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Developing User Needs for S-Mode

Jacobson, E
Lützhöft, M
Department of Shipping and Marine Technology, Chalmers University of Technology,
SE-412 96 Göteborg, Sweden
E-mail: eva.jacobson@chalmers.se margareta.lutzhoft@chalmers.se

Introduction

Recent rising accident costs published by IUMI indicate that not only are shipping accidents rising, but it may be due to advanced technology as well as the oft-quoted human element [1]. This issue has been highlighted by the Nautical Institute for some time. The NI has during conferences and other meetings with end-users of bridge instruments found that the interaction with new technology is getting too complex. This is often due to varying designs of different manufacturers, and research shows that seafarers have to work hard to get full use of the instruments [2]. Modern ships are equipped with complex and sophisticated technical systems that often are integrated with one another. Studies have shown that the use of some of these systems may have a negative effect on the operator's behaviour as well as a lack of understanding of potential risks in their use [2, 3].

Limited education in system handling and system safety is another issue which is getting difficult for institutions to handle. In most maritime academies there is only one manufacturers' brand available, and this is the one that is used for training. Since different brands look and act differently, the education is always underspecified. The lack of a complete understanding of these complex integrated systems, what Woods calls "buggy knowledge" [4], has been a factor in several accidents. The introduction of a "standard mode" could simplify both the use of complex systems as well as the education of such systems.

Since the instrumentation and configuration of information differs between ship bridges, errors in understanding the presented information could occur for both officers and pilots. There is also the possibility that the officers, especially those who have recently joined a ship, or pilots who "join" new ships frequently, may not be able to handle situations that require take-over on short notice. Recent examples include the Cosco Busan and the Prospero accidents. Compared to airplanes, commercial, private and military, one seldom finds those problems in the airplane cockpit because avionic instruments and equipment are standardised. A pilot can move between different types of airplanes and will find that basic information is the same.

In order to address these issues, the concept of S-mode as a default setting for navigation displays has been proposed under the agenda of the IMO e-Navigation project. The S-mode concept, as discussed in Seaways [5], aims at increasing safety, by minimizing error in handling and at reducing "clutter" on displays. It is meant to be easy to learn, and as learning progresses, more layers or controls can be added. This paper reports the first steps towards collecting user needs for S-mode.

Purpose

The purpose of this study is to take first steps toward creating a simple but efficient methodology for systematically capturing user needs of information for a standardised navigation display, S-mode. Naturally, we will need to consult a much larger user group and use an international approach to define the user needs for S-Mode.

Method

The study started with a number of expert meetings, of which the goal was to decide which method to use when performing the study. The method was to be simple enough to use for a mariner after a brief instruction, oral or written, and at the same time powerful enough to yield a useful result. A decision was made to start with a methodology that would combine the use of a question form, interviews and workshops. A question form was prepared and was based on radar information. The decision to use radar as the first research object was because the radar still is the most used equipment onboard and the seafarers are familiar with the functions and commonly have opinions about the radar. Thus, this study

aimed to identify a beginning of defining S-mode for radar.
In the first step a list of all available radar information and controls/buttons was made. The next step was to identify suitable scenarios to be used to describe S-mode to the participants, without being too leading. Three scenarios were identified and constituted the introductory part (page 1) of the question form:

"Case 1: You are awakened in the middle of the night by the OOW and you go to the bridge. The ship is in highly trafficked waters and the OOW has called you to get assistance with the traffic situation. To get a quick overview of the situation you press S-mode.

Case 2: You arrive on a new ship as OOW. The instruments are of a make that you are not familiar with. You are asked to take the watch almost immediately. There is very little time for a hand-over/briefing. In order to get a learning period with less functions and/or easier handling you press S-mode.

Case 3: You are a pilot. Every day you go onboard 3-4 ships, of which some are completely new to you. All bridges have different instruments and configuration. To navigate safely you press S-mode."

The questions based on the scenarios were in the following categories:

- What does the radar look like when you press S-mode
  - Radar presentation
  - Overlay/underlay in place
- Available controls/buttons
- Other available information
- Available menus, other comments

The questions (shown in table 1) constituted page 2 and 3 of the question form.

Procedure
The question form has been distributed to groups of seafarers in for example conferences or courses. They have been asked to fill in the form after having received some brief information about the project and the concept of S-mode. It is therefore difficult to estimate the ratio between number of forms distributed and forms received, as one would do in for instance a questionnaire study.

The participants were informed about the study and a questionnaire was given by hand. After the participants had answered the questionnaires those were collected and evaluated. About half-way (after xx participants) a preliminary analysis was performed of the data collected. The question form was found to work quite well, and a minor revision was made before proceeding with the study and adding further participants. To date, we have collected forms from 54 seafarers, merchant and navy officers.

The development of S-Mode as proposed within the IMO e-Navigation project is only intended for Merchant vessels, and the use of naval officers to give input is due to their experience as professional navigators.

Results
17 officers from Sweden, 7 officers from other European countries, 23 officers from the Swedish navy, and 7 master mariner students from Chalmers participated in the first phase of the study. The participants were informed about the study and a question form was given by hand. After the participants had answered the question forms they were collected (some were sent back later by mail) and analysed.

Radar presentation
The result is presented in numbers of answers from participants. We made a separation between the answers from the navy and the merchant seafarers to see if there were any remarkable differences in the answers. All participants have not filled in answers on all the questions.

Radar presentation	***All (merchant/navy)***	***All (merchant/navy)***	**n=**
	Yes	**No**	
Range 6	41 (24/17)	5 (1/4)	46
Range 12	5 (4/1)	23 (12/11)	28
Other	11 (3/8)	10 (7/3)	21
North up	48 (28/20)	7 (3/2)	55
Head up	4 (2/2)	29 (16/13)	33
Course up	4 (3/1)	28 (15/13)	32
Variable range marker	36 (21/15)	13 (9/4)	49
Electronic bearing line	36 (21/15)	11 (7/4)	47
Cursor	37 (21/16)	4 (2/2)	41
ARPA plot stays/becomes available	46 (25/21)	1 (1/0)	47

Radar presentation	**All (merchant/navy)**	**All (merchant/navy)**	**n=**
Vectors relative	10 (3/7)	26 (16/10)	36
Vectors true	35 (21/14)	7 (5/2)	42
Nav lines (manually placed)	8 (5/3)	31 (17/14)	39
Programmed route (lines)	34 (20/14)	15 (7/8)	49
Predictor (own course/speed) no. of minutes	24 (12/12)	20 (14/6)	44
Own vector length minutes	45 (28/17)	4 (1/3)	49
Target vector length minutes	40 (25/15)	4 (1/3)	44
	Low	**Medium**[1]	
Autoclutter rain	37 (17/20)	8 (7/1)	45
Autoclutter sea	32 (15/17)	13 (9/4)	45
Overlay/underlay in place	**Yes**	**No**	
Map/ENC/ECDIS (what info)	30 (18/12)	15 (9/6)	45
AIS	43 (27/16)	10 (4/6)	53
Other	1 (1/0)	9 (4/5)	10
Colours/dimming	17 (11/6)	6 (3/3)	23
Day settings	15 (12/3)	19 (11/8)	34
Night settings	12 (6/6)	18 (12/6)	30
Twilight settings	20 (15/5)	10 (5/5)	30
Other	3 (1/2)	9 (4/5)	12
	Hardware	**Software/ menu**	
Variable HU/NU/CU?	23 (18/5)	22 (11/11)	45
VRM	48 (28/20)	4 (4/0)	52
EBL	47 (28/19)	4 (4/0)	51
Cursor	34 (19/15)	15 (11/4)	49
Gain	44 (26/18)	7 (5/2)	51
Clutter sea manual	42 (25/17)	9 (6/3)	51
Clutter rain manual	42 (25/17)	9 (6/3)	51
Clutter sea auto	17 (11/6)	27 (17/10)	44
Clutter rain auto	17 (11/6)	27 (17/10)	44
Vector length	18 (13/5)	31 (18/13)	49
Vector mode (rel/true)	30 (18/12)	18 (12/6)	48
Nav lines	9 (7/2)	38 (22/16)	47
	Yes	**No**	
Lat/long	44 (26/18)	3 (0/3)	47
Time	35 (20/15)	9 (5/4)	44
Speed	47 (27/20)	1 (0/1)	48
Course	46 (26/20)	1 (0/1)	47
Drift	35 (23/12)	7 (3/4)	42
Autopilot settings	23 (17/6)	20 (10/10)	43
Next course	26 (15/11)	20 (11/9)	46
Next pos/waypoint	22 (14/8)	20 (11/9)	42
ETA wp	23 (16/7)	19 (9/10)	42
ETA final	16 (13/3)	26 (12/14)	42
CPA	42 (24/18)	4 (2/2)	46
TCPA	42 (24/18)	4 (2/2)	46
Other	7 (6/1)	2 (2/0)	9

Table 1. The question form with number of persons answering inserted

Radar presentation	***All (merchant/navy)***	***All (merchant/navy)***	***n=***
	Yes	**No**	
True motion	9 (9/0)	4 (4/0)	13
Relative motion	6 (6/0)	5 (5/0)	11

Table 2. Additional questions in version two of the form, number of persons answering

[1] There was also the option "high" but no participants chose it.

The question form was updated with two additional radar presentations (see table 2), which had escaped notice in the first version. 14 participants have answered this version of the question form.

Results from the survey are as follows; the majority of the participants wanted the range to be 6 nm as default, although some of them have made a comment that it depends on if you are in the archipelago, by the coast or in open water. North up is chosen by 87% of the participants. The participants also chose a variable range marker, an electronic bearing line and a cursor as default. ARPA plot should stay or become available and vectors should be true. There should be a programmed route and all manually placed navigation lines should be removed in S-mode. The predictor based on own course and speed yielded two almost identical groups – half want it, half do not. When studying the number of minutes wished for in detail, the picture is even more muddled: 1,5 to 12 minutes, whereof 5 participants chose 6 minutes. Own vector length together with target vector length should also be shown; 6 minutes was chosen by the majority but also 3 minutes and 12 minutes was chosen by some of the participants. Autoclutter rain and sea should be low.

Overlay/underlay in place should include map, ENC, ECDIS and AIS. Regarding the dimming possibility the opinion differs. Of those who answered the question colours/dimming should be possible and there should be twilight settings too. If day settings should be default or not is rather equal, but there is a difference between the navy and the merchant seafarers – 75% of the merchant seafarers want day settings whereas 25% of the naval want it. Twilight settings should also be default and also in this case there is a majority of the merchant seafarers, 72%, that want it as default. Among those who not answered yes or no on this question the comment is that all dimming settings should be done automatically and be depending of the surrounding light and probably done by light sensors.

Variable HU/NU/CU are chosen equally as hardware and software, there is one difference, of those 23 participants who chosen hardware 18 was merchant seafarers and 5 naval. Available controls/buttons chosen as hardware was VRM, EBL, cursor, gain, clutter sea manual and rain manual and vector mode (relative/true). Clutter sea auto, rain auto, vector length and navigation lines should be in software or as a menu choice.

Other available information in S-mode should be latitude/longitude, time, speed, course, drift, CPA and TCPA. There should be no information of ETA final in S-mode. There are very small differences on whether autopilot settings, next course, next position/waypoint, ETA waypoint should be presented or not on the display.

14 participants answered the revised version of the form with the additional two points; if there should be a presentation of true motion and relative motion in S-mode. Of those the majority chose true motion as default but the difference to those choosing relative motion is not large.

Method discussion

The first step of the collection has worked well. In order to get good quality data, we see that it is indeed important to be available to present the idea behind the concept. The short scenarios worked reasonably well, whereas an alternative would be to write a longer description and send the form out as a questionnaire. However, questionnaire return rates found in various maritime studies are not encouraging. We judge that the data will be better and possibilities to discuss with seafarers more important than sending out a questionnaire to an uncontrolled number of unknown seafarers and get a dismal return rate.

Since the format was still very much like a questionnaire, there is the possibility that participants could misinterpret questions, and the corresponding difficulty in interpreting their answers. For instance in the question about autoclutter rain and sea there was the possibility to choose between low, medium and high. We made a mistake in the formulation of that question because it could be interpreted as autoclutter should be low as default, when of course autoclutter is automatic. Since most participants chose “low” we think they may have read *autoclutter* to mean *clutter*, but we cannot be sure.

The majority of the participants chose true motion as default mode but there were many who wanted relative motion to be default and also some who chose both relative end true motion – which again points out a deficiency in the method to be corrected in future studies.

Conclusions and future work

Gratifyingly, many of the results are quite clear and could probably be used as design

guidelines. Others need more probing to reach a conclusion and should be discussed in expert groups, including seafarers, maritime academy teachers and representatives of manufacturers.

In this study we did not see major differences between the data collected from merchant shipping and from the navy, although there are some small variations in a few areas. This might be caused by education and the design of navigation tools in the Swedish navy, and the fact that the navy sails more often in the archipelago and because of that they need to read radar data that have a closer range.

More data must be collected since to date we have 54 persons participating in the study. It will also be necessary to include seafarers from other cultures to make sure that there are no cultural differences in understanding the purpose of S-mode.

We anticipate moving forward with an IT tool of some type in order to collect data from many seafarers in cooperation with the Nautical Institute, to for example reach academies around the world. The study should also be expanded to encompass the other tools on the bridge, such as ECDIS. It may even be the case that some engine control room equipment may be due for an S-mode.

This approach is decidedly a bottom-up approach in two respects. We are collecting data from seafarers directly and data regarding minute design details on separate pieces of equipment. To gain a complete picture of what S-mode can be we also need a top-down approach in which we study what the work on the bridge is today and may be expected to be in the future.

Such a study would provide us with a systems view – a total picture – of the task being performed on the bridge today and tomorrow as well as identify the decisions the equipment in our ship control centres needs to support.

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