POSITIONING AND INFORMATION ACCESSIBILITY STUDY OF EXISTING BRIDGE CONTROL DEVICES FROM THE OPERATORS PERSPECTIVE

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Thesis for Bachelor of Marine Technology

The Degree Programme in Maritime

EXAMENSARBETE

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Syftet med denna avhandling är att studera plasering och egenskaper hos befintliga styrenheter från användarens perspektiv. I synnerhet syftar utredningen på att identifiera de potentiella utmaningarna hos kontrollenheter i placering och information.

Syftet med studien är att använda denna information för att utveckla i framtiden en ny kontrollenhet. Avhandlingen ingår i ABB Marine Pilot Control produktutvecklingsprojekt och genomförs i samarbete med Aalto Universitet, yrkeshögskolorna Novia och Metropolia.

Undersökningen gjordes med hjälp av ett elektroniskt frågeformulär och slutanvändarintervjuer med ABB (i samband med ABB Pilot Control användbarhetsstudie).

Språk: Engelska Nyckelord: Fartygs Kontrollenhet, Placering &Tillgänglighets studie

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Tiivistelmä

Opinnäytetyön tarkoituksena on tutkia nykyisten käytössä olevien ohjauslaitteiden sijoittelua ja ominaisuuksia käyttäjän näkökulmasta. Erityisesti tutkimuksella pyritään selvittämään ohjauslaitteiden mahdollisia haasteita laitteiden sijoittelussa sekä niiden tuottamassa informaatiossa.

Tutkimuksen tavoite on hyödyntää näitä tietoja jatkossa, uuden ohjauslaitteen kehittämisessä. Opinnäytetyö on osa ABB Marine Pilot Control -tuotteen tuotekehityshanketta, ja se tehdään yhteistyössä Aalto-yliopiston, Novian ja Metropolian kanssa.

Tutkimuksessa käytetyt menetelmät olivat online-kyselylomake ja loppukäyttäjän haastatteluja ABB: n kanssa (osana ABB Pilot Controlin käytettävyyttä koskevaa tutkimusta).

Kieli: Englanti Avainsanat: Laivan ohjauslaite, Sijoittelu & Käytettävyys tutkimus

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BACHELOR'S THESIS

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Abstract

The objective of this research is to study the layout and utilization rates of bridge control devices in different operational situations, as well as the availability of the information needed in operational situations. The research aims to identify the potential challenges for control devices layout.

The aim of the study is to utilize this information to develop a new Control Interface. This study is a part of product development project for ABB Marine Pilot Control product, and is made in collaboration with Aalto University, Novia and Metropolia.

Methods used in this study was an online questionnaire and end-user interviews with ABB (as part of ABB Pilot Control usability study).

Language: English Key words: Bridge Control Device, Positioning & Accessibility study

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1 DICTIONARY

OS/AB= Ordinary Seaman/ Able Seaman

IMO= International Maritime Organization

SOLAS= International Convention for the Safety of Life at Sea

DGPS= Differential Global Positioning System

ECDIS= Electronic Chart Display and Information System

RPM= Speed of Rotation (r/min.)

ROT= Rate of Turn

RORO/ROPAX= Roll on Roll of / Roll on and passenger Vessel

TILLER= Lever used to Turn the Rudder

IBS= Integrated Bridge System

ENC= Electrical Navigational Charts

RCS= Remote Control System

GT= Gross tonnage

EBL= Electronic Bearing Line

VRM= Variable Range Marker

POD= Combined Propulsion and Steering device

DP= Dynamic Positioning

AIS= Automatic Identification System

2 INTRODUCTION

ABB Marine & Ports is a worldwide company developing electric, digital and connected solutions for the Marine Industry. ABB has a business unit in Helsinki, whose main product is Azipod propulsion system. ABB Marine & Ports also has overall responsibility for various types of delivery projects, such as passenger ship, tanker, ferry and mega yacht projects. Often the delivery content includes not only propeller systems, but also generators and main boards, transformers, ship automation and frequency converters. In addition to the above-mentioned devices, deliveries often also include bridge control devices. The Remote-Control System is a modular product platform including a wide range of control units and panels. Also suitable for conventional shaft line propulsion system.

This research is part of a product development, ABB Ability™ Marine Pilot Control. The study has started in September 1st 2018 and continued until February 2019. The research belongs to ABB Marine Digital Solutions R&D.

This thesis is a study of existing equipment used for ship operation, their connection to the operational situation, and is part of a product development project. This study focuses only on placement and Graphic Indicator information accessibility from the operator's perspective.

Before my Maritime studies I was employed by ABB Marine & Ports. This is one of the reasons I was involved in this project. Also because of my desire to be part of the development of better future Bridge Control devices.

2.1 Purpose

This thesis study is a part of product development project for ABB Ability™ Marine Pilot Control product, and is done in collaboration with Aalto University, Metropolia and Novia. The study is divided in three categories where the University students have their own scope. Aalto University student, ABB Digital Solutions, industrial design trainee Niko Aho is evaluating the usability aspects of the ABB Ability™ Marine Pilot Control Device. As the subject being industrial-design, the scope is haptic, ergonomic and visual research on the multi-use Control Device. Metropolia student Lauri Katainen is researching technical solutions for the multi-use Control Device and how to technically implement desired indications and functions. Also, how to improve the existing prototype and study what kind of market there is for that purpose. The objective of the third, this thesis is to evaluate

equipment positioning and Graphic Indicator Information Accessibility. Focus of the study is in challenges concerning currently used bridge Control devices. Studying the layout and utilization rates of bridge equipment in different operational situations, as well as the availability of the information needed in operational situations is also part of the study.

2.2 Formulation of the research problem

The purpose of this survey is to evaluate bridge control device positioning and Graphic Indicator Information Accessibility. In particular, the research aims to identify the potential challenges for bridge control devices. The aim of the study is to utilize this information to design new bridge control device layouts.

2.3 Limitation

This research is part of a research collaboration and the focus of this study is distinctively a study of existing bridge control devices positioning and the graphic indication information accessibility. Therefore, the study concentrate's only on identifying the most relevant controls and monitor's and the challenges of device positioning and information accessibility related to operational situations. The study is focusing on ergonomics, visual and audio indication.

2.4 Methods

The research consisted of online questionnaire and end-user interviews. Interviews were conducted during and after test simulations in ABB Marine & Port test environment. They were recorded and hand written. The survey was based on qualitative inquiry as online questionnaire on the internet. The survey was open for one month. The questionnaire contained open and multiple-choice questions. The participant had the chance to choose between a Finnish or English questionnaire. The surveys are analysed as one.

The participants received the invitation personally or via shipping company email addresses. Aboa Mare, Novia students were also invited to take part of the study via group email.

3 SURVEY QUESTIONNAIRE

Survey participants were a variety of persons with different professional maritime experience and rank. The online questionnaire was designed to investigate the situation when a ship travels from open sea to a pilot position and further along a fairway to the harbour. Therefore, the questions were divided into three parts, the first of which sea mode is, the second, fairway navigation and the third manoeuvring mode. All the three situations have the same question setup where the participants will answer the questions what the most important equipment are in their profession. Is the steering gear and monitor indications ergonomically located? What are the most important steering gear, monitor and graphical indicator? As well identify bridge control device alarms audio and visual indications. The participant also had the chance to give important aspects and information about their current bridge control devices.

3.1 Description of the Participant's

Invitations to the online questionnaire were sent to Finnlines ship bridges, AB Ronja Marine and VG Shipping office to be forwarded to the vessels. Nineteen people responded to the Finnish survey and nine to the English survey.

3.2 Respondent's Professional Maritime Experience

Five of the respondent's had less than five years of professional maritime experience and five had over ten years of professional maritime experience. Ten of the respondents had between six to ten years of experience. This gives the survey a good cross-section of the opinions of different age groups on the use of bridge control devices.

Figure 1.

Answered 32 and skipped 0.

3.3 Respondents' rank

To define what steering gear and indications are essential in the operator's perspective, the seafarer's role was important to know. Of the respondents, nine in all, were masters and the next highest number were OS/AB and watchkeeping officers.

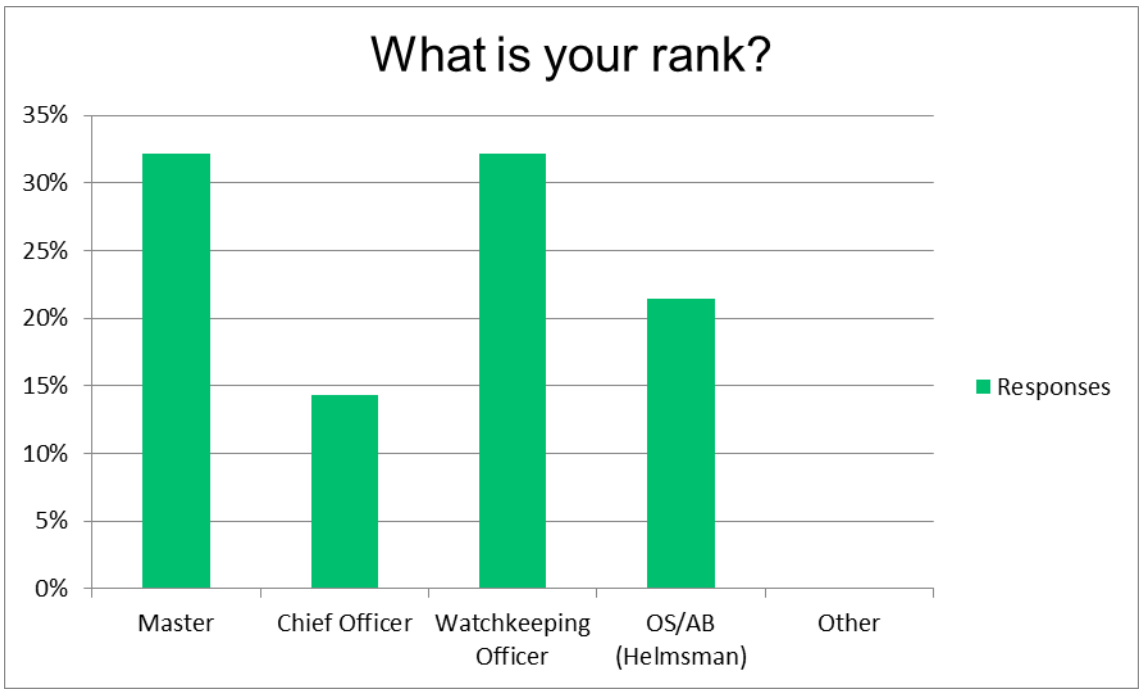

Fig.2

Answered 28 and skipped 0.

3.4 Respondents' Vessel type

Most of the respondents worked on RoRo or RoPax vessels. Secondly respondents' worked on passenger vessels. Rest of the respondents were employed in fishing, offshore, towing and container vessels. One of the respondent's was working as a pilot.

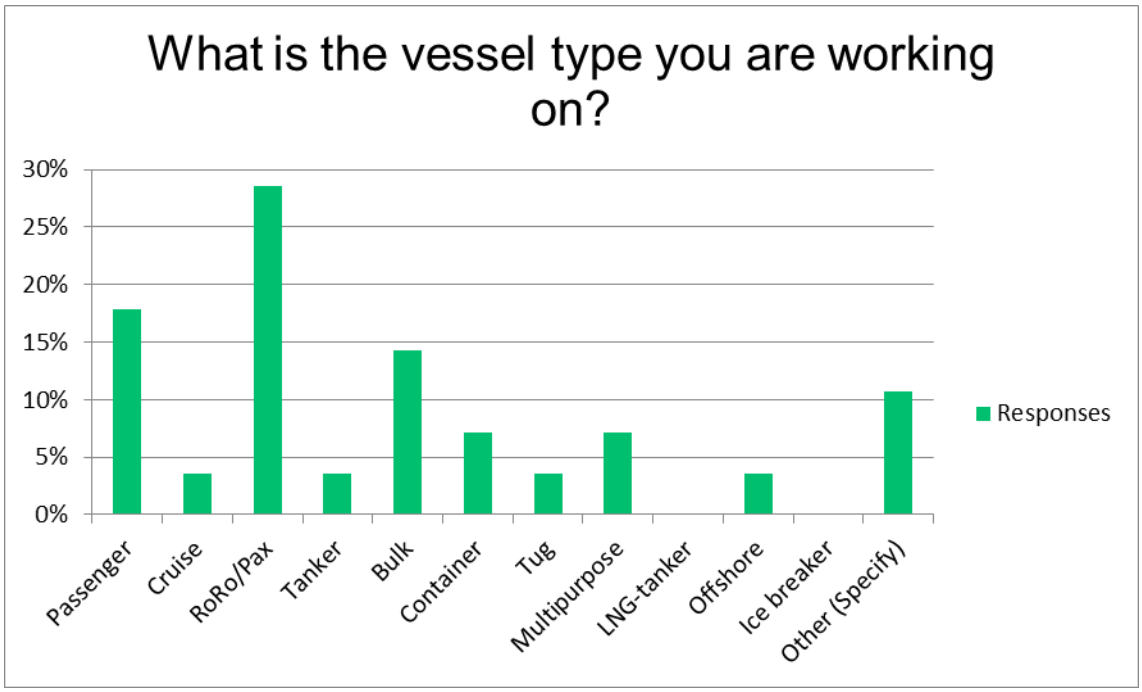

Fig.3

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3.5 Structure of the survey

The survey questions were divided into three parts, the first was sea mode, second was fairway navigation and the third manoeuvring mode. The structure and content of the query was similar for each operational function. The bridge control devices, steering gear and monitors with indicators were separated in own question groups. Firstly, we wanted to know what devices the operator is using depending on his rank during his normal watch on bridge. What steering gear is used and what monitors ,alarms and indicators are monitored.

The following devices were selected for questions concerning steering gear:

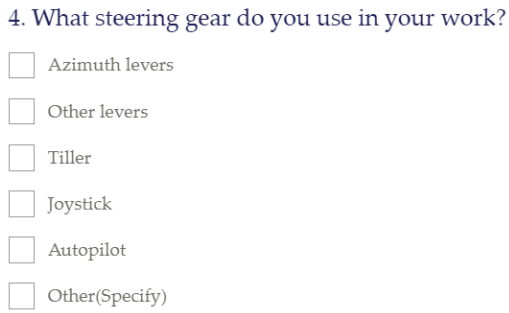


Fig.4

Following devices were selected to the group Monitors and Graphic indicators:

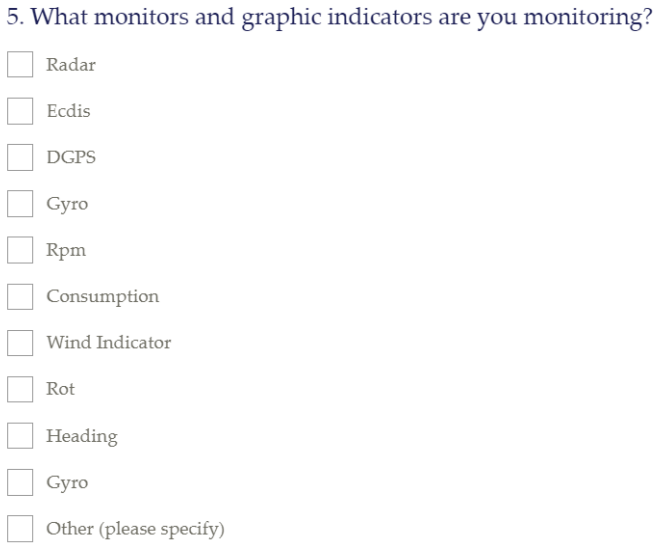


Fig.5

Question's concerning ergonomically positioning had a rating scale with alternatives:

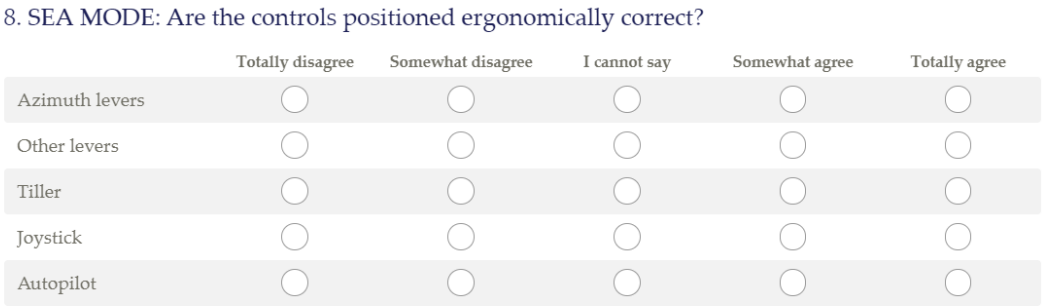


Fig.6

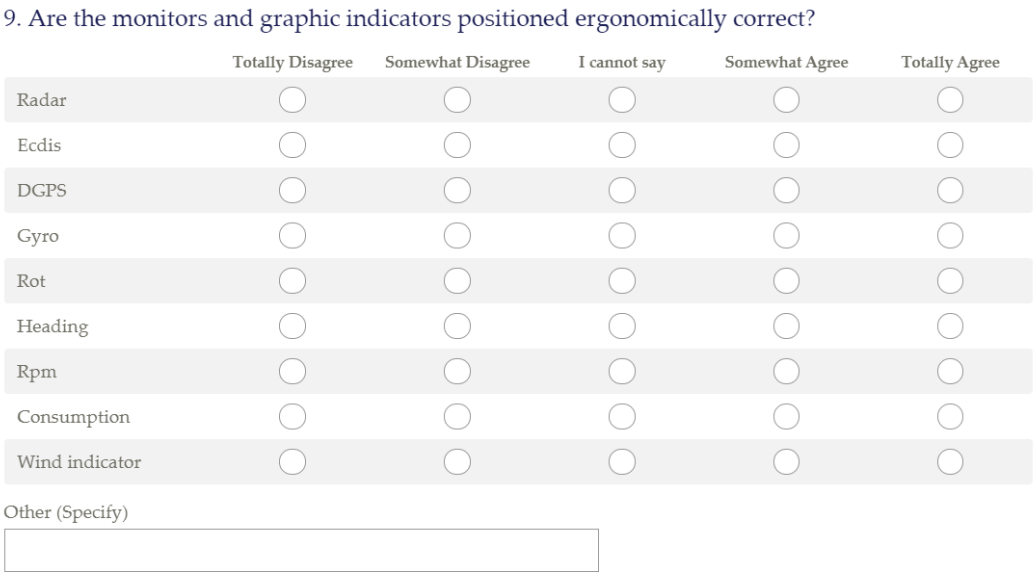


Fig.7

4 RULES AND REGULATIONS CONCERNING ERGONOMIC WORK

4.1 Guidelines on ergonomic criteria for bridge equipment and layout

The rules of classification societies contain recommendations on the placement of bridge equipment, but the ergonomic information contained in the rules is more indicative and does not contain any justifications for instructions.

SOLAS regulations addresses designers, manufacturers and shipowners with respect to the bridge design and layout. However, the responsibility for ensuring correct bridge procedures ae adopted lies with the master. The regulation addresses the principles to be followed in the design and layout of ships bridges and the establishment of bridge procedures using ergonomic criteria.

4.2 Steering a vessel

A vessel with propeller powered platform is controlled with remote control devices (RCS). These are wheel, joystick, tiller, azimuth and other levers. The steering situation (e.g. sea mode) defines the steering mode where the operator adjusts the pitch (blade angle). The traditional wheel (helm) has been replaced on many vessels by mini-wheel and tiller.

The platform can be controlled by autopilot. That can be controlled computer-assisted according to a pre- planned route. The operator can adjust the speed of the vessel to adapt to the particular traveling distance and desired arrival time. The computer then calculates the speed required by the vessel including sea currents and winds. The operator only has to enter the wanted arrival time.

5 RESPONDENT'S ANSWERS AND ANALYSE

5.1 SEA MODE

In sea mode depending on the vessel type and size there are different instructions on who is controlling the ship. The most important thing to know is what control devices are used and what monitor's and graphic indicators are being monitored, what are the primary tools in this operation. Also to find out are the controls and monitors placed ergonomically well. As well important to know what tools are necessary so they are placed in the immediate vicinity of the operator.

5.1.1 Steering gear used by the operator

The most used steering gear in sea mode on all ships are autopilot, the tiller, joystick and azimuth levers. Small tonnage vessel's sailing in the archipelago use tiller, lever and joystick because of narrow fairway. The watchkeeping person is using the steering gear as the watchman is sitting beside him and only monitoring by sight and with the help of the ECDIS and radar.

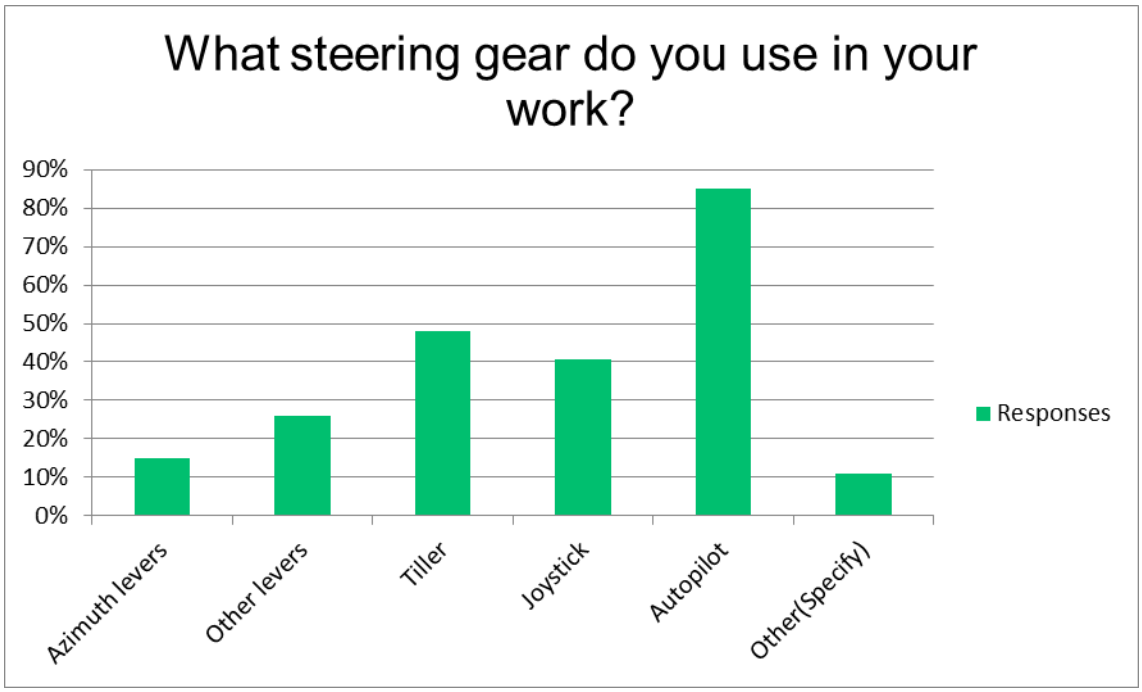


Fig.8 All respondents'

Answered 27 and skipped 1.

5.1.2 Monitored graphic indicators and monitors

Because of SOLAS, Chapter V (Safety of Navigation), all vessels irrespective of size and type must carry nautical charts onboard. Electronic Nautical Charts (ENC) are used in the ECDIS. The ECDIS' uses digitised chart data that is displayed as a seamless chart used in an electronic navigation system, the data is displayed on the monitor. The voyage plan is prepared on the chart before departure and the voyage is then following the route on the ENC. The watchkeeping person is also monitoring radar, DGPS, gyro, heading, wind indicator, pitch and rpm. The watchman is monitoring by sight and all indications and monitors are essential for safe navigation. As master you also have the responsibility for the economical consumption and usage of engines of the vessel. There are no major differences in the operation in Sea Mode between the operators. Large gross tonnage vessels may have a control interface with two seats with identical steering gear and monitors. This makes the operation most safe since there is two persons' navigating.

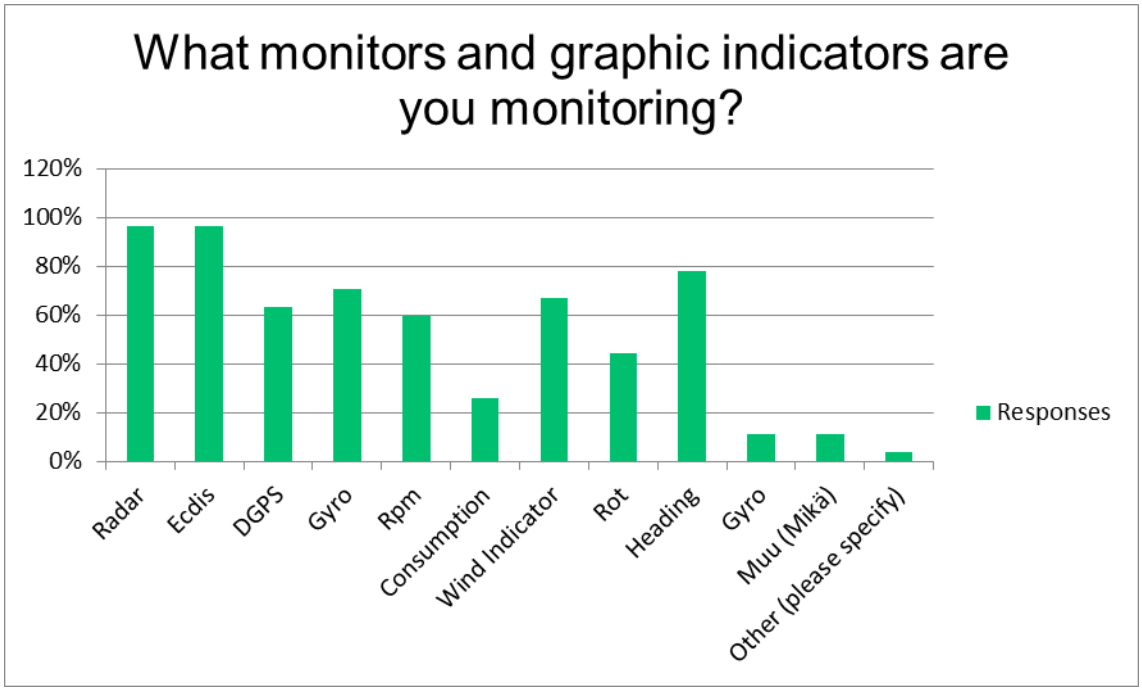


Fig.09 All respondents'

Answered 27 and skipped 1.

5.1.3 Ergonomic positioning of the Control's

The number of respondents' using azimuth levers thought that the levers were placed rather ergonomically. Many of the respondents did not have azimuth levers on the vessel they work on. Respondents' of the same amount were saying against and behalf of somewhat ergonomically installed tiller. The joystick and autopilot were by far best placed ergonomically. These two are the most used steering gear in sea mode. Problems arise when switching from one control device to another in case of emergency. Then the placement is the first priority. The steering gear should be placed at a close distance so that the user does not have to change seat position. Some thought that a movable panel with steering gear that can be placed in front of the seat with the operator's own adjustments would be ergonomically good.

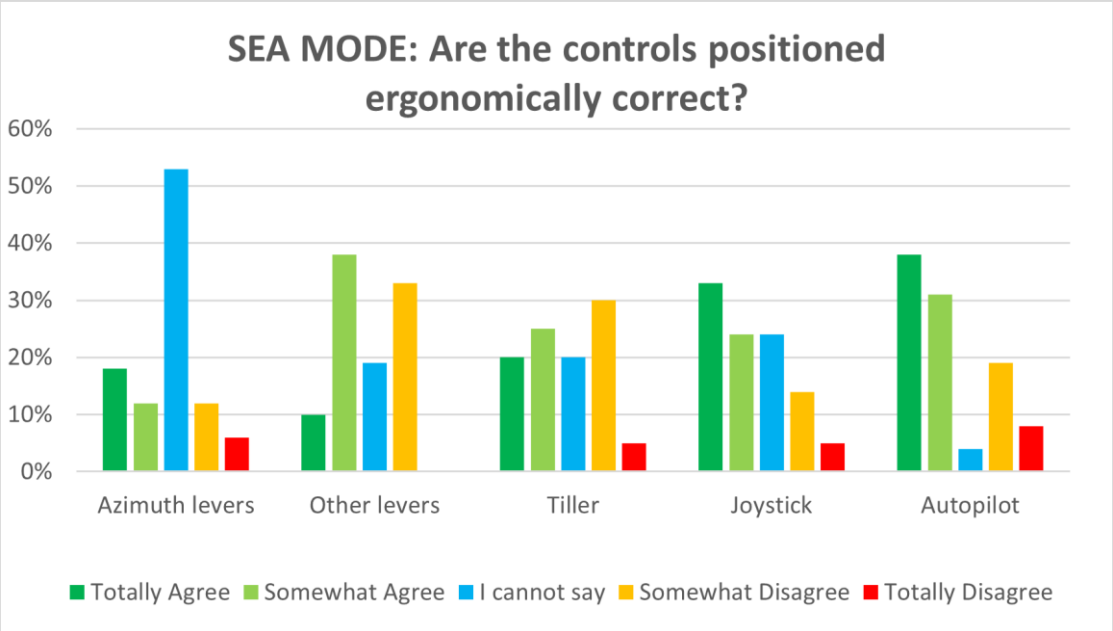


Fig.10 All respondents' Answered 26 Skipped 2.

5.1.4 Steering gears ergonomic positioning by master and officer

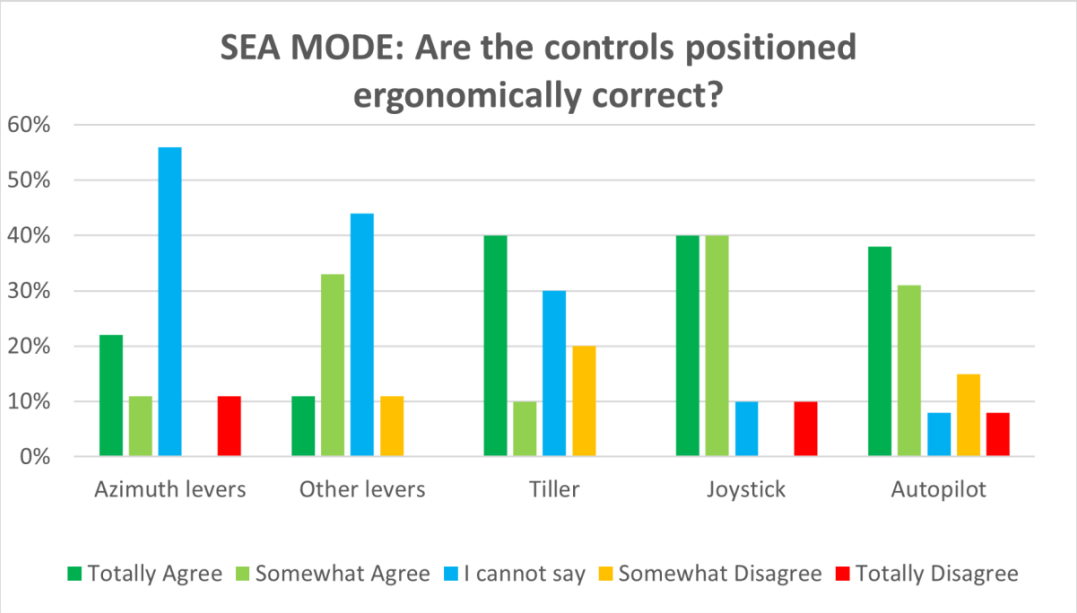


Fig.11 Master respondents' Answered 13 Skipped 1.

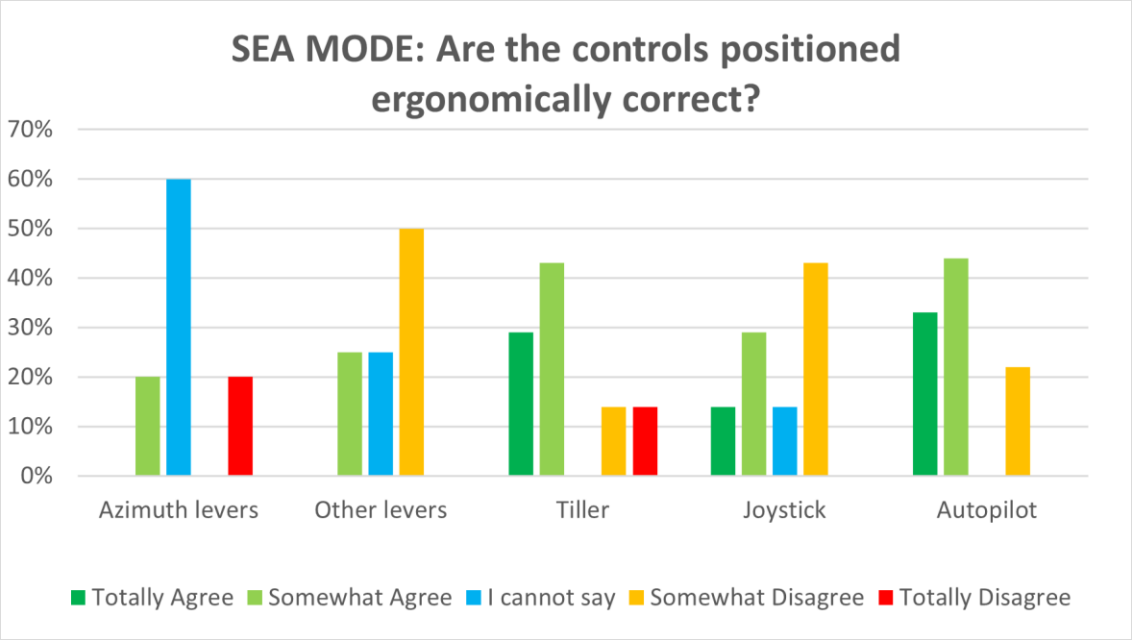


Fig.12 Officer respondents' Answered 9 Skipped 0.

5.1.5 Monitors and graphic indicators ergonomic positioning

Many of all respondents totally agreed that that the monitors and graphic indicators are positioned ergonomically or at least somewhat ergonomically. One respondent thought that all the monitors and graphic indicators were installed totally non- ergonomic. A few

replied that the monitors and graphic indicators are placed ergonomically wrong with no further explanation. Some will certainly be explained by the fact that the vessel is older and the monitors and graphic indicators are installed later on the vessel. Respondents' opinions were that there may be many reasons, but the most important indicators should be in the close vicinity of the operator. Since the operator is monitoring the ECDIS and radar simultaneously the monitors should be placed in front of the seat to reduce unnecessary head movement and neck tension. The operator is tracking traffic out the window at the same time he is manoeuvring the vessel.

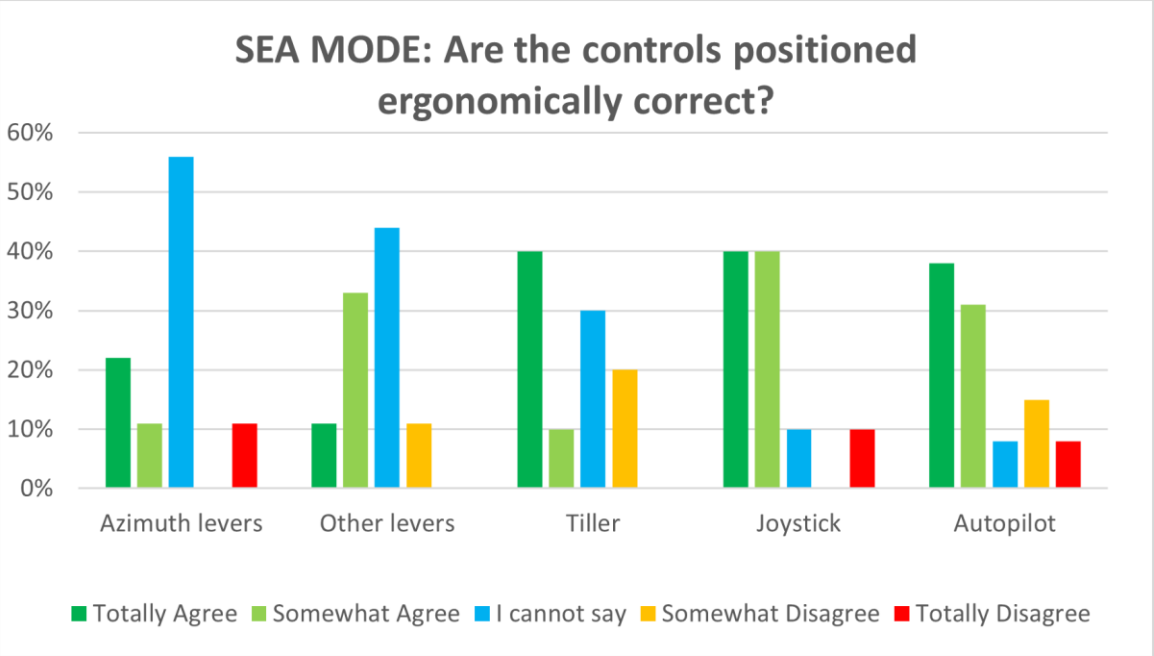


Fig.13 All respondents' Answered 26 Skipped 2.

5.1.6 Monitors and graphic indicators ergonomic positioning by master and officer

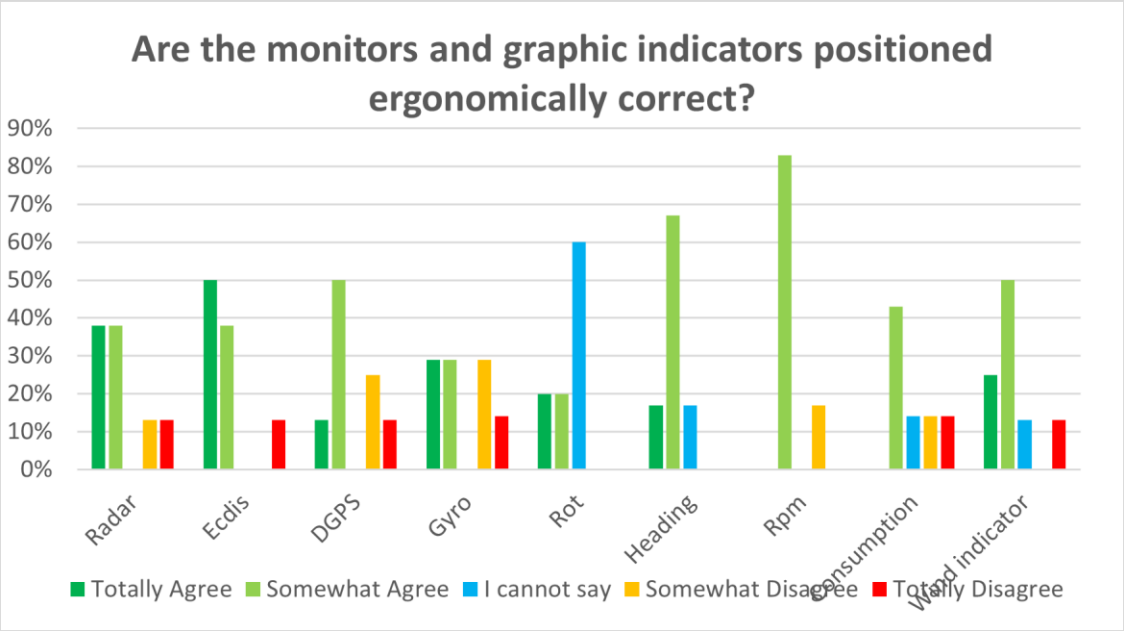


Fig.14 Master respondents' Answered 13 Skipped 1.

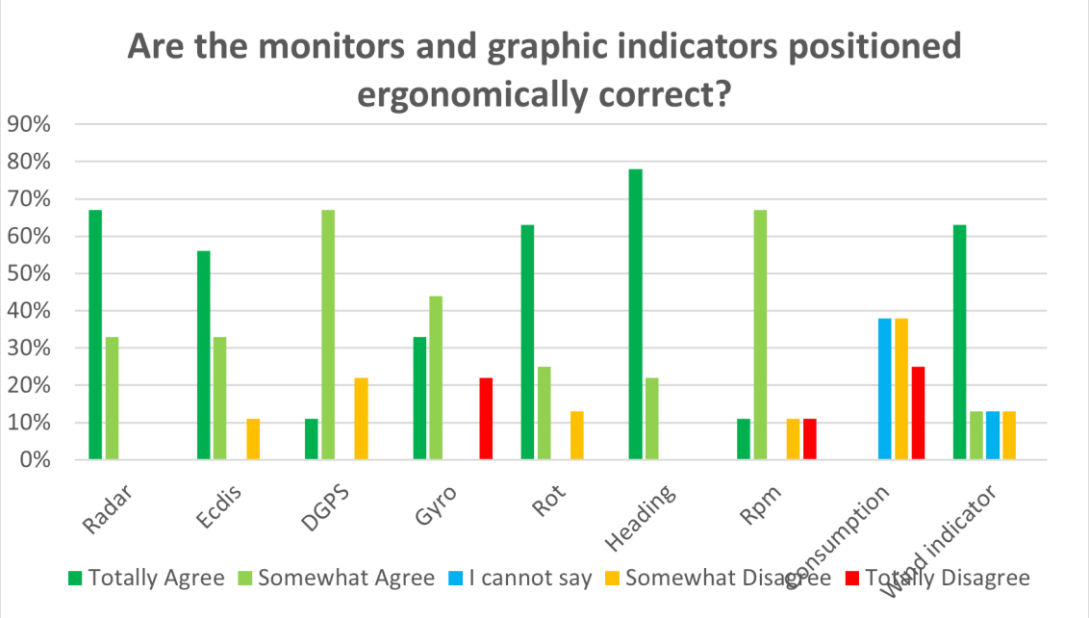


Fig.15 Officer respondents' Answered 9 Skipped 0

5.1.7 Controls that are necessary for the operator in Sea Mode

For safe navigation in open sea mostly used steering gear for the watchkeeping officer is autopilot, helm, tiller, joystick and azimuth levers.

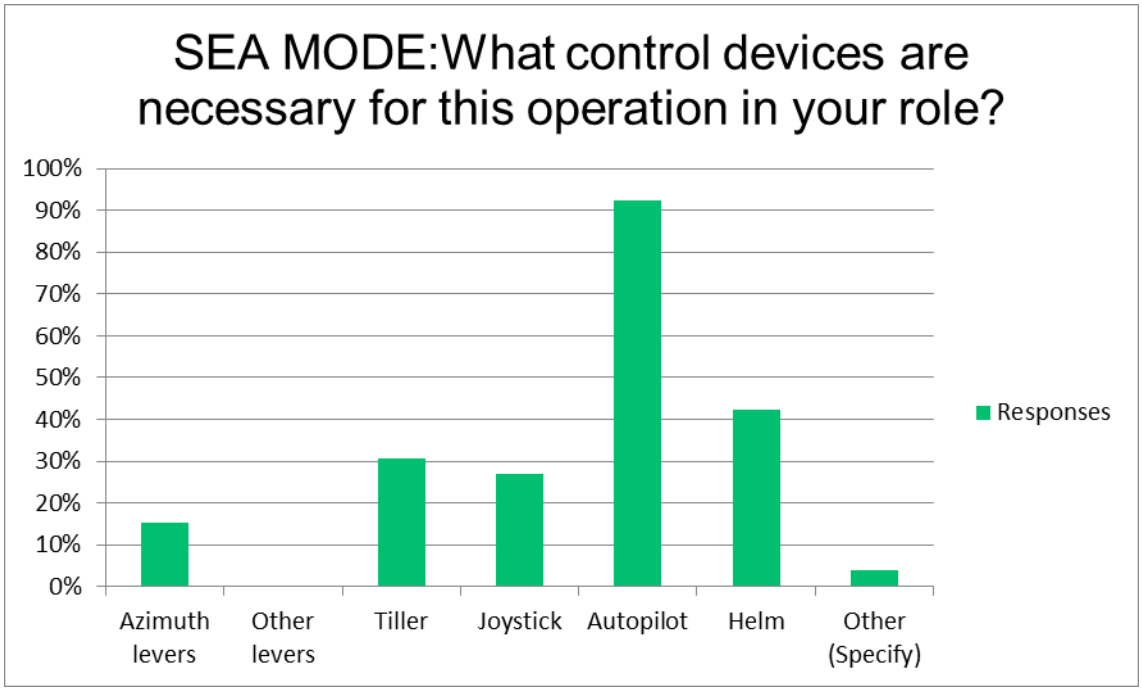


Fig.16 All respondents' Answered 26 and skipped 2.

5.1.8 Monitor's and graphic indicators needed for operational situation in sea mode

The ECDIS and radar are almost equally important for the master and watchkeeping officer in open sea. Heading and gyro were after that most needed. DGPS is nearly as important. Rot and wind indicator were the least important in this operational situation. For the watchman the mostly followed monitor is the ECDIS and after that radar. These monitors are essential for the AB as he/she can follow the route, positioning and heading on one screen. Also mark targets and report potential dangers. Features also needed for measuring distances to objects are EBL, VRM and vectors.

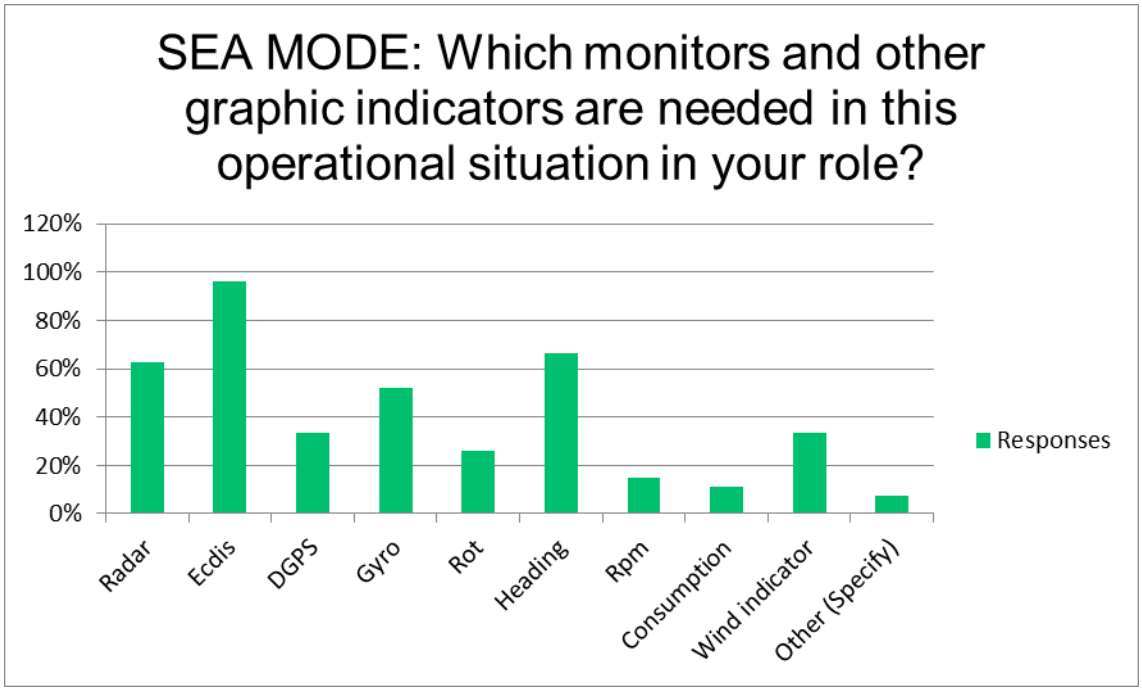


Fig.17 All respondents' Answered 27 and skipped 1

5.1.9 Monitors and graphic indicators priority in sea mode

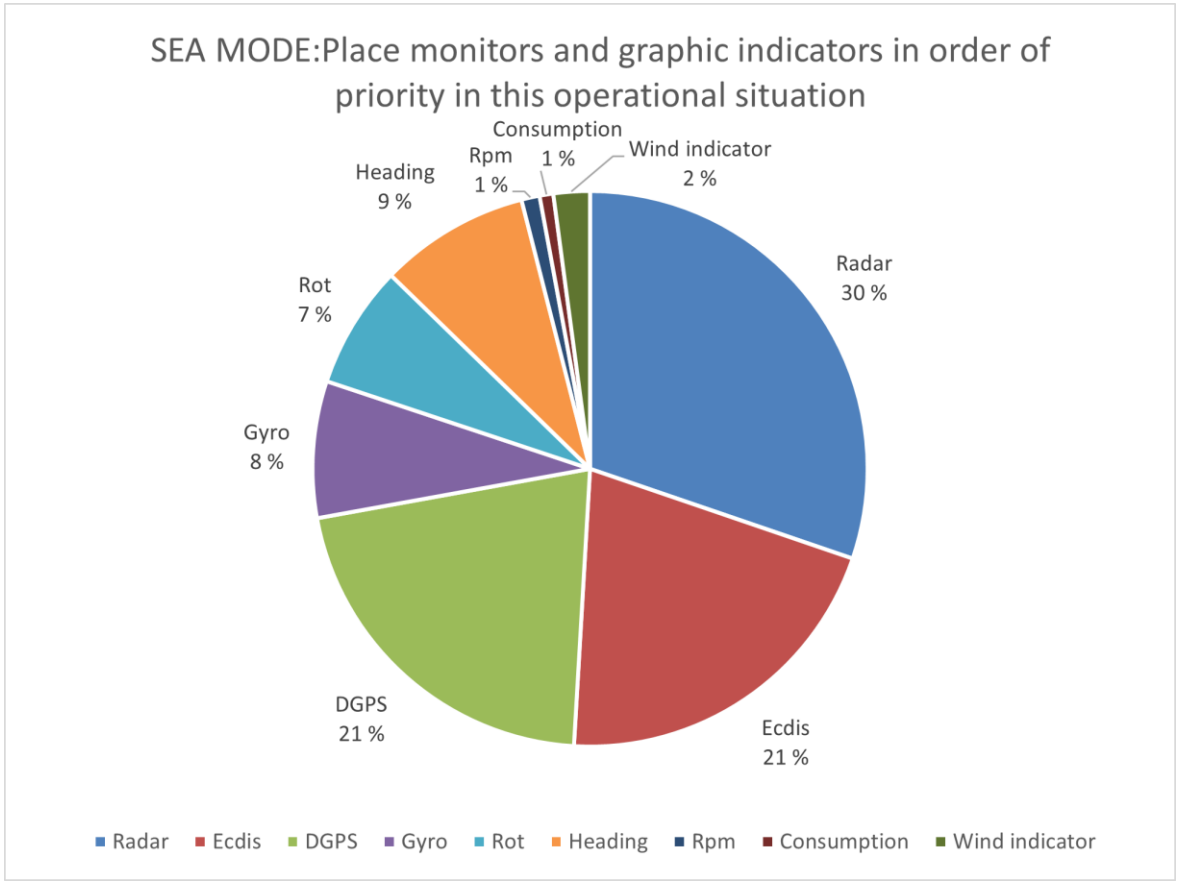


Fig.18 All respondents' Answered 27 Skipped 1.

5.1.10 Distinguishing between alarm's

Over half of the Finnish respondents thought that distinguishing between alarms is difficult and arises because of monotone beeping and the same alarm sound for different alarms. Many large GT vessels have check lists for different alarm's that help the operator to distinguish what alarm is in question. Non-differing sound alarm is not preferable on a vessel where the operator should be navigating and not simultaneously trying to find the cause of the alarm with the help of a check list. All recipient's answers expressed the same concern. Blinking lights and audible alarms are important but distinct sound and light would be an absolute must to identify the type of alarm. One of the respondents suggested an audible voice speaking and identifying the alarm. The respondent compared the voice alarm to the system used in aircraft cockpits.

5.2 FAIRWAY

5.2.1 Control devices necessary for the operator in fairway navigation

For the operator on watch, autopilot, joystick, helm, tiller and azimuth levers are necessary. For the helmsman the devices used is rudder, autopilot and azimuth levers. The wheel is operated by the helmsman and given orders by the master or pilot.

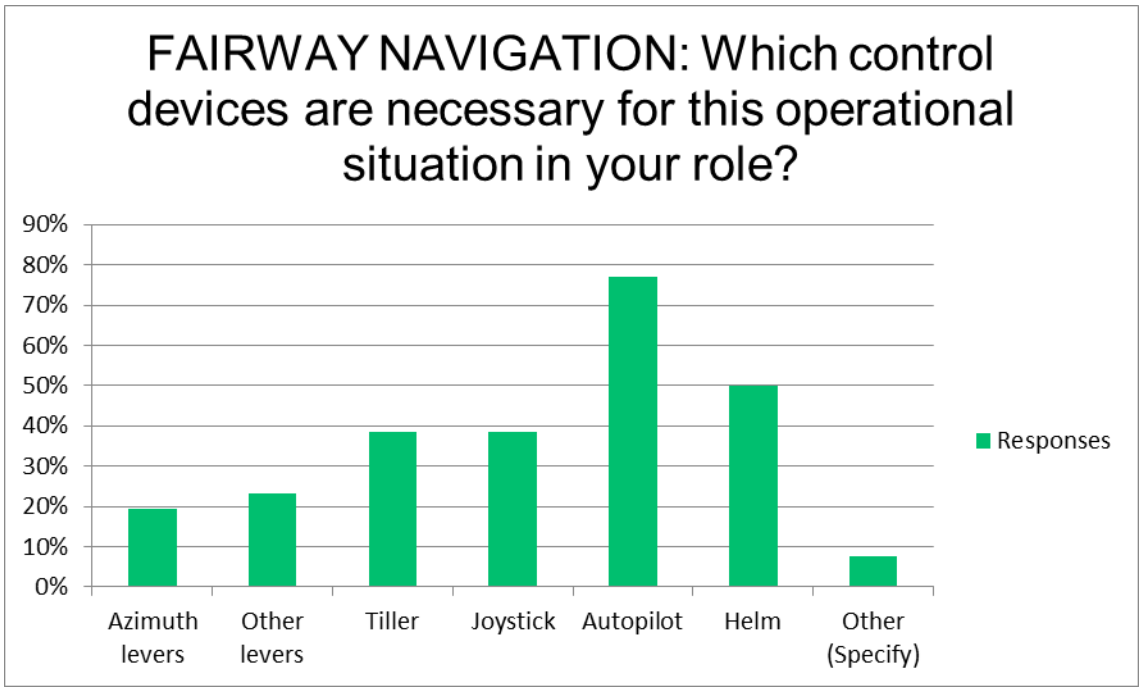


Fig.19 All respondents'

Answered 26 and skipped 2.

5.2.2 Monitors and Graphic Indicators needed in Fairway Navigation

For the vessel to follow the route the most significant monitors and graphic indicators are radar, the ECDIS and heading. ROT, gyro, and predictor are also similarly important. The helmsman is using radar and heading. If the helmsman is steering the ship, he will be following ROT and rudder angle while the pilot is giving commands. Since the rudder angle may be small and vary from starboard to port rapidly it is important for the helmsman to follow the indicator precisely when given orders.

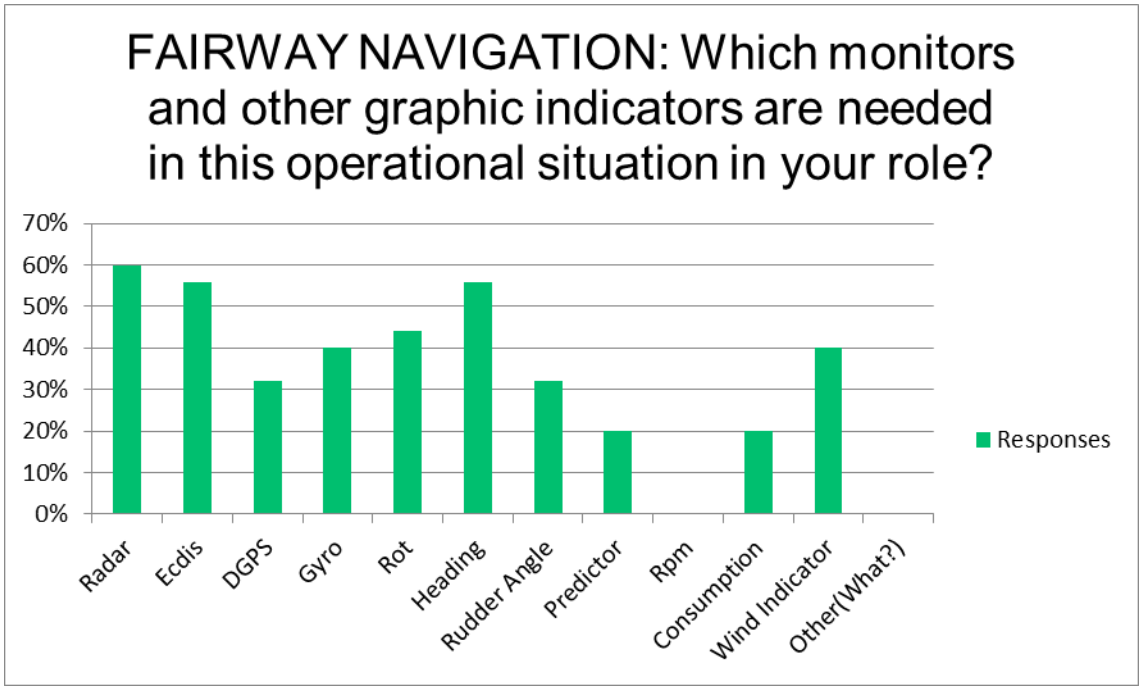


Fig.20 All respondents'

Answered 25 and skipped 3.

5.2.3 How the Control Interface support ergonomic work in fairway navigation

Respondents' found problems with the positioning of the instruments. Words used to describe the positioning was, too far, wrong, and non-ergonomic.

When there are two seats with identical control panels it should be possible to take over if the person sitting next to you make a mistake.

Hand rudder is located too far and overall the instruments seem to be in a way that the operator must lean over to use the instruments.

Some of the respondents' felt that ergonomics were bad or missing. Three of the respondents' thought the ergonomics were good.

In older vessels the equipment is installed later and are positioned where there is room for them. This makes the operation of the vessel challenging and non-ergonomic.

The navigation seems to be relatively easy in wide fairways when using autopilot, tiller and joystick.

For the helmsman the real challenge is to keep the vessel on track when given orders. The indicators and repeaters for rudder angles and ROT. Many vessels have repeaters installed above the window that makes it easy for the operator to follow the vessels turns as the helmsman is concentrating on the indicator with the best vicinity to keep the course. In shallow waters and narrow fairway, the rate of turn and rudder angle are crucial to keep the course. The helmsman is only using the graphic indicators and eyesight when manoeuvring. The importance of repeaters steps in when there is a mistake and the operator in command must take over. The operator can then see from the indicator easily if the turn is too tight.

Concerns for the helmsman are the graphic indicators positioning. The watchman is standing when manoeuvring and the graphical indicators should be positioned in a way that there is not a need to turn the head up to monitor the graphic indicators and then down to the helm.

5.2.4 Suggestions of indications or adjustment's needed in fairway navigation

Most of the respondents did not need any changes to the indications or adjustments.

With thrusters, pitch or electric load that hardly gives the idea how many percent of the total capacity is in use as the levers are usually not linear in that respect. A possibility of an integration with predictor and propulsion would help. Namely when you move the ME-

pitch for example. It would then be indicated by the predictor what will happen to speed over time. Will the vessel accelerate or decelerate and to what value?

Also a few wishes from respondents for IBS on vessels to avoid running around the bridge. On some vessels the overdrive is a problem because of the positioning. The overdrive has been mistaken for steering joystick.

As the pilot or master are in charge the watchkeeping officer is usually measuring the distance to the dock by looking out the bridge wing. Suggestion's for this was to install measuring devices.

5.2.5 Pilot work noticed in the control unit

In many of the larger GT vessels there is a plug for the pilots' PCs that can be connected separately to the ECDIS and radar. Autopilot settings are changed, and rudder angles are decreased. Two identical seats with control panels in the control unit. Monitors and indicators should be accessible for the persons in monitoring role to ensure safe manoeuvring.

5.2.6 Check list use on vessels before arrival and departure

Most of the vessels are using a checklist. Some small tonnage vessels are an exception. The importance of the checklist can be noticed by counting the number of switches and buttons for different systems start up and shut down. Multiple monitors and graphic indicators are also a part of this procedure. For the person responsible for start-up and shutdown it is impossible to assume that the person can by any means remember all in the procedure.

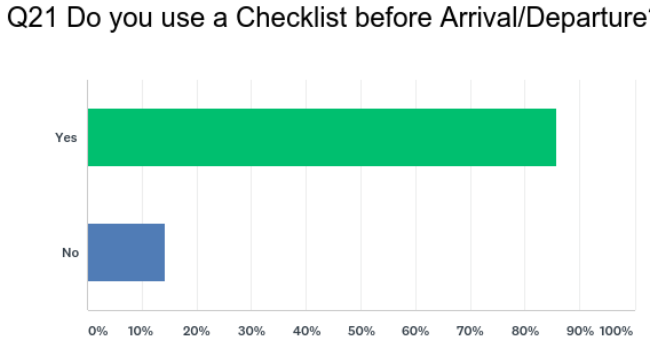


Fig.21 All respondents'

Answered 22 and skipped 6.

5.3 MANOUVERING MODE

5.3.1 Switching from centre control interface to the bridge wing control on approach

On many small tonnage vessels, the control is not moved to the bridge wing due to only one centre control interface. In this case the operator must leave the helm and move to the bridge wing to measure the distance. Some early built vessels can only have tiller, thruster levers and VHF on the bridge wing control with no monitors installed at all. On large GT vessels the control is moved by pressing one button and acknowledging on the wing control. One switch and button press are also a common procedure. The vessels that have the button and acknowledging procedure usually have the monitors and indications separately started on the bridge wing.

5.3.2 Control devices that are necessary for the operator in manoeuvrings mode

Vessels with azimuth or other thruster levers where the most used control devices with the combination of mini wheel, tiller or joystick. Vessels with helm are using the combination of helm and thruster levers.

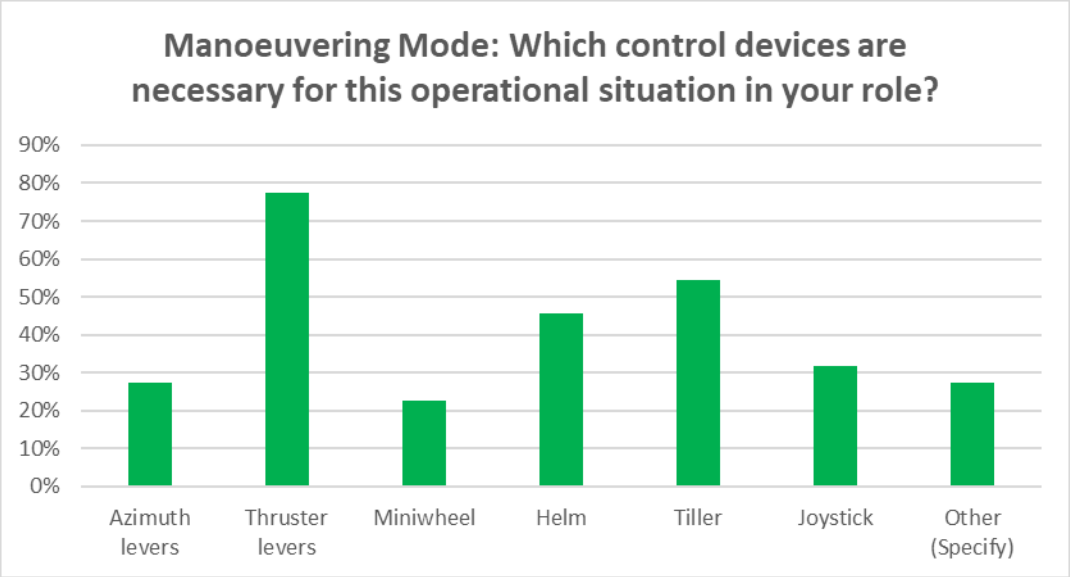


Fig.22All respondents'

Answered 22 and skipped 6

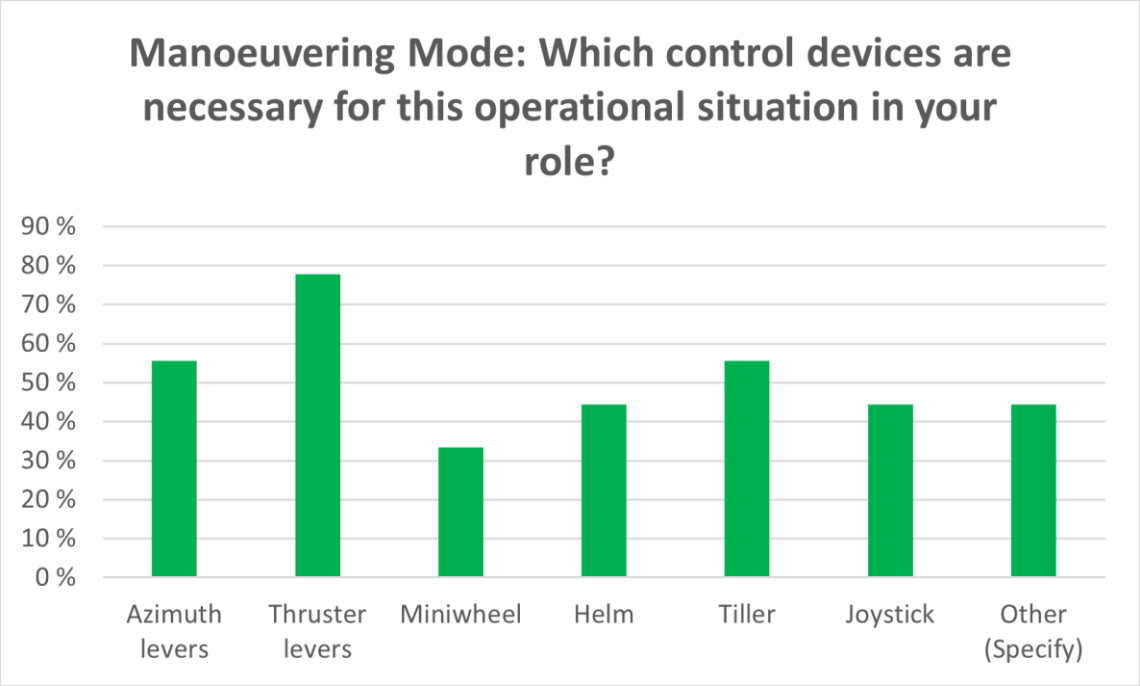


Fig.23 Master

Answered 9 and skipped 0.

5.3.3 Ergonomic positioning of the controls in manoeuvring mode

Of respondents' using azimuth levers a few thought's that the levers were positioned totally wrong and again some said that they were positioned fairly good or good ergonomically.

The other control devices seemed to be installed somewhat ergonomically. Problems here arises considering the location of the entire bridge control unit layout. The placing can be wrong since the operator also must have visual sight outside to the aft and fore. Some of the respondents, working on small tonnage vessels must walk outside from the bridge to see the ships positioning. Tillers and joysticks can be positioned so that the monitors are out of sight when manoeuvring.

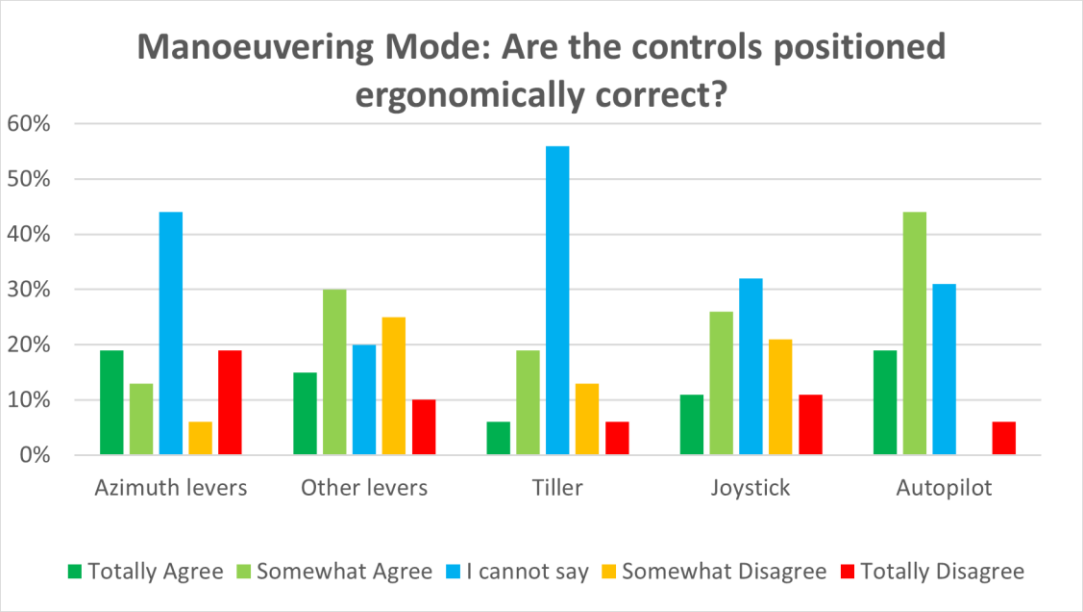


Fig.24 All respondents'

Answered 21 and skipped 5.

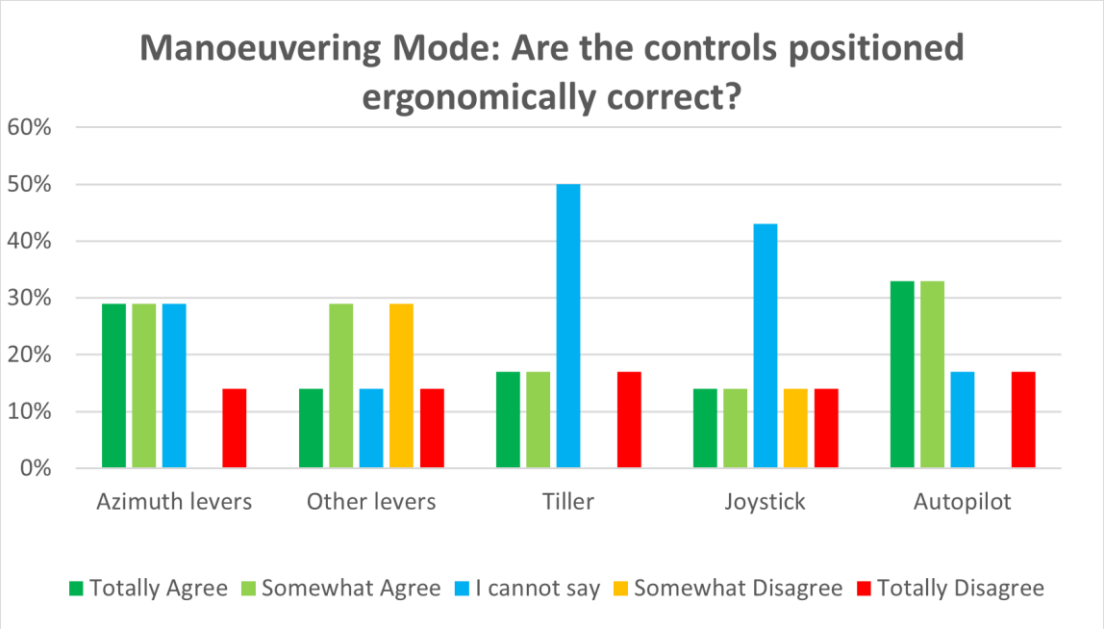


Fig.25 Master

Answered 8 and skipped 1.

5.3.4 Monitors and graphic indicators ergonomic positioning

ECDIS and radar are positioned ergonomically well and the other instruments as well except for the wind indicator that is an important tool when manoeuvring seemed to be installed wrong ergonomically. The indicator is too small or located too far from the operator's position.

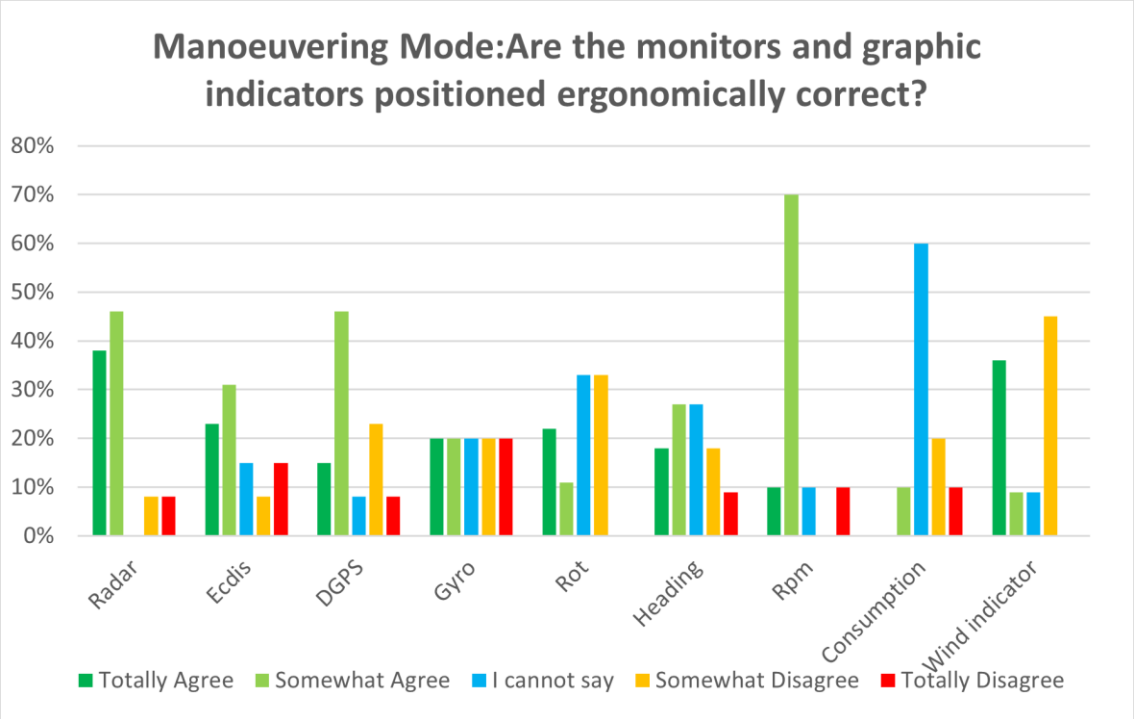


Fig.26 All respondents'

Answered 13 and skipped 6.

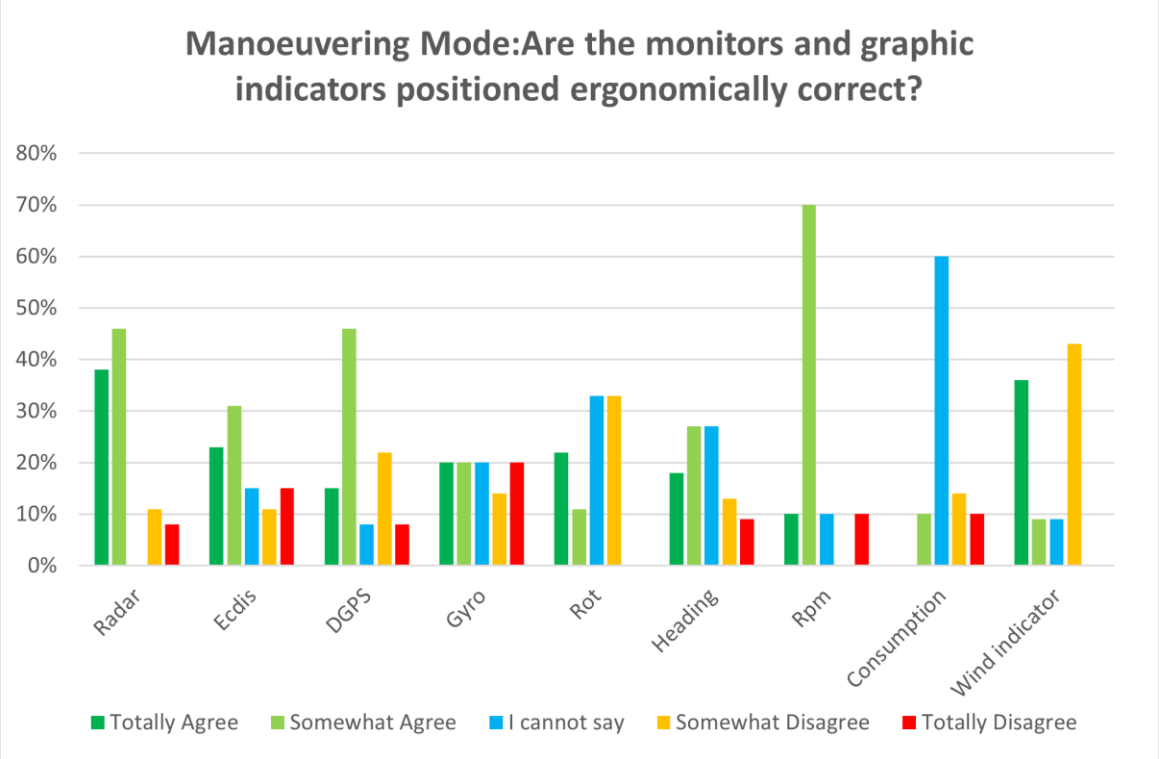


Fig.27 Master. Answered 7 and skipped 2.

5.3.5 Monitors and graphic indicators that are necessary for the operator in manoeuvring mode

In manoeuvring mode most important for all respondents, were radar, ECDIS (predictor, vessel's movement), ROT, predictor and wind indicator. Secondly heading, gyro, DGPS, pivot point and rpm.

In the ECDIS the operator is using predictor and heading to predict the vessel's movement.

Other necessary graphic indicators mentioned are pitch and pivot point. One respondent replied that the pivot point is dynamic and that he has not come up with a monitor that indicates reliably pivot point.

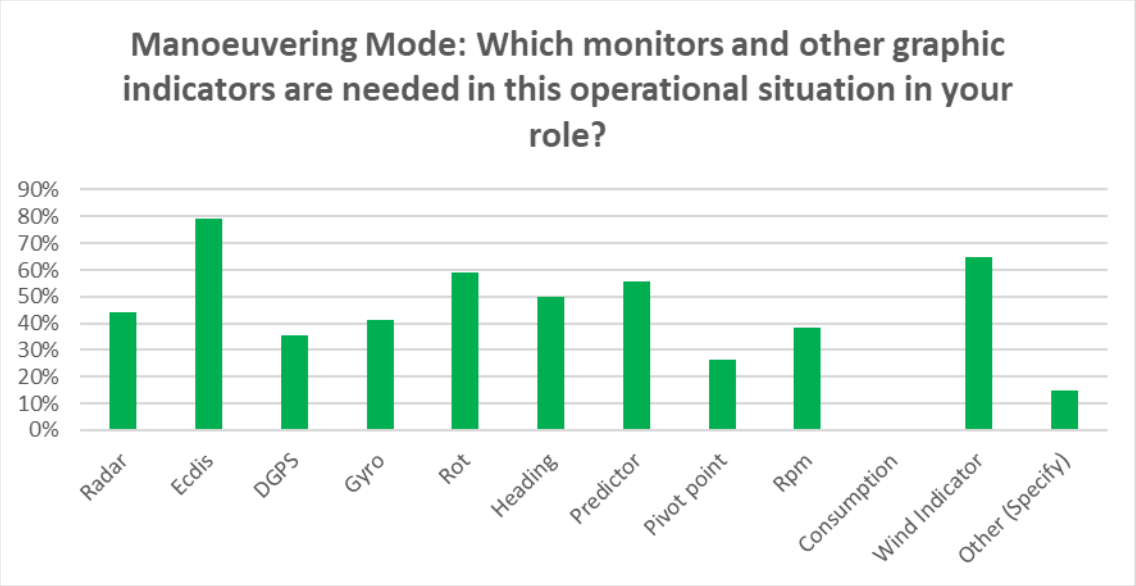


Fig.28 All respondents'. Answered 22 and skipped 6.

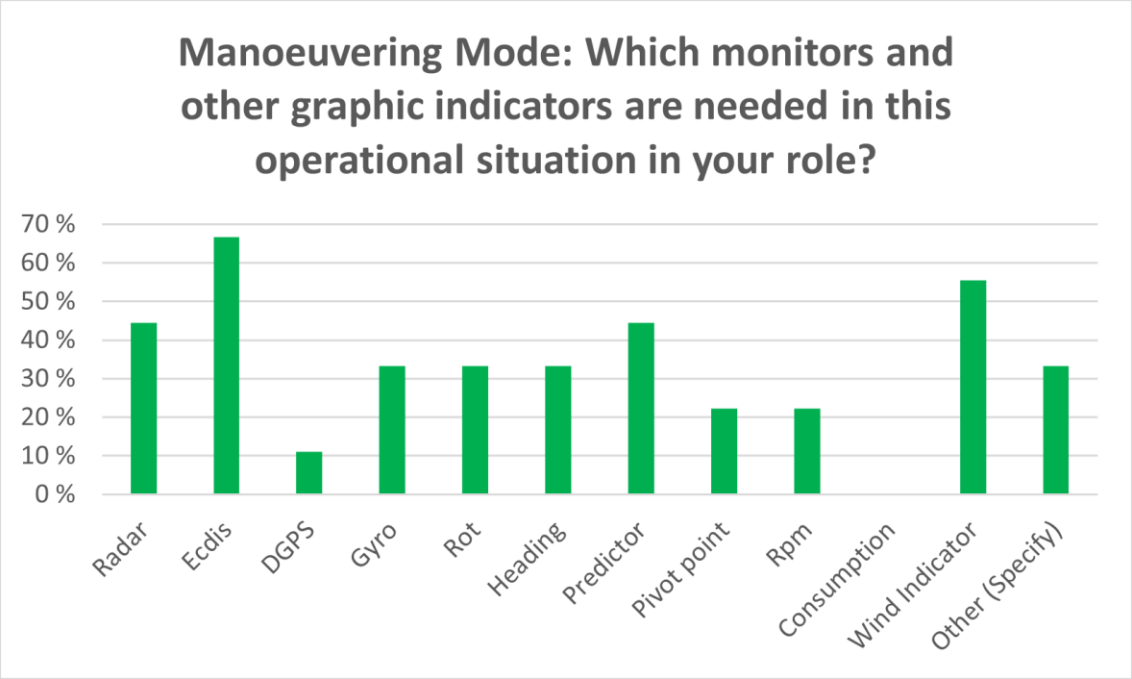


Fig.29 Master. Answered 9 and skipped 0.

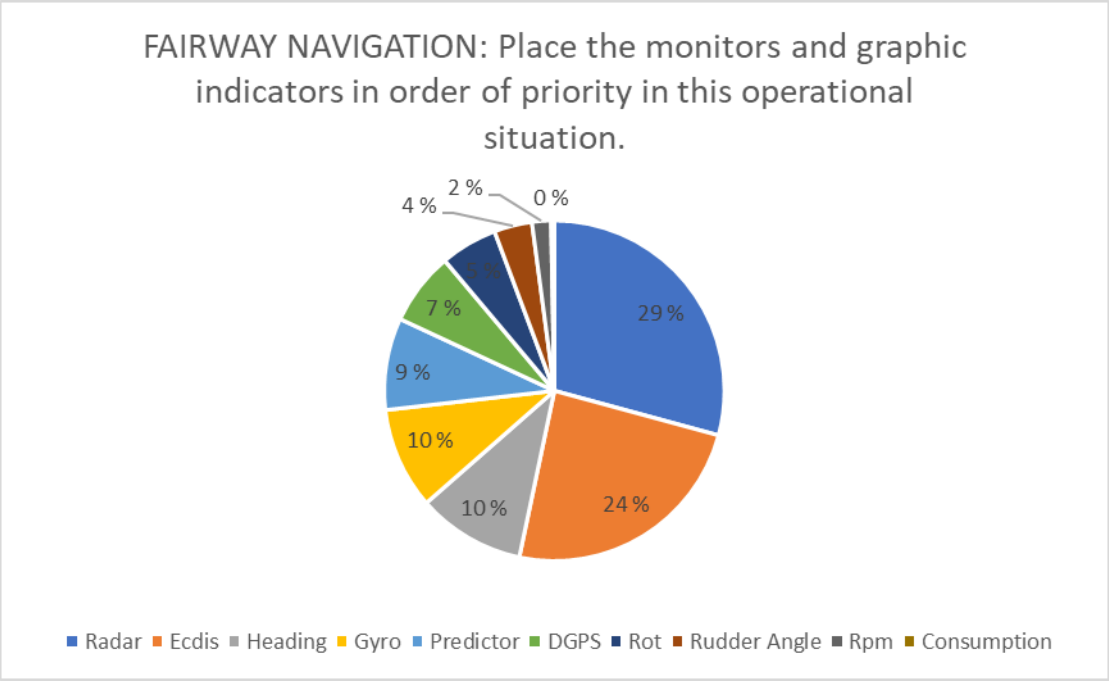


Fig.30 All respondents'. Answered 10 and skipped 3.

5.3.6 Respondents' opinion on, if there is missing a graphic indicator in manoeuvring mode

Vectors and predictor is important on approach, provided by the ECDIS. Most of the close quarter movements are best judged by eye-sight. In case of malfunction all the above should be easily accessible in order to monitor the possible misleading information. The

positioning is again a key point in this operation as well. Multiple indicators or a movable console could improve the operator to move on the bridge wing using visual observation. The ECDIS, radar, wind indicator and speed log are desired to the bridge wing console. For some respondents the true wind indicator was also missing.

5.3.7 Distance measurement to the dock

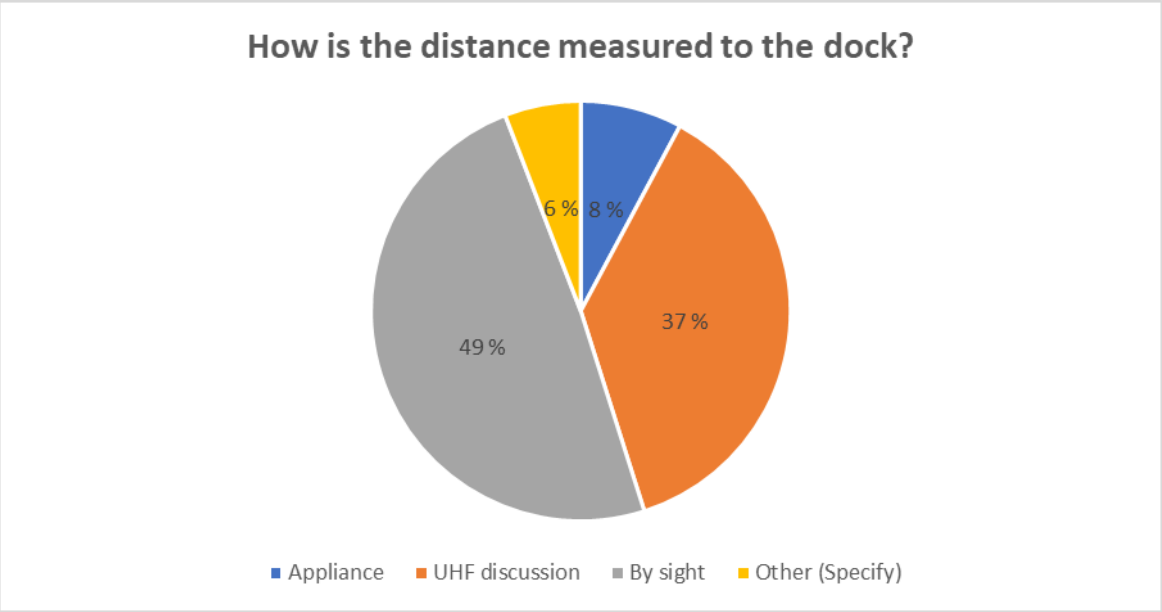


Fig.31 All respondents'. Answered 25 and skipped 3.

On many vessels the operator is manoeuvring the vessel on the bridge wing and the chief officer is measuring by eyesight distance's and discussing via UHF with the crew mooring. The watchkeeping officer is in the mooring station giving distances to the chief officer while the Master is maneuvering. Distances given by eyesight is never a good choice since one man's meter can be another one's 2 meters.

5.3.8 Monitors and graphic indicators positioning on the bridge wing control

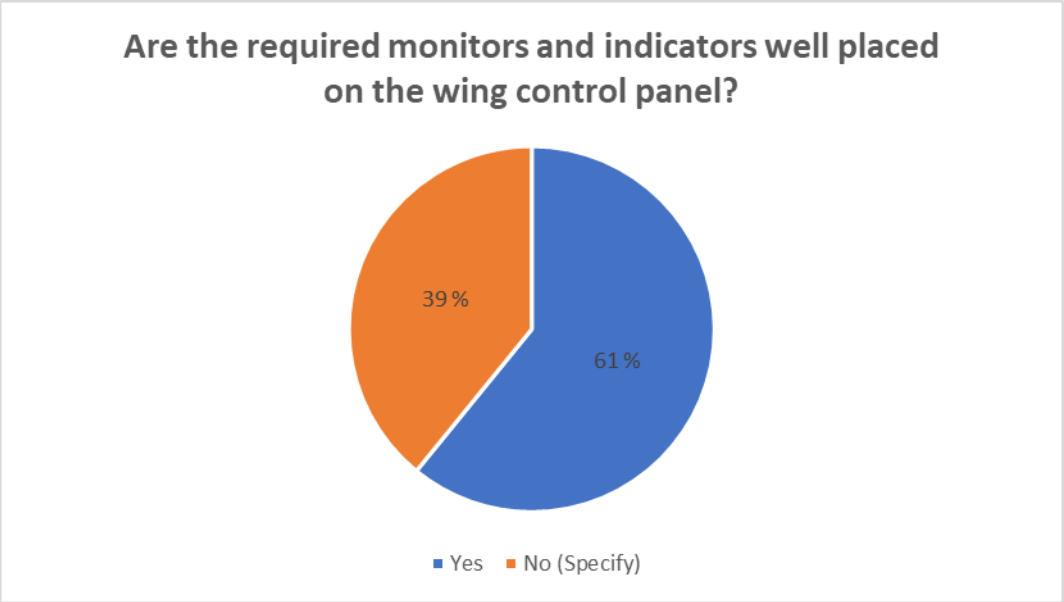


Fig.32 All respondents'. Answered 23 and skipped 5.

6 ALARM AND LIGHT INDICATION IN THE CONTROL UNIT

6.1 Alarm sounds in the control unit

- Route deviation
- Control failure
- Engine alarm
- -ECDIS
- Over ride
- Collision alarm
- Autopilot
- AIS positioning failure
- UPS

- Azipod alarm
- Satellite compass failure
- Dead man´s switch

Respondents' also answered in various ways that they do not know what alarms there are, high pitched beeps, blinking lights and too many alarms.

6.2 Distinguishing between alarms

Over half of the Finnish respondents thought that distinguishing between alarms is difficult and arises because of monotone beeping and the same alarm sound for different alarms. Many large GT vessels have check lists for different alarm's that help the operator to distinguish what alarm is in question. Non-differing sound alarm is not preferable on a vessel where the operator should be navigating and not simultaneously trying to find the cause of the alarm with the help of a check list. All respondents' answers expressed the same concern. Blinking lights and audible alarms are important but distinct sound and light would be an absolute must to identify the type of alarm. One of the respondents suggested an audible voice speaking and identifying the alarm. The respondent compared the voice alarm to the system used in aircraft cockpits.

6.3 Sound and linght indication's

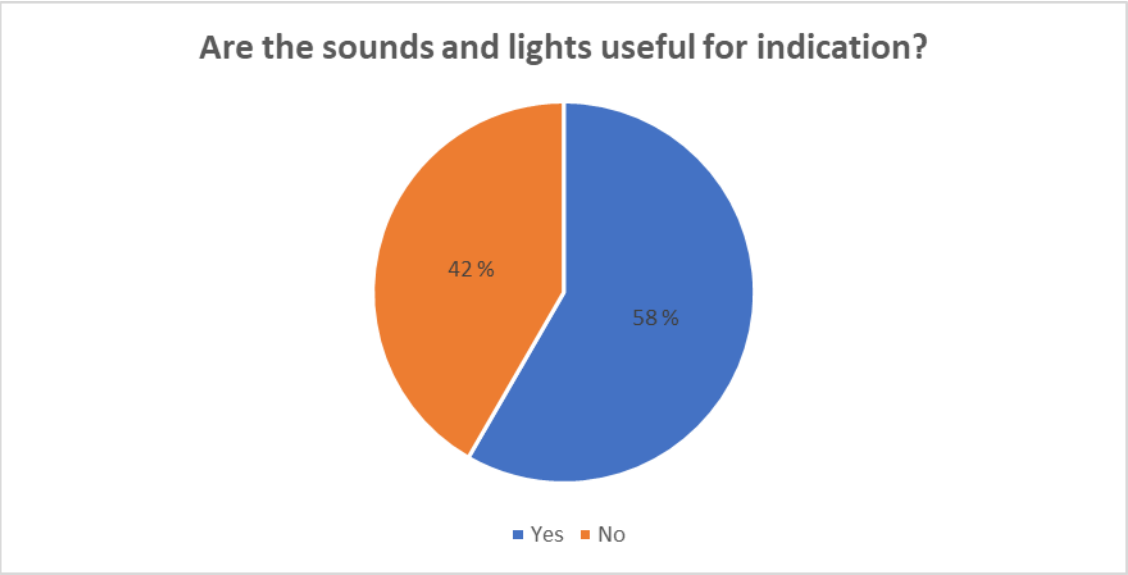


Fig.33 All respondents'. Answered 24 and skipped 4.

6.4 Suggested improvements for alarm, sound and light indications

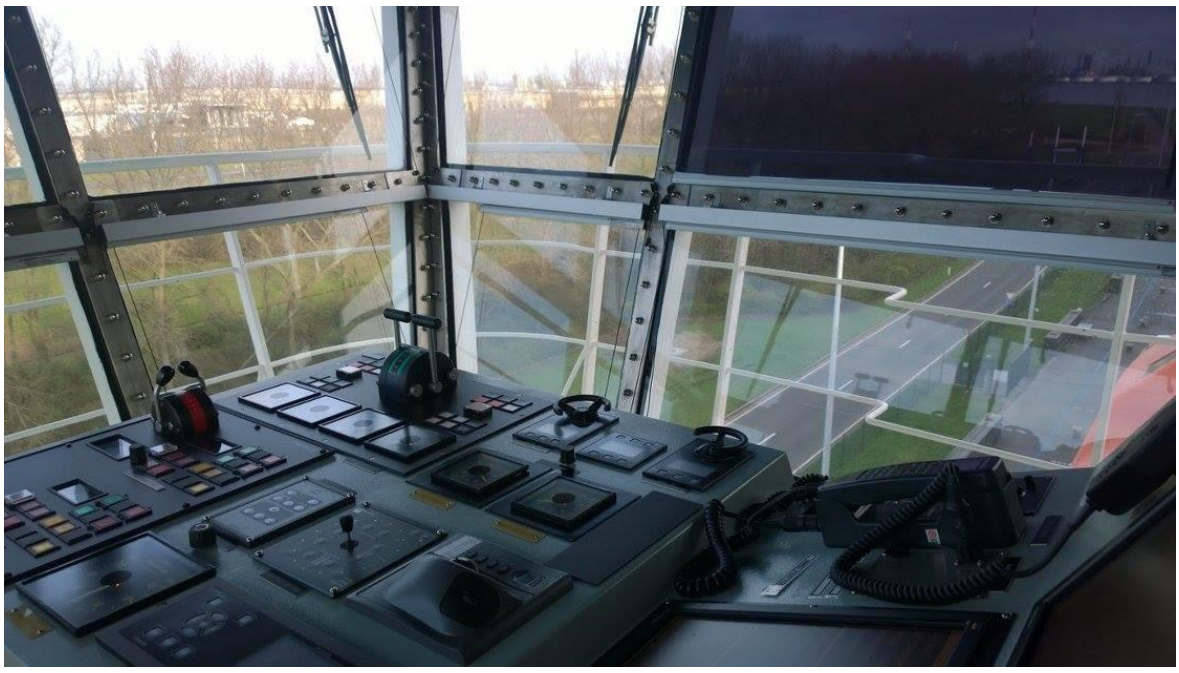
Integration of various equipment and especially the monotone beeping of alarms could be variable. Different sound for every alarm. Audio group's and special sound's for specific events. Different sounds and lights to identify alarms.

7 OBSERVATIONS ON VARIOUS VESSEL'S CONTROL INTERFACES

7.1 Two seat bridge control unit with identical steering gear and monitors

Pic.1 taken by M. Vaha

In the picture above is a centre bridge control unit on a RoRo Vessel. Two seats with identical ECDIS' and radar, monitors on both sides. Two autopilots are installed in the centre console between the two seats. At the bottom shown is the helm place. The wheel is not shown in the picture. On the right side there is a carboard mug on the handle to indicate that the handle is not suitable for use. The handle in question is override. Often mistaken for tiller. The vessel's speed handle is in the middle. To see the percentage of the rpm on the handle the operator must stand up the see the indicator on the handle.



Pic.2 taken by M. Vaha

This is the same RoRo vessel as above and the picture is taken from the starboard bridge wing. The angle of view is from the bow of the ship behind the console indirectly towards the rear. The mini wheel is located as the actual propeller blades on the ship. To manoeuvre the ship the operator is standing with his back to the window using his left hand to adjust the speed and the right hand to use the bow thrusters. Directly in front of the operator, the console has an ECDIS monitor from which the operator is following the movement of the ship. To see the bow and stern, the operator must turn his head 60 degrees in either direction. The ECDIS monitor is located a bit far so the operator must zoom in the scale to see the predictor and heading. Because of no measuring aid the distance is being given via UHF conversation.

7.2 Multi-use vessel's control unit

Pic.3 taken by M. Vaha

This control interface is on a multi- purpose vessel with PODs and DP function. This bridge control device is located toward the aft of the ship. This setup is ergonomically good since you are sitting in the middle and have the both levers at your fingertips on both sides. Monitors are also located in way that you can only by moving your eyes see outside and the Information on the monitors at the same time.

Pic.4 taken by M. Vaha

The same multi-function vessel from the actual bridge control unit. To use the PODs the operator must stand. The monitor with ROT, heading and rudder angle is at the height of the roof that burdens the operators' neck and shoulders. Ergonomically not a good situation. Also, the levers' positioning can be challenging because of the detents not giving a feeling of the movement. To be sure of the angle the operator must look down on the hand's and lever's position. On both sides are identical steering gear and monitor layout with seats.

7.3 RoRo/RoPax bridge console

Pic.5 taken by M. Vaha

This is the centre bridge control unit of a RoRo/Pax vessel. The bow and stern thrusters handle have no indicator or colouring to indicate is the ship turning to port or starboard. The ECDIS has been installed later so the monitor is too far from the operator's seat. For a shorter operator the view outside is obstructed with the monitors.

7.4 RoRo cargo vessel's bridge equipment

Pic. 6 taken by M. Vaha

Pic.7 taken by M. Vaha

These two pictures are taken from a RoRo cargo vessel. The upper picture is the bridge wing console from starboard side and the lower is the port side console. Here the vessel only has installed the bow thruster lever, tiller and the throttle. The ECDIS has been installed later and therefore only the monitor is installed on the bridge wing and the computer with keyboard and mouse is located in the centre control interface. During manoeuvring the operator cannot adjust the monitor's setup or dimmer. The adjustments

must be done before departure/arrival since it cannot be done from the actual console the operation is happening from.

8 ANALYSIS AND INTEPRETATION OF RESULTS

1 Personally, I recognized and related to many of the same problems the respondents' named as challenges with the steering gear as well with the monitor's and graphic indication's. Steering in open sea can be challenging when the navigational monitors are located too far from the operator. A positive thing on many vessel's is the autopilot that is installed at your fingertips, the hand does not have to lean on the joystick and the next course can be set beforehand. This does not load the operator's body ergonomically. In my opinion the steering gear should be positioned at a close distance so that the user does not have to change seat position. A movable panel with steering gear that can be placed in front of the seat with the operator's own adjustments would be ergonomically good.

2 Negative observations identified was many alarm's and colour indications that is difficult to identify because of the monotone beeping and flashing lights. Different sounds to specify the alarm and indications for each alarm would be crucial. Fairway navigation on small tonnage vessels have problems with the steering gear placing as well with monitors and graphic indicators. Some Tillers have no colour markings on them to indicate turning to port or starboard. Lack of repeaters makes it also hard to navigate since you must walk on the bridge to see outside and at the same follow the course. Manoeuvring mode is overall the most challenging thing when discussing ergonomic working conditions and bridge control interfaces. The operators must have a clear view to the fore and rear but also see the entire side of the vessel. The ECDIS and other aids that visualize in real time the vessels position must be located in close vicinity together with the steering gear. The ideal situation for the operator is where the monitors and graphic indicators that predict the vessel movement are located well with vision and can be easily adjusted and dimmed. Sensors to predict the movement and obstacles would be a big step since now the measurement to the harbour is done by eyesight and UHF conversation. Also, the usage of the ECDIS as an instrument to track close quarter movement is not preferable. If the AIS receiver is located wrong on the vessel the signal of the vessels location and measures are misleading.

9 SUGGESTED SOLUTIONS

A new Ideal solution for many of the above-mentioned problems would be ABB Ability™ Marine Pilot Vision.

ABB Ability™ Marine Pilot Vision is a situational awareness solution that makes vessel operations safer and more efficient. The solution offers multiple real-time visualizations of a vessel's surroundings presenting the ship and its environment in ways beyond the capabilities of the human eye.

9.1 How the ABB Ability™ Marine Pilot Vision works

A virtual model of the ship is superimposed on real surroundings measured using various sensor technologies, making it possible to monitor the vessel and its surroundings from a birds-eye view and switch to other views instantaneously. The solution makes it easier to predict vessel motions with respect to the actual surroundings and gives the user visibility of previously hidden obstacles or collision risks.

9.2 Benefits

- Improved situation awareness onboard and onshore.

- Continuous visibility covering all blind spots around the ship during docking operations as well as at open sea.

- Better situation awareness in challenging weather conditions such as high waves, wind, rain and fog.

- Real-time and intuitive docking assistance, extending the capabilities of human eye.

- Incident and damage prevention for infrastructure and other ships.

- Improved efficiency

(ABB Marine S&D, ABB Ability™ Marine Pilot Vision, 2019)