Intuitive operation and pilot training when using marine azimuthing control devices

AZIPILOT

Report Title:

Deliverable 4.4:

Review of bridge operational practice and human interface

Contents

1 EXECUTIVE SUMMARY

The present report contains the main results of the task 4.4 of the AZIPILOT project.
The WP4 of the project is specifically addressed to maritime pilots, ship operators/managers, pilot associations, end-users and in general all the subjects interested in the operational practice with the azimuthing control devices (ACD).
The main aim of the WP4 is to collate, review and audit available material that is relative to the operational of azimuthing control devices when manoeuvring ships in pilotage waters. The outcomes of the work will then be used to improve current techniques and tools also with the involvement of dedicated Authorities and Regulatory Bodies.

The task was focused on a r eview of bri dge operational practice and human interface, in particular addressed to ship using azimuthing control devices (ACD). The main objectives are to promote understanding of the needs of the bridge crews and ensure that these information are passed back to the bridge and systems design engineers, with the scope of enhancing usability and efficiency of these systems.

The task includes the following sections:

- The first section cover a Task Analysis review concerning bridge systems and their practical operation. The data considered are mostly related with the SOLAS instructions for the operation of ships equipped with ACDs in different navigational and manoeuvring situations. After that a review of the systems and tools to manage ACDs is performed, also reporting some pictures which help to better have in mind the configuration on the bridge.
- The second part concerns an evaluation of ergonomics and usability related to bridge operational practice and the human interface. There will be considered the way controls and displays are fitted on the bridge and the impact of such a distribution on the usability and user-friendliness of the ACD systems. Guidelines from SOLAS will be also included in this section.
- The last part of the report will take into consideration feelings and comments of t he operators of ACDs: pilots and officers. There will be included the perceived pros and cons of these systems with an indication of the crew needs; the last part of the deliverable will contain some examples of m odifications and expedients made by the crew to make operations more user-friendly.

The main outputs of these study, through the assessment of systems available and feelings by the interviewees, concern some suggested modifications to be applied to actual systems to allow a better familiarization and usability of d evices. Besides that, there was again pointed out that training remain the best perceived way to improve the usability of such systems.

The work summarized in this deliverable has been conducted by South Tyneside College and Cons.A.R.

2 Task analysis of bridge systems

In the IMO MSC Circular 78/11/3, and specifically in the Annex B concerning the Bridge design, some references from the SOLAS Chapter V are reported. According to that Convention:

"The bridge shall be designed and arranged with the aim of:
- facilitating the tasks to be performed by the bridge team and the pilot in making full appraisal of the situation and in navigating the ship safely under all operational conditions;
- promoting effective and safe bridge resource management;
- allowing for expeditious, continuous and effective information processing and decision-making by the bridge team and the pilot;
- preventing or minimizing excessive or unnecessary work and any condition or distraction on the bridge which may cause fatigue or interfere with the vigilance of the bridge team and the pilot."

The design of bridges is governed by:
- functions and related tasks to be carried out on the bridge, systems used and methods of task performance;
- the range, layout and location of workstations required for performance of bridge functions;
- the fields of vision required for visual observations from each of the workstations;
- composition of the bridge team and the procedures required for safe operations under all identified conditions;
- the type and range of equipment to be provided for performance of the tasks at the individual workstations and elsewhere on the bridge.

2.1 Function, tasks and means

In the above mentioned MSC Circular a table is reported which lists the main bridge functions and tasks to be carried out on the bridge. The types of approved equipment that are related to the performances or different tasks are indicated. The list reported may serve as basis for outfitting of workstations. The type of equipment installed on the individual bridge, the system configurations and automation level may affect the method of navigation, operational procedures and qualification levels.
Table I is an abridged extract from Appendix B1 of the IMO Maritime Safety Committee Circular 78/11/3[1] *** SOLAS V/15: *"Evaluation of ergonomics and usability related to bridge operational practice and the human interface"*.
The table has been abridged to only cover tasks relating specifically to azimuthing devices.

Table 1 – Bridge design – Functions, tasks and means

Tasks to be performed	**Equipment** to be operated	**Information** to be viewed	**Remarks**
Navigation – Grounding avoidance			
In Transit			
Maintain route/alter course by - manual steering - using autopilot - automatic route-keeping	Manual steering control Heading control system Track control system* (ECDIS)		* Alternative to heading control Interfaced to ECDIS, gyro, speed, radar when part of INS

[1]International Association of Classification Societies Ltd. (IACS) Recommendations for the Application of SOLAS Regulation V/15

Monitor/Take action: - operational warnings - system failure alarms	Alarm panel		If installed
Monitor heading, turn, rudder angle, speed, propulsion		Gyro repeater Indicators: - rudder angle - rate-of-turn* - RPM, Pitch - speed log	* > 50 000 grt
Traffic surveillance - Collision avoidance			
Manoeuvring			(For route-keeping)
Change steering mode	Steering mode switch		
Alter heading	Heading control	Heading (Gyro)	
Observe rudder angle		Rudder angle	
Override steering	Override control		
Manual steering control			
Change speed	Propulsion control	RPM/Pitch	
Harbour manoeuvring	Thruster		Optional
Anchoring			
Manoeuvre Positioning (Identify anchor position)	Manual steering control Propulsion control (Thruster control.) Radar Chart GNSS	Heading Rudder angle RPM/Pitch Water depth	Performed at front workstations or in combination with docking station Information to be provided for pilots.
Observe ship's safety state			
Monitor alarm conditions: - Navigation Equip. & system failures Operational warnings	Main alarm panel w/indicators and acceptance button*	Alarm list	
- Machinery condition		Machinery alarms	Installations related to the ship's specification
Manual steering			(Rating)
Maintain, adjust, alter heading according to order	Steering control Intercom (Command)	Gyro repeater Magnetic comp. Rudder angle Rate-of-turn	
Conning functions			
Determine & direct course and speed in relation to waters and traffic			
Monitor:			
- heading		Gyro repeater	May be digital
- rudder angle		Rudder angle	
- rate-of-turn		RoT indicator	
- propulsion		RPM/Pitch	
- speed		Speed log	
- water depth		Echo sounder display	Anchoring
Docking operations (bridge wings)			
Directing steering	Intercom (command)	Heading	

		Rudder angle	
Directing speed	Intercom (command)	RPM/Pitch	
Perform manoeuvring	Steering Propulsion control Thruster control		Additional installation by owners

Regulations for the design of bridge systems distinctly pertaining to azimuthing devices is an area that appears to have not been specifically developed. This section of the report intends to delineate the general Task Analysis of MSC 78/11/3 associated with Azimuthing Devices.

As can be seen from Table I, the essential tasks involved in bridge systems, with respect to azimuthing devices, are to be able to manoeuvre the vessel, and be able to realise how the vessel is responding to the manoeuvring orders.

It is the intention to show how these tasks are implemented in practice. Due to the vast number of c ombinations and permutations available for achieving these tasks, the analysis will concentrate on generic hardware, or that of major manufacturers.

3 Practical operation of bridge systems with respect to ACD

At the beginning of this chapter, two pictures are reported which represent two different types of ACD consoles on different ships.

Figure 1 – Centre Console onboard Swedish car ferry

Figure 2 – Bridge Wing Console on board Fox Luna

As can be seen from figures 1 and 2, control levers look different to one another, along with their associated displays. The way in which the control levers and displays work are, however, essentially the same.

3.1 Azimuthing Control Lever

Figure 3 – Aquamaster AquaPilot Control Lever

The control levers for Azimuthing Devices generally consist of a rotating handle with a circular scale at the base. An arrow located on the handle shows the thrust direction from this scale. The handle may also be pushed forward or back, controlling the prime movers rpm or propeller pitch.

3.2 Thrust Direction Indicator

Figure 4 – Aquamaster Thrust Direction Indicator

Figure 4 shows a Thrust Direction Indicator (TDI) from the Aquamaster range. In this figure, the display is not illuminated, however in figure 1, the TDI can be seen to be active. The reasoning behind the TDI is that the operator has a visual indication of where the thrust is being directed (in this case along with the throttle) in real time. The machinery response will lag behind the manoeuvring order, so the thrust indicator on the control handle may not necessarily be that of the TDI.

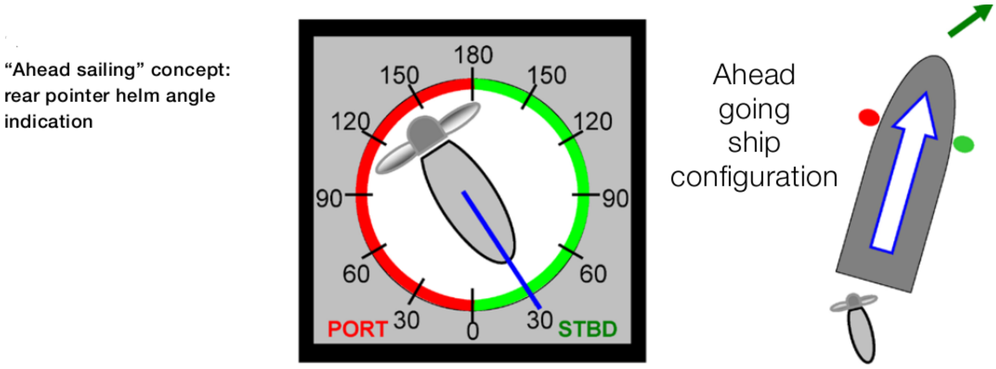

Figure 5 – Example of using the Thrust Direction Indicator

Figure 5 depicts an example of how a TDI operates in practice aboard a vessel fitted with ABB Azipods. It can be seen that although the layout is similar to that of Aquamaster, there are also some differences.

3.3 Azimuthing related Control Panel

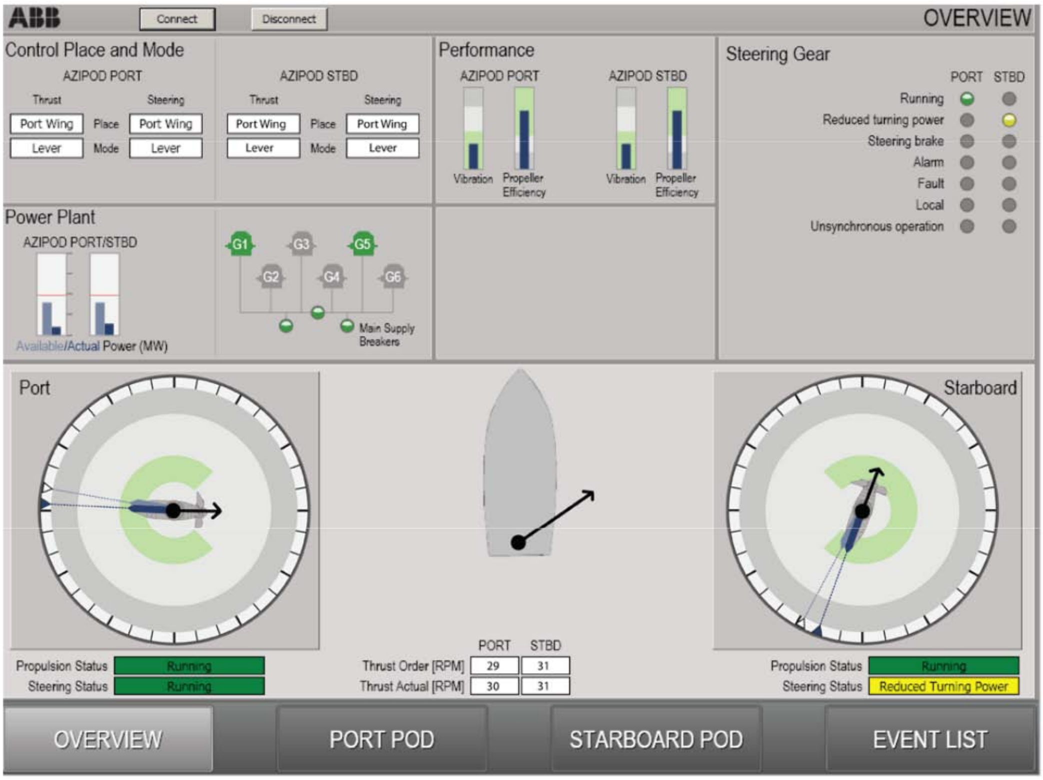

Figure 6 – ABB Intelligent Bridge Control Interface

Figure 6 is a screen shot of the Intelligent Bridge Control Interface for Azipod devices. Amongst other elements of the display are the mode of operation, where the device is being controlled from (the port wing in this case) and some information as to how the Azipod is performing, along with any limitations that are imposed on the Azipod.

3.4 Modes of Operation

Different scenarios require different modes of operation. For example, operating the vessel in open sea (high speed) will require a different mode of operation to that of manoeuvring the vessel in harbours. These contrasting modes of operation impose different limitations and restrictions on the capability of the azimuthing propulsion plant. These limitations are imposed for a variety of reasons, including the reduction of dangerous levels of vibration and to reduce the mechanical wear on seals and bearings inside the azimuthing device.

Practical examples of operational modes are:

- *Open Sea Mode* – Power available to the azimuthing devices is typically unlimited, and the turning angle of the device is greatly restricted.
- *Manoeuvring Direct Mode* – Power available to the azimuthing devices is limited (50-60% of total). The turning angle of the device is limited. (max. 35 degrees helm angle)
- *Aziman Mode* is used for docking situations – Power available to each azimuthing device is severely restricted. The devices can be rotated through 360 Deg. Figure 7 depicts maximum efficiency of each device in various positions during Aziman Mode.

REFERENCE – Towline, August 2009, National Association of Fleet Tug Sailors, pp12.

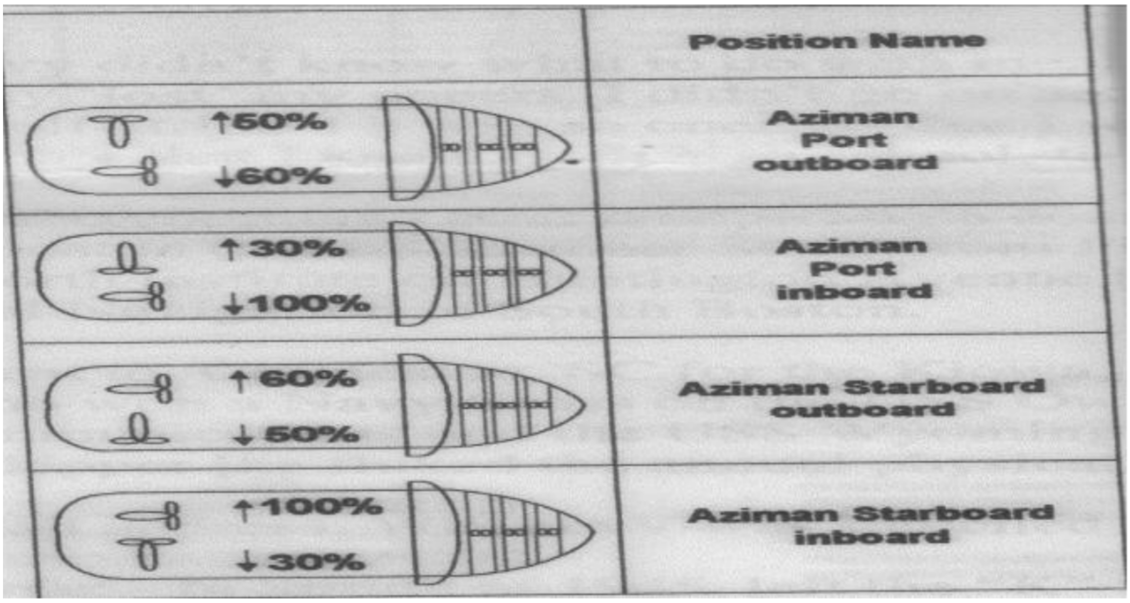

Figure 7 – Maximum efficiency of Azipods in various positions during Aziman mode

A *Joystick mode* is sometimes available, where a joystick is used to control not only the aft propulsors, but also forward ones too. This joystick has various different names depending on the manufacturer. The Joystick control system is a low speed manouvering aid which could be useful in situations where operators area is of limited size and where objects to avoid or to approach are visible and close.

4 Evaluation of Ergonomics and usability related to Bridge Operational Practice and Human Interface

The role of the Human Element has been addressed to bridge design, design and arrangement of navigational systems and equipment and bridge procedures with respect to SOLAS Regulation V/15 by two different approaches. Two projects have proposed forms of demonstrating conformance; the International Association of Classification Societies (IACS) standard for bridge design, equipment and arrangement (BDEA), and the Advanced Technology to Optimise Man-power On Ships (ATOMOS) project.[2]

The IACS standard is interpreted as a standardised bridge arrangement, rather than defining a path between the goals of the Regulation and assessable ergonomic criteria. It indicates that Type Approval is not only necessary, but it is sufficient. Apart from meeting SOLAS V Regulation 22 on navigation bridge visibility, no other ergonomic guidance in the BDEA document is required to be used to obtain a certificate.

The ATOMOS approach differs from the IACS approach in that it seeks to integrate ergonomic criteria into the decision making process as it relates to bridge design, the design and arrangement of navigational systems, and equipment and bridge procedures. ATOMOS also recognises that a structured risk assessment is required to assess the extent to which the decisions required under Regulation V/15 meet the aims.

The IMO Maritime Safety Committee Circular 982 entitled "Guidelines on Ergonomic Criteria for Bridge Equipment and Layout." has produced criteria to support provisions of the SOLAS V/15 regulations. (Principles relating to Bridge Design, Equipment, Arrangements and Procedures). Chapter 5.3 of the Circular refers to Ergonomic Requirements of Workstation Layout. The more pertinent criteria are listed in Table II:

Table 2 – Extracts from MSC 982 –
Guidelines on Ergonomic Criteria for Bridge Equipment and Layout

5.3.1.3 Left-to-Right Viewing Angle
The console should be designed that from the normal working position the total required left-to-right viewing angle should not exceed 190°. This angle shall be reduced whenever possible through appropriate control-display layout.

5.3.2.1 Logical Arrangement
The devices, displays and controls should be fitted in a logical arrangement and combined into function groups.

5.3.2.2 Location Consistency
Location of recurring functional groups and individual items should be similar from console to console.

5.3.2.4 Control and Display Location
Controls and their associated displays should be located that the information on the displays can be easily read, during the operation of the controls.

5.3.3.3 Location of Primary and Frequently Used Controls
The most important and frequently used controls should have the most favourable position with respect to ease of reaching and grasping (particularly rotary controls and those requiring fine settings), e.g., keys for emergency functions should have a prominent position.

5.3.3.4 Consistent Arrangement
The arrangement of functionally similar or identical controls should be consistent from workstation to workstation, panel to panel throughout the bridge.

5.3.4.1 Immediate Field of View
The most important and/or frequently used displays should be located within the operator's immediate field of view (viewing area with eye rotation only)

[2] IMO Marine Safety Committee 78/18/3

5.3.5.1 Functional Labelling
Controls and displays should be labelled clearly and unequivocally according to their function, possibly by using standardized symbols.

5.3.5.2 Label Terminology
The selection and use of terminology for labels should be consistent between controls and displays.

4.1 Orientation of consoles

From table II it can be seen that the arrangements of consoles need to be consistent throughout the whole bridge.

When an operator is used to controlling the vessel in which the controls are orientated in a certain way, but then needs to relocate to a bridge wing, then, depending upon the situation, the orientation of the bridge wing controls may be different to that of the centre console. For example, in order to get a clearer view of the quayside, the operator *may* position themselves so that they are ninety degrees to the bridge wing console. Now that the orientation of the operator has changed, the orientation of the Azimuthing Devices tends to become less intuitive. To combat this, there are designs, like that of Figure 8. These console designs rotate along with the orientation of the operator, so the relative orientation does not change, taking away one less thing to think about for the operator.

Figure 8 – Marine Technologies Integrated Bridge System

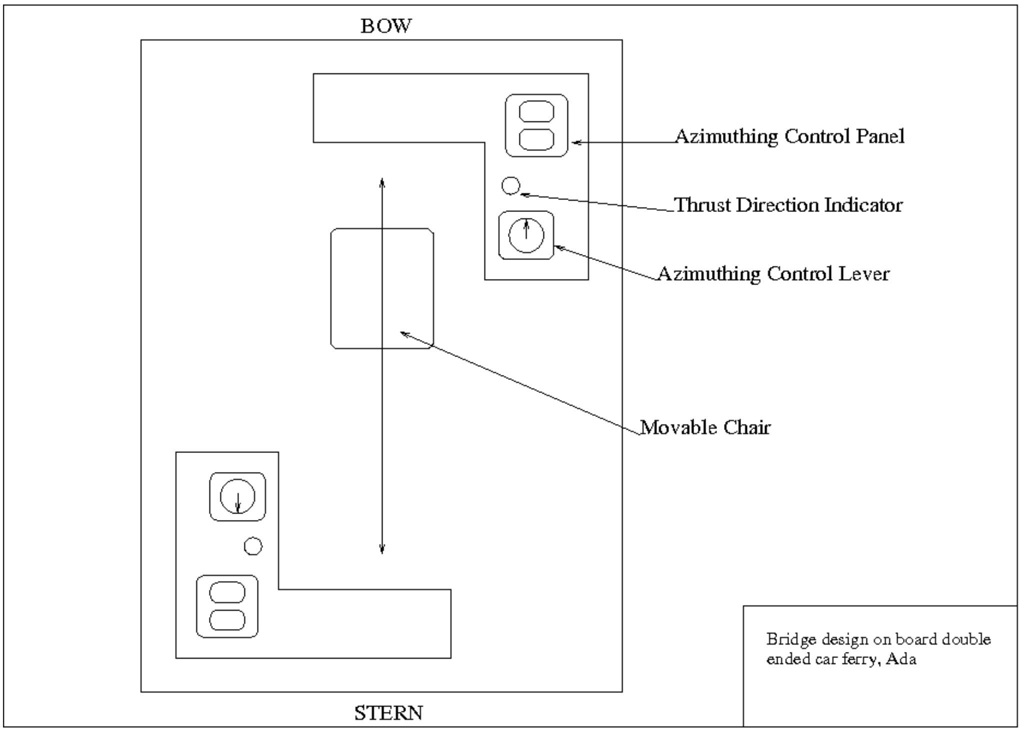

Figure 9 – Bridge design of double ended car ferry, Ada

Figure 9 shows the layout aboard the double ended car ferry, Ada. The operator when going ahead faces towards the bow. When going astern, the operator swivels his chair around 180 deg. and faces the stern. The orientation of the console has not changed however.

4.2 Operational modes awareness

Among the more salient characteristics of controlling azimuthing devices is intuitive operation. It is desirable that the operator should be able to instinctively control the manoeuvring of a vessel in a variety of modes.

There exists a number of guidelines on Operational Modes of bridge systems. Obviously, the operator needs to know what mode the azimuthing device is in, otherwise, the vessel will not respond in the expected manner. It is also imperative that the operator understands the different limitations that are applied to the azimuthing devices in these various modes, otherwise the vessel will not respond in the expected manner.

Table 3 – Extract from MSC Circular 1061 –
Guidance for the Operational use of integrated Bridge Systems

2.1 Mode awareness Mode awareness is based on the knowledge and purpose of various operation modes included in the IBS. Use of different operation modes should follow bridge procedures based on company automation policy.

Table 4 – Extract from Safety of Navigation Circular 265 –
Guidance on the Application of SOLAS Regulation V/15 to INS, IBS, and Bridge Design

8 Operational mode awareness 8.1 The system and its physical arrangement should provide convenient and continuous access to essential information such as heading, rudder or azipod angle, and propeller RPM or pitch and, if available, rate-of-turn for both the bridge team and the pilot to information necessary for the safe navigation. If any auxiliary or separate console or workstation is provided for the pilot, it should provide the same quality and quantity of navigation information needed by the

pilot as the main console or workstation. 8.2 The system should continuously indicate to the bridge team and pilot the system operating modes currently in use and provide simple access to other available operating modes. 8.3 The system should indicate failures in a clear and unambiguous manner to enable the bridge team and pilot to understand the nature of the failure. 8.4 Information should be presented consistently within and between different subsystems. Standardized information presentation, symbols, abbreviations and coding should be used according to resolution MSC.191(79). 8.5 Where standardized symbols are not available, information, symbols and coding should be visually representative and should be consistent with established information presentation, symbols and coding. The used symbols should not conflict with the symbols specified in SN/Circ.243. Any inconsistencies that might cause confusion or errors should be avoided.

4.3 Usability and Mode awareness

Different manufactures have different terminology for what are essentially the same mode of operation. This can become confusing. Operators coming aboard various vessels with differing terminology need to know what each different term is equivalent to. From Table III, item 2.1 it can be seen that different operation modes should follow bridge procedures based on company automation policy. These procedures and terminology should be clearly laid out in the Vessel Operating Manual.
Moreover, to allow the best interaction and usability of operators with the devices, the current mode of operation must be clearly detected. This is fundamental for the operator who have to know the propulsion characteristics and limitation due to the particular mode of operation currently active. The mode of operation active is generally indicated on t he monitor or the controls.

4.4 Usability and representation of Conning Symbols

Table 4, item 8.4 states that information presented to the operator should be of a standard form, according to MSC 191(79). However, MSC 191(79), entitled “Performance Standards for the Presentation of Navigation-Related Information on Shipborne Navigational Displays ” relates to symbols used in navigation, rather than for conning. It can be seen from various figures in this report that conning displays vary from one manufacturer to another. One example is the Thrust Direction Indicator. Whilst the displays themselves look fairly intuitive, in an emergency, where the operator is used to a different system, the potential for mistakes is increased.

4.5 General notes on Bridge Operating Procedures and Azimuthing Devices

There is an abundance of differing configurations of azimuthing devices, and their associated controls. For example, pull type, push type, FPP, CPP, CRP, etc. Each of these configurations vary to one degree or another on t he various manufacturers. These configurations require handling in their own specialised way. It can therefore be dangerous to assume that although an operator may be proficient in handling one type of configuration, that they are capable of handling another.

Different configurations and interfaces for the bridge systems, in particular regarding azimuthing systems, could lead to human errors and accidents during manoeuvres, especially during emergencies and situation of manoeuvres in restricted waters (in ports). These potential dangers could be avoided through a better design of these systems and in particular through a better standardization.

5 Problems connected to bridge systems

From interviews performed and contributions and data provided by officers and pilots, some problems have been detected concerning the use of ACD systems.
Some of this problems are due to the lack of standardization of these systems, others to the fact that the use of these systems require the operator to change his concept of leading the ship from the traditional manner, other again to the configuration of the bridge layout.

Although the interface of the Bridge System is functional to safety of navigation, in a view that thanks to field experience everything can be improved, it would be good for the future that new constructions may provide an additional location, situated in a favourable position for the middle and final part of the manoeuver (change in port / approach to pier).
Therefore the pilot from a dedicated workstation (wing bridge) should be able to control power and direction of the thrusters, rate of turn, bow of the ship, wind speed.

For what regard the way the manoeuvring order are given, the suggestion of a standardized set of sentences could represent the starting point of a wider and better shared system of instruction exchange, which could help all person involved in the manoeuvre to be informed about, without risks of misunderstanding due to the wording used.

Another problems underlined by people interviewed is represented by the fact that nowadays, very often, the most followed way of doing manoeuvres is by suggesting the result to achieve rather than the way to do that. For instance, the speed value is suggested rather than the engine power needed to have that or the direction to follow is suggested rather than the propulsion angle to set.

Generally, all interviewed persons said that the azimuthing systems are very intuitive and, after good training and some field practice, the use of these system is simple. The main difficulties are given by the fact that manoeuvring ships with this systems, the response is much more immediate than that of the traditional systems (rudder): so operator/officer has to change his mind and understand that it’s something completely different from the rudder and propeller shafts. So, everyone agree that a well organized training course is necessary for the future operators.

6 Examples of different bridge interfaces

In this paragraph, there will be shown interfaces from two different type of vessels: the first set of photos represents the bridge configuration onboard a Costa Crociere cruise ship, while the second one shows the configuration onboard an Italian gas tanker, Venere.

Figure 9 – Costa Crociere's configuration 1

In this photo, the handle controls are positioned in order to perform a manoeuvre forward with the maximum control of the direction.

Figure 10 – Costa Crociere's configuration 2

In the second photo, controls are positioned in a way to perform a manoeuvre backwards with full control of the direction.

Figure 11 – Costa Crociere's configuration 3

In the photo above there is represented the configuration used to stop the ship, by opposing the two pods.

Figure 12 – Costa Crociere's control panel

The last photo above represents the control panel onboard the cruise ship considered. Also buttons to select the mode of operation can be seen there.

Figure 13 – Main deck bridge configuration onboard Venere

This console is used from the staff and the controls of the ACD (handle levers), which are showed in the next photo, are easy to be used.

Figure 14 – ACD main controls onboard Venere

Different situation is represented for wing controllers. The configuration is shown in the following two pictures: interviewed personnel of the ship said that these controllers (joysticks) are difficult to use and so they prefer not to use them in favour of the main central controls.

Figure 15 – Wing console onboard Venere

Figure 16 – Joystick on the wing console onboard Venere

As can be seen from the images reported above, the consoles and devices used to control the azimuthing systems differs from one ship from another depending on the manufacturer and the type of ship. There is a general lack of standardization which could lead to human errors or misunderstandings, especially when officers skip from one ship to another (familiarization process needed).
In general, the interviewed persons said that these aspects is not so dangerous as expected, if the officer has received a good training about these systems; to better understand we can compare this situation to when someone change his car: at the beginning driver has to familiarize with the new environment and tools, but the basic concept of driving is always the same.

7 Ad hoc modifications to bridge systems' interfaces

According to the persons listened and interviewed about the use and functionalities of the azimuthing systems and devices, it seems to be a very intuitive way of driving a ship. You have at your disposal a great power and an easy way to manoeuvre the ship, especially when you are in situations of restricted water or in emergency (crash stop). It's simple to use if you have attended an adequate training course and you have done a good practice onboard. The fact that these systems are different with the ship considered, seems not to be a problem to the operator.
Controls and interfaces are clear enough and provide to the operator of the ACD all necessary information to perform manoeuvres in a right way and without problems.
We expected to find on board some examples of modifications (labels, notes, checklists, etc.) made "ad-hoc" by the officers on the bridge to better explain the use of these systems and to make controls more user-friendly. In most of the cases we have not found what expected, as crew members assured that the bridge interface are sufficiently clear and gives you all needed information.

The case of the Italian gas tanker, Venere, represent an anomaly in this scenario: in fact, as we can see from the pictures included in the previous chapter, main deck controls are different from the wing controls and crew said us that the latter are difficult to use. To overcome this problem, and to allow the use of the main deck station while berthing, a CCTV system has been installed so that the operator can see a view of the ship's side approaching the jetty.
Pictures are reported below.

Figure 17 – CCTV system onboard Venere (1)

Figure 18 – CCTV system onboard Venere (2)

Figure 19 – CCTV monitors onboard Venere

Another innovative modification to the traditional way of driving a ship, and in particular for what concerns the use of azimuthing systems, is the use of a particular belt, for which at the moment, a pilot study has been done for tug captains.
The use of ACD requires, especially during manoeuvres, a great attention to the driver of the vessel. The belt, opportunely connected to a system with a software which has the supervision of the manoeuvre, could give the operator physical stimulation to inform him about the potential errors with a certain anticipation, so that he could be able to make right adjustments.
Some pictures of the system described above are reported here:

Figure 20 – The belt

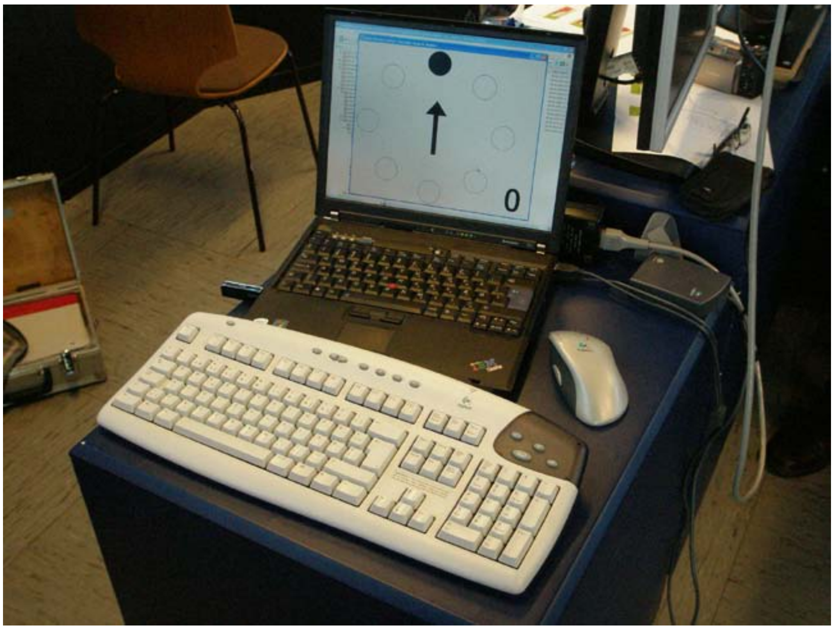

Figure 21 – Control system for the belt

Another interesting example of modification made to the Azimuthing Controllers is present on the ship Viscount, of the Faversham Ships Company. The ship is equipped with twin Shottles.
Onboard this ship, when the controllers are rotated in one direction, you can see that the Shottle unit turned the other way. The Captain of the ship explain this behaviour saying that he prefers this fitting, especially when sailing through a river passage and he turns the controller in the way he wants the ship to go. The Shipping Company also declared that this is an arrangement fitted on several ships of their fleet and that all Captains sailing on them are happy with this solution.
Following some pictures are reported of the particular fitting onboard the Viscount.

Figure 22 – Viscount configuration 1

Figure 23 – Viscount configuration 2

Figure 24 – Viscount configuration 3

8 Inputs for improvements

MSC 86/23/4 states that the identification of user needs should be "the first step in the implementation process" of the e-navigation implementation plan. It further states that a structured approach will be required to capture evolving user needs, making use of the existing agreed methodology, to incorporate ensuing changes into the strategy and implementation plan.
Eventually NAV 55/WP.5 developed the "Preliminary Detailed Shipboard User Needs and Priorities". NAV 55/WP.5 confirms that user needs are of paramount importance and the driving force for the e-navigation concept and that it is necessary to verify and update the user requirements as and when necessary during the implementation process of the Organization's e-navigation strategy.

The introduction of e-navigation will require standardization of technical components, standardization of information exchange and automation. New functions as well as procedures will need to be integrated with existing ones. Introduction of e-navigation will need to be accompanied by training. Obviously, what said for the e-navigation could be fairly addressed to the navigation in general.

The following table presents some of the topics contained in the NAV55/WP.5 Annex 1 "Preliminary Shipboard user needs and priorities".

Table 5 – NAV55/4 Annex 1 *"Preliminary shipboard user needs and priorities"*

User Need	Justification	Relation to IMO Strategy (Section 8.2)	Priority in terms of work required	Issues to Consider
Human Machine Interface Issues				
Improved Ergonomics Mariners have expressed a desire for bridge layouts, equipment and systems to be better designed from an ergonomic and user friendly perspective.	Many bridges have been designed without much thought given to the effective layout of equipment or workstations. Mariners have expressed that in an e-navigation era, work stations, navigation displays, communication devices, and other bridge equipment must be designed to improve effective bridge operation. Such layouts should take into account expanded bridge teams and the pilot.	• Human Machine Interface • Human Centred presentation needs	Harmonize and apply existing documentation Take note of: IMO documents: • MSC.252(83) (INS) • MSC/Circ.982 (Ergonomic Criteria for Bridge Equipment and Layout) • NAV 55/4, annex 1 (Bridge Equipment, System Arrangements and Integration) • MSC.191(79) (Pres. Of Nav-Related Info on NavDisplays) Other industry standards.	It should be noted that much work has been done in this area, however not widely applied. Consideration of more prescriptive bridge layout requirements. Consideration of more prescriptive work station requirements. Better application of centralized and effective dimming of screens. Innovations and new technology solutions, should concentrate on the needs and capabilities of the users. Promotion of access to information at one place where appropriate (multi-functional workplaces).
Standard interface Mariners expressed a desire for greater standardization of functionality for navigation displays (human/machine interface	Navigation system functions, operations and presentation (including ECDIS, Radar, AIS, GPS, GMDSS, etc.) can vary widely between manufacturers and even between models by a single manufacturer. The differences include where certain information is displayed (i.e. speed and course), how it is displayed, menu functions and interface devices such as knobs or joysticks. This makes type specific training difficult, and leads to ineffective use of features particularly by those watch-keepers who are new to a vessel.	• Human Centred presentation needs • Human Machine interface • Analysis	Research should be conducted regarding the functionality of standard interfaces. Take note of: IMO documents MSC.191(79) (Pres. Of Nav-related info on NavDisplays) MSC.252(83) (INS) NAV 55/4, annex 1 (Bridge Equipment, System Arrangements and Integration) Other industry standards.	Design specification for current equipment. Note should be made of concept of S-Mode as proposed at NAV54 (NAV54/13/1) Needs to update and establish balance between standardization and innovation.
Familiarization requirement mariners need all safety-related equipment to be provided with familiarization material specific to the model and installation.	Mariners often join ships where non-standard equipment and functions exist. It was thought that if these pieces of equipment or systems could be provided with familiarization material or tutorials safety would improve.	• Human Machine interface • Analysis • Impelementation issues	Identify where familiarization material specification needs to be developed for existing and developing performance standards. Take note of: IMO document (SN.1/Circ.274) Guidelines for application of the modular concept to performance standards.	Consideration should be given to requiring such familiarization material to be provided by the manufacturer. Consider example using INS Performance Standards (MSC.252(83))
Alert management Bridge alerts (emergency alarms, alarms, warnings and cautions) must be coordinated, weighted, and support decision making without undue distraction.	It isi uncommon for the bridge of a ship to have in excess of 500 alarms pertaining to navigation, propulsion, cargo, and communication systems. These alarms are usually uncoordinated, physically located all over the bridge, and give little indication of severity without interrogation, which distracts the navigator. As systems become increasingly complex, all bridge alarms must be coordinated to avoid undue distraction.	• Human Centered Presentation needs • Data and Systems Integrity • Analysis	Investigate possibility to apply existing IMO regulations on INS alert management and bridge alert management. Take note of: IMO documents MSC.252(83) (INS) NAV55/4, annex2 (BAM) DE52/4/2 (Code on Alerts and Indicators)	

On the strength of the information presented in the table above and of the replies received from the persons interviewed, there could be suggested modification to the actual systems available on board, with regard of the ACD, which could allow a better familiarization and usability of the devices and give the operator a better understanding of the actual situation. Some of these inputs are listed below:

- The control handles of the ship should be turned slowly, as the pods will not move as fast as the handles can be turned (a lot of operators turn the handles quickly, thinking that this is having an effect). Hardware (control handles) should be configured so that they can only be turned at the same rate as the pods can be moved;
- The consoles could be equipped with an alarm system (visual or acoustic) so that the operator could be supported during manoeuvres, being continuously aware of the situation and warned in time if something is going bad;
- There should be an agreement among all manufacturers of ACDs in a view to standardize their equipments in terms of tools available, labels, wording used, etc. In that way, operators could be familiar to the systems whatever ship they sail and risks of errors connected to misunderstanding could drastically be reduced.

Above all, the main way to improve the usability of these systems is the training. All interviewees, in fact, have stressed the importance of attending a good training course for azimuthing systems, as they consider that, apart from the configuration onboard and the available tools, the primary objective for the operators should be to gain a different "forma mentis" required to effectively use this technology.