several predefined navigational statuses: 0. Underway using engine. 1. at anchor. 2. Not under command. 3. Restricted manoeuvrability. 4. Constrained by her draft. 5. Moored. 6. Aground. 7. Engaged in fishing. 8. Underway sailing. (USCG, 2017b) Besides, we have message 11 and 12. Power-driven vessel towing astern (regional use in the US) and Power-driven vessel pushing ahead or towing alongside (regional use in the US) (USCG, 2017b). Reserved for future amendment of navigational statuses and not yet in use are message 9, 10 and 13. Message 14 and 15 are for use for search and rescue purposes.

Table 2-5: Underway using engines.

Description	Symbol design
Rule 23 Power-driven Vessels Underway (a) *"A power-driven vessel underway shall exhibit: a masthead light forward; a second masthead light abaft of and higher than the forward one; except that a vessel of less than 50 meters in length shall not be obliged to exhibit such light but may do so; sidelights; and a stern light"* (COLREG, 1975).	

The symbol for “underway using engine” (table 2-5) is the symbol, as we know it. It should be understood as a vessel with lantern configurations according to rule 23 a. The vector from the activated AIS symbol gives course and speed. This applies with few exceptions also for all the other symbols. What is additionally displayed is only a change in navigation status or additional selected information that is relevant to safe navigation.

Table 2-6: Not under command

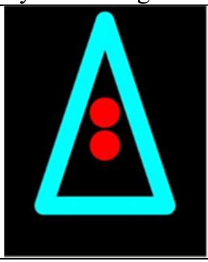
Description	Symbol design
Rule 27 Vessels Not Under Command (a) *“A vessel not under command shall exhibit: two all-round red lights in a vertical line where they can best be seen”* (Colreg, 1975)	

Table 2-7: Restricted manoeuvrability

Description	Symbol design
Rule 27 Vessels Restricted in Their Ability to Manoeuvre (b) *“A vessel restricted in her ability to manoeuvre, shall exhibit: three all-round lights in a vertical line where they can best be seen. The highest and lowest of these lights shall be red and the middle light shall be white”* (COLREG, 1975)	

Table 2-8: Constrained by her draft.

Description	Symbol design
Rule 28 Vessels Constrained by Their Draft. *“A vessel constrained by her draft may, in addition to the lights prescribed for power-driven vessels in Rule 23, exhibit where they can best be seen three all-round red lights in a vertical line”* (COLREG, 1975)	

Table 2-9: Moored.

Description	Symbol design
There are no rules for vessels moored regarding lantern configurations.	

Table 2-10: Engaged in fishing.

Description	Symbol design
Rule 26 Fishing Vessels (a) "*A vessel engaged in fishing, whether underway or at anchor, shall exhibit only the lights and shapes prescribed in this Rule"*. (c) "*A vessel engaged in fishing, other than trawling, shall exhibit: two all-round lights in a vertical line, the upper being red and the lower white"* (COLREG, 1975)	

Table 2-11: Under way sailing.

Description	Symbol design
Rule 25 Sailing Vessels Underway (c) *"A sailing vessel underway may exhibit at or near the top of the mast, where they can best be seen, two all-round lights in a vertical line, the upper being red and the lower green"* (COLREG, 1975).	

2.4.2 Symbols based on dynamic messages, combined with static messages.

In the symbols below (table. 2-12. 13, 14 and 15) the information comes from both dynamic and static messages. In particular, the ship`s length determines which of the lantern configurations will be displayed.

Table 2-12: At anchor, vessel > 50m.

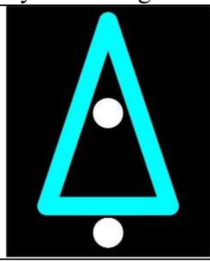
Description	Symbol design
Rule 30 Anchored Vessels (a) *“A vessel at anchor shall exhibit where it can best be seen: in the fore part, an all-round white light; at or near the stern and at a lower level than the light in the fore part, an all-round white light”* (Colreg, 1975).	

Table 2-13: At anchor, vessel < 50m.

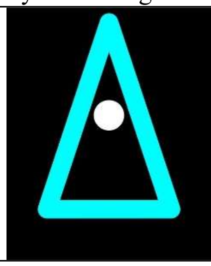
Description	Symbol design
RULE 30 Anchored Vessels (b) *“A vessel of less than 50 meters in length may exhibit an all-round white light where it can best be seen”* (COLREG, 1975)	

Table 2-14: Aground, vessel > 50m.

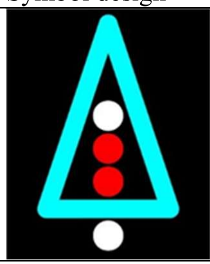
Description	Symbol design
Rule 30 Vessels Aground (d) *“A vessel aground shall exhibit the lights prescribed in paragraph (a) of this Rule and in addition, where they can best be seen: two all-round red lights in a vertical line”* (COLREG, 1975)	

Table 2-15: Aground, vessel < 50 m.

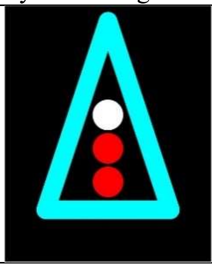
Description	Symbol design
Rule 30 Vessels Aground (d) *"A vessel aground shall exhibit the lights prescribed in paragraph (b) of this Rule and in addition, where they can best be seen: two all-round red lights in a vertical line,"* (COLREG, 1975)	

Table 2-16: Vessel when towing astern.

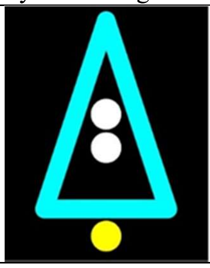
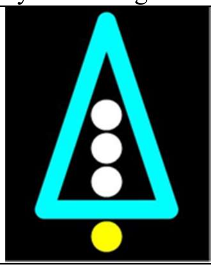
Description	Symbol design
Rule 24 Towing (a) *"A power-driven vessel when towing astern shall exhibit: instead of the light prescribed in Rule 23 (a), two masthead lights in a vertical line. Sidelights; a stern light; a towing light in a vertical line above the stern light"* (COLREG, 1975).	

Table 2-17: Vessel when towing astern, tow exceeds 200 meters.

Description	Symbol design
Rule 24 Towing (a) continues *"When the length of the tow, measuring from the stern of the towing vessel to the after end of the tow exceeds 200 meters, three such lights in a vertical line; sidelights; a stern light; a towing light in a vertical line above the stern light"* (COLREG, 1975).	

2.4.3 Symbols based on static messages.

We can also use information from the static messages such as the type of ship when the vessel has a status covered by Colreg, like "pilot vessel" (USCG, 2017a). The difference is that the dynamic messages can be changed, or turned on and off as needed while the static messages will be displayed permanently on activated AIS symbols. To be able to display lanterns based on signals from static messages, this must only be allowed when the vessel's navigation status is "Underway using engine" When the navigation status changes from this, the idea is that the signal from the static message closes simultaneously, and the change in navigation status displays in the AIS symbol.

Table 2-18: Pilot vessel.

Description	Symbol design
Rule 29 Pilot Vessels (a) *"A vessel engaged on pilotage duty shall exhibit: at or near the masthead, two all-round lights in a vertical line, the upper being white and the lower red. (b) A pilot vessel when not engaged on pilotage duty shall exhibit the lights or shapes prescribed for a similar vessel of her length"* (COLREG, 1975).	

It is also possible to distinguish class A and B AIS by displaying class B AIS in a different colour than class A AIS. This will require a rule change as today it is only allowed to display the AIS symbol in the same colour on the screen (IHO, 2010; ITU, 2014)

Table 2-19: Class B-AIS.

Description	Symbol design
There are no rules for Class B-AIS The symbol displayed in this table shows an alternative colour in order to separate Class B- AIS from Class A-AIS.	

2.4.4 Symbols suggested for future amendments.

The basic design, which shown in table 2-4, is designed with regard to being able to cover all Colreg's lantern rules so that this is prepared in relation to a future new and upgraded version of the AIS system, if it comes.

Table 2-20: A vessel engaged in dredging, safe passage port side.

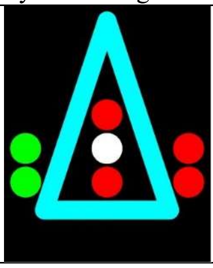
Description	Symbol design
Rule 27 - Continued (d) *"A vessel engaged in dredging or underwater operations, when restricted in her ability to manoeuvre, shall exhibit the lights and shapes prescribed in subparagraphs (b) of this Rule and shall in addition, when an obstruction exists, exhibit: two all-round red lights to indicate the side on which the obstruction exists; two all-round green lights in a vertical line to indicate the side on which another vessel may pass"* (COLREG, 1975)	

Table 2-21: A vessel engaged in dredging, safe passage starboard side.

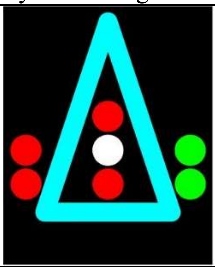
Description	Symbol design
Rule 27—Continued (d) *"A vessel engaged in dredging or underwater operations, when restricted in her ability to manoeuvre, shall exhibit the lights and shapes prescribed in subparagraphs (b) of this Rule and shall in addition, when an obstruction exists, exhibit: two all-round red lights to indicate the side on which the obstruction exists; two all-round green lights in a vertical line to indicate the side on which another vessel may pass"* (Colreg, 1975)	

Table 2-22: Restricted manoeuvrability, towing.

Description	Symbol design
Rule 27 -Continued (c) *"A vessel engaged in a towing operation which severely restricts the towing vessel and her tow in their ability to deviate from their course shall, in addition to the lights or shapes prescribed in subparagraphs (b) of this Rule, exhibit the lights or shape prescribed in Rule 24"* (COLREG, 1975)	

Table 2-23: Vessel when engaged in trawling.

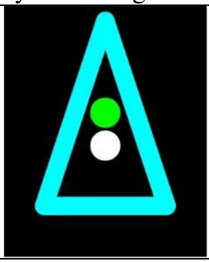
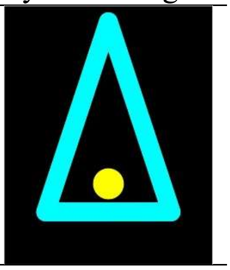
Description	Symbol design
Rule 26 Fishing Vessels (a) "*A vessel engaged in fishing, whether underway or at anchor, shall exhibit only the lights and shapes prescribed in this Rule"*. (b) "*A vessel when engaged in trawling, by which is meant the dragging through the water of a dredge net or other apparatus used as a fishing appliance, shall exhibit: two all-round lights in a vertical line, the upper being green and the lower white"* (COLREG, 1975)	

Table 2-24: Air-cushion vessel in the non-displacement mode.

Description	Symbol design
Rule 23 Power-driven Vessels Underway, continued (b) *"An air-cushion vessel when operating in the non-displacement mode shall, in addition to the lights prescribed in paragraph (a) of this Rule, exhibit an all-round flashing yellow light"* (COLREG, 1975).	

2.5 **Situation Awareness and Workload.**

This section addresses our ability to perceive the world around us through our senses, Situational Awareness (SA), which is seen in the context of workload and how workload affects our ability to perceive information. The author has chosen to focus on the well-known methods Situation Awareness Global Assessment Technique (SAGAT) and National Aeronautics and Space Administration Task Load Index (NASA TLX) as tools to measure this (Endsley, 1988; Hart & Staveland, 1988).

2.5.1 Situation Awareness and SAGAT

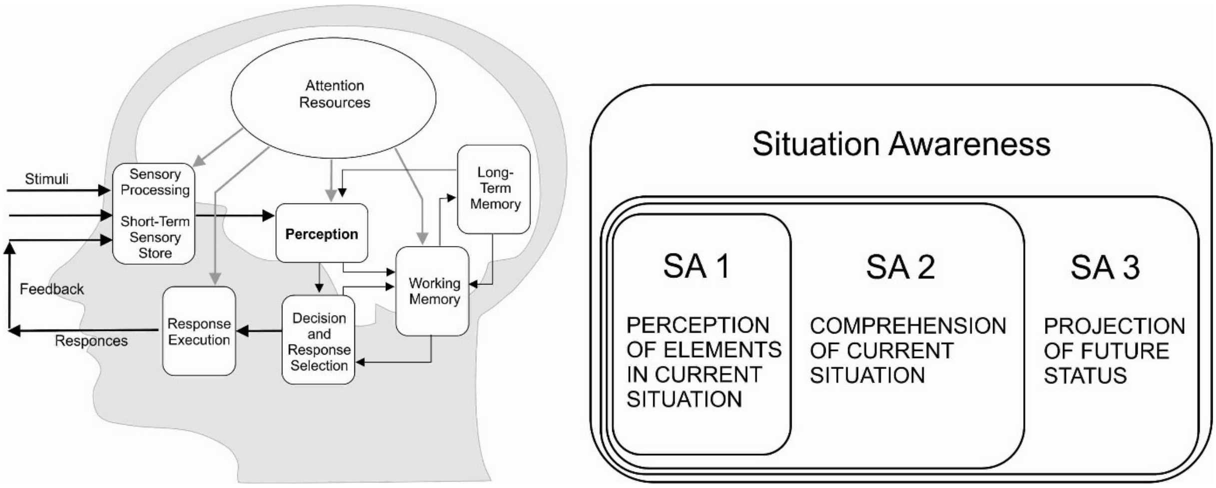


Figure 2-3: The authors own reproduction of Wicken's model combined with Endsleys SA model (Endsley, 1988; Wickens et al., 2013)

To perceive the world around us and solve problems, we seek information through our sensory organs, such as the eyes, ears, nose, fingertips, and body. We focus on where we expect to find this information from our environment that helps us solve our ongoing tasks. What we perceive is first processed by our short-term memory into something we can understand further. Our understanding is transferred to working memory, which interacts with the long-term memory and our attention resources like previous experiences before it forms a perception of our surroundings and how we should relate to what we have perceived. This process is illustrated above (fig. 2-3) in Wicken's information processing model (Wickens et al., 2013). We can absorb an unlimited amount of stimuli through our senses. Nevertheless, the amount of information we can keep in working memory is limited to between 5 and 9 different elements (Miller, 1956). What we perceive is the basis for what decisions we make

(Klein & Crandall, 1996). A person's situational awareness becomes the crucial function in most physical decisions (Endsley, 2016).

By having situational awareness, you are aware of your surroundings, what situation you are in and what this means now and in the immediate future. The formal definition of SA is broken down into three separate levels as seen in the tree level model in figure 2-3: SA level 1: *"perception of the elements in the environment."* SA level 2: *"comprehension of the current situation."* SA level 3: *"projection of future status" (Endsley, 2016; Stanton et al., 2001)*. In other words, you perceive that there is something there at level one. At level two, you understand what it is and what it means to you and your situation. At level three, you imagine or predict what you have to do with the problem or situation that has arisen.

At level 1, the navigator may misperceive important information due to poor system design or communication. In other cases, the information may be available but difficult to obtain or difficult to perceive. There may be confusing menus on a computer screen, or difficult weather conditions may result in reduced visibility. A high workload can also result in misconceptions. At level two, one can misunderstand the situation even if the information is perceived correctly, which may be due to a lack of experience with the type of situation that has arisen. This in turn can lead to one at level three getting the wrong idea of what one should do (Endsley, 1995). Previous studies indicate that as much as 71% of errors made by navigators are due to deficient SA (Nishizaki et al., 2017).

For many years, having a good understanding of the situation has been related to training and experience and knowing what to look for. The problem with today's user interface is not a lack of information but finding what one needs when one needs it. It has gradually been recognised that more data is not the same as more information (Endsley & Garland, 2000b). Today's focus on SA in system design and user interfaces has arisen as a result of increasingly complex systems. By simplifying the way information is disseminated, we can help navigators maintain good SA (Endsley & Garland, 2000b).

A widely used approach to direct and objective measure SA is SAGAT. Administration of SAGAT means that in a simulator exercise, you stop the activity at random times and turn off sources of information, so-called "freezes". Then the participant in the experiment answers questions about their perception of the situation. The answers are compared to actual data about the real situation. The number of correct answers gives a picture of the participant's SA. SAGAT is best suited for determining SA in controlled simulation exercises and is not as well suited for real-time measurement of SA (Bolstad & Cuevas, 2010). An SA analysis does not include static knowledge such as procedures and rules for performing a task. The analysis focuses only on the dynamic situation information that influences what the navigators should do. The SAGAT technique has shown that it has a high degree of validity, sensitivity and reliability for measuring SA (Endsley & Garland, 2000a).

The relationship between SA and workload is also essential. SA can vary regardless of workload. When the workload exceeds the maximum human capacity, the navigator's SA is in danger. Navigators can make trade-offs between effort levels and how much they need to know. Designers must measure SA and workload independently and test both SA and workload during the development of a new user interface design to understand the effect of a particular design concept (Endsley & Garland, 2000b)

2.5.2 Workload and NASA TLX

Wickens, defines mental workload as the difference between cognitive requirements for a task and what attention resources the navigator has available to solve the task (Rubio et al., 2004). Mental workload and assessment of its significance are essential during the design and evaluation of technically complex systems. Increased use of new technology and the use of increasingly complex procedures has led to greater demands being placed on navigators with todays integrated and complex bridge systems. Navigators have a limited attention capacity, and these attention resources are aimed at the relevant tasks (Stanton et al., 2013, p. 212).

The NASA Task Load Index (Hart & Staveland, 1988) is a multidimensional subjective assessment tool used to derive a mental workload assessment. Initially, the method was based on a weighted average of six workload subscale assessments. Today it is most common to use the results from the six dimensions directly and sum these to a total score. This method is also known as "Raw TLX" (Byers et al., 1989; Hart, 2006). We can then compare "Total Scores" from test and control groups.

The six dimensions, or subscales, in the NASA TLX (table 2-25) consist of mental demand, physical demand, temporal demand, performance, effort and frustration level (Hart, 2006; Hart & Staveland, 1988).

Table 2-25: Description of the six dimensions in NASA TLX (Hart & Staveland, 1988).

Title	**Endpoints**	**Descriptions**
Mental Demand	Low/High	*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	Low/High	*"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	Low/High	*"How much time pressure did you feel due to the rate or pace at which the task or task elements occurred? Was the pace slow and leisurely or rapid and frantic?"*
Performance	Good/Poor	*"How successful do you think you were in accomplishing the goals of the task set by the experiment? How satisfied were you with your performance in accomplishing these goals?"*
Effort	Low/High	*"How hard did you have to work (mentally and physically) to accomplish your level of performance?"*
Frustration levels	Low/High	*"How insecure, discouraged, irritated, stressed, and annoyed versus secure, gratified, content, relaxed, and complacent did you feel during the task?"*

The participants in the experiment answer the questions in a questionnaire after a task has been completed (Appendix B). It is the participant's self-assessment of the subjective workload described on a scale. Usually, a scale from 1 to 20 (Byers et al., 1989; Hart, 2006).

3 Methodology

This section describes the development of new software, experiment design, performance variables and ethics of the experiment conducted at the navigation labs at USN. Development of the experiment, selection of participants, experiment procedure and implementation and data analyses.

3.1 Development of Software and installation.

Based on the new basic design for AIS with lanterns described in tables 2-4, Pål K. Hansen, Vice President of R&D in Telko AS, programmed a new upgraded version; 4.8.3.4 P.9 of TECDIS. The program itself is confidential and will not be described here. This upgrade contains the presentation of lanterns on AIS symbols. It can install on a TECDIS system upgraded to version 4.8.3.0 or later.

The new program was uploaded from a USB stick to station-J of the TECDIS desktop simulators at USN`s navigation lab in room D2-91 at Campus Vestfold.

This procedure was followed to activate lanterns on AIS symbols:

1. Windows; C: \ Program files (x86) \ TECDIS and open TELchart.ini in a text editor.
2. Find the '[Options]' section of this file
3. Add the following line under [Options]: ais_symbol_lights=1
4. Save the file and exit.
5. To deactivate the function, change the line so it says: ais_symbol_lights = 0

When the function is activated, the presentation of lanterns and alternative colours for AIS targets is valid in “Dusk” and “Night” palettes, but not in “Day”.

3.2 **Experiment design.**

This experiment was based on a non-randomised convenience sampling regarding participants. Therefor it is considered to be a in the category quasi-experimental designs (Frankfort-Nachimas et al., 2015). The groups in the first part of the experiment consist of the test group A and control group B. The groups in the second part consists of control groups A and test group B. The same participants participate in each state of the independent variable. It will then be possible to obtain data from repeated measures within the groups (Field & Hole, 2003, pp. 79–82).

3.3 **Performance variables**

The author used both quantitative and qualitative methods to obtain the performance variables. The validated test method NASA TLX (Hart, 2006; Hart & Staveland, 1988) measured subjective workload. Objective measurements of situational awareness were obtained using the SAGAT method (Endsley, 1988). Qualitative data from the interviews were based on the step-by-step deductive inductive (SDI) strategy. (Tjora, 2017, pp. 195–203).

3.4 **Ethics**

All participants gave their written consent to participate in the experiment by signing the registration form (Appendix A). All participants taking part in the experiment will be held anonymous. They were continuously registered with an arrival number. Odd numbers were placed in group A and even numbers were distributed to group B. All the data from the experiment obtained through the questionnaire, interviews and observation logs will be treated anonymously. The experiment and its survey are therefore considered not to be subject to disclosure.

3.4.1 Experiment flow diagram.

Read the diagram in figure 3-1 from the bottom to the top.

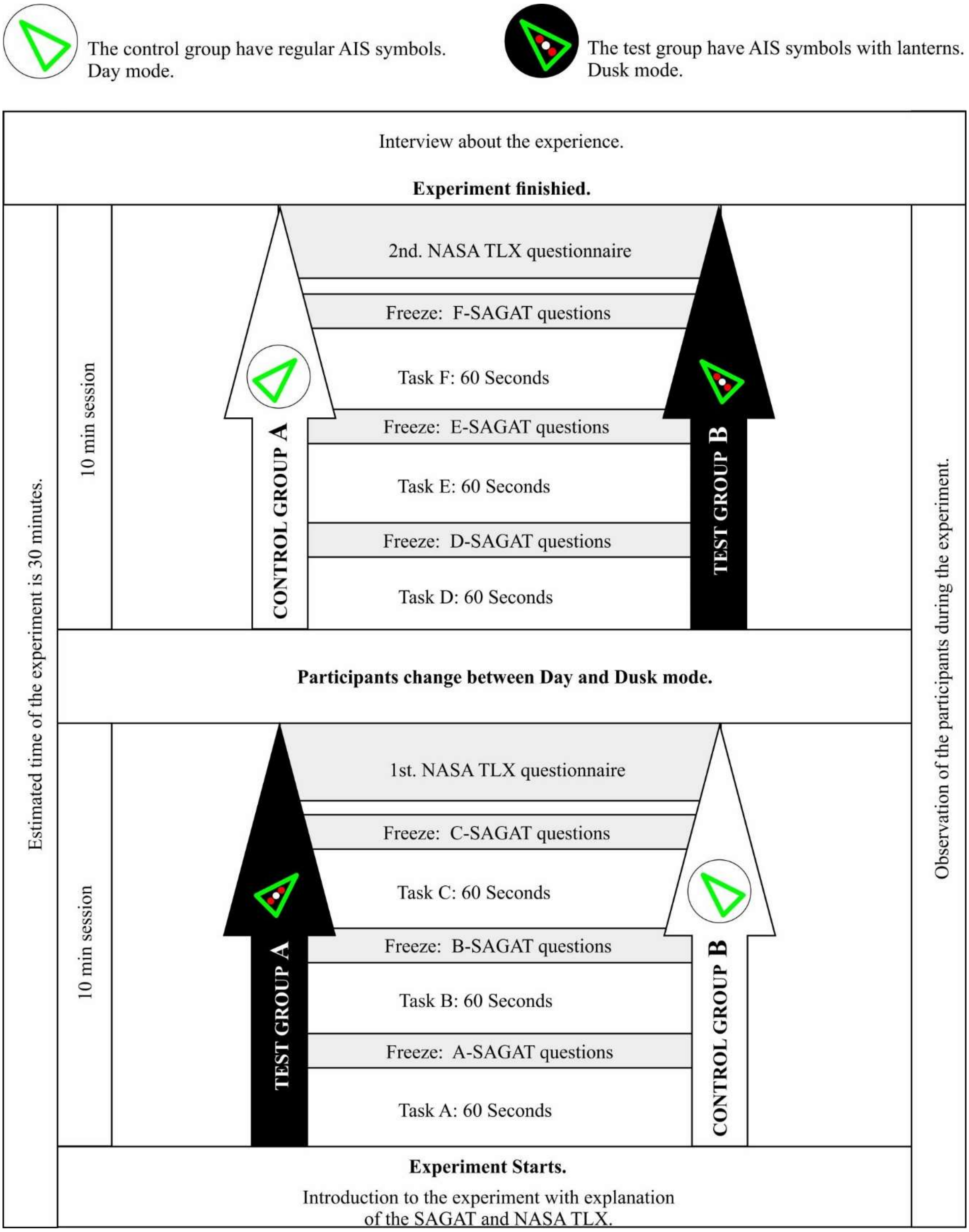


Figure 3-1: The authors own illustration of the experiments flow diagram.

3.5 Development of the experiment.

The simulator trial was prepared and administered from a K-Sim instructor unit: *“Kongsberg SBS-INS-01, 172.16.200.11”*. Table 3-1 shows which symbols and which navigation statuses were included in the experiment.

Table 3-1: AIS Symbols with lanterns included in the experiment.

Message	Navigation Status
0	Underway using engine
1a	At anchor < 50 m
1b	At anchor > 50 m
2	Not under command
3	Restricted manoeuverability
4	Constrained by her draught
5	Moored
6a	Aground < 50 m
6b	Aground > 50 m
7	Engaged in fishing
8	Underway sailing

For the participants to become familiar with the AIS symbols with lanterns, all the symbols used in the exercise were placed side by side in a bay outside the sailing area where the tasks took place.

Six different tasks were created along a fixed northbound route through the Hjeltefjord west of Bergen in Norway, with seven ships involved in each task for use in the SAGAT questions (Miller, 1956). The vessels in the "SAGAT A" task were named "A1" to "A7". The ship's corresponding naming was done for all the six SAGAT tasks, from "SAGAT A" to "SAGAT F" (Appendix C).

The six different SAGAT tasks were placed in clusters around their respective waypoints on the route. The ECDIS screen was displayed on a scale of 1: 15000. In order for all participants in the experiment to get exactly the same tasks, it was decided that the situations shown are static. No ships move during the tasks. With the help of a colleague at USN, The author performed preliminary experiment tests. These tests decided that 60 seconds was an appropriate time to study each task before turning it off.

Figures 3-2, shown in dusk mode, and 3-3, shown in day mode below, show the “A SAGAT” task. The ships named A1 to A7 grouped in a situation around waypoint 3.

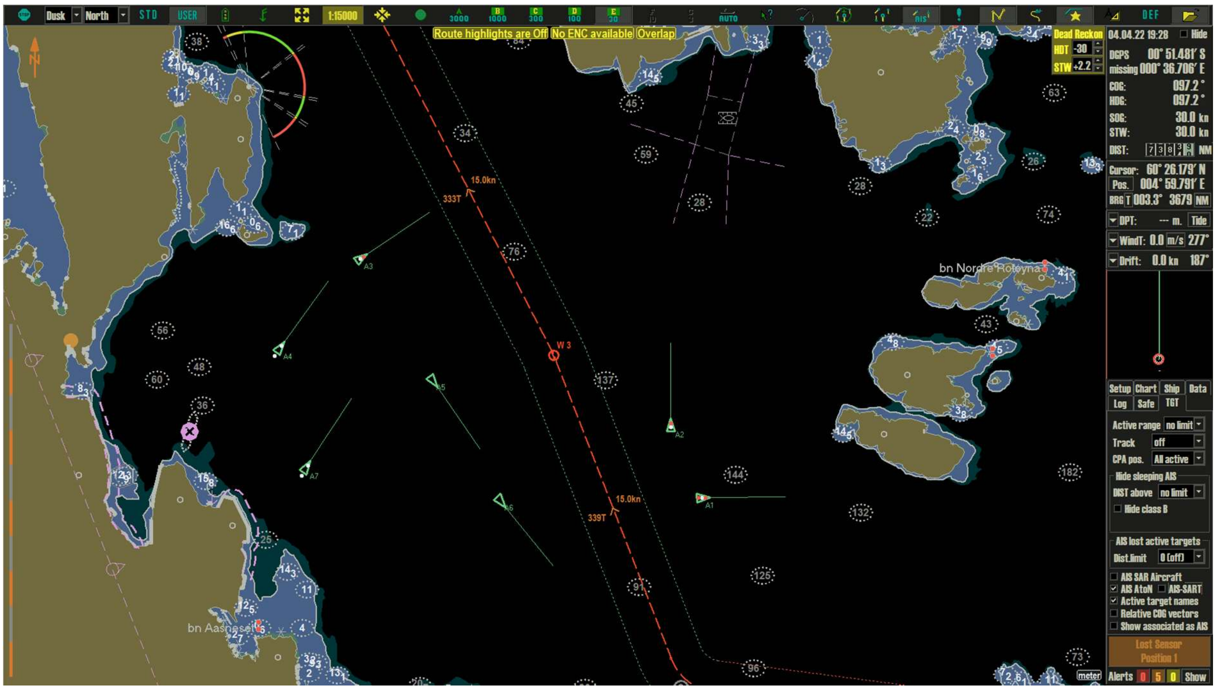


Figure 3-2: The A SAGAT task in dusk mode. AIS symbols with lanterns. Rendered with consent from Telko AS.

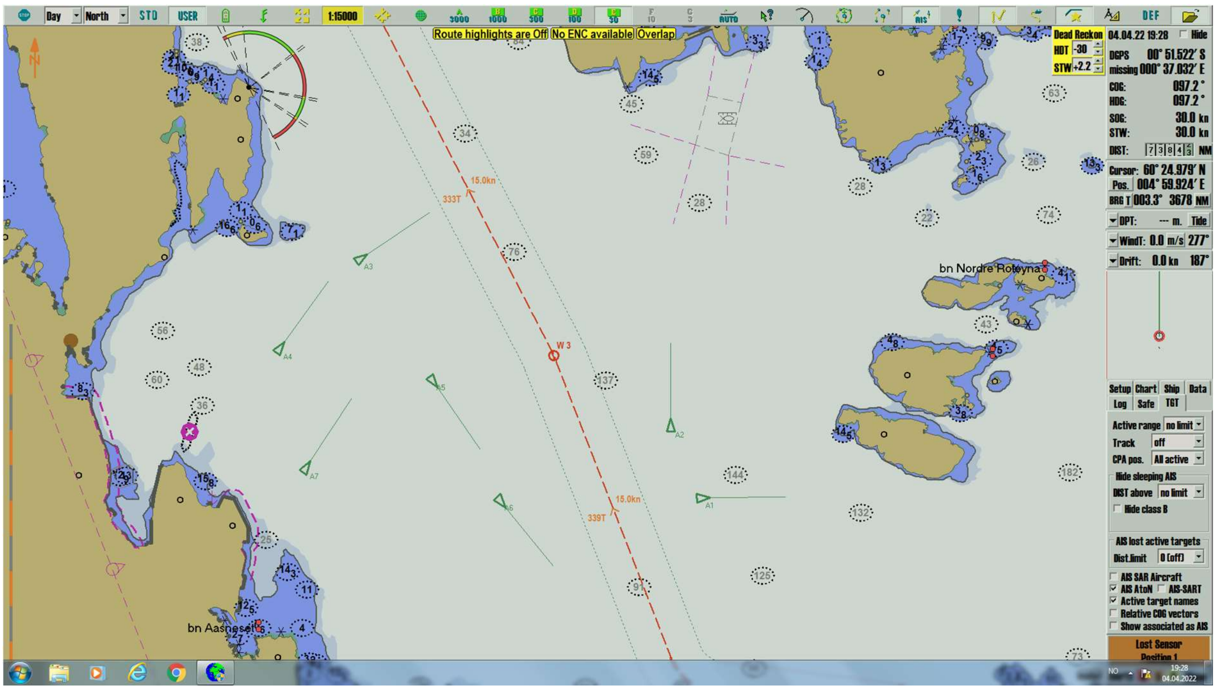


Figure 3-3: The A SAGAT task in day mode. Regular AIS symbols. Rendered with consent from Telko AS.

3.6 **Selection of participants.**

Participants in the experiment were recruited from the university's nautical students from 2nd and 3rd grade. No preliminary calculations were made of how many participants would participate in the experiment, but the intention was to include as many as possible. The recruitment took place by the author visiting the students during one of their lectures and gave a short appeal about the project with the help of a PowerPoint presentation. The students who wanted to participate signed on to a registration and consent form (Appendix A), with their desired date and time. Sixteen students participated in the experiment. There were fifteen men and one woman divided into 15 from 2nd grade and one from 3rd grade (table 3-2).

3.6.1 Demographic data

Tabell 3-2: Descriptive statistics of demographic data.

		Groups					
		Group A		Group B		Total	
Level of education		N	%	N	%	N	%
2nd-year student		8	100,0%	7	87,5%	15	93,8%
3rd-year student		0	0,0%	1	12,5%	1	6,3%
	Total	8	100,0%	8	100,0%	16	100,0%
Male / Female							
Male		7	87,5%	8	100,0%	15	93,8%
Female		1	12,5%	0	0,0%	1	6,3%
	Total	8	100,0%	8	100,0%	16	100,0%
Age Groups							
19-24		5	62,5%	7	87,5%	12	75,0%
25-29		2	25,0%	0	0,0%	2	12,5%
35-39		1	12,5%	0	0,0%	1	6,3%
40+		0	0,0%	1	12,5%	1	6,3%
	Total	8	100,0%	8	100,0%	16	100,0%

There were no participants in the age group 30-34 years. Therefore, this group is omitted from the table.

3.7 Implementation of the experiment

The experiments took place between 5 and 8 April 2022 at the university's desktop navigation laboratory. Figure 3-4 below shows the TECDIS simulator, the questionnaire for use during the experiment and a screenshot of the AIS symbols included in the experiment. This A4 sheet with the image of the AIS symbols with lanterns was at the participants' disposal as a "remember-note" during the entire experiment.

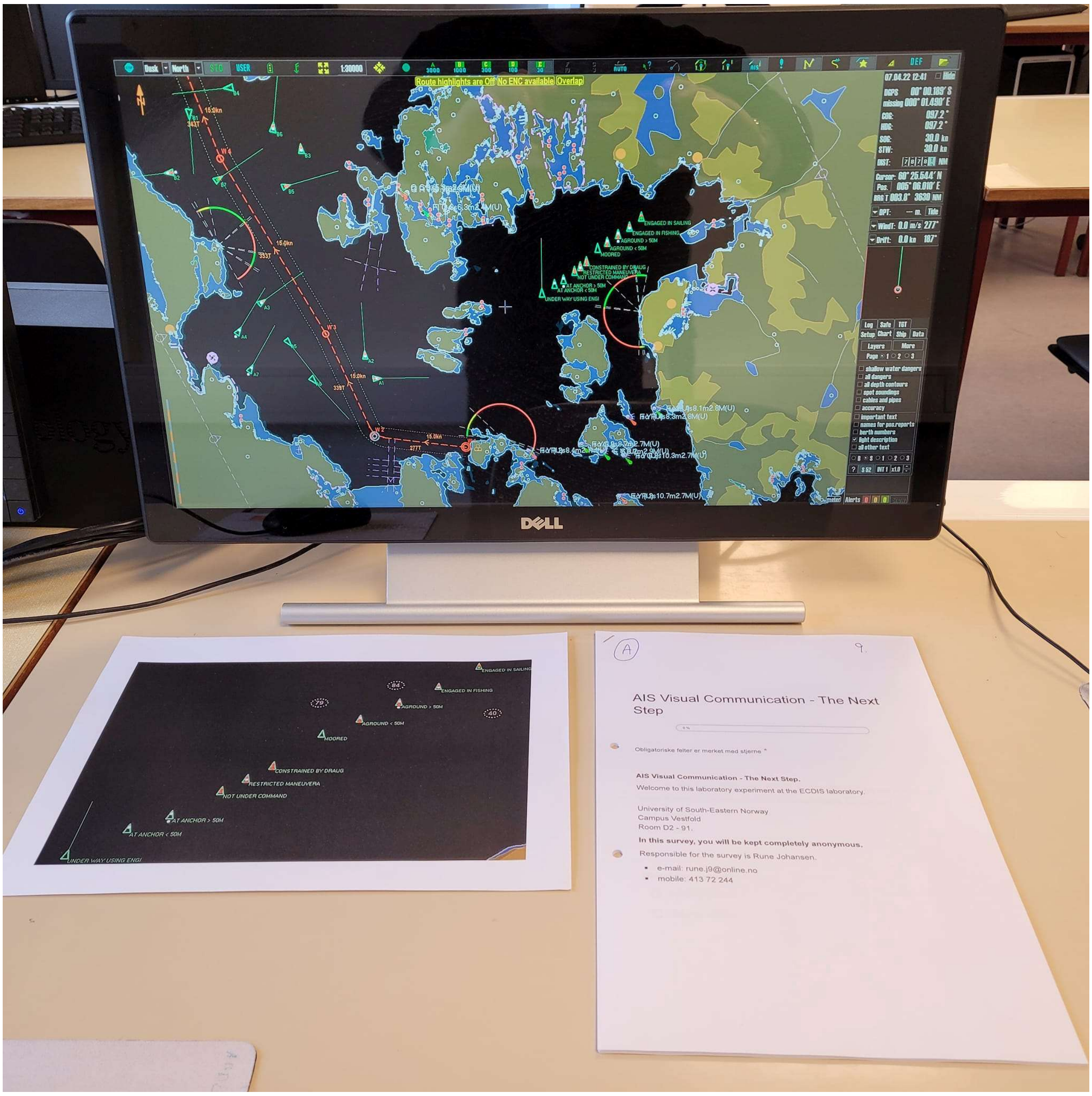


Figure 3-4: The author's own picture of the TECDIS simulator, the "remember-note" with symbols and the questionnaire. Rendered with consent from USN.

When participants arrived at the desktop navigation lab to participate in the experiment, the author directed them to the desktop simulator where the experiment took place. First, the participants were divided into either group A or group B. A questionnaire marked with which group they belonged to was handed out. The questionnaire was created in an online digital solution from the University of Oslo and printed out on paper (Appendix B). First, they answered the demographic questions. Then began the review of how the experiment should take place (fig. 3-1).

All AIS symbols with lanterns were displayed on the TECDIS screen and explained (fig. 3-5). It was demonstrated how by clicking on the symbols, you could get a text box in the upper left corner of the screen with descriptive information about the vessel, including information such as the ship's length and navigation status. Except for the sips name, the latter is the only way to obtain information using regular AIS symbols.

Figure 3-5: Screenshot of all the AIS symbols with lanterns used in the experiment. Rendered with consent from Telko AS.

The author then reviewed all the assignments in the questionnaire. For the SAGAT assignments, it was carefully explained how the participants should answer the questionnaire and what time they had available for each assignment on the screen. There were no time limits to the answering part. They were instructed to solve the task as follows: They sail north along the route plotted in TECDIS, they must analyse the situation concerning the duty to give way, and they must use TECDIS actively to obtain information about the other vessels' navigation status and the ships length. They were informed that all vessels were stationary in the simulation, but they were to assess duty to give way situations from vessels with crossing courses. The course indicator on the AIS symbol indicated the direction of the other ships.

All the dimensions of the NASA TLX questionnaire were reviewed with the participants. They were also given an explanation of how each dimension of subjective workload should be ranked on a scale of 1 - 20. Participants were advised to answer one dimension at a time by first reading the description of the individual dimension and then ranking it.

A stopwatch on the author's mobile phone was used to keep track of time. The author turned the tasks on the screen on and off by turning the AIS signals on and off on ECDIS. Switching to the next task was done when the participants answered the questions in the questionnaire by zooming in on, and placing, the next waypoint to the centre of the screen on a scale of 1: 15000. The AIS signals were turned on for the next task when the participant was ready.

During the whole experiment, there was an opportunity to ask questions if there was something unclear to the participants, and there was also small talk between the different tasks. After completing the questionnaire, the author interviewed the participants by asking them to tell in their own words what their views were on the experiment and what they thought about having lanterns on the AIS symbols. The interview was summarised and written directly into a Word document on the author's PC. At the same time, the participants sat next to him, read through and gave their consent to the content of the summarised interview. Immediately after the participants had left the navigation lab, a brief observation of each participant was written down in the same Word document.

For the SAGAT assignments, a count was made of the number of correct answers. There was only one correct answer for each ship in each task. For the NASA TLX tasks, the answers were used directly. All answers were entered in a codebook in SPSS. The summaries of each interview were written down in a table where keywords and sentences from the text, so-called codes, were also extracted.

3.8 **Data analyses**

IBM SPSS version 28 was used for most statistical analyses performed. For manual calculations, reference is made to the formula used.

Descriptive analysis of categorical data is performed for the demographic data, which is presented in a cross-table showing the distribution (Johannessen, 2009).

To evaluate data from the part of the survey based on SAGAT and NASA TLX, "Repeated measure ANOVA" is used. From the repeated measure ANOVA, three analyses are presented: Descriptive Statistics, Mauchly's Test of Sphericity and the test of the Within-Subjects Effect.

From the descriptive analyse, in the repeated measure ANOVA, the overall mean from both groups was summed up to a "Total Score" and compared. Manual calculation of the Confidence Interval (CI) for the overall mean was done, using the following formula:

$$CI = \bar{X} \pm Z\left(\frac{\sigma}{\sqrt{n}}\right)$$

In SPSS, "Mauchly`s test" tests that the variances of the differences between conditions are equal. Sphericity means that the population variances of all possible difference scores are similar. Mauchly's test for the sphericity is assumed if $p > .05$. If the test is significant it means less power, which increases the chances of type II failure . (Field & Hole, 2003, p. 184; Pallant, 2013, p. 290)

Tests of Within-Subjects Effects is where we read the result of the repeated-measures ANOVA test. If the F-value has a $p < .05$, there is a statistically significant difference between the mean values for the different variables (Field & Hole, 2003, p. 187). Partially eta-squared power size statistics provide a picture of the proportion of variance of the dependent variable that is explained by the independent variable, the values can vary on a scale from 0 to 1 (Pallant, 2013, p. 218). $\eta 2 = .01$ indicates a small effect; $\eta 2 = .06$ indicates a mean effect; $\eta 2 = .14$ indicates large effect. (Pallant, 2013, pp. 271–272)

When the experiment only consists of two groups, it is not possible to perform a posthoc test in SPSS. An error bar chart has therefore been prepared which gives a good picture of the differences within the variables and the differences between the groups.

In order to assess the statistic reliability of each question battery used for NASA TLX, "Reliability Statistics" in SPSS were performed in order to calculate "Cronbach’s Alpha" (Cortina & Schmitt, 1993). Cronbach's alpha coefficient tells us how the variables in the measurement series are related. The coefficient is to be regarded as approved above .7 but it should preferably be above .8 in order for internal consistency reliability in the data set to be considered good (Pallant, 2013, pp. 101–105).

The answers to the additional questions for SAGAT tasks were calculated in SPSS and presented in cross-tabulations. Pearson's chi-square test for independence were calculated and used to discover if there was a relationship between the two groups. If the chi-square value is more significant than .05, you reject your null hypothesis (Field & Hole, 2003, pp. 260–262; Pallant, 2013, pp. 227–229). In addition, the groups' correct answers were summarised and shown in a bar chart diagram for direct comparison.

The treatment of the interviews and observations was based on the stepwise deductive inductive (SDI) strategy. A textual analysis was performed of the summarised interviews with empirical coding (Tjora, 2017, pp. 195–203)

4 Results

A *p*-value greater than .05 states that we want to keep the null hypothesis and a *p*-value less than .05 will cause us to reject the null hypothesis and retain an alternative hypothesis. (Johannessen, 2009).

- The null hypothesis: *"There is no difference between the populations"*.
- The alternative hypothesis: *"There is a difference between the populations"*

4.1 The first part of the experiment

4.1.1 SAGAT A, B and C

The error bar chart in Figure 4-1 shows the mean score from the first three SAGAT tests divided into test group A and control group B.

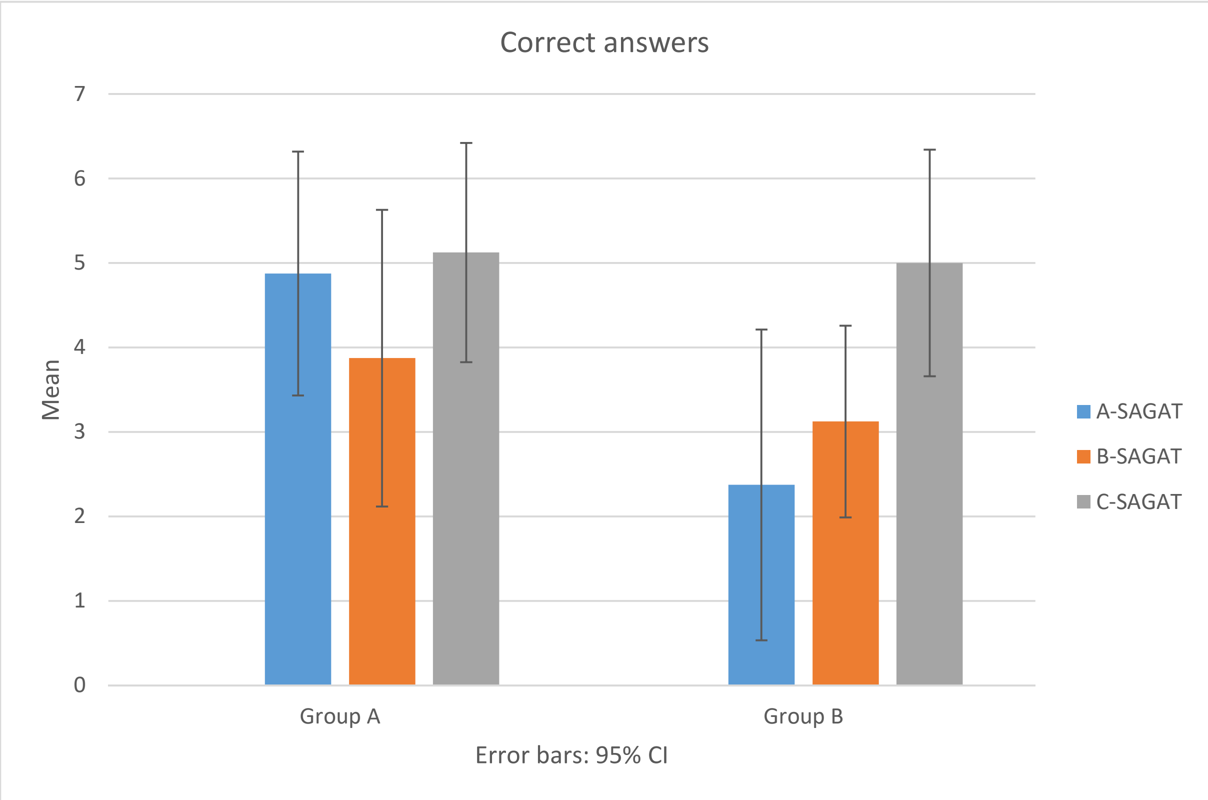


Figure 4-1: The error bar chart from the SAGAT tests after the first session

Repeated measures ANOVA

Table 4-1: Descriptive statistics and calculation of "Total Score"

	Test group A			Control group B		
Variable	N	M	SD	N	M	SD
A-SAGAT	8	4,880	1,727	8,000	2,380	2,200
B-SAGAT	8	3,880	2,100	8,000	3,130	1,356
C-SAGAT	8	5,130	1,553	8,000	5,000	1,604
Overall Mean - Total Score:		4,630	1,793		3,503	1,720

The margin of error for the overall mean is calculated for a 95% confidence interval. $\bar{X}$ = mean, σ = SD, Z = 1.96

$$95\%\ CI = \bar{X} \pm Z\left(\frac{\sigma}{\sqrt{n}}\right) = \frac{4{,}63+3{,}503}{2} \pm 1{,}96\left(\frac{\frac{1{,}793+1{,}72}{2}}{\sqrt{16}}\right) = 5{,}07 \pm 0{,}86 \approx \pm 16{,}9\%$$

In Table 4-1, the mean is calculated for each variable. The overall mean is calculated for test group A and control group B and represents the total score from the SAGAT session A, B and C (Endsley, 1988). Based on the figures, We see that the participants in test group A have 32,3% (95% CI [15.4, 49.2]) higher score when using AIS symbols with lanterns, compared to control group B who have ordinary AIS symbols.

For the implementation of Mauchly's Test of Sphericity, table 4-2, and the Tests of Within-Subjects Effects, table 4-3, SAGAT ABC consists of SAGAT A, B and C. Treatment consists of groups A and B.

Table 4-2: Mauchly's Test of Sphericity

Within Subjects Effect	χ^2	df	sig.
SAGAT ABC	0,406	2	0,816

Mauchlys test, $\chi2(2) = .41$, $p = .82$ did not indicate any violation of sphericity (Pallant, 2013, p. 290; Field & Hole, 2003, p. 186).

Table 4-3: Tests of Within-Subjects Effects

Source		df	F	Sig	η2
SAGAT ABC	Spherity Assumed	2	4,131	0,027	0,228
SAGAT ABC*Treatment	Spherity Assumed	2	2,076	0,144	0,129
Error (SAGAT ABC)	Spherity Assumed	28			

For SAGAT ABC, the difference between the means is statistically significant: $F(2,28) = 4.13$, $p = .027$ we reject the null hypothesis of equal means and keep the alternative hypothesis: There is a difference between the populations. η2 = .23 indicates a large effect.

For SAGAT ABC * treatment, the difference between the means is not statistically significant: $F(2,28) = 2.08$, $p = .144$ we keep the null hypothesis for equal means. η2 = .13 indicates a medium effect (Field & Hole, 2003, p. 190; Pallant, 2013, pp. 271–272).

4.1.2 Additional questions for SAGAT tasks A, B and C.

The bar chart in Figure 4-2 shows the sum of the correct answers to the additional questions from the first part of three SAGAT tests divided into test group A and control group B.

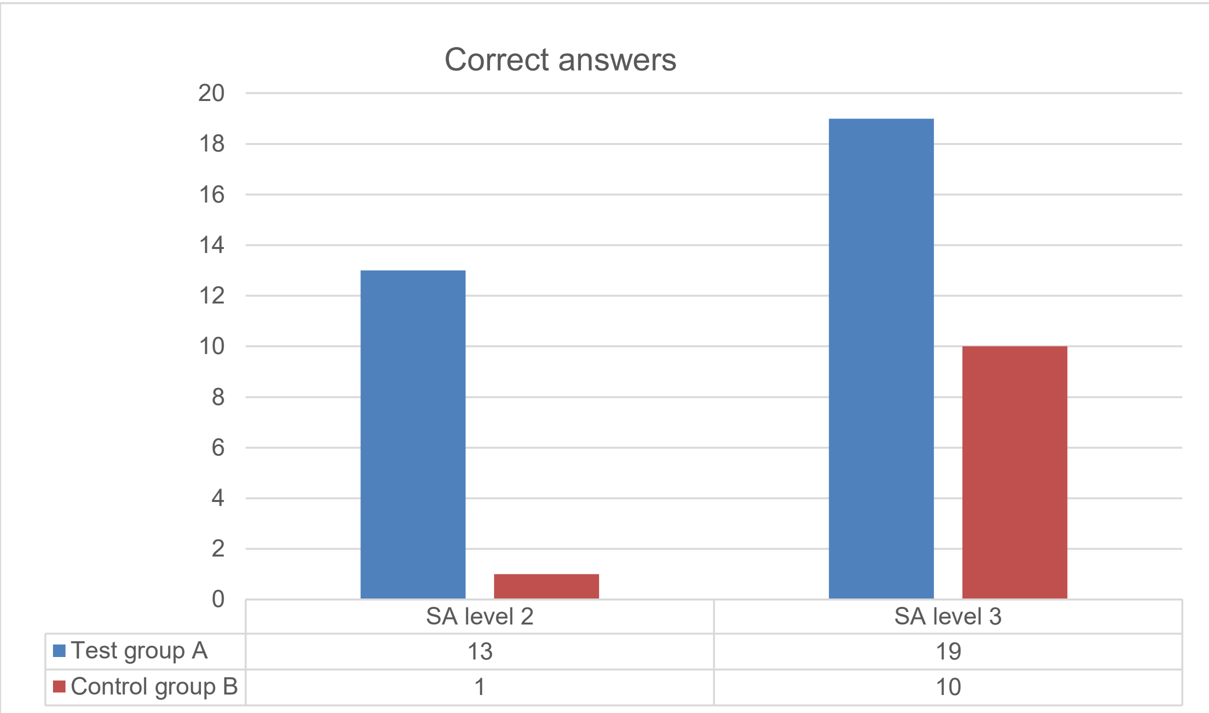


Figure 4-2: The number of correct answers from the Additional questions for SAGAT tasks A, B and C.

SAGAT ABC Situational Awareness level 2

Table 4-4: Additional questions. Situational Awareness level 2.

		Test group A		Control group B		Total	
		N	%	N	%	N	%
SA2-ABC	0 - correct answers	1	12,5%	7	87,5%	8	50,0%
	1 - correct answers	1	12,5%	1	12,5%	2	12,5%
	2 - correct answers	6	75,0%	0	0,0%	6	37,5%
Total		8	100,0%	8	100,0%	16	100,0%

Pearson Chi-square test for independence: X^2 (2, N = 16) = 10.5, p = <.05. The null hypothesis is rejected, the alternative hypothesis is retained, there is a difference between the populations. (Johannessen, 2009, pp. 135–139)

Test group A received 13 correct answers, and control group B received 1 correct answers which is a 92.3% lower score.

SAGAT ABC Situational Awareness level 3

Table 4-5: Additional questions. Situational Awareness level 3.

		Test group A		Control group B		Total	
		N	%	N	%	N	%
SA3-ABC	0 - correct answers	1	12,5%	2	25,0%	3	18,8%
	1 - correct answers	0	0,0%	2	25,0%	2	12,5%
	2 - correct answers	2	25,0%	4	50,0%	6	37,5%
	3 - correct answers	5	62,5%	0	0,0%	5	31,3%
Total		8	100,0%	8	100,0%	16	100,0%

Pearson Chi-square test for independence: X^2 (3, N = 16) = 8.0, p <.05 The null hypothesis is rejected, the alternative hypothesis is retained, there is a difference between the populations.

Test group A received 19 correct answers, and control group B received 10 correct answers which is a 47.4% lower score.

4.1.3 NASA TLX after the first session

The error bar chart in Figure 4-3 with the results from the NASA TLX after the first session and shows the distribution in both test group A and control group B.

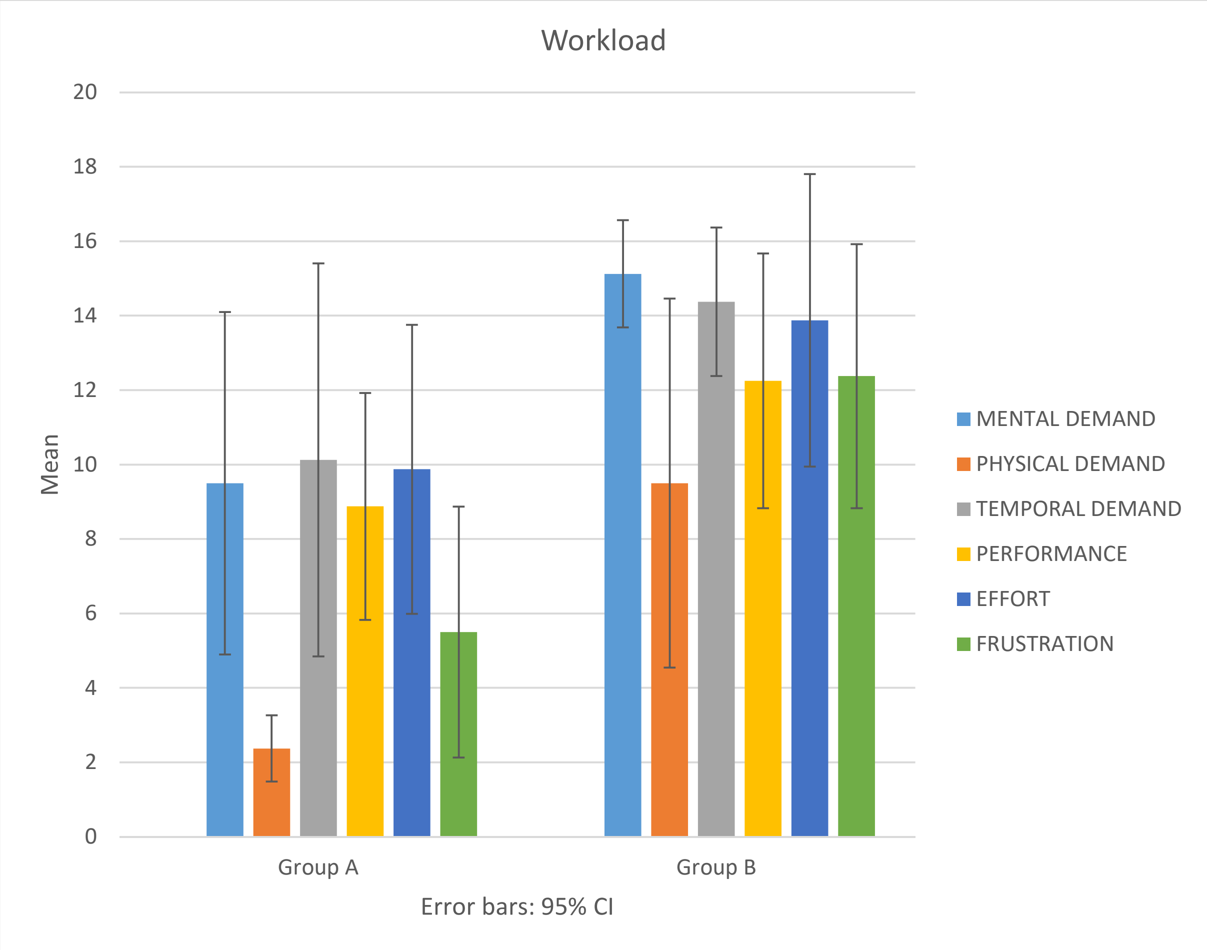


Figure 4-3: The error bar chart from the NASA TLX after the first session.

Table 4-6: Reliability Statistics.

Scale	N	Cronbach`s Alpha
All variables	6	0,836

In table 4-6, the Cronbach`s Alpha coefficient is .84 and indicates very good internal consistency reliability for the scale with this sample (Cortina & Schmitt, 1993; Pallant, 2013).

Repeated measures ANOVA.

Table 4-7: Descriptive statistics and calculation of total score.

	Test group A			Control group B		
Variable	N	M	SD	N	M	SD
Mental Demand	8	9,50	5,50	8	15,13	1,73
Physical Demand	8	2,38	1,06	8	9,50	5,93
Temporal Demand	8	10,13	6,31	8	14,38	2,39
Performance	8	8,88	3,64	8	12,25	4,10
Effort	8	9,88	4,64	8	13,88	4,70
Frustration	8	5,50	4,04	8	12,38	4,24
Overall Mean - Total score:		7.71	4,20		12,92	3,85

The margin of error for the overall mean is calculated for a 95% confidence interval. $\bar{X}$ = mean, σ = SD, Z = 1.96

$$95\%\ CI = \bar{X} \pm Z\left(\frac{\sigma}{\sqrt{n}}\right) = \frac{7{,}71+\quad ,92}{2} \pm 1{,}96\left(\frac{\frac{4{,}2+3{,}85}{2}}{\sqrt{16}}\right) = 10{,}315 \pm 1{,}97 \approx \pm 19{,}1\%$$

In Table 4-7, the mean is calculated for each variable. The mean expresses the subjectively imagined workload of each dimension or variable. The overall mean is calculated for test group A and control group B and represents what is known as the "Total Score" in NASA TLX. (Hart, 2006; Hart & Staveland, 1988). Based on the figures, we see that the participants in the trial's control group B experience a workload that is 67.5% (95% CI [48.4, 86.6]) higher when using regular AIS symbols compared to test group A who have AIS symbols with lanterns.

For the implementation of Mauchly's Test of Sphericity, table 4-8, and the Tests of Within-Subjects Effects, table 4-9, Workload consists of all the dimensions of the NASA TLX; Mental, physical, temporal, performance, effort and frustrations, Group consists of groups A and B, and will be referred to as treatment.

Table 4-8: Mauchly's Test of Sphericity

Within Subjects Effect	χ^2	df	sig.
Workload	7,299	14	0,925

Mauchlys test, $\chi2(14) = 7.30$, $p = .93$ did not indicate any violation of sphericity (Pallant, 2013, p. 290).

Table 4-9: Tests of Within-Subjects Effects

Source		df	F	Sig	η2
Workload	Spherity Assumed	5	7,226	0,000	0,34
Workload*Treatment	Spherity Assumed	5	0,714	0,615	0,049
Error (Workload)	Spherity Assumed	70			

For Workload, the difference between the means is statistically significant:

$F(5,70) = 7.27$, $p = .000$ we reject the null hypothesis of equal means and keep the alternative hypothesis: There is a difference between the populations. $\eta2 = .34$ indicates a large effect.

For workload * treatment, the difference between the means is not statistically significant:

$F(5,70) = .71$, $p = .615$ we keep the null hypothesis for equal means. $\eta2 = .05$ indicates a small effect (Pallant, 2013, pp. 271–272).

4.2 The second part of the experiment

4.2.1 SAGAT D, E and F.

The error bar chart in Figure 4-4 shows the mean score from the second parts three SAGAT tests divided into control group A and test group B.

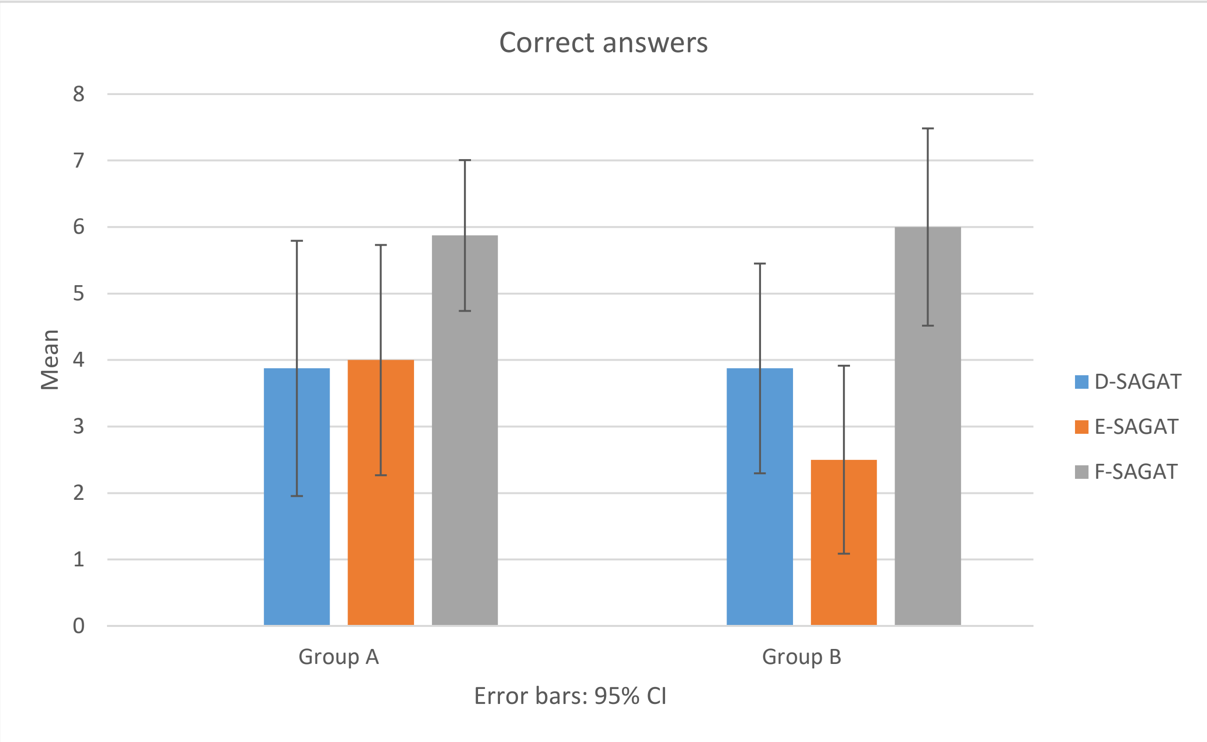


Figure 4-4: The error bar chart from the SAGAT tests after the second session.

Repeated measures ANOVA.

Table 4-10: Descriptive statistics and calculation of total score.

	Control group A			Test group B		
Variable	N	M	SD	N	M	SD
D-SAGAT	8	3,88	2,30	8	3,88	1,89
E-SAGAT	8	4,00	2,07	8	2,50	1,69
F-SAGAT	8	5,88	1,36	8	6,00	1,77
Overall Mean - Total Score:		4,59	1,91		4,13	1,78

The margin of error for the overall mean is calculated for a 95% confidence interval. $\bar{X}$ = mean, σ = SD, Z = 1.96

$$95\%\ CI = \bar{X} \pm Z\left(\frac{\sigma}{\sqrt{n}}\right) = \frac{4{,}59+4{,}13}{2} \pm 1{,}96\left(\frac{\frac{1{,}91+1{,}78}{2}}{\sqrt{16}}\right) = 4{,}36 \pm 0{,}9\ \approx \pm\ 20{,}6\%$$

In Table 4-10, the mean is calculated for each variable. The overall mean is calculated for control group A and test group B and represents the total score from the SAGAT session D, E and F (Endsley, 1988). Based on the figures, We see that the participants in control group A have 11,1% (95% CI [-9.5, 31.7]) higher score when using ordinary AIS symbols, compared to test group B who have AIS symbols with lanterns.

For the implementation of Mauchly's Test of Sphericity, table 4-11, and the Tests of Within-Subjects Effects, table 4-12, SAGAT DEF consists of SAGAT D, E and F. Treatment consists of groups A and B.

Table 4-11: Mauchly's Test of Sphericity

Within Subjects Effect	χ^2	df	sig.
SAGAT DEF	1,588	2	0,452

Mauchlys test, $\chi2(2) = 1.59$, $p = .45$ did not indicate any violation of sphericity (Pallant, 2013, p. 290).

Table 4-12: Tests of Within-Subjects Effects

Source		df	F	Sig	η2
SAGAT DEF	Spherity Assumed	2	10,364	0,000	0,425
SAGAT DEF * Treatment	Spherity Assumed	2	1,071	0,356	0,071
Error (SAGAT DEF)	Spherity Assumed	28			

For SAGAT DEF, the difference between the means is statistically significant: $F(2,28) = 10.36$, $p = .000$ we reject the null hypothesis of equal means and keep the alternative hypothesis: There is a difference between the populations. η2 = .46 indicates a large effect.

For SAGAT DEF * Treatment, the difference between the means is not statistically significant: $F(2,28) = 1.07$, $p = .356$ we keep the null hypothesis for equal means. $\eta 2 = .07$ indicates a medium effect (Pallant, 2013, pp. 271–272).

4.2.2 Additional questions for SAGAT tasks D, E and F.

The bar chart in Figure 4-5 shows the sum of the correct answers to the additional questions from the second part of three SAGAT tests divided into control group A and test group B.

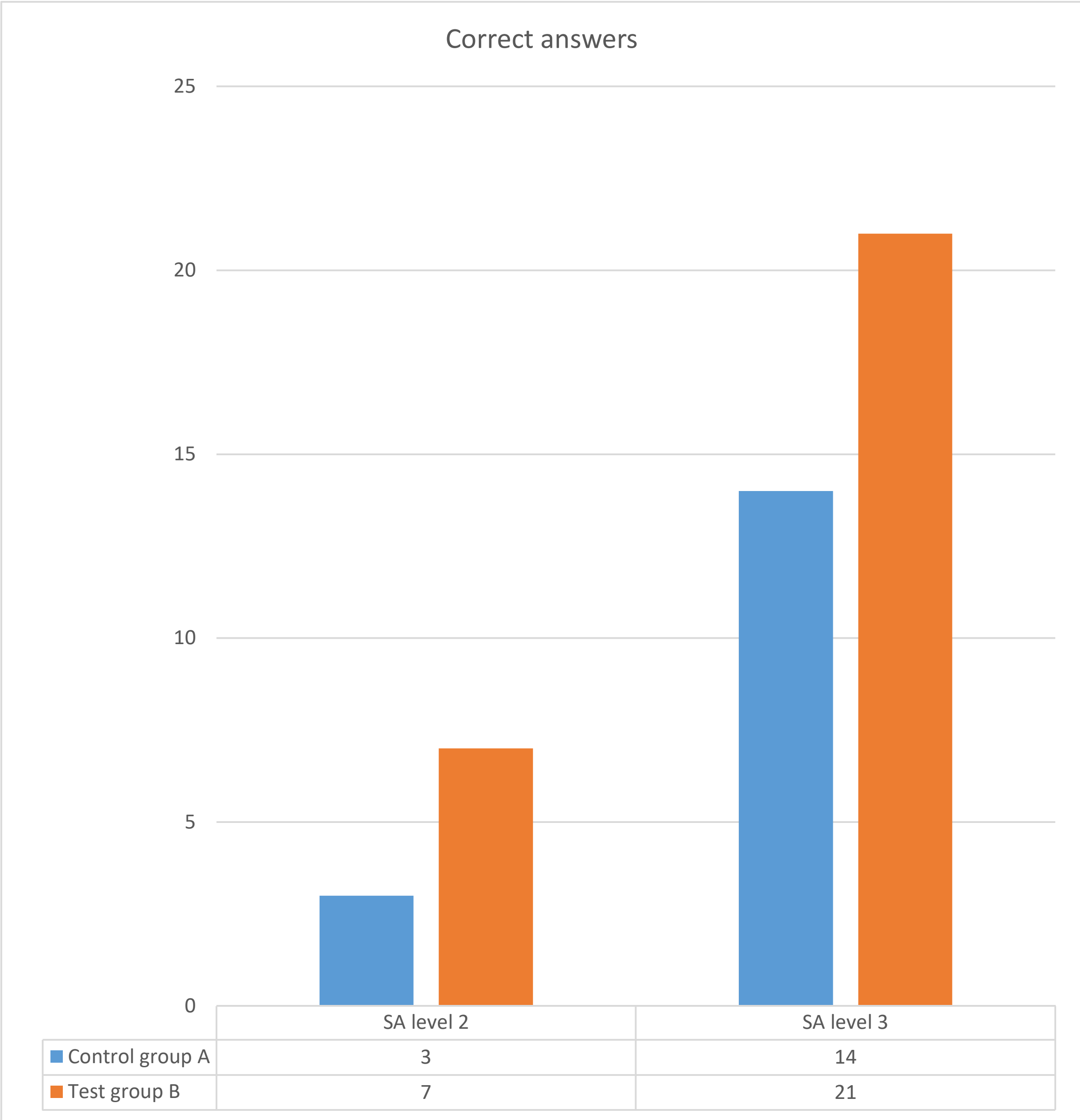


Figure 4-5: The number of correct answers from the Additional questions for SAGAT tasks D, E and F.

SAGAT DEF Situational Awareness level 2.

Table 4-13: Additional questions. Situational Awareness level 2.

		Control group A		Test group B		Total	
		N	%	N	%	N	%
SA2_DEF	0 - Correct answers	6	75,0%	2	25,0%	8	50,0%
	1 - Correct answers	1	12,5%	5	62,5%	6	37,5%
	2 - Correct answers	1	12,5%	1	12,5%	2	12,5%
Total		8	100,0%	8	100,0%	16	100,0%

Pearson Chi-square test for independence: X^2 (2, N = 16) = 4.67, p >.05. The null hypothesis is retained.

Control group A received 3 correct answers, and test group B received 7 correct answers which is a 133% higher score.

SAGAT DEF Situational Awareness level 3.

Tabell 4-14: Additional questions. Situational Awareness level 3.

		Control group A		Test group B		Total	
		N	%	N	%	N	%
SA3-DEF	0 - Correct answers	1	12,5%	0	0,0%	1	6,3%
	1 - Correct answers	1	12,5%	1	12,5%	2	12,5%
	2 - Correct answers	4	50,0%	3	37,5%	7	43,8%
	3 - Correct answers	2	25,0%	2	25,0%	4	25,0%
	4 - Correct answers	0	0,0%	2	25,0%	2	12,5%
Total		8	100,0%	8	100,0%	16	100,0%

Pearson Chi-square test for independence: X^2 (4, N = 16) = 3.14, p >.05. The null hypothesis is retained.

Control group A received 14 correct answers, and test group B received 21 correct answers which is a 50% higher score.

4.2.3 NASA TLX after the second session.

The error bar chart, figure 4-6, shows the results from the NASA TLX after the second session and shows the distribution in both control group A and test group B.

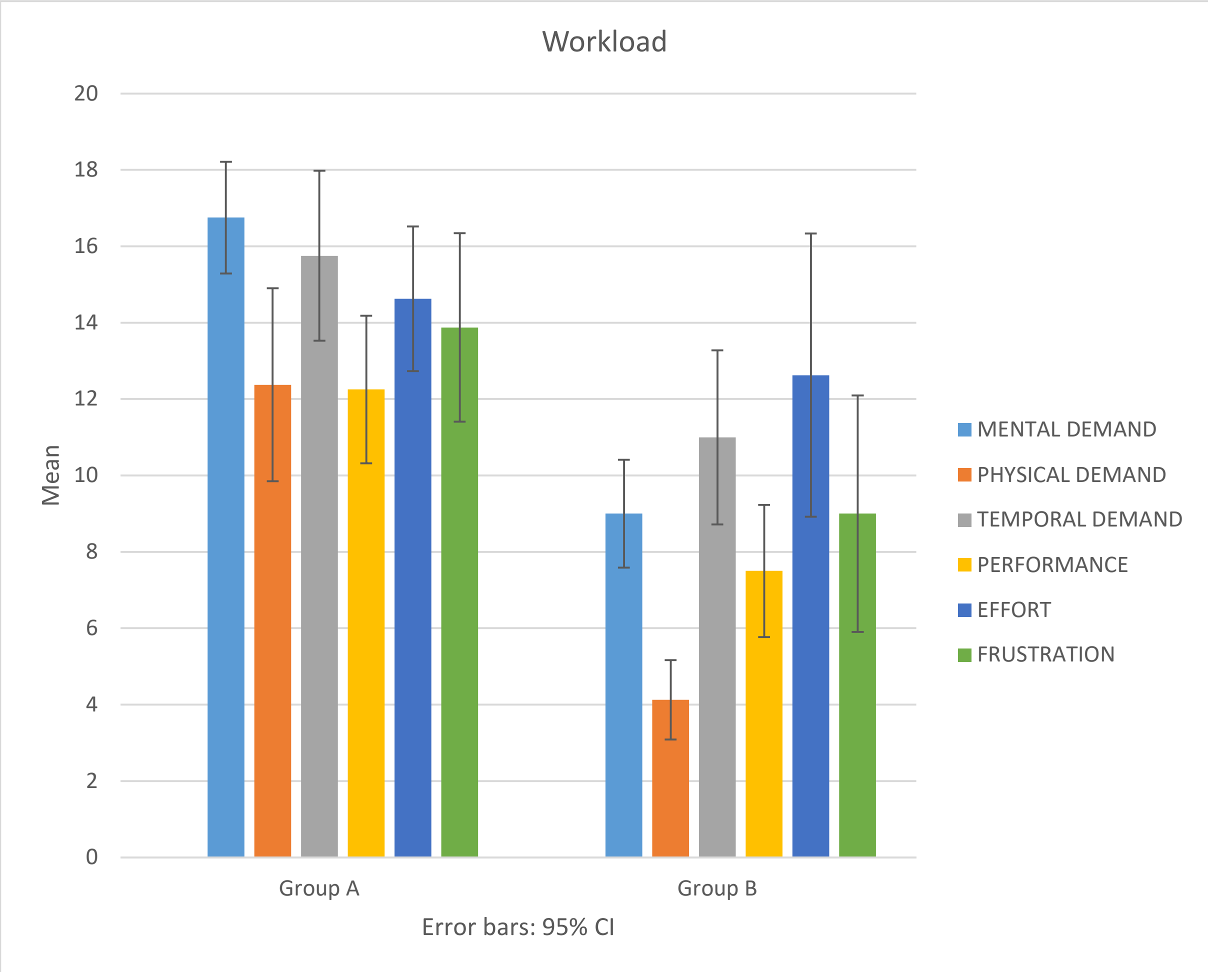


Figure 4-6: The error bar chart from the NASA TLX after the second session.

Table 4-15: Reliability Statistics

Scale	N	Cronbach`s Alpha
All variables	6	0,911

In table 4-15, the Cronbach`s Alpha coefficient is .91 and indicates very good internal consistency reliability for the scale with this sample (Cortina & Schmitt, 1993; Pallant, 2013).

Repeated measures ANOVA

Table 4-16: Descriptive statistics and calculation of total score.

	Control group A			Test group B		
Variable	N	M	SD	N	M	SD
Mental Demand	8	16,75	1,75	8	9,00	1,69
Physical Demand	8	12,38	3,02	8	4,13	1,25
Temporal Demand	8	15,75	2,66	8	11,00	2,73
Performance	8	12,25	2,32	8	7,50	2,07
Effort	8	14,63	2,26	8	12,63	4,44
Frustration	8	13,88	2,95	8	9,00	3,70
Overall Mean – Total Score		14,27	2,49		8,88	2,65

The margin of error for the overall mean is calculated for a 95% confidence interval. $\bar{X}$ = mean, σ = SD, Z = 1.96

$$95\%\ CI = \bar{X} \pm Z\left(\frac{\sigma}{\sqrt{n}}\right) = \frac{14{,}27+8{,}88}{2} \pm 1{,}96\left(\frac{\frac{2{,}49+2{,}65}{2}}{\sqrt{16}}\right) = 11{,}575 \pm 1{,}26 \ \approx \ \pm 10{,}9\%$$

In Table 4-16, the mean is calculated for each variable. The mean expresses the subjectively imagined workload of each dimension or variable. The overall mean is calculated for group A and group B and represents what is known as the "Total Score" in NASA TLX. (Hart, 2006; Hart & Staveland, 1988). Based on the figures, we see that the participants in the trial's control group A experienced a workload that is 60.7% (95% CI [49.8, 71.6]) higher when using regular AIS symbols compared to test group B who have AIS symbols with lanterns.

For the implementation of Mauchly's Test of Sphericity, table 4-17, and the Tests of Within-Subjects Effects, table 4-19. Workload consists of all the dimensions of the NASA TLX; Mental, physical, temporal, performance, effort and frustrations. Treatment consists of groups A and B.

Table 4-17: Mauchly's Test of Sphericity

Within Subjects Effect	χ^2	df	sig.
Workload	14,424	14	0,428

Mauchlys test, $\chi2(14) = 14.43$, $p = .43$ did not indicate any violation of sphericity.

Table 4-18: Tests of Within-Subjects Effects

Source		df	F	Sig	η2
Workload	Spherity Assumed	5	15,507	0,000	0,526
Workload * Treatment	Spherity Assumed	5	4,419	0,001	0,24
Error (Workload)	Spherity Assumed	70			

For workload, the difference between the means is statistically significant:

$F(5,70) = 15.5$, $p = .000$ we reject the null hypothesis of equal means and keep the alternative hypothesis: There is a difference between the populations. $\eta2 = .53$ indicates a large effect.

For Workload * Treatment, the difference between the means is statistically significant:

$F(5,70) = 4.42$, $p = .001$ we reject the null hypothesis of equal means and keep the alternative hypothesis: There is a difference between the populations. $\eta2 = .24$ indicates a large effect. (Pallant, 2013)

4.3 Interviews and observations.

Table 4-19: Interviews. Date: 05.04.2022.

Participant	Group	Summary	Coding
1	A	*"I am a little weak on lantern rules, but with the help of the "remember note", it was much easier to imagine what you had around you and what you had to do when you could see the lanterns compare to regular AIS symbols. The most difficult part of the exercise was remembering the different ones after the AIS was turned off"*	• Week on Colreg • Hard to remember when AIS off • Better overview with lanterns
2	B	*"It was stressful to click on all the ships trying to remember their status and length. It was less stressful with lanterns despite that I am week on rules, helpful with the remember note. I think it was much easier to plan when the lanterns were on. Very difficult to remember after AIS was shut off."*	• Week on Colreg • Stressful ordinary AIS • Less stressful with lanterns • Easier to plan with lanterns
3	A	*"It was easy to remember the status of the different boats and the location between them, but I had trouble remembering what the different boats were called. The hardest part of the exercise was remembering after the AIS was turned off. It was much easier to understand the situation you had in front of you when there were lanterns on the AIS symbols, when you saw them on the screen, compared to regular AIS symbols."*	• Hard to remember when AIS off • Easier to plan with lanterns • Hard to remember boat names
4	B	*"I became so preoccupied with remembering navigation status that I forgot to look for give way situations in the first session. It was a little easier when you saw the lanterns in terms of understanding the situation around you and which boats you had a duty to give way to when you saw them on the screen."*	• Eager to get navigation status right • Forgot to analyse the situation in the first session • Easier to understand situation with lanterns
5	A	*"Very comfortable and clear with lanterns on the AIS symbols, easy to imagine the situation ahead. The most difficult part of the task was remembering after the AIS was turned off. I am a little unsure of Colreg yet, but with the "remember note" with the symbols, it went well. It was much more stressful to get an overview of the situation with usual symbols."*	• Comfortable with lanterns. • Easy to imagine the situation ahead • More stressful with ordinary AIS.
6	B	*"I am so bad at remembering, I got "brain freeze" every time AIS was turned off. It was stressful to find information about the navigation status of the regular symbols, it was very nice to see the AIS symbols with lanterns, easier to understand the situation, but I forgot it as soon as you turned them off."*	• Hard to remember when AIS off • Easier to understand situation with lanterns

7	A	*"I am so bad at lantern rules that I thought it was easier to remember the different boats and their statuses with the usual AIS symbols because it was written in the text box what the different ones were. Still, when the AIS signals were on, it was easier, with the help of the "remember note", to imagine who I had a duty to give way to and how to navigate further."*	• Week on Colreg • Hard to remember when AIS off • Easier to plan with lanterns

Table 4-20: Observations. Date: 05.04.2022.

Participant	Group	Summary of the observations of the participants.
1	A	Eager and a little nervous. Excused himself having week knowledge of lantern rules. Listened carefully under the introduction briefing, struggled in the first SAGAT test focusing on symbols forgot to remember boat names. This got better throughout the exercise.
2	B	Relaxed, low knowledge on Colreg, eager to click on symbols memorising status not paying much attention to the overall situation.
3	A	Socially and outgoing, followed during the briefing and asked several questions, seemed to have a good overview of the rules for lanterns. Seemed interested in the project.
4	B	Open and friendly person. Considered to have a good understanding of Colreg. Followed the brief carefully. Appeared purposefully and systematically during the experiments.
5	A	Polite and attentive, listened carefully during the exercise review, solved the tasks systematically and concentrated.
6	B	The candidate seemed a little shy with a slightly evasive look. Opened the conversation by saying that the knowledge in Colreg was weak, but that the basics were in place. Quietly followed the briefing, and asked a few questions during the briefing. Complained about brain freeze during the exercise.
7	A	The candidate arrived late in the day but was still awake and obvious. Listened carefully during the briefing before starting. Worked systematically through the tasks.

Table 4-21: Interview. Date: 06.04.2022.

Participant	Group	Summary	Coding
8	B	*"If I had known Colreg better, it would have been much easier to get an overview and to navigate with lanterns on the AIS symbols. Think it was a very good and simple idea that was very helpful. Was difficult to remember different statuses in the first exercise but found a system to remember and then it was easier on the next attempts."*	• Week on Colreg • Easier with lanterns • Very good and helpful idea.

Table 4-22: Observation. Date: 06.04.2022.

Participant	Group	Summary of the observation of the participant.
8	B	The candidate was quiet and concentrated, followed closely during the briefing. Seemed determined and concentrated during the experiments. Used the "remember note" actively during the exercises with lanterns on the AIS symbols.

Table4-23: Interviews. Date: 07.04.2022.

Participant	Group	Summary	Coding
9	A	*“It would have been easier if I had known Colreg better. It was much easier to see the connection between the boats with lanterns on AIS. It was difficult to remember the different ones. It was easy when the signals were on.”*	• Week on Colreg • Easier with lanterns
10	B	*“The lanterns helped. Hard to remember after it was turned off. There was high time pressure. Better overview of the voyage ahead.”*	• Lanterns helped • High time pressure • Lanterns gave better overview
11	A	*“It was easier to remember the length of ships with lanterns on AIS. Easier for me to remember status from text box. I am average in Colreg. Difficult to remember and great time pressure.”*	• Easier to remember length with lanterns • Easier to remember status from textbox
12	B	*“It was much easier to remember when there were lanterns on the AIS signals. It was also much easier to plan ahead, the time pressure in the exercise was great, difficult to remember which ship had which status in both alternatives.”*	• Easy to remember and plan with lanterns • Hard to combine ship name and status.
13	A	*“It was easier to get details about the ships navigation status and whether the boats were big or small with lanterns on AIS. I focused on remembering the navigation status and forgot to analyse the situation. I had more time to watch the voyage with lanterns. It was far more work with ordinary AIS symbols to find information and more challenging to plan the voyage further ahead.”*	• More details with lanterns • More difficult to plan ahead with ordinary symbols
14	B	*“Felt that you got a better overview with lanterns on the AIS symbols; you got an overall situation compared to ordinary symbols. With the ordinary symbols, it was difficult to have an overview of the activity of the various vessels. Before you had checked, the last one had forgotten the first ones with ordinary ones. With the use of lanterns, you got an overview at first glance. An ingenious and simple idea”*	• Better overview with lanterns • Overview at first glance with lanterns • Good idea
15	A	*“I think it was easier with lanterns, got a quicker overview. Instead of clicking on them one by one, you got a lot more information from the lantern configuration and could therefore concentrate on several things at the same time. High time pressure when there were ordinary AIS signals. In the exercise, I was much focused on navigation status and lost track of the traffic picture with AIS without lanterns.”*	• Easier to get overview with lanterns • High time pressure in the exercises

Table 4-24: Observations. Date: 07.04.2022.

Participant	Group	Summary of the observation of the participants
9	A	Quiet and careful, very attentive to the brief. Told that they had received very little instruction in the Colreg due to the Covid-19 pandemic. Used a long time to the answers.
10	B	A little nervous but polite and outgoing, listened carefully during the exercise review, asked questions along the way, solved the tasks systematically and concentrated.
11	A	The participant followed closely during the briefing, asked several questions, and seemed to have a good overview of the rules for lanterns.
12	B	The participant first apologised with little knowledge of Colreg, eager to click on symbols to memorise the navigation status without much attention to the general situation.
13	A	Seemed safe and confident. Carefully followed under brief. Worked systematically during the exercises, talked loudly to himself to memorize the different navigation statuses
14	B	The participant expressed to like the idea of AIS visual communication, followed closely during the briefing, and asked several questions during the exercise.
15	A	The last participant of the day seemed a little tired and expressed a little weak knowledge of the rules for lantern use in Colreg, followed closely during the briefing.

Table 4-25: Interview. Date: 08.04.2022.

Participant	Group	Summary	Coding
16	B	*"As soon as I see lights on the AIS symbol, it means that there is something I need to be more aware of. With regular AIS symbols, I read the traffic picture as if everyone was "Underway using engine". It is much easier to have an overview when you see the lights in the AIS symbol than to have to click on each one to get text information from the ordinary symbols. With lanterns, you get the information right away and it is easier to keep track of which ones are what when you see them on the screen. The most difficult part of the exercise was to remember the names of the vessels and connect them with the correct status in the answer. However, it is not important to remember names. What is important is how I should relate to the other vessels and the use of lanterns in the AIS symbol was very helpful."*	• Lanterns tell me to pay attention • Better overview with lanterns • Lanterns give you information right away • Hard to combine ship name with status.

Table 4-26: Observation. Date: 08.04.2022.

Participant	Group	Summary of the observation of the participant.
16	B	The candidate expressed interest in the project. Watched closely during the brief and was quiet and concentrated during the exercises. Was a bit unstructured while gathering information in the first session, but quickly found a system to map the situation and memorize information.

5 Discussion

The upgraded version of TECDIS developed for this experiment is based entirely on the criteria described in section 2.4. It works very well in dusk and night mode, where there is a black background, but not in day mode. The screen technology approved for use by ECDIS today has too low a screen resolution. A lantern displayed in the AIS symbol consists of four pixels. It is impossible to define a white lantern with a black ring in day mode when shown against a white background. According to the research and development department in Telko AS, we must have ECDIS screens with 4K technology to display lanterns on the AIS symbols in day mode. However, it must be emphasized that TECDIS version 4.8.3.4 S.9 with activated lantern function does not currently comply with the requirements of the ECDIS standards for the presentation of AIS targets. It is intended for research purposes only.

The participants were not recruited from a random sample. They were recruited from the university's nautical students from the 2nd and 3rd grade. For demographic reasons, data from such a sample will not directly be transferable to the population of navigators as a whole. However, the main purpose of this experiment was to find out whether the participants experienced differences in SA and workload in the two alternative ways of presenting AIS information, and for that purpose, the participants in the experiment have worked well. They are all considered novices at the same level of experience. By wanting to participate, we can assume that they were motivated. They are all well used to simulator training and tested under challenging conditions. Another thing we can assume from the participants is the possibility that they were more vigilant in this test situation than they normally would have been because they were observed through the experiment (Adair, 1984). It should also be mentioned that the students in the last two years have received much of their teaching digitally through online solutions such as Teams and Zoom because the Covid -19 pandemic and the requirements for social distancing prohibited regular teaching in lecture halls.

Most of the participants had in common that they had little faith in their own knowledge of lantern configurations as defined in Colreg, which must be said to be natural since they are still students. This knowledge has not yet matured or been practised beyond simulator training. However, it turned out later in the experiment that most did well and they had a "remember note" with all the configurations at their disposal.

The task in the experiment was to monitor the sailing on northbound courses. They were asked to keep an eye on intersecting traffic and assess duty to give way situations. Furthermore, they were instructed to obtain as much information as possible about the other vessels 'navigation status and, in addition, information that tells whether the other vessels' length was above or below 50 meters. The participants were given 60 seconds to solve the task. There were six such exercises throughout the experiment, and there were seven vessels in each task.

In the first exercise, called A SAGAT, the participants in test group A were calm and observant in their monitoring of the situation. In contrast, the participants in the control group B clicked a little randomly around the different vessels to get information. In this first task, the participants in the test group had an average of 4.88 correct answers against the control group's 2.38 right answers (Fig. 4-1). This is a difference of 51.2% (95% CI [34.3, 68.1]).

This difference changed quickly through the upcoming exercises. It was mainly in the control group that a more systematic review developed in that they dealt with the other vessels in numbered order and memorised the vessels' navigation status. In the last exercise after the second part, the test group had an average score of 6.0 correct answers against the control group's 5.88 correct answers.

Ideally, SAGAT should be administered so it happens randomly when you get so-called "freezes" (Endsley, 1988; Endsley & Garland, 2000a), but it requires more resources than was available for this experiment. For this first part of the SAGAT questions, only task A satisfied the requirements for a well-conducted SAGAT experiment. The other five tasks from B to F are unfortunately less suitable as a basis for assessment, and this is because the random element disappeared, and the participants were given the opportunity to specialise in solving the tasks because they were equal in character and in exposed time. This is a weakness of the experiment that was not anticipated by the author.

Only when we look at the results from the additional questions after each SAGAT exercise we can see the effect of the two different ways of presenting AIS information. In the first part, the control group had a score of 92.3% lower than the test group for questions regarding SA level 2. Correspondingly, a score of 47.4% lower for the questions regarding SA level 3. For the additional questions in the second part, we see the same. The control group has a score that is 57.1% lower than the test group for questions regarding SA level 2 and correspondingly 33% lower score for questions relating to SA level 3.

It is clear that the test group that has AIS symbols with lanterns has received more information both at SA level 2 and at SA level 3 which is what is most important in relation to safe navigation, to see from the situation, which vessels one must give way to. There is much to suggest that the control group, in this test situation, experiences so-called change blindness, which means they are so preoccupied with their task that they do not perceive other things even if they happen right in front of them (Flin et al., 2015).

After each session, participants responded to a NASA TLX questionnaire (Hart, 2006; Hart & Staveland, 1988). This is a self-evaluation of the participant's subjective perception of the workload in the experiment. The differences between the two ways of presenting the navigation status in the AIS symbols become clear.

After the first session the participants in the trial's control group B experience a workload that is 67.5% (95% CI [48.4, 86.6]) higher when using regular AIS symbols compared to test group A who have AIS symbols with lanterns. There is a margin of error of 19.1%, but even the lower limit of 48.4% is a significantly higher self-evaluated workload.

In the NASA TLX after the second session, we see that the participants in the experimental control group A experienced a workload that is 60.7% (95% CI [49.8, 71.6]) higher when using regular AIS symbols compared to the test group B, which has AIS symbols with lanterns. There is a margin of error of 10.9%. The lower limit is 49.8%, almost the same result as after the first session, which still is a significantly higher self-evaluated workload. In other words, the participants in the control group have worked at least 50% more to achieve the same SA as the participants in the test group by what they have perceived as their primary task, to get an overview of the navigation status of surrounding vessels. Therefore, they have also lost some of the overviews and scored lower on additional SA level 2 and SA level 3 questions.

An interview was held after each participant completed their experiment (tables 4-19 to 25). The author summarises here the most important things that came to light. The participants shared many of the same views. Most expressed that they felt weak about Colreg. When they saw lanterns on the AIS symbol, they perceived this as something they had to be aware of. The participants found it much easier to keep a good overview in the exercises where the lantern symbols were in use. They found it more stressful and easier to lose track of other vessels when they had to click on regular AIS symbols to get the information in text boxes compared to information from symbols directly on the screen. During the exercise, many had difficulty remembering the names of the vessels and, at the same time, retaining the navigation status, which was crucial to be able to answer the first parts of the SAGAT questionnaires. They expressed that it was easier to plan the voyage when the AIS signals with lanterns were on, and they had the whole picture in front of them.

The last thing mentioned in the section above is the whole purpose of AIS Visual Communication, to create a user interface where you always have an overview of the situation you have around you or are about to sail into. The idea is that AIS symbols with lanterns should be a good aid in heavy traffic and or reduced visibility. In situations with heavy traffic and reduced visibility, it is common for many vessels to staff the bridge team with several navigators so that they can cooperate and relieve each other. For this collaboration to work well, they are dependent on having a common understanding of the reality around them and their own vessel. When using lantern configurations in the AIS symbol on the screen, this can be a good tool for everyone to have access to the same information at the same time.

There has been a good agreement between the results from the statistical analysis and the interviews with each participant. This indicates that the results from this experiment have provided data with good reliability and validity.

This experiment has been entirely about navigators on ships and how AIS Visual Communication affect them. As a proposal for future research on this topic, I would propose focusing on operators at Vessel Traffic Services (VTS) and operators of future shore control centres for unmanned ships.

6 Conclusion

The results from the experiment and interviews have made it probable that the use of lanterns on the AIS symbol helps navigators to get increased situational awareness. It is also likely to lead to reduced workload levels. In isolation, this can be a good contribution to increased navigational safety.

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8 Appendices

8.1 APPENDIX A: Registration and consent form

Registration and consent form

I have received and understood information about the project "AIS Visual Communication." With my signature, I consent to answer questionnaires, participate in an experiment exercise on a desktop simulator and give an interview after the experiment.

	Participants signature:	Day:	Time:	Mobile:	e-mail.
1					
2					
3					
4					
5					
6					
7					
8					
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12					
13					
14					
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30					

8.2 APPENDIX B: Questionnaire used during the experiment

8.2.1 Welcome and information page.

AIS Visual Communication - The Next Step.

Welcome to this laboratory experiment at the ECDIS laboratory.

University of South-Eastern Norway
Campus Vestfold
Room D2 - 91.

In this survey, you will be kept completely anonymous.

Responsible for the survey is Rune Johansen.

- e-mail: rune.j9@online.no
- mobile: 413 72 244

8.2.2 Demographic data.

Group A: starts the exercise in "DUSK" mode with lanterns on the AIS symbol.
Group B: starts the exercise in "DAY" mode with regular AIS symbols.

- ○ Group A
- ○ Group B

*

What year are you in?

- ○ 2nd-year student
- ○ 3rd-year student

*

Male or female

- ○ Male
- ○ Female

*

Age group

- ○ 19 -24
- ○ 25 -29
- ○ 30 -34
- ○ 35 - 39
- ○ 40 +

8.2.3 Questionnaire to A SAGAT

A - SAGAT

Check the correct navigation status for each vessel. If you do not remember it, check "I Don't know."

	A 1	A 2	A 3	A 4	A 5	A 6	A 7
I Don't know	○	○	○	○	○	○	○
Under way using engine	○	○	○	○	○	○	○
At anchor	○	○	○	○	○	○	○
Not under command	○	○	○	○	○	○	○
Restricted Manoeuvrability	○	○	○	○	○	○	○
Constrained by draught	○	○	○	○	○	○	○
Moored	○	○	○	○	○	○	○
Aground	○	○	○	○	○	○	○
Engaged in Fishing	○	○	○	○	○	○	○
Under way sailing	○	○	○	○	○	○	○

What are the correct measures in relation to vessel: A 3 *

- ○ Maintain course and speed.
- ○ Give way to the vessel
- ○ I dont know

What is the length of vessel: A 4 *

- ○ Longer than 50 m
- ○ Less than 50 m
- ○ I dont know

8.2.4 Questionnaire to B SAGAT

B - SAGAT

Check the correct navigation status for each vessel. If you do not remember it, check "I Don't know."

	B 1	B 2	B 3	B 4	B 5	B 6	B 7
I Don't know	○	○	○	○	○	○	○
Under way using engine	○	○	○	○	○	○	○
At anchor	○	○	○	○	○	○	○
Not under command	○	○	○	○	○	○	○
Restricted Manoeuvrability	○	○	○	○	○	○	○
Constrained by draught	○	○	○	○	○	○	○
Moored	○	○	○	○	○	○	○
Aground	○	○	○	○	○	○	○
Engaged in Fishing	○	○	○	○	○	○	○
Under way sailing	○	○	○	○	○	○	○

What are the correct measures in relation to vessel: B 7 *

- ○ Maintain course and speed.
- ○ Give way to the vessel
- ○ I dont know

What are the correct measures in relation to vessel: B 4 *

- ○ Maintain course and speed.
- ○ Give way to the vessel
- ○ I dont know

8.2.5 Questionnaire to C SAGAT

C - SAGAT

Check the correct navigation status for each vessel. If you do not remember it, check "I Don't know."

	C 1	C 2	C 3	C 4	C 5	C 6	C 7
Under way using engine	○	○	○	○	○	○	○
At anchor	○	○	○	○	○	○	○
Not under command	○	○	○	○	○	○	○
Restricted Manoeuvrability	○	○	○	○	○	○	○
Constrained by draught	○	○	○	○	○	○	○
Moored	○	○	○	○	○	○	○
Aground	○	○	○	○	○	○	○
Engaged in Fishing	○	○	○	○	○	○	○
Under way sailing	○	○	○	○	○	○	○

What is the length of vessel: C 5 *

- ○ Longer than 50 m
- ○ Less than 50 m
- ○ I dont know

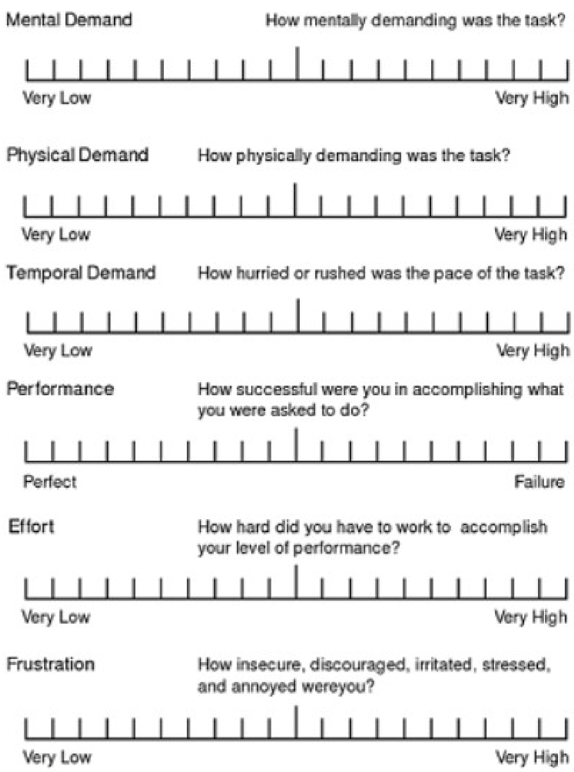
What are the correct measures in relation to vessel: C 6 *

- ○ Maintain course and speed
- ○ Give way to the vessel
- ○ I dont know

8.2.6 Questionnaire for NASA TLX after the first session.

First, read the description of the NASA TLX

Title	Endpoints	Descriptions
Mental Demand	low/high	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	low/high	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	low/high	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	good/poor	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	low/high	How hard did you have to work (mentally and physically) to accomplish your level of performance?
Frustration level	low/high	How insecure, discouraged, irritated, stressed, and annoyed versus secure, gratified, content, relaxed, and complacent did you feel during the task?



8.2.7 Questionnaire to D SAGAT

D - SAGAT

Check the correct navigation status for each vessel. If you do not remember it, check "I Don't know."

	D 1	D 2	D 3	D 4	D 5	D 6	D 7
I Don`t know	○	○	○	○	○	○	○
Under way using engine	○	○	○	○	○	○	○
At anchor	○	○	○	○	○	○	○
Not under command	○	○	○	○	○	○	○
Restricted Manoeuvrability	○	○	○	○	○	○	○
Constrained by draught	○	○	○	○	○	○	○
Moored	○	○	○	○	○	○	○
Aground	○	○	○	○	○	○	○
Engaged in Fishing	○	○	○	○	○	○	○
Under way sailing	○	○	○	○	○	○	○

What are the correct measures in relation to vessel: D 3 *

- ○ Maintain course and speed.
- ○ Give way to the vessel
- ○ I dont know

What is the length of vessel: D 4

- ○ Longer than 50 m
- ○ Less than 50 m
- ○ I dont know

8.2.8 Questionnaire to E SAGAT

E - SAGAT

Check the correct navigation status for each vessel. If you do not remember it, check "I Don't know."

	E 1	E 2	E 3	E 4	E 5	E 6	E 7
I Don't know	○	○	○	○	○	○	○
Under way using engine	○	○	○	○	○	○	○
At anchor	○	○	○	○	○	○	○
Not under command	○	○	○	○	○	○	○
Restricted Manoeuvrability	○	○	○	○	○	○	○
Constrained by draught	○	○	○	○	○	○	○
Moored	○	○	○	○	○	○	○
Aground	○	○	○	○	○	○	○
Engaged in Fishing	○	○	○	○	○	○	○
Under way sailing	○	○	○	○	○	○	○

What is the length of vessel: E 3 *

- ○ Longer than 50 m
- ○ Less than 50 m
- ○ I dont know

What are the correct measures in relation to vessel: E 7 *

- ○ Maintain course and speed.
- ○ Give way to the vessel
- ○ I dont know

8.2.9 Questionnaire to F SAGAT

F - SAGAT

Check the correct navigation status for each vessel. If you do not remember it, check "I Don't know."

	F 1	F 2	F 3	F 4	F 5	F 6	F 7
I Don't know	○	○	○	○	○	○	○
Under way using engine	○	○	○	○	○	○	○
At anchor	○	○	○	○	○	○	○
Not under command	○	○	○	○	○	○	○
Restricted Manoeuvrability	○	○	○	○	○	○	○
Constrained by draught	○	○	○	○	○	○	○
Moored	○	○	○	○	○	○	○
Aground	○	○	○	○	○	○	○
Engaged in Fishing	○	○	○	○	○	○	○
Under way sailing	○	○	○	○	○	○	○

What are the correct measures in relation to vessel F 7 *

- ○ Maintain course and speed
- ○ Give way to the vessel
- ○ I dont know

What are the correct measures in relation to vessel F 6 *

- ○ Maintain course and speed.
- ○ Give way to the vessel
- ○ I dont know

8.2.10 Questionnaire for NASA TLX after the second session.

First, read the description of the NASA TLX

Title	Endpoints	Descriptions
Mental Demand	low/high	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	low/high	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	low/high	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	good/poor	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	low/high	How hard did you have to work (mentally and physically) to accomplish your level of performance?
Frustration level	low/high	How insecure, discouraged, irritated, stressed, and annoyed versus secure, gratified, content, relaxed, and complacent did you feel during the task?

Mental Demand — How mentally demanding was the task?

Very Low — Very High

Physical Demand — How physically demanding was the task?

Very Low — Very High

Temporal Demand — How hurried or rushed was the pace of the task?

Very Low — Very High

Performance — How successful were you in accomplishing what you were asked to do?

Perfect — Failure

Effort — How hard did you have to work to accomplish your level of performance?

Very Low — Very High

Frustration — How insecure, discouraged, irritated, stressed, and annoyed wereyou?

Very Low — Very High

8.3 APPENDIX C: ECDIS Screenshots of the SAGAT tasks

8.3.1 Route and description of symbols used in the experiment.

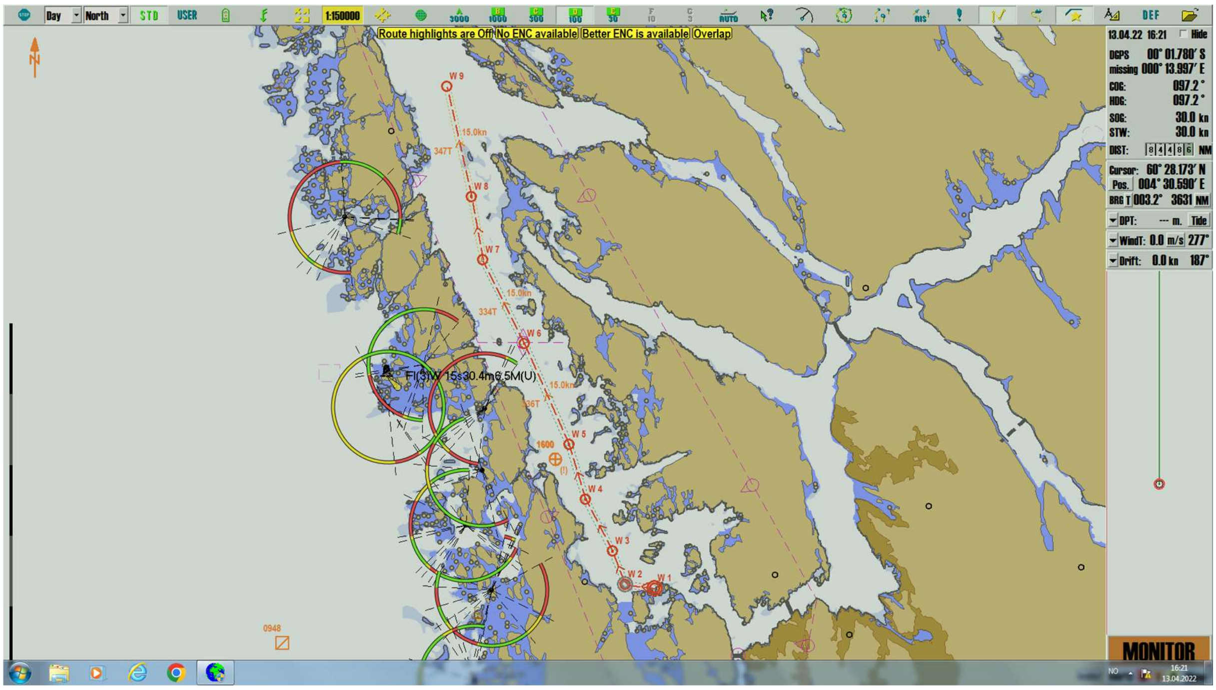


Figure 8-1: North bound route in Hjeltefjorden outside Bergen, Norway.

Figure 8-2: Descriptive picture before the start of the SAGAT tasks.ECDIS in dusk mode. AIS symbols with lanterns.

8.3.2 A SAGAT

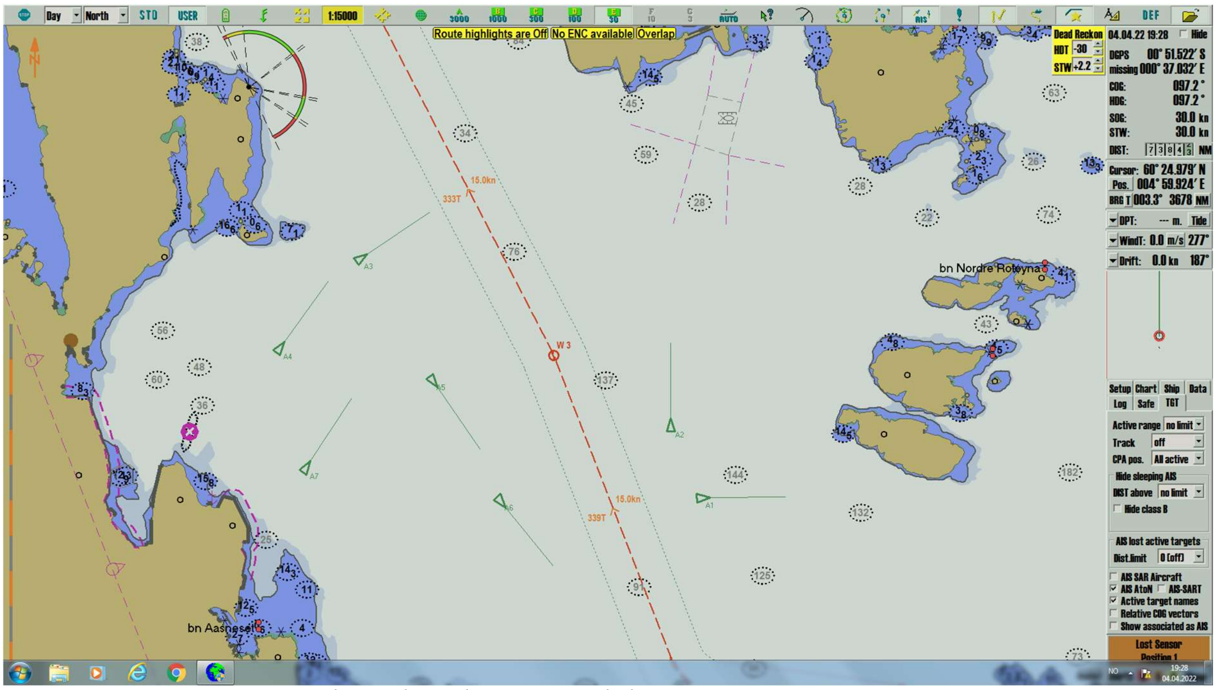


Figure 8-3: A SAGAT, ECDIS in day mode. Ordinary AIS symbols.

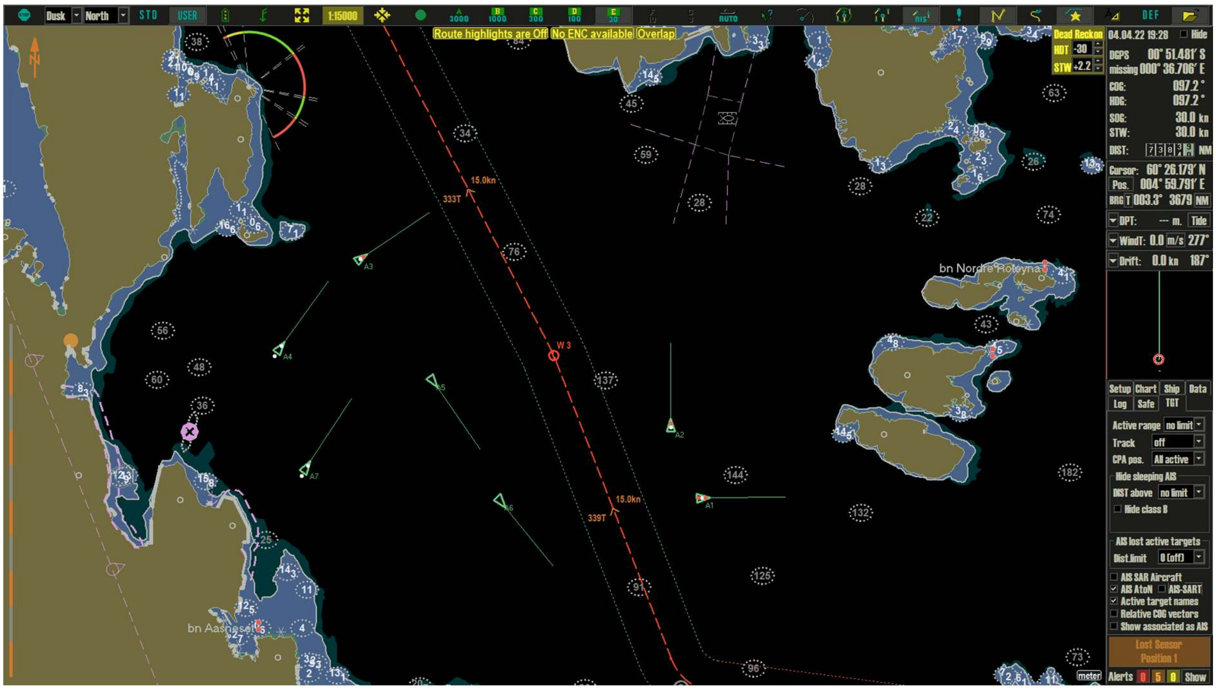


Figure 8-4: A SAGAT, ECDIS in dusk mode. AIS symbols with lanterns.

8.3.3 B SAGAT

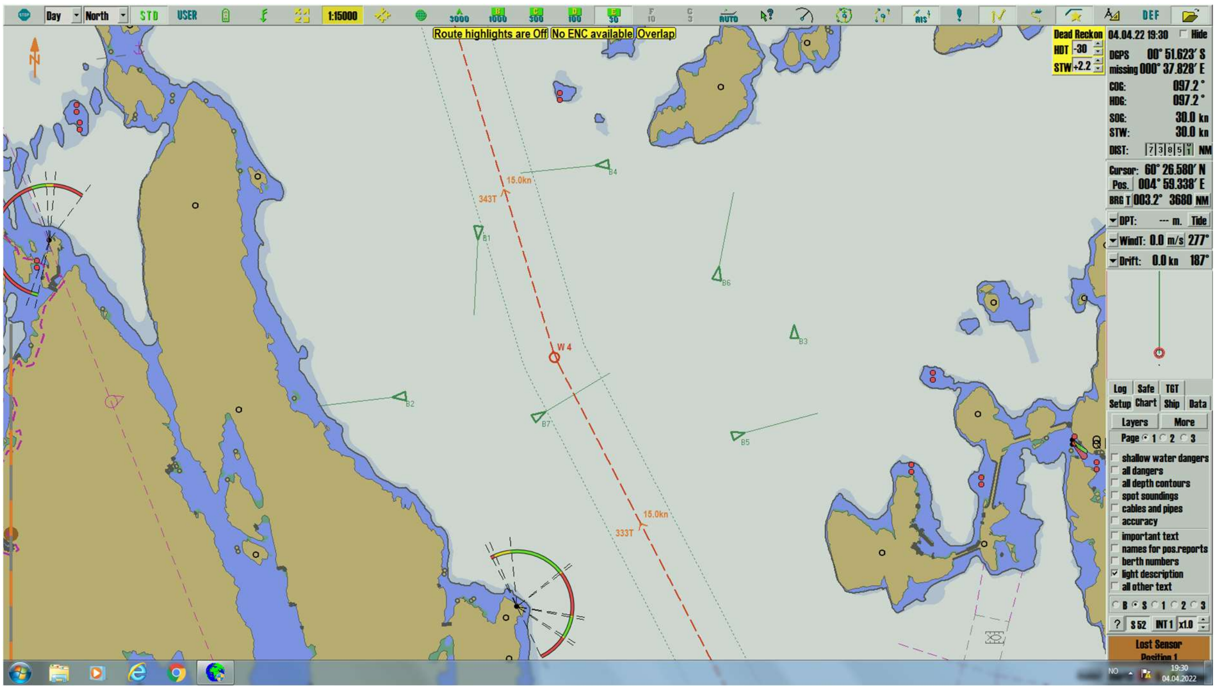


Figure 8-5: B SAGAT, ECDIS in day mode. Ordinary AIS symbols.

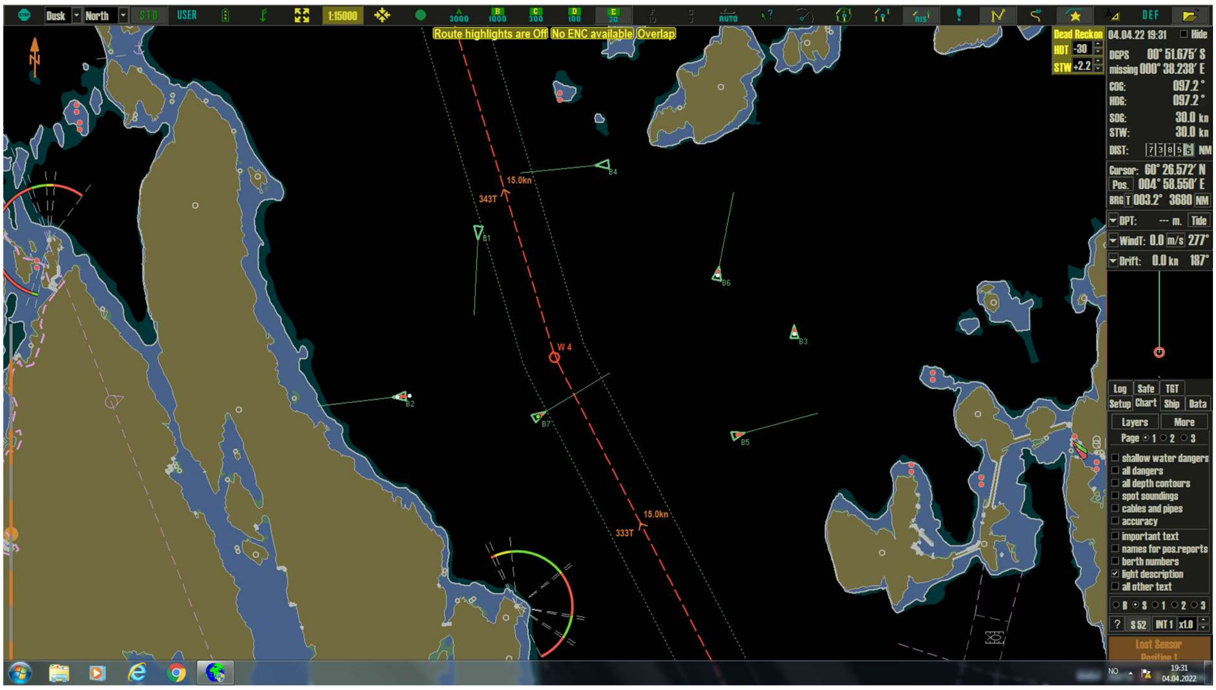


Figure 8-1:B SAGAT, ECDIS in dusk mode. AIS symbols with lanterns.

8.3.4 C SAGAT

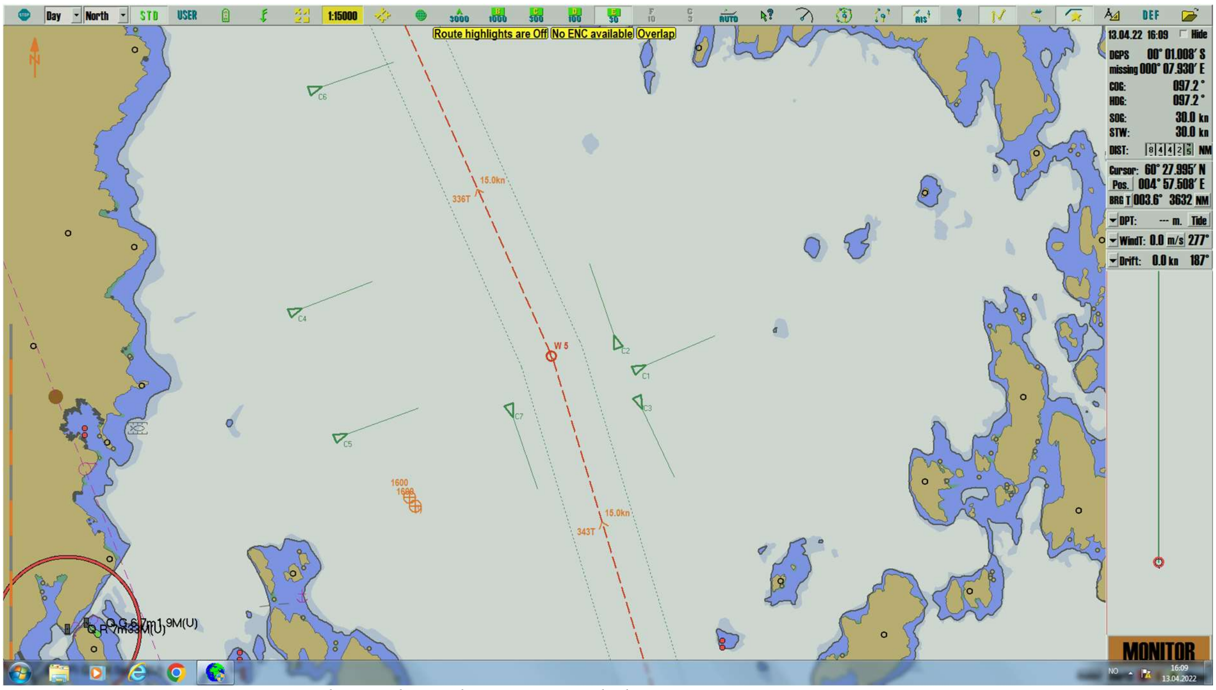


Figure 8-2:C SAGAT, ECDIS in day mode. Ordinary AIS symbols.

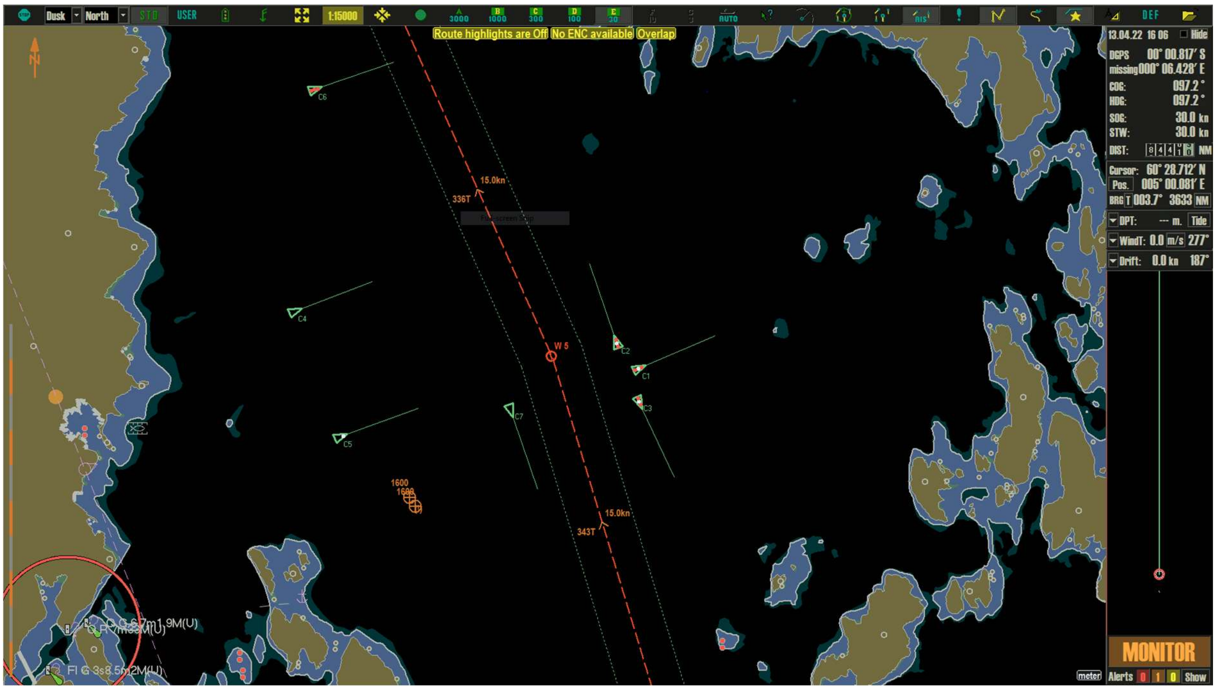


Figure 8-3:C SAGAT, ECDIS in dusk mode. AIS symbols with lanterns.

8.3.5 D SAGAT

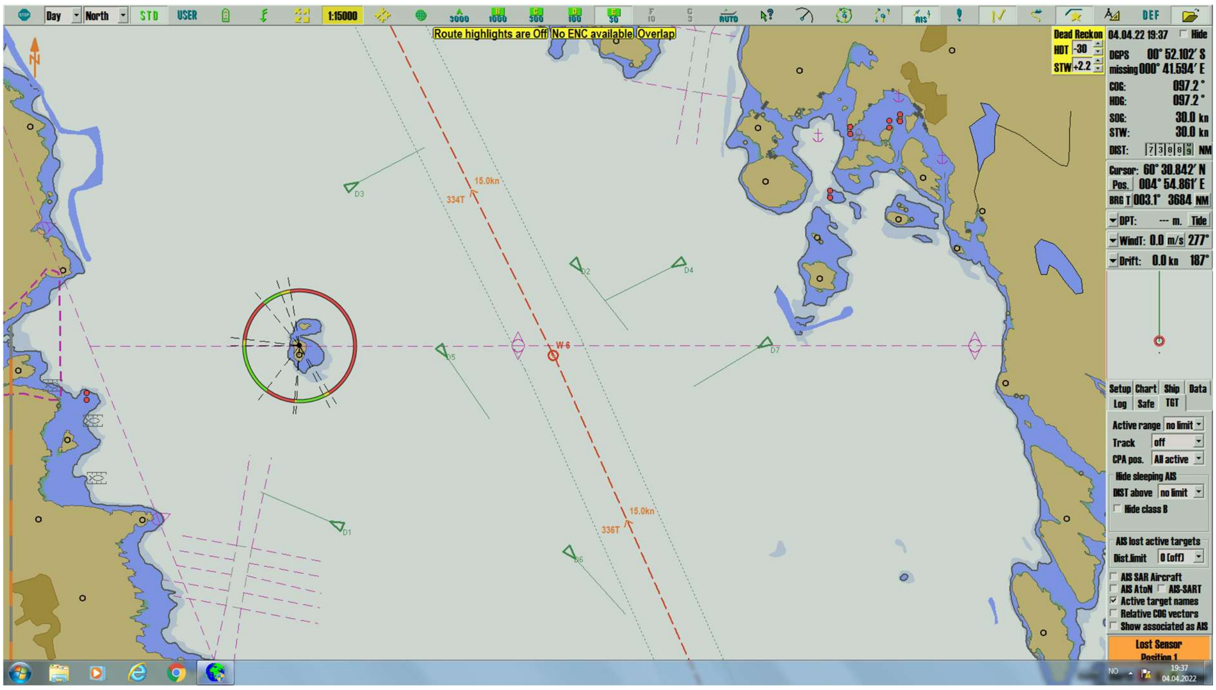


Figure 8-4: D SAGAT, ECDIS in day mode. Ordinary AIS symbols.

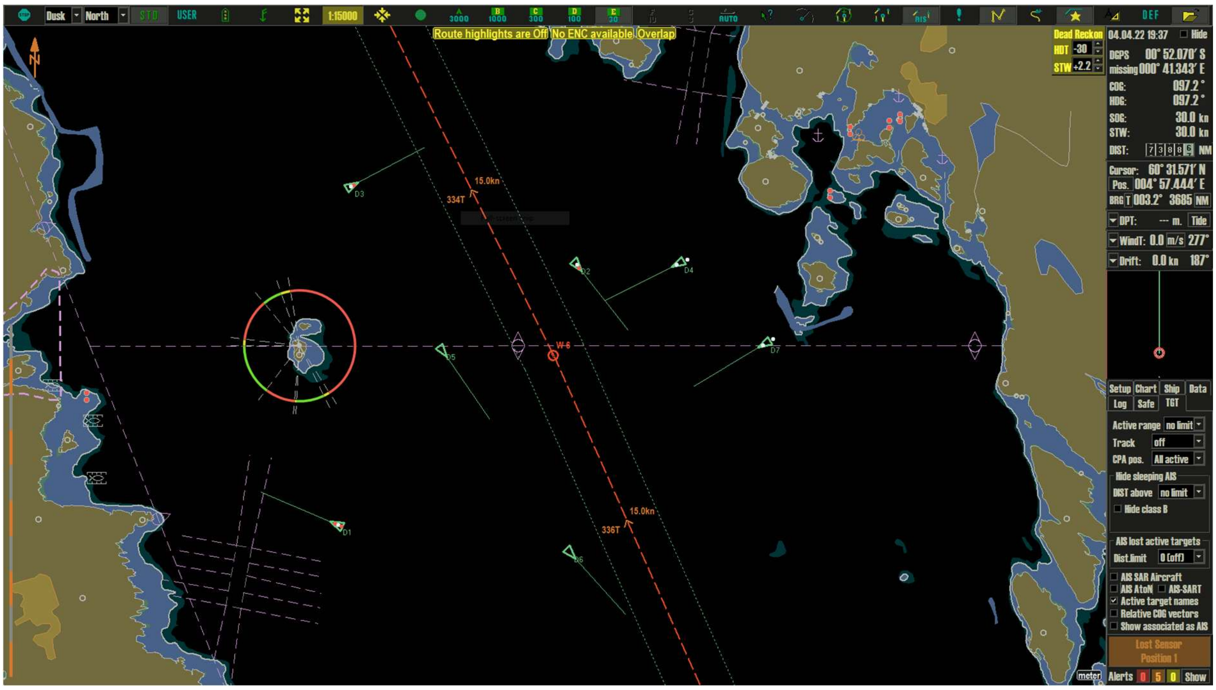


Figure 8-5: D SAGAT, ECDIS in dusk mode. AIS symbols with lanterns.

8.3.6 E SAGAT

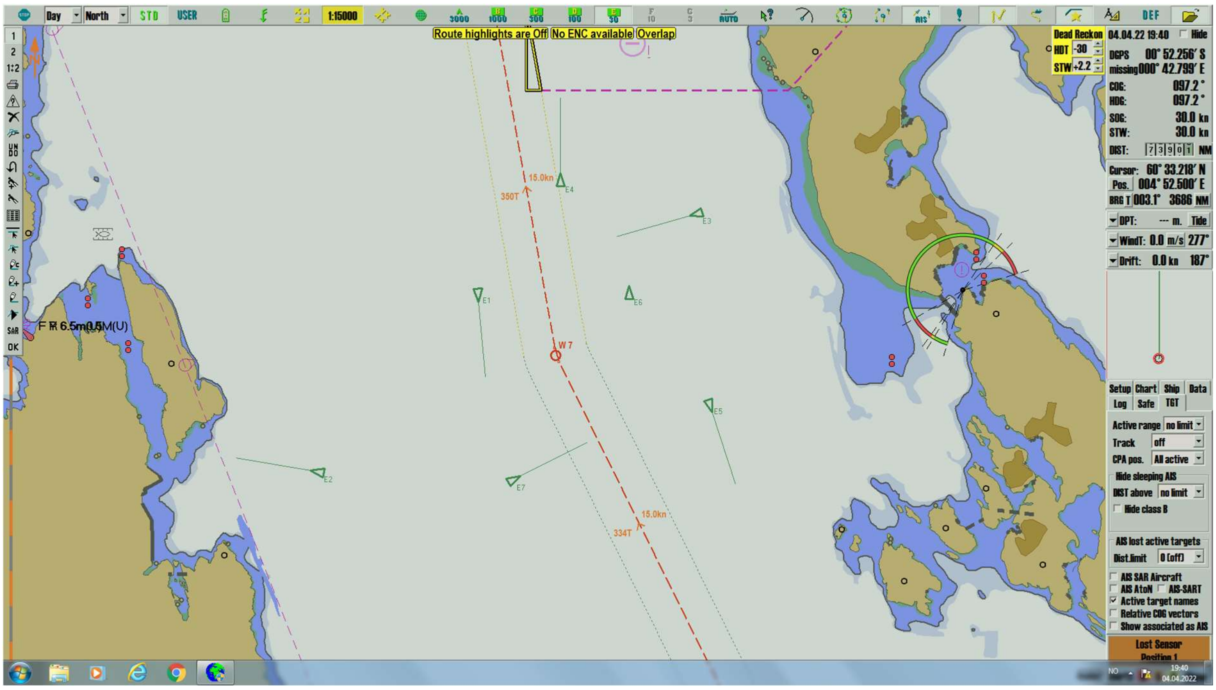


Figure 8-6: E SAGAT, ECDIS in day mode. Ordinary AIS symbols.

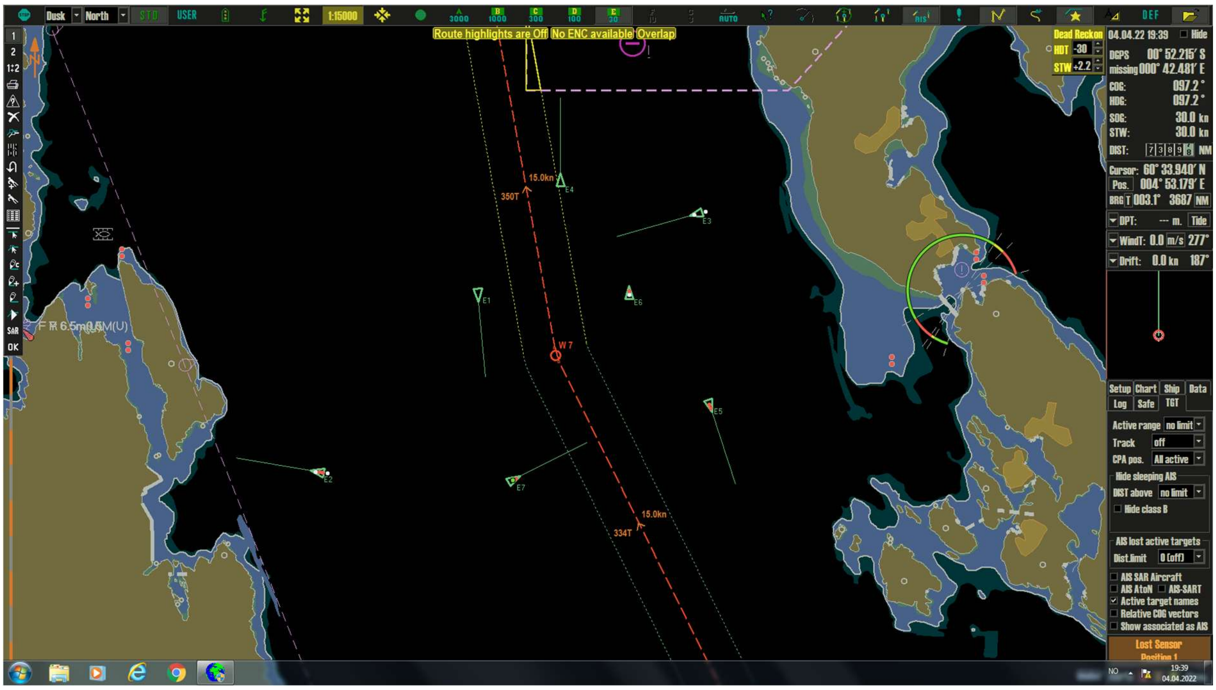


Figure 8-7: E SAGAT, ECDIS in dusk mode. AIS symbols with lanterns.

8.3.7 F SAGAT

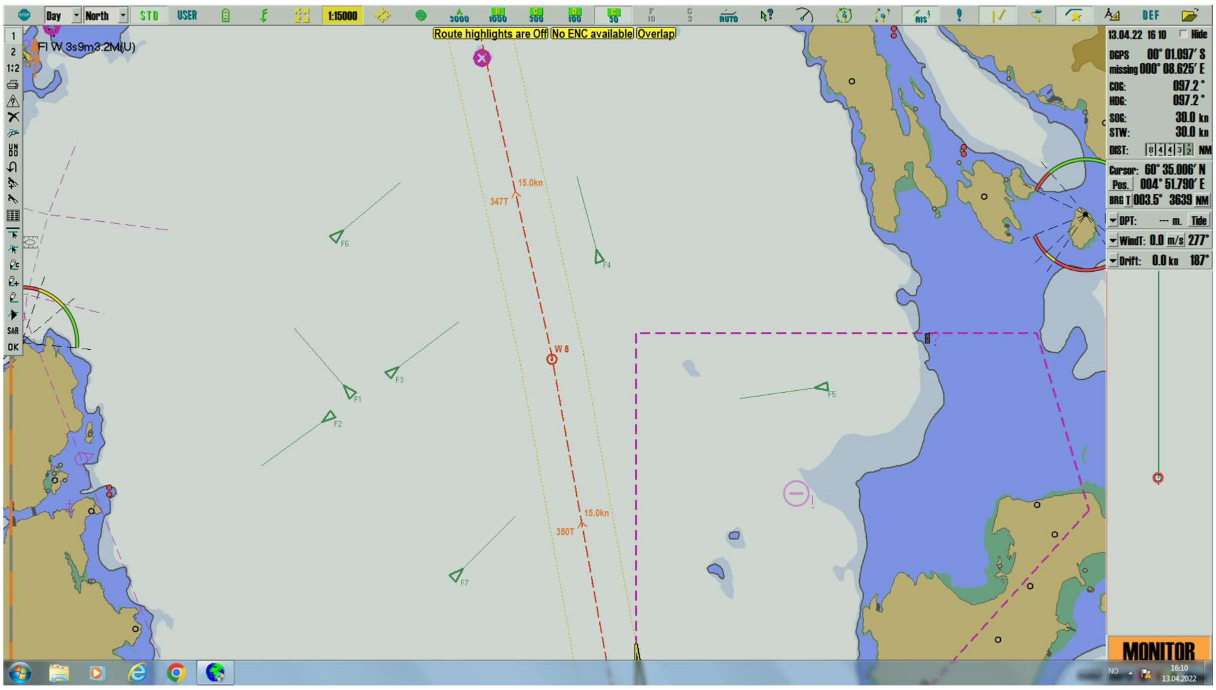


Figure 8-8: F SAGAT, ECDIS in day mode. Ordinary AIS symbols.

Figure 8-9: F SAGAT, ECDIS in dusk mode. AIS symbols with lanterns.