

Research Study and the Model for Improving the Safety of Navigation when Using the AIS

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ABSTRACT: The use of the Automatic Identification System (AIS) devices for ensuring the safety of navigation and the errors occurring when using AIS equipment have been the focus of a number of research studies. The users of AIS equipment installed onboard sea-going vessels are required to familiar with the proper use of the devices and potential errors that may occur. A significant problem revealed in this study is the lack of understanding of potential error sources and the necessity to eliminate such errors prior to transmission of the AIS data message reading of the errors and failure to update the data processed by the AIS system. This results in a hypothesis on the insufficient training of seafarers and their familiarisation with the AIS devices and errors. This research is aimed at increasing the safety of navigation in the Adriatic Sea, as well as other seas, i.e. better accident prevention and protection of human life and material property at sea. The results produced by the research are used as an input for creating a model for enhancing the safety of navigation when using the AIS, through additional training of the seafarers.

1 INTRODUCTION

The Automatic Identification System (AIS) has been discussed in a number of studies as it represents an aid that significantly contributes to the safety of navigation [6, 9, 10, 13–15]. Some of these studies focus on the errors that occur when using the AIS system [2, 3, 7, 8]. The users of on-board AIS devices should be familiarised with the proper use of the equipment and the errors that may be made when using it. The problem of insufficient AIS familiarisation may also arise from the failure of updating the data that the system processes. This leads to a hypothesis on the insufficient training of seafarers and their familiarisation with the AIS devices and their errors. This research is aimed at increasing the safety of navigation in the Adriatic and other seas, and thereby, better accident prevention and protection of human life and material property at

sea. The research involved a survey carried out on various vessels operated by Jadrolinija shipping company and in coast stations, including a number of seafarers and shore-based staff over a period of one month. The questionnaires were delivered to the crew members trained for using AIS devices. The results produced by the survey are presented in tables and diagrams. They have been evaluated and compared to the expected outcomes through the comparative analysis. The results produced by the survey will be used for creating a model for improving the use of the AIS system.

2 ERRORS IN USING THE AIS EQUIPMENT

The errors occurring in using the Automatic Identification System (AIS) equipment can be divided

into two categories: technical and human errors [3]. Technical errors refer to the loss of signal, offset of the ship's position, incompliance of the targets displayed on AIS, ECDIS or radar. Due to these drawbacks, the AIS receiver is not allowed to be used as the principal aid to navigation. Human errors mainly refer to the inappropriate use of the devices, e.g. failing to enter important data about the status of the vessel (whether it is under way, moored or at anchor), or failing to enter the updates on dangerous cargo, estimated time of arrival (ETA) or estimated time of departure (ETD). The system and errors can be shown through the model in Figure 1.

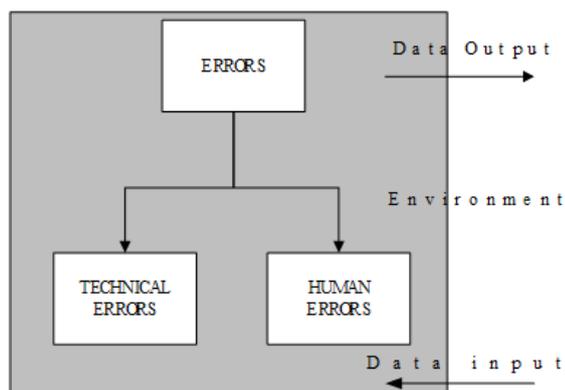


Figure 1. General model of errors in the AIS system [3]

3 METHODOLOGY OF COLLECTING INFORMATION

This research uses the survey in the form of questionnaires, which is a common tool in numerous studies [1, 4, 5, 11, 12]. The questionnaires provide information, opinions and views on the issue. Compared to other tools of collecting information (observation, interviews, assessment, testing and analysis of technical documentation), the survey has the following advantages:

- provides insights into the experience,
- provides information on the past, present and future, and
- represents an economical tool.

3.1 Comparative analysis of information

A comparative analysis of the responses obtained through the questionnaires has been performed. The following responses have been analysed:

- how many types of AIS devices are the seafarers familiar with, with regard to their rank and age, and
- familiarisation with the AIS equipment errors, with regard to their rank and age.

The first question provided an insight into the types of AIS devices that the seafarers are familiar with. The accuracy of the responses were analysed, with reference to the rank of the seafarer. The second question provided an insight into the familiarisation of seafarers with the errors in the AIS devices. The accuracy of the responses were analysed, with

reference to the rank of the seafarer. The comparative analysis has been used to present the obtained results in tables (Tables 1 – 3).

Table 1. Total number of respondents and their rank and age distribution

Respondents and their age	20-40	40-55	55 and older
Master	4	11	4
1 st Mate	5	4	1
Officer in charge of a navigational watch	7	2	0

Table 2. Number of correct responses for types of AIS devices by the age and rank

Respondents and their age	20-40	40-55	55 and older
Master	2	10	1
1 st Mate	4	3	0
Officer in charge of a navigational watch	4	1	0

Table 3. Number of correct responses for familiarisation with AIS errors by the age and rank

Respondents and their age	20-40	40-55	55 and older
Master	2	5	0
1 st Mate	3	2	0
Officer in charge of a navigational watch	1	1	0

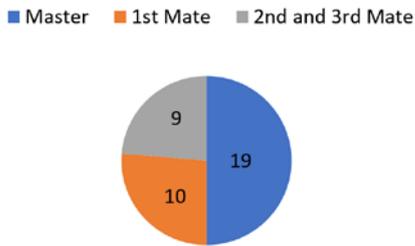
3.2 Selection of the gathered data

The selection of the gathered information is considered an important part of the research work. All relevant data must be systematically categorised, with regard to their quality. The information that is irrelevant for the study has to be excluded. Without a quality selection, the gathered data cannot produce results that are relevant and useful for the research. The selection of the gathered data can be, in this case, observed through three stages:

- data processing,
- establishing the validity, and
- interpretation of the validity (bringing into relationship with the ideas that drive the research).

The survey involved 38 respondents and was aimed at establishing the level of their competency in using the Automatic Identification System (AIS) devices. Based on the research results, the goal was to establish the elements that are essential for shaping a standardised training course in using AIS equipment and to analyse the discrepancies of the produced results. The surveyed population mainly consisted of the masters (50% respondents) and senior and junior deck officers serving on board vessels of Jadrolinija shipping company (the remaining 50% respondents).

Number of surveyed seafarers



Graph 1. Number of seafaring respondents by rank

After the survey was performed on vessels of various size and fitted with various equipment, the data gathered by questionnaires were subjected to the selection procedure. The questions referred to (Annex 1):

- age of respondents,
- qualification,
- rank on board,
- number of types of AIS devices the respondent is familiar with,
- familiarisation with AIS device functioning,
- familiarisation with the AIS system errors,
- incidence of testing AIS devices,
- timely updating information on the voyage,
- incidence of failing to update information,
- detecting the insufficiency of data from other vessels (speed, distance from the ship, course, position, and the like),
- use of the AIS as an aid to navigation, aimed at preventing collision at sea, along with other aids to navigation,
- information about stations for testing AIS devices,
- recognising the AIS acronym.

The selection of the gathered information was performed with regard to the AIS acronym for the purpose of recognising and interpreting the basic AIS features.

The data were selected with reference to the age, education and rank of the respondents. This form of selection was necessary as it is assumed that younger and better trained crew members provide accurate answers to a relatively larger extent.

On the other hand, the survey results are expected to be poorer than the results that might be gathered on the deep-sea vessels. Namely, the officers engaged on international voyages use the AIS system more often than the officers engaged in domestic trade, for the purpose of observing other vessels, and their familiarisation with the AIS system is more often controlled by the Port State Controls (PSC) and other authorised entities, such as the United States Coast Guard (USCG).

3.3 Validation of data

It was suggested that, after the selection of the above-mentioned information, the validation of the information was carried out. The validation took into consideration the data that were essential in the operation of the Automatic Identification System (AIS) devices and in showing to what degree the crew

members in charge of using the AIS were trained for using the available equipment.

The validation was carried out through checking the familiarisation with the AIS equipment and with implementing the basic procedures (five basic procedures) when using the AIS:

- testing the AIS devices with shore-based stations,
- testing the AIS devices with nearby vessels,
- entering necessary parameters before and during putting out to sea,
- recognising the errors of the very device, and
- level of knowledge in using the very device.

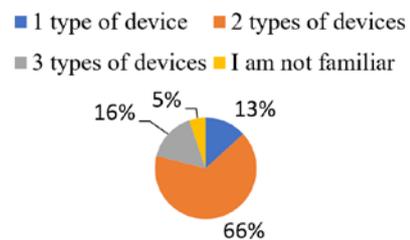
3.4 Presentation of the processed data

During the survey, each question obtained various responses. They are presented in the graphs below. The responses refer to the vital part of the survey, which can be viewed from the standpoint of the safety of navigation, i.e. the set of rules and regulations ensuring a safe navigation. The following function of the safety of maritime navigation when using AIS equipment is suggested:

$$f(S) = (T, W, E, D) \quad (1)$$

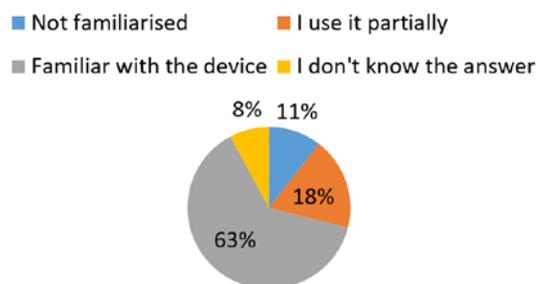
The above function can serve as a base for suggesting a technically acceptable definition of the safety of navigation (S) as a process consisting of the following elements: T – familiarisation with the AIS devices, W – operation of AIS devices, E – errors of AIS devices, and D – drawbacks of AIS equipment.

Familiarisation with types of AIS devices



Graph 2. Familiarisation with the types of AIS devices (T)

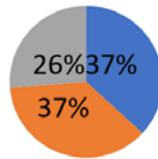
Familiarisation with AIS functioning



Graph 3. Familiarisation with the operation of AIS equipment (R)

Familiarisation with AIS errors

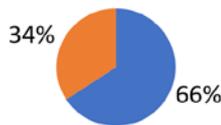
■ YES ■ NO ■ PARTIALLY



Graph 4. Familiarisation with errors in AIS equipment (E)

Familiarisation with the equipment drawbacks

■ YES ■ NO



Graph 5. Recognising the drawbacks of the AIS equipment (D)

The above graphs, and the processed data they show, refer to the relevant parts of the survey, including:

- familiarisation with the types of AIS devices,

- familiarisation with the operation of AIS devices,
- familiarisation with the errors of AIS devices, and
- familiarisation with the drawbacks of AIS equipment.

4 MODEL FOR IMPROVING THE SAFETY OF NAVIGATION WHEN USING THE AIS

In the comparative analysis of two questions, Table 3 shows a relatively high rate of incorrect answers compared to Table 2. This results in concluding that the issue of familiarisation with the types of errors in the AIS system is far more complex and less familiar than the issue of familiarisation with the types of the AIS devices. Considering the results produced by the comparative analysis, it can be concluded that it is necessary to introduce additional measures in terms of seafarers' training, in order to familiarise them better with the AIS errors and, consequently, bring the safety of navigation to a higher level. A thorough analysis of error types and their definition by risk degree is suggested. A model for improving the training of seafarers aimed at raising the safety of navigation level is suggested (Figure 2). The new and enhanced model represents an upgrade of the previously developed training models [3].

The above presented model indicates that the AIS standard comprises two classes:

- Class A, and
- Class B.

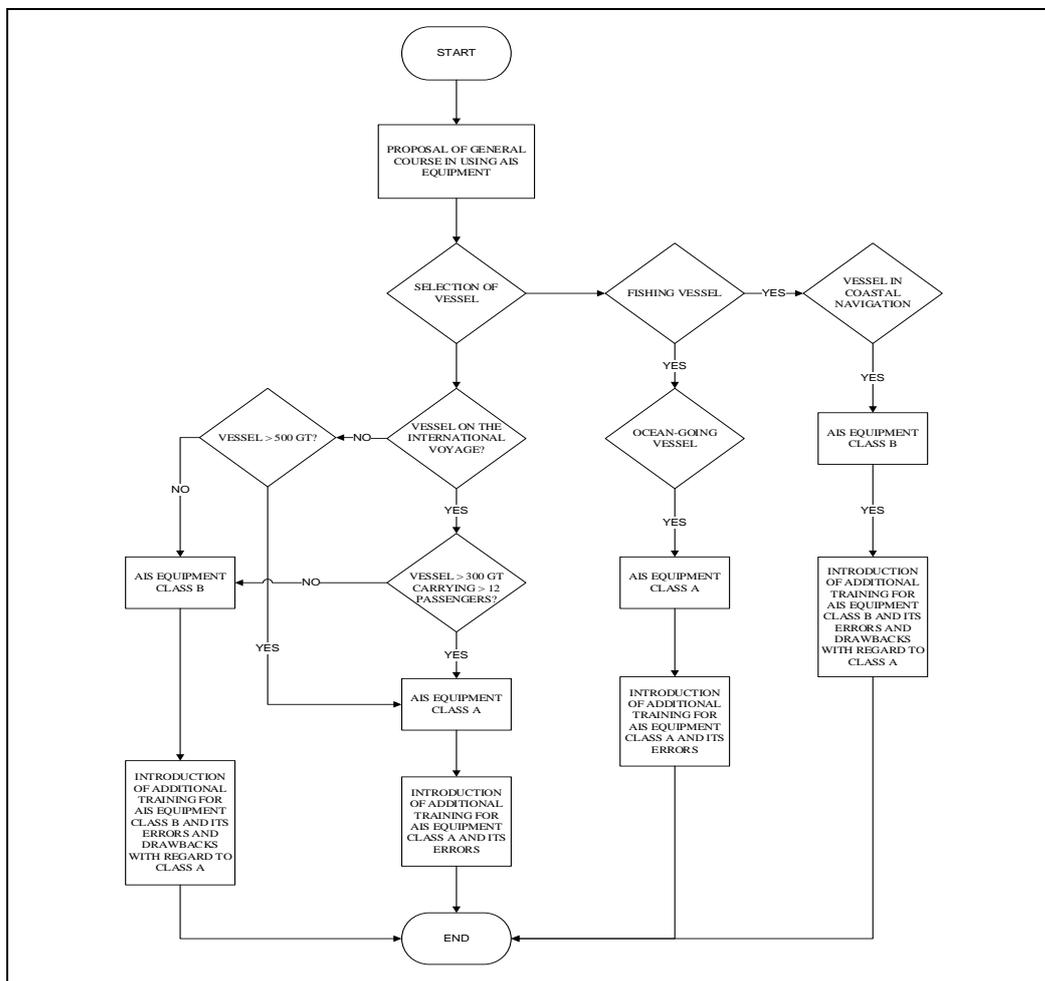


Figure 2. General model for improving the seafarers' training and familiarisation with AIS equipment

Class A is mandated for all vessels of 300 GT and above engaged on international voyages, cargo vessels of 500 GT and above not engaged on international voyages, as well as for all passenger vessels (carrying more than 12 passengers) regardless of their size. It is estimated that, these days, around 40,000 vessels use Class A equipment, while Class B has been in place since 2007. Class B allows a new generation of AIS devices that are more affordable, but have a limited range and features. Class B equipment is typically installed on smaller vessels such as fishing and recreational boats. The survey results and the empirical experience suggest that a large number of seafarers do not use AIS equipment to the full, with all the available features and possibilities. Furthermore, the model involves fishing vessels (most of them use Class B devices, while large ocean-going fishing vessels may also carry Class A equipment). Speaking empirically, fishing vessels do not update the system and it often occurs that a fishing vessel appears on the screen as a target that does not move, the so-called sleeping target. Another problem is the inability of such vessels to timely detect large merchant ships as targets, especially in poor visibility. Therefore, the additional training is suggested as presented in the model (Figure 2).

5 CONCLUSION

The Automatic Identification System (AIS) equipment in coastal navigation is still in the stage of development and implementation. Some of the vessels still fail to use the AIS features to the full, mainly due to insufficient training of the crew. This was one of the essential reasons for conducting a survey on the use of the AIS system and the familiarisation with AIS devices and their drawbacks among the ship masters and mates on the Jadrolinija company vessels. The results of the questionnaires indicate that most of the officers in charge have elementary knowledge that allows them to use basic features of the AIS equipment. However, somewhat harder questions provide a more detailed insight into the training and familiarisation, which are insufficient. Therefore, a general model for improving the safety of navigation when using the AIS is suggested, involving additional training of seafarers. It will be possible to further update and adjust the model, depending on the future research and the results produced.

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Supplement

QUESTIONNAIRE (Annex 1)

This survey is anonymous and is designed to study the use of AIS devices in coastal navigation

Place _____

Date _____

Note: circle only one answer

1. Age
 - a) from 20 to 40
 - b) 40 to 55
 - c) 55 and older
2. Education
 - a) high school

- b) undergraduate study (2-year, 3-year or 4-year)
3. Rank on board (deck department):
- master
 - 1st mate
 - Officer in charge of a navigational watch
4. How many types of AIS devices do you know?
- 1
 - 2
 - 3
 - I don't know
5. Are you familiar with the AIS equipment?
- I am not familiar with the equipment
 - I use the equipment partially
 - I am familiar with the equipment very well
6. Are you familiar with the drawbacks / errors of the equipment?
- yes
 - no
 - partially
7. How often do you test the device?
- Once a week
 - Once a day
 - Once a month
 - I don't test the device
 - When I can
8. Does it happen that you don't manage to timely update the device when sailing?
- YES NO
9. If the response to Q8 is yes, how often does it happen?
- On almost every voyage
 - Once a day
 - Once in 3 days
 - Rarely
10. Do you notice that the information you receive from other vessels is insufficient (e.g. missing course, speed, position and the like)
- YES NO
11. Do you use the AIS as an additional aid to navigation, along with other sources (e.g. for detecting speed of another vessel, distance from other vessels, their courses, etc.)
- YES NO
12. State the stations you can test the device with.
13. What does AIS stand for?