

# ALGORITHM FOR ANALYZING THE AUTOMATIC IDENTIFICATION SYSTEM DATA TO IDENTIFY TYPICAL SCENARIOS FOR VESSEL DIVERGENCE AND TESTING THE SYSTEMS OF AUTONOMOUS SHIPPING

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The problem of analyzing data from the automatic identification system (AIS) in order to highlight typical situations where vessels meet at sea and identify the actions of navigators to diverge in these situations is discussed in the paper. This problem has become relevant recently due to the need to have a base of reference actions for testing the systems of autonomous shipping (SAS), the interest in the development of which has recently only increased in connection with the creation of maritime autonomous surface ships (MASS). The AIS data analysis algorithm consists of preliminary stage of data filtering and two main stages. At the preliminary stage, data containing errors that significantly complicate subsequent analysis and are associated with incorrect information are excluded. It has been revealed that such data can constitute up to 10% of the total information. Further, at the first stage of filtering, the vessels whose navigation status does not imply movement or their speed is less than 3 knots are eliminated. At the first stage of filtering, the number of records on navigation status per day reduces from 1.5-2 million to 0.4-0.5 million. The second stage of filtering is the analysis of typical interaction of vessels

under the crew control in various conditions and situations. The task of this filtering stage is to select groups of vessels according to the following criteria: timestamp and location of the vessel; the latter must correspond to a given range for the estimated distance between vessels, which is selected from a number of pre-determined options. Thus, as a result of filtering, three typical scenarios are selected. The first scenario is vessels movement on parallel courses without and with interaction. The second scenario is vessels movement on reciprocal courses without and with interaction. The third scenario is vessels movement on crossing courses without and with interaction. During the analysis of typical scenarios and to develop an approach for testing the SAS of MASS using archival AIS data, nine typical situations of vessels interaction during a dangerous convergence are considered and described. The approach to testing SAS IANS proposed in this work includes assessment of time it takes to complete a given route, deviation from the route and speed mode, comparison of completed maneuvers and the MASS interaction with other vessels.

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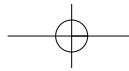
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**Introduction**

Navigation safety is a key issue in global shipping. This issue is especially acute when designing and creating unmanned vessels. An important component of this issue is the problem of safe divergence of vessels at sea. To solve it, first of all, it is necessary to analyze situations of dangerous convergence of vessels in a real navigation situation. This will allow you to highlight the maneuvers that navigators undertake to avoid collision in various navigation situations. To analyze such situations, it is necessary, first of all, to obtain a sufficiently large amount of data. One of the sources of information about situations of possible collisions can be an automatic identification system (hereinafter referred to as AIS). Analyzing this information can allow researchers to identify situations of dangerous convergence and actions to diverge in these situations.

The AIS, used in shipping, is designed to identify vessels, their location, movement parameters and other data using radio communication protocols [1,2,3] in the VHF band (161.975 MHz and 162.025 MHz). In accordance with the SOLAS 74/88 Convention, the AIS is mandatory for vessels of over 300 m<sup>3</sup> gross tonnage engaged in international voyages, vessels of 500 m<sup>3</sup> gross tonnage or more (not engaged in international voyages) and all passenger vessels. Smaller displacement vessels and yachts may be equipped with a Class B AIS receiver. The AIS system is used to identify other vessels, avoid possible collisions, and also as input data for vessel tracking management systems (hereinafter referred to as VTMS)

With the advent of autonomous surface vessels, ensuring the navigation safety of maritime autonomous surface ships (hereinafter referred to as MASS) has become an urgent task. The concept of the autonomous shipping functioning involves the implementation of two main segments - autonomous vessels and remote control centers for these vessels, which are usually located on the shore [4]. Their cumulative operation is ensured by specially developed software and hardware, which in this work are called systems of autonomous shipping (hereinafter referred to as SAS). The desire to improve navigation safety has led to the development of several theoretical and practical approaches to achieve higher level of safety and efficiency in maritime navigation using AIS data. Despite the wide range of research methods in this area [5-10], few studies examine real-world AIS data in a generalizable context [5-7] and a small number of studies bases their analysis on well-defined parameters [8-10].

In this paper, it is proposed to use AIS data to analyze the vessels movement under a crew control, in order to compare possible options when operating vessel by the SAS. The objectives of the work are to develop an algorithm for processing and filtering data from AIS, as well as to develop an approach for testing SAS of MASS using archived AIS data.

**Methods and materials**

The set of data transmitted via AIS channels and the structure of their messages is standardized and described in detail in [1,2,3], and therefore is not presented in this work. AIS messages have two types - metadata about the vessel and data about its movement. In general, from AIS messages we will select only the necessary information for subsequent analysis, namely:

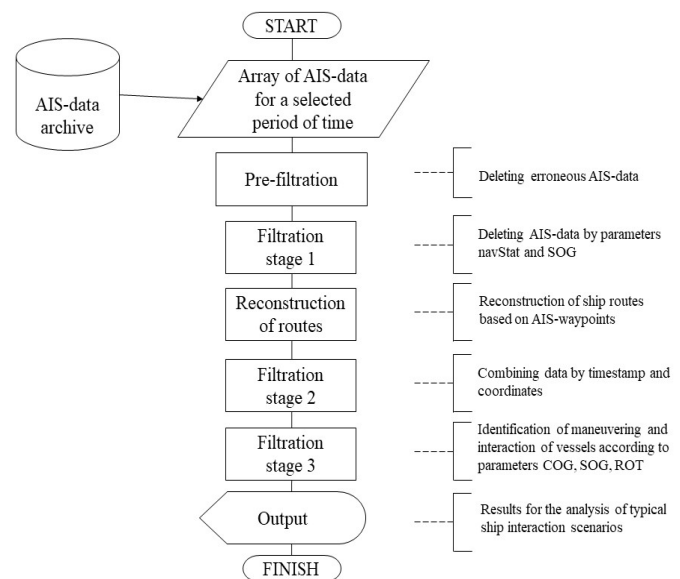
MMSI	- Maritime Mobile Service Identity, nine-digit individual number assigned to the vessel
IMO	- Unique identifier of the vessel in accordance with the RESOLUTION A.600(15) – IMO SHIP IDENTIFICATION NUMBER SCHEME
shipType	- Vessel type
navStat	- Vessel navigation status
coordinates	- Vessel coordinates, WGS-84
SOG	- Speed over the ground
COG	- Course over the ground
ROT	- Rate of turn
HEADING	- Gyrocompass heading
timestamp	- Time, UTC

In [11], the authors had proposed the use of archived AIS data to determine the safe speed of autonomous vessels in various navigation situations. The sources of archival and current AIS data for the Baltic Sea are the following services – [12-13]. The archives contain information on vessels movement from 2006 to the present day; operational data is received (upon request) with a delay of several minutes. Since most of the archival data is anonymized and contains limited sets of information, the collection of operational AIS data was organized. For this purpose, special software was developed in Python programming language in the Jupyter Notebook environment. It requests a set of AIS data from a web service with a period of 1 minute and saves them into a database for further analysis. The time period was chosen from July 1 to September 30, 2022, since the specified time refers to the most intense shipping in the Baltic Sea.

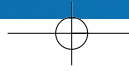
**Results and their discussion**

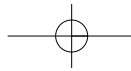
**AIS data processing algorithm**

The proposed algorithm for processing AIS data allows us to identify various navigation situations and determine the actions of navigators in real situations of dangerous convergence. A schematic flowchart of the AIS data processing algorithm is presented in Figure 1.



**Fig. 1.** Schematic flowchart of the AIS data processing algorithm



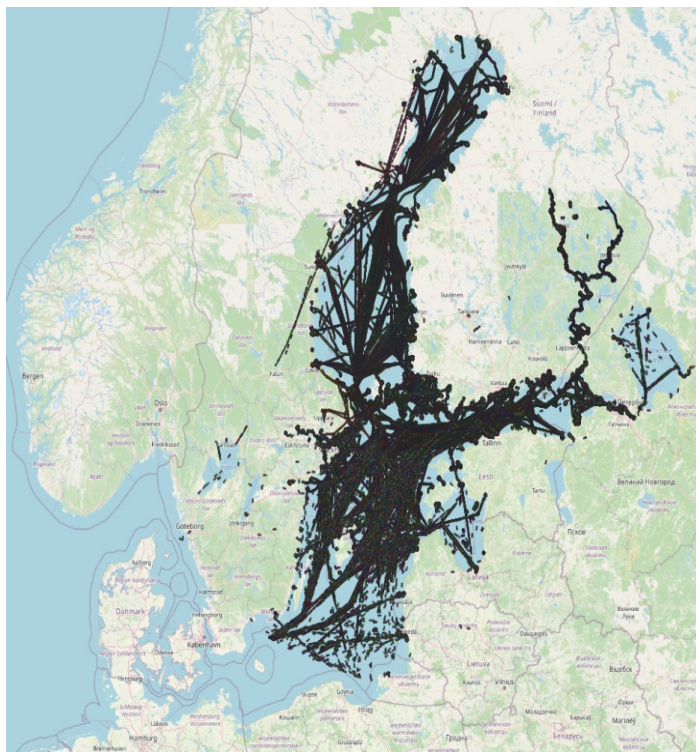


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**Preliminary filtering of AIS data (error elimination)**

The number of vessels positions according to AIS data for analysis within one day ranges from 1.5 to 2 million (Fig. 2). However, some of the data contains errors that significantly complicate subsequent analysis. These errors are associated with incorrect information and the location of vessels, timestamps, data repetition, incorrect vessel identification, the presence of virtual aids to navigation, etc. Such data can constitute up to 10% of the total array; in this work, they were subjected to forced filtering.

Algorithms for such filtering are quite well known and partially disclosed in [5-10] and are implemented directly by filtering inside the database using the SQL query language.



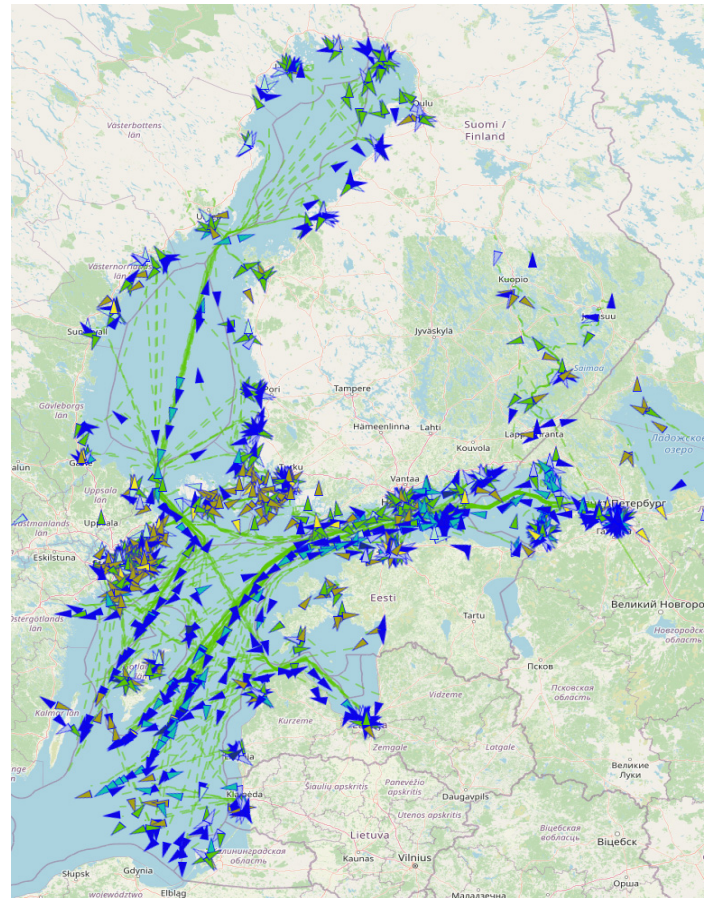
**Fig. 2.** Vessels positions in the Baltic Sea for 1 day (Sep. 2022)

**The first stage of filtering AIS data**

Since a complete array of AIS data is not required to analyze the movement, behavior and interaction of vessels with each other, a filtering stage, which consisted of excluding vessels whose navigation status (AIS parameter - navStat) does not imply movement, i.e. ridded at anchor, moored at the pier, participating in fishing, etc., is performed. Additionally, the vessels whose speed is less than 3 knots are excluded. After this filtering stage, the amount of relevant AIS data for subsequent analysis is reduced to 0.4–0.5 million positions per day.

**Building vessels movement routes based on AIS data**

At the next stage, using AIS data for each identified vessel, a route is built using waypoints (AIS parameter – coordinates) in automatic mode. An example of the constructed routes is presented in Figure 3. These calculations are necessary to identify areas in the Baltic Sea water area where ship routes intersect.



**Fig. 3.** Vessels movement routes in the Baltic Sea for 1 day (green lines, September 2022)

**The second stage of filtering AIS data**

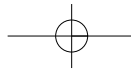
Since this work requires an analysis of the typical interaction of vessels in various conditions and situations under the crew control, the task of this filtering stage is to select such vessels (groups of vessels) according to the following criteria: timestamp (AIS parameter – timestamp), which must correspond to a specified time range (for example, 5÷10 minutes); the vessel location (AIS parameter – coordinates), which must also correspond to a given range for the estimated distance between vessels, which is selected from among the options under consideration:

- 3÷6 miles;
- 1÷2 miles;
- The distance corresponding to the stopping distance of the selected vessel (for example, selected from the vessel maneuvering characteristics booklet);
- Estimated zone of a possible collision between two vessels, as a parameter R, determined from the linear dimensions (length, width) of the vessels, positioning accuracy and probable deviation of the vessel course in the local coordinate system of each vessel and calculated as:

$$R = (L_1 + L_2) \times (1 + k_1) + (W_1 + W_2)/k_2 + P$$

where:





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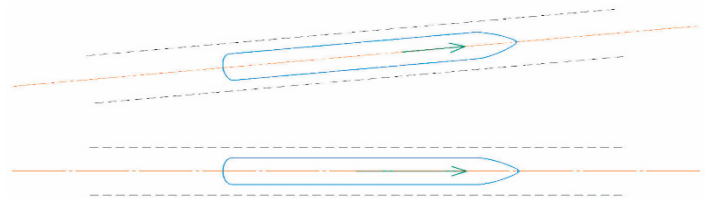
- R – Estimated collision zone
- $L_1$  – length of vessel No. 1
- $L_2$  – length of vessel No. 2
- $W_1$  – width of vessel No. 1
- $W_2$  – width of vessel No. 2
- $k_1$  – calculated coefficient =  $\sin(\beta)$ ;  $\beta \approx 5 \div 8^\circ$ ;  $\sin(6^\circ) = 0.105$
- $k_2$  – calculated coefficient =  $\cos(\beta)$ ;  $\beta \approx 5 \div 8^\circ$ ;  $\cos(6^\circ) = 0.995$
- P – vessel position accuracy  $\approx 20m$ , or parameter "accuracy AIS"

A similar approach was proposed by the authors in [14-16] with some changes or additions; the coefficients  $k_1$  and  $k_2$  are determined based on the maneuvering characteristics of the vessel or by the method of statistical processing of AIS data, namely the difference between the parameters "COG" (Course over the ground) and "HEADING" (Gyrocompass heading) at the moment the vessel begins maneuvering; according to our data, this difference in headings is  $5 \div 8^\circ$ ; in addition, the vessel ROT parameter, which determines the turning speed, can be taken into account.

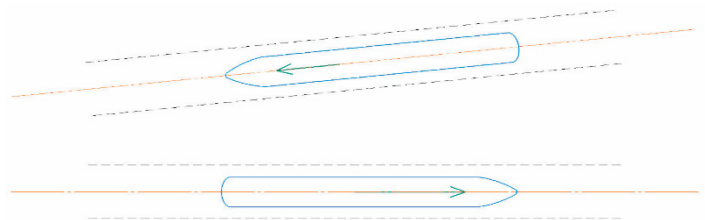
Thus, it is possible to identify groups of vessels interacting with each other (Fig. 4).

**Identification of typical scenarios for interaction between vessels**

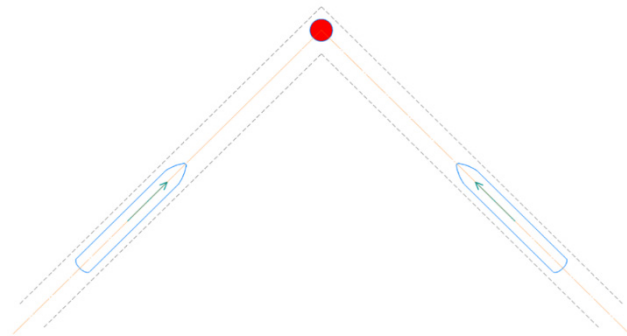
Typical scenarios are presented in Figures 5-7, but are not limited to them. It is assumed that for identified real cases of vessels convergence that coincide with typical scenarios, interaction between vessels may or may not occur.



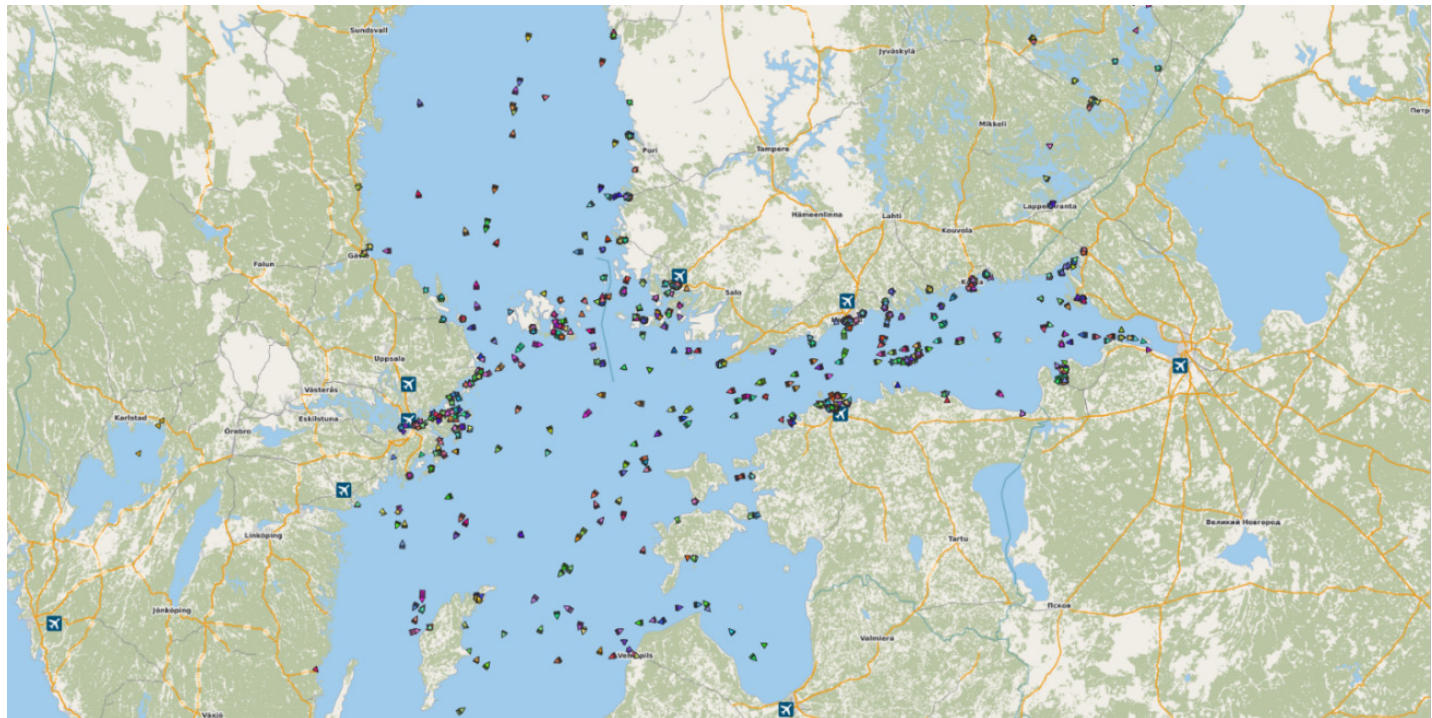
**Fig. 5.** Typical scenario under consideration No. 1 (vessels movement on parallel courses without interaction, with interaction)



**Fig. 6.** Typical scenario under consideration No. 2 (vessels movement on reciprocal courses without interaction, with interaction)



**Fig. 7.** Typical scenario under consideration No. 3 (vessels movement on crossing courses without interaction, with interaction)



**Fig. 4.** A sample of AIS data with positions of vessels interacting with each other



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During the analysis and development of the approach for testing SAS of MASS using archival AIS data, various situations are considered, including.

1. The movement of two vessels on parallel courses. The vessels move in the open sea in the lane of 0.5÷0.7 miles wide in one direction, their speed is constant, the course (COG parameter) does not have sudden changes; the ROT (rate of turn) parameter along the entire route under study is 0, the difference in the COG (Course over the ground) and the HEADING (Gyrocompass heading) parameters ranges from -0.5 to +0.5, which indicates the absence of vessel maneuvers.

2. The movement of two vessels on parallel courses, with one of the vessels overtaking the other. The vessels move in the open sea in the lane of 0.5÷0.7 miles wide in one direction, their speed is constant, one vessel overtakes another without performing any maneuvers. For both vessels, the course (COG parameter) does not have any sudden changes; the ROT (rate of turn) parameter along the entire route under study is 0, the difference in the COG (Course over the ground) and the HEADING (Gyrocompass heading) parameters ranges from -0.5 to +0.5, which indicates the absence of vessel maneuvers.

3. Divergence of two vessels on reciprocal courses. Vessels move in the open sea in the lane of 0.5÷0.7 miles wide in reciprocal courses, their speed is constant, at one point in time the vessels diverge without maneuvering, for both vessels the course (COG parameter) does not have sudden changes; the ROT (rate of turn) parameter along the entire route under study is 0, the difference in the COG (Course over the ground) and the HEADING (Gyrocompass heading) parameters ranges from -0.5 to +0.5, which indicates the absence of vessel maneuvers relative to each other.

4. Divergence of two vessels on crossing courses. The vessels move in the open sea in the lane of 0.5÷0.7 miles wide, narrowing at the point of divergence to 0.2 miles in one direction and on crossing courses. The vessels speed is constant, one vessel is ahead of the other, the time difference to the point of possible crossing of the vessels is 5 minutes, the distance to the crossing point is 3÷4 miles, for both vessels, the course (COG parameter) varies within 5°, the ROT (Rate of turn) parameter along the entire route under study is 0, the difference between the COG (Course over the ground) and HEADING (Gyrocompass heading) parameters ranges from -0.5 to +0.5, which indicates the absence of significant maneuvers of the vessels relative to each other.

5. Divergence of two vessels on crossing courses. The vessels move in the open sea in the lane of 0.5÷0.7 miles wide on crossing courses; at a distance of 3÷4 miles to the point of possible collision, one of the vessels makes a maneuver, i.e. changes the course to move away from the crossing point, after 5 minutes the vessel returns to its previous course with a second maneuver; maneuvering is clearly monitored by the difference between the "COG" (Course over the ground) and the "HEADING" (Gyrocompass course) parameters and by changing the "ROT" (Rate of turn) parameter. The second vessel moves without changing speed, course and does not perform any maneuvers.

6. Divergence of two vessels on crossing courses. The vessels move in the open sea in the lane of 0.5÷0.7 miles wide on crossing courses; at a distance of 3÷4 miles to the point of possible collision, one of the vessels reduces speed and changes course to move away from the crossing point; maneuvering is clearly monitored by the difference between the "COG" (Course over the ground) and the "HEADING" (Gyrocompass course) parameters and by

changing the "ROT" (Rate of turn) parameter. The second vessel moves without changing speed, course and does not perform any maneuvers.

7. Interaction of vessels on parallel courses. The vessels move towards the exit from the port water area in the lane with a variable width from 0.2 to 0.7 miles on coinciding courses, one of the vessels is ahead of the other with reaching a constant course, the distance between the vessels is up to 2 miles. Maneuvers of both vessels with changes in speed and course occur; the parameters of interaction between the vessels are illustrated by AIS data.

8. Interaction of the tanker with the service boat in the water area to leave the port. The tanker performs several maneuvers, incl. reduces the speed to 6 knots and changes course several times; the boat approaches the tanker only with a decrease in speed and without changing course. The interaction of two vessels at the meeting point lasts no more than 5 minutes, while both vessels are moving at a speed of no more than 6 knots. Then the vessels diverge on different courses and pick up the required speed. It should be noted that this situation had occurred at the end of February, i.e. during the beginning of freezing-over.

9. Interaction of two vessels when diverging on crossing courses. The vessels move in the open sea at a distance of 3–4 miles (to the point of possible crossing). The peculiarity of this case is that the vessels do not change their speed; both vessels perform the maneuvers only by changing the course of movement. To diverge, one of the vessels undertakes two course-changing maneuvers at a constant speed. For both vessels, the ROT (rate of turn) parameter along the entire route under study is 0, which indicates the absence of sharp turns; the maneuvering time when diverging is 15 minutes; for the vessel performing the maneuvers the difference between the "COG" (Course over the ground) and "HEADING" (Gyrocompass heading) parameters ranges from -5 to +5.

### Approach to testing SAS of MASS using archival AIS data

The sets of archival AIS data can be used as initial data for testing the operation of SAS of MASS. Despite their limitations in terms of complete coverage of the navigation situation (there is no hydrometeorological information, radar images, navigation and hydrographic support, etc.), AIS data is quite sufficient to identify possible interaction between vessels, incl. groups of vessels in a real situation, taking into account the actions of the vessel crew and the possibility of preliminary analysis of maneuvers performed by the crew. Thus, the archival AIS data for a certain shipping area is considered as a model one for setting test tasks for SAS of MASS, incl. reference tasks for modeling various navigation situations.

To develop model tasks for testing SAS of MASS, it is proposed to use archival information from AIS for a certain period of time (for example, 4-8 hours, or for the corresponding range of ship's AIS receivers and transmitters, i.e. up to 50 km, taking into account the time of the vessel movement) for water area with dense traffic of vessels in various directions and with various navigation situations. Model data is pre-synchronized with a frequency of 1 minute and can be transferred to the tested SAS of MASS using a given protocol to analyze its operation with the same frequency.

An example of a set of archival AIS data for a period (navigation situation in the Baltic Sea) is presented in Figure 8. Test tasks

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for SAS of MASS can include a wide variety of navigation situations, for example, in accordance with the situations described earlier, or others, such as those requiring MASS maneuvering and those not requiring maneuvering.

An example of a test task to check the SAS of MASS performance is presented in Figure 9. The initial location of the vessel, its performance characteristics (according to the register book), speed and heading angle are transmitted to the SAS being tested. For the tested SAS, the task for the vessel to pass to a given location is set, but at the same time there is no information on the route, safe speed, the need of maneuvering, or any other information. Then, every minute, the tested SAS receives constantly updated information about other vessels (coordinates, speed, course, etc.) in the navigation area, which comes from the selected AIS archive. At the same time, the location and maneuvering parameters of the model vessel with the crew are unknown in advance to the SAS.

It should be noted that the number of such tasks is not limited in any way, i.e. there is the possibility of large-scale testing of SAS of MASS. Thus, the authors in [10], using a special algorithm, had created up to 1 thousand model situations and ungrouped them according to several criteria; it should be noted that only a small part of the scenarios had a pattern of a possible collision of vessels. In [17], the authors had proposed a modified approach, namely the generation of model scenarios based on archival AIS data by moving the timestamp, which allows creating various situations regarding the divergence and interaction of vessels. In [18], the authors had proposed a hierarchical method for assessing the graphical representation of possible vessel interactions with a 15-minute forecast horizon. In [19], the authors had proposed methods and models for clustering various navigation situations, which were further divided into normal and abnormal, on the basis of which various scenarios for testing MASS were developed.

The analysis of the results of testing the SAS of MASS proposed in the work includes:

- assessment of time it takes to complete a given route of the MASS under the control of SAS and the crew;
- assessment of deviation from the route of the MASS under the control of SAS and the crew;
- assessment of speed mode of the MASS under the control of SAS and the crew;
- comparison of completed maneuvers of the MASS under the control of SAS and the crew;
- comparison of maneuvers performed by the SAS and the crew (start, end, rate of turn);
- comparison of the MASS interaction with other vessels in cases similar to the crew control.

The results of a comparative analysis of the SAS of MASS operation and the crew actions are formalized according to the proposed table, where for each test parameter a criterion assessment is performed; it can have a qualitative assessment or a quantitative indicator, for example, in %, or be considered as (not) reaching the set threshold (critical) value. For all maneuvers undertaken, a qualitative assessment "Yes/No" is used.

When testing SAS of MASS using archival AIS data, a program with tests, which, depending on the goals and scope of testing, contains the following calculation justifications, is first drawn up:

- m nimum/maximum number of test tasks;
- pecified sequence of tests execution:

- movement of the MASS on a parallel course without interaction with other vessels;
- movement of the MASS on a parallel course with overtaking;
- movement of the MASS on crossing courses without interaction with other vessels;
- movement of the MASS on crossing courses with maneuvering in relation to other vessels;
  - pecial tests.

Table 1

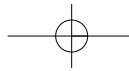
Description of formalized parameters

Test parameters	Vessel under the crew control	SAS of MASS	Criteria-based assessment
<b>Quantitative assessments</b>			
Time it takes to complete a given route (route sections)	$T_{CREW}$	$T_{SAS}$	deviation percentage
Speed on the route section	$V_{CREW}$	$V_{SAS}$	deviation percentage
Vessel heading	$\Theta_{CREW}$	$\Theta_{SAS}$	deviation percentage
Distance to the "dangerous" vessel at the beginning of the maneuver	$A_{CREW}$	$A_{SAS}$	deviation percentage
Maneuver start time	$M_{CREW-1}$	$M_{SAS-1}$	deviation percentage
Maneuver end time	$M_{CREW-2}$	$M_{SAS-2}$	deviation percentage
Turning rate when maneuvering	$Y_{CREW}$	$Y_{SAS}$	deviation percentage
.....	.....	....	...
<b>Integral assessment</b>			<b>deviation percentage</b>
<b>Qualitative assessments</b>			
Maneuver undertaken by changing course	Yes/No	Yes/No	Yes/No
Maneuver undertaken by changing speed	Yes/No	Yes/No	Yes/No
Maneuver undertaken by changing course and speed	Yes/No	Yes/No	Yes/No
.....	.....	....	...
<b>Integral assessment</b>			<b>Yes/No</b>

Assessment of the SAS operation quality is carried out in real or accelerated time mode.

**Conclusion**

To the development of already known approaches [5-10, 15-19] to processing data obtained from AIS, in this work it is proposed to use data from AIS to analyze movement during potentially dangerous divergence maneuvers of vessels. Processing of this data will make it possible to develop recommendations to prevent the occurrence of situations of dangerous convergence of vessels, both under the control of a crew and autonomous ones [20]. This will make it possible to automatically solve the problems of assessing the navigation situation [21] and making decisions on maneuvering to avoid collisions [22], which will obviously improve the operation safety of autonomous sea vessels.



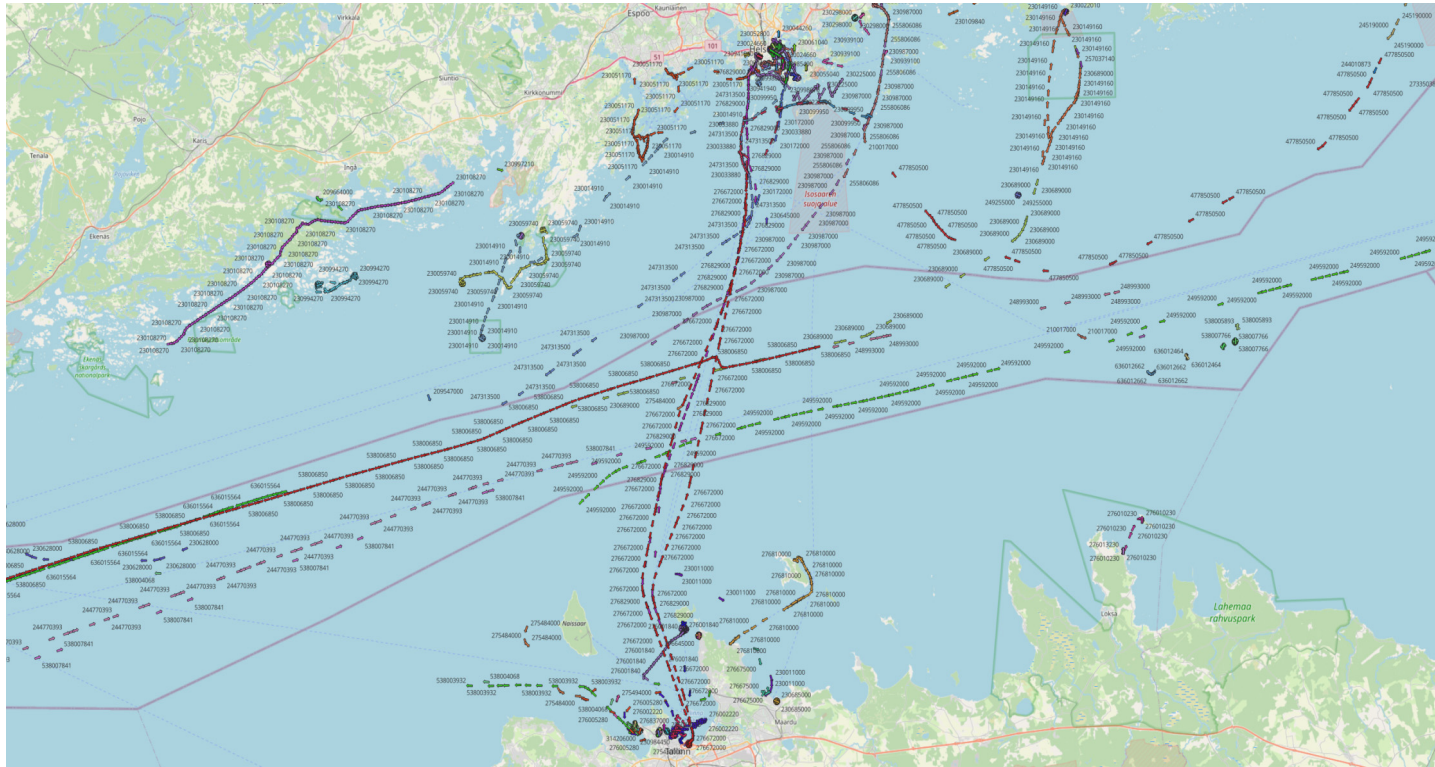
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The MASS development in the future will require changes in the navigation and hydrographic support of waterways [23], which can also be preliminary analyzed using AIS data, for example, in the conditions of developing special test water areas [24].

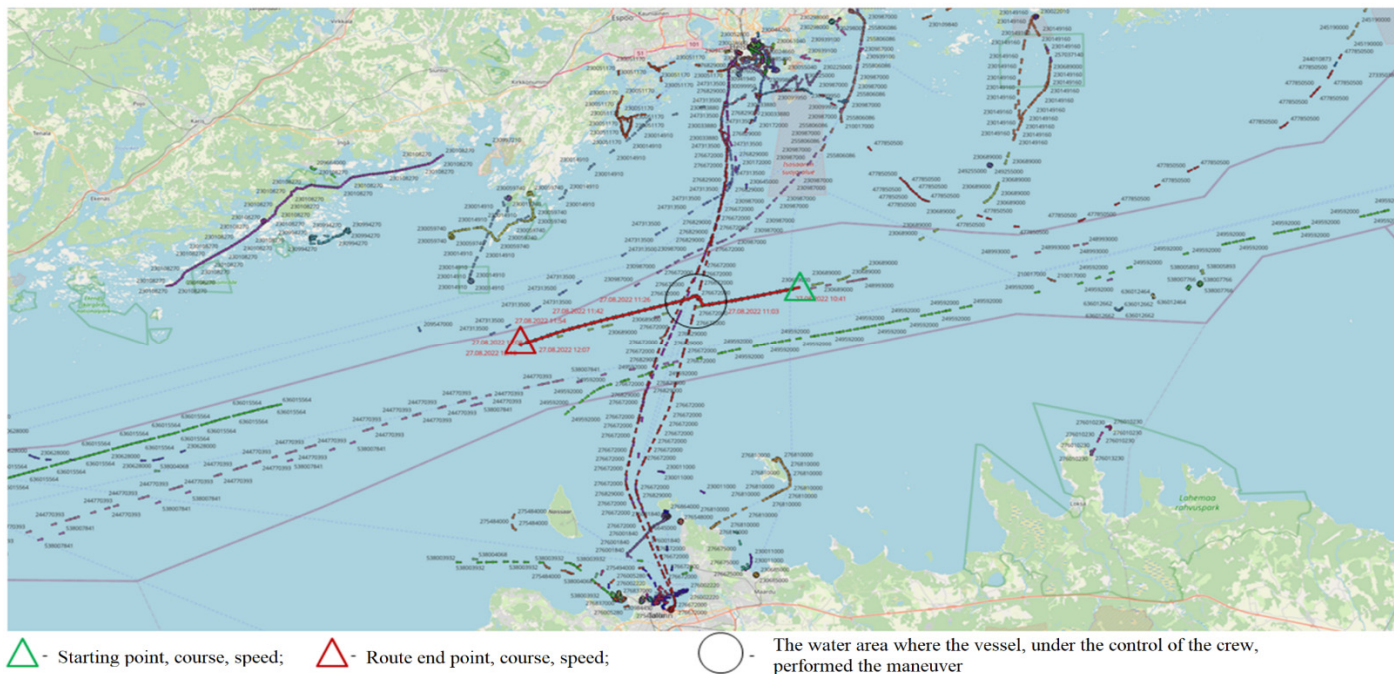
An algorithm for processing and filtering data from AIS is proposed, and an approach for testing SAS of MASS is formulated. It is shown that this approach can be implemented in a simple and computationally efficient way. Identification of such situations

and creation of a database of dangerous convergences can be used to prevent vessels collisions with the designation of dangerous sections of the route.

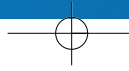
Admiral Makarov State University of Maritime and Inland Shipping invites interested parties to test the developed systems for autonomous shipping and is ready to provide both test tasks and AIS data sets for modeling the navigation situation.



**Fig. 8.** Initial AIS data for testing SAS of MASS



**Fig. 9.** An example of a test task to check the SAS of MASS performance



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## АЛГОРИТМ АНАЛИЗА ДАННЫХ АВТОМАТИЧЕСКОЙ ИДЕНТИФИКАЦИОННОЙ СИСТЕМЫ ДЛЯ ВЫДЕЛЕНИЯ ТИПОВЫХ СЦЕНАРИЕВ РАСХОЖДЕНИЯ СУДОВ И ТЕСТИРОВАНИЯ СИСТЕМ АВТОНОМНОГО СУДОВОЖДЕНИЯ

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### Аннотация

В статье рассматривается проблема анализа данных автоматической идентификационной системы (АИС) с целью выделения типовых ситуаций встречи судов в море и выявления действий судоводителей по расхождению в этих ситуациях. Эта проблема становится актуальной в последнее время в связи с необходимостью иметь базу эталонных действий для тестирования систем автономного судовождения (САС), интерес к разработке которых в последнее время только усиливается в связи с созданием морских автономных надводных судов (МАНС). Алгоритм анализа данных АИС состоит из предварительного этапа фильтрации данных и двух основных этапов. На предварительном этапе исключаются данные, содержащие ошибки, существенно осложняющие последующий анализ и связанные с некорректной информацией. Выявлено, что такие данные могут составлять до 10% от общего массива информации. Далее, на первом этапе фильтрации отсеиваются суда, навигационный статус которых не предполагает движение или двигались со скоростью менее 3 узлов. На первом этапе фильтрации с 1,5 до 2 млн записей о навигационном статусе в сутки оставалось до 0,4-0,5 млн. Вторым этапом фильтрации стал анализ типового взаимодействия судов в различных условиях и ситуациях под управлением экипажа. Задачей данного этапа фильтрации стал отбор групп судов по следующим критериям: временная метка и местоположение судна, последнее должно соответствовать заданному диапазону по расчетному расстоянию между судами, которое выбирается из числа определенных заранее вариантов. Таким образом, в результате выполнения фильтрации были отобраны три типовых сценария. Первый - движение на параллельных курсах без взаимодействия, с взаимодействием. Второй - движение на встречных курсах без взаимодействия, с взаимодействием. Третий - движение на пересекающемся курсе без взаимодействия, с взаимодействием. Во время анализа типовых сценариев и для разработки подхода тестирования САС МАНС по архивным данным АИС были рассмотрены и описаны 9 типовых ситуаций взаимодействия судов во время опасного сближения. Предлагаемый в работе подход тестирования САС МАНС включает: оценку времени прохождения заданного маршрута; оценку отклонения от маршрута; оценку режима скорости; сравнение совершенных маневров; сравнение взаимодействия МАНС с другими судами.

**Ключевые слова:** морское автономное надводное судно, система автономного судовождения, безопасность мореплавания, автоматическая идентификационная система, анализ навигационной обстановки, расхождение судов, метод анализа данных.

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