EMSA
European Maritime Safety Agency

Meeting: 2nd SSN / LRIT Group Meeting

Place and date: Lisbon, 18 October 2017

Agenda item: SSN / LRIT 2.6.1: Traffic Density maps – progress report

Document number: SSN/LRIT 2.6.1

Submitted by EMSA

Summary	The HLSG agreed “on mandating EMSA to start preparing for providing traffic density maps, based on AIS data, to interested parties upon request, as a new service and then report back to the next HLSG”. This paper presents the first results of the EMSA evaluation.
Action to be taken	As per paragraph 4.
Related documents	HSLG DM 2 (Brussels, 20 June 2017) - meeting minutes, item 4.4.

1. Introduction

The rapid growth in shipping traffic, the commitment to monitor marine protected areas and the obligation to ensure that the level of human activities is consistent with good environmental status require a robust planning strategy to understand the interaction between all uses of the maritime space. Maritime Spatial Planning (MSP) is essential for economic reasons, and also for security and safety purposes. The use of Traffic Density Maps (TDM) is a simple and effective way of displaying vessel movement patterns, which contributes to a better understanding of maritime traffic, It also helps to answer important questions, such as the locations of the main shipping lanes, who they are used by and which ship types are navigating on which route. The source used to create TDM is historical data on ship positions.

EMSA has received several requests from Member State authorities, EU Institutions and other bodies for ship positioning data (mainly AIS and LRIT) in order to enable the requesters to produce TDM. The issue was discussed at the HLSG 2 meeting (Brussels 20 June 2017), where several questions were asked by the Member States. The ensuing discussion pointed to the relevant consequences of making traffic density maps publicly available, and of providing aggregated (rather than raw) data to requesters. The HLSG agreed “on mandating EMSA to start preparing for providing traffic density maps, based on AIS data, to interested parties upon request, as a new service and then report back to the next HLSG”.

In the past, EMSA produced TDM on the basis of ad hoc requests to complement specific studies or projects. Following the HLSG mandate for EMSA to develop a tool/service to generate TDM, the agency contacted several Member State authorities, EU Institutions and research bodies with prior experience in developing TDM. In particular EMSA contacted the HELCOM Secretariat (that produces TDM using the AIS data hosted by the HELCOM regional server) as well as the Norwegian Coastal Administration and the Italian Coast Guard (which produce TDM using the AIS data hosted by the North Sea/North Atlantic and the Mediterranean regional servers respectively). Furthermore EMSA evaluated documents produced by private entities and Research and Development projects with prior experience on TDM.

The Agency also contacted users who expressed their interest in the TDM service in order to better understand the user requirements. In particular EMSA participated in a Video Conference with the EMODnet steering group (organized by DG MARE) that has an interest in the TDM for Maritime Spatial Planning purposes and the Netherlands regarding the request of AIS data for the Royal Netherlands navy. The feedback received will be analyzed to define the service meeting, to the extent possible, the user requirements.

The EMSA analysis demonstrated that, before developing a TDM service, it is necessary to define/agree the methodology, which needs to be shared and fully understood by the users. It should be noted that, even if the most sophisticated methodology is used to develop the service, the added value will be limited if the users do not have the necessary knowledge to read and comprehend it.

Furthermore it is important to develop a TDM service that offers users a dynamic environment that allows for the configuration of certain parameters (e.g. area or type of ships), as well as the possibility to zoom in, import additional digital layers, customise and superimpose them on other maps while respecting the principle of anonymity of the specific vessels and their location.

The objective of this paper is to set the basis for developing a TDM service by proposing the methodology for its creation. Furthermore, it proposes a phased in approach, whereby the service will be developed gradually taking into account the possibilities offered by technological developments and user requirements. Questions relating to access rights are not addressed in this document (e.g. who and how will have access to the TDM service and if the maps will be available to the public).

2. Methodology

The HLSG mandated EMSA to begin preparing for the provision of TDM based on AIS data. Terrestrial AIS (T-AIS) is the most appropriate source of ship positioning data (SPD) within coastal areas, because of its high update rate (e.g. ship reporting intervals are approx. 10 seconds, depending the conditions). Member States have developed a network of shore based AIS stations that covers almost all of the EU coastal regions. All of this information is collected at EU level and stored centrally by EMSA in a database.

EMSA also accumulates satellite-based positioning data (S-AIS) in order to monitor maritime traffic that is beyond EU coastal waters and outside the range of the T-AIS ground station networks. The S-AIS data service covers the entire globe, including the poles, and almost 100% of the AIS messages detected by satellites are available within 60 minutes at the present time.

There is no international standard definition or method for the creation of TDM. However, most methodologies are based on grid-based approaches whereby the area to be monitored is divided into cells within a spatial grid. The cells are characterised by the number of ships sailing through these cells. Grid-based methods are effective when the area under surveillance is small, while their effectiveness decreases as the size of the monitored area increases (e.g. global scale). The main limitation of the grid-based approach is the computational burden.

A database management system is used for the SPD records that are produced by maritime traffic. The ship's track is built by using all of the recorded and aggregated SPD, regardless of its source (T-AIS or S-AIS). The SPD are aggregated by selecting specific AIS information fields, and by grouping the observations according to these key fields. This aggregation leads to a reduction in the total data size. Then, the processed SPD is sent to a server for the generation and management of geospatial data. The last step involves overlaying the geo-referenced SPD information over the corresponding geographical maps in order to obtain the final SPD visualisation view.

Research by EMSA identified the following three grid-based methods:

- **Ship voyage calculation method:** Based on the calculation of how many times trips cross each cell of a grid during a given time period.
- **Ship position calculation method:** Based on the calculation of how many positions are reported from ships in each cell of the grid during the time period.
- **Ship route calculation method:** Rebuilds the ship track from the recorded positions (i.e. how many routes are recorded for each distinct ship in each cell of the grid during the time period).

The method proposed by EMSA to generate TDM is the **ship route calculation based method**. This method is preferred because it can be implemented in all regions (coastal and open sea), utilising all of the available SPD that EMSA accumulates.

The selected method allows for the connection of the dedicated ship's positions and the approximation of the ship's route within areas with low coverage (see in Fig. 1 below):

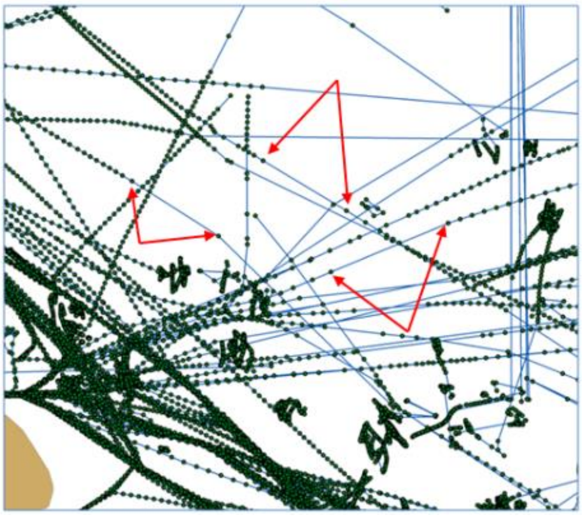

Figure 1: Restoring the ships' routes

It should be noted that the "gap filling" method is based on the assumed route of a given ship, and that although this is sufficient for TDM purposes, it cannot be used for some other types of monitoring outside the fully covered areas (e.g. monitoring of fishing vessel activities).In the creation of TDM in EU coastal areas, T-AIS will be used as the main source, while outside these areas only S-AIS will be used. The steps to create TDM are explained in Annex I.

3. Proposed way forward

Applying the above methodology, EMSA has produced a sample TDM by period, area and ship type (see Annex 2). TDM samples for more regions, ship types, etc. are available on the EMSA web site at: http://emsa.europa.eu/related-projects/tdms.html

EMSA plans to use the existing maritime infrastructure and application environment of the SafeSeaNet Ecosystem Graphical Interface (SEG) to develop the TDM web service. To this end, a phased-in approach is proposed, whereby the service will be developed gradually taking into account the possibilities offered by technological developments and user requirements.

As a first step, the parameters on which the service is provided will be based on fixed time periods (e.g. one month), sea areas (i.e. Baltic Sea, North Sea/North Atlantic, Atlantic, Mediterranean Sea and Black Sea) and ship types (i.e. cargo, tanker, passenger and fishing).

The EMSA analysis found out that there are several possibilities for enhancing the service, such as the creation of maps based on configurable areas, time periods, types of ships, distribution of maps via a “geoserver,” production of vectorised maps, etc. Once more knowledge and experience has been be gained, and based on the user requirements and resources allocated to EMSA, the TDM service may evolve to provide more sophisticated services to its users.

4. Actions proposed

Member States are invited to provide feedback on the proposed methodology and the way forward.

Annex I

Traffic Density Maps construction

The steps for the creation of TDM are: aggregation of positions; creation of lines; counting of lines; division of lines by ship type and; creation of traffic density maps. The steps are described below:

1. Aggregating positions

The SPD are collected and aggregated by time period (configurable) and target area and prepared in order to recreate vessel paths as lines. The output of this process is a list of points (ships positions) that can be down-sampled to create the line. Data with high frequency acquisition (e.g. T- AIS data) are down sampled to 1 or 2 hours, while other data (e.g. S-AIS) are not down sampled.

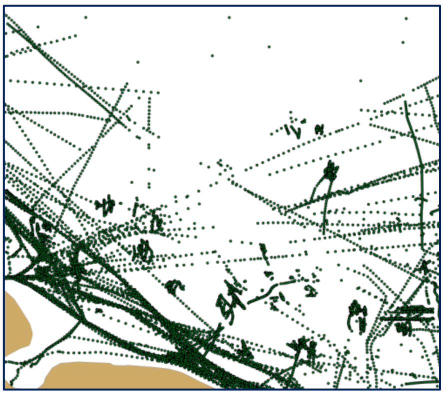

Figure 2: Ships' positions

2. Filtering positions

The SPD are processed in order to exclude improbable positions (e.g. positions that are incompatible with the other data relating to the target vessel) or positions that indicate that there was an error (e.g. longitude and latitude equal to 0).

Depending on the system processing capability, additional methodologies might be applied in order to highlight the number of positions to be treated. For example, filtering out the SPD and keeping only one position by dedicated MMSI within the grid cell. However, it should be noted that these methods may decrease the accuracy of the presentation of the ship routes.

3. Creating lines connecting the dedicated MMSIs (positions)

The routes of ships are created, and the time period for the SPD would be configurable (e.g. 10 days for EU coastal areas).

Records with the same MMSI are converted to lines by using the acquisition time stamp to order the points. The output of this process is a file containing the route lines (e.g. as a shape-file) by MMSI for a period of time (configurable).

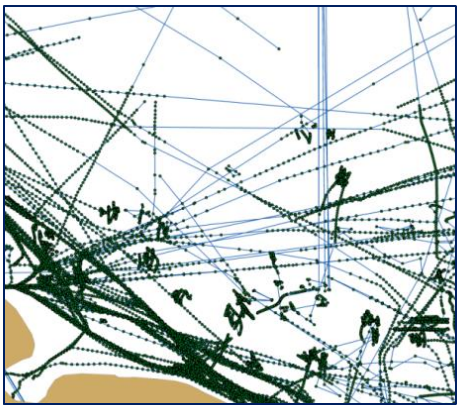

Figure 3: Lines representing the ships routes

4. Dividing lines by ship type

The file is divided into different ship types, and the result is a set of files by ship type which include the lines (for a period of time).

5. Constructing a map

The density map is created by counting the number of lines crossing each cell and visualising the number of crossings using a colour code.

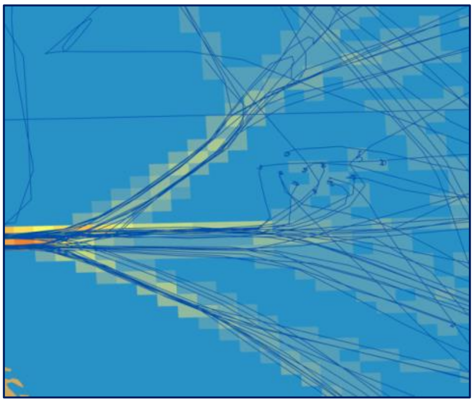

Figure 4: TDM visualisation

The process to create a map can be divided into the following steps:

5.1 Selecting cells

The area is divided into a number of cells (1*1 km large squares).

Figure 5: The area is divided into cells

5.2 Selecting positions

The aggregated SPD (position reports) are selected for a specific ship.

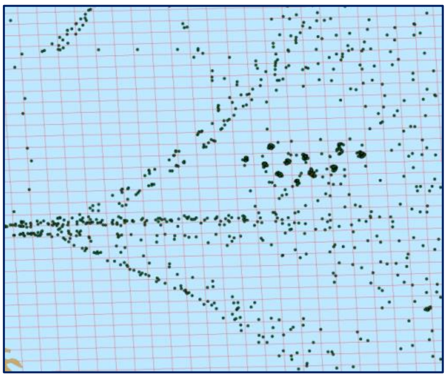

Figure 6: Ships positions per cell

5.3 Selecting lines

The selected positions are connected by lines, and the lines are selected inside each of the cells.

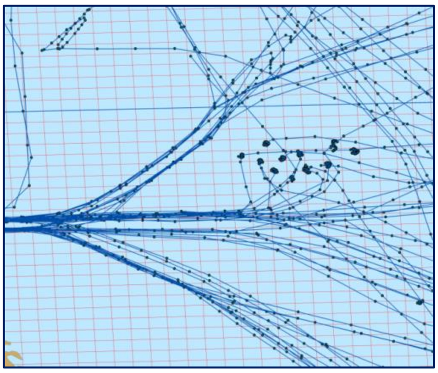

Figure 7: Ship positions connected by lines

5.4 Counting and summing

The system counts the number of lines (crossings) inside each of the cells using a spatial join.

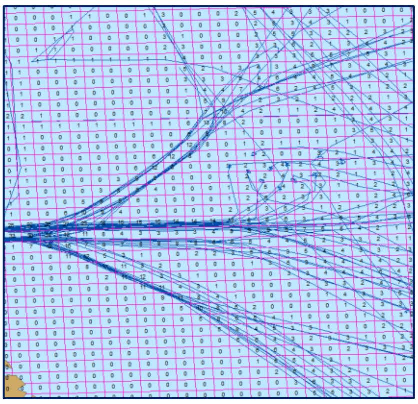

Figure 8: Counting of the number of lines crossing each cell

All of the crossings in each cell will be summed, and depending of the final type of map to be produced, the maps can be combined.

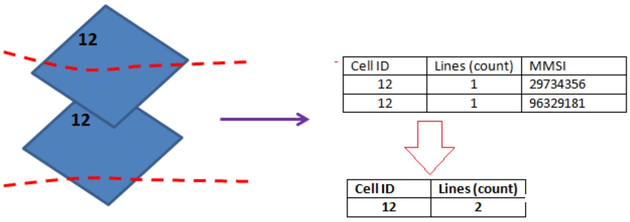

Figure 9: Summary of crossings

5.5 Correlation

The result of the summing is aggregated as a shapefile and/or transformed into a GIS grid to make it lighter. The outcome would be a set of maps stored in a folder with sub-folders and/or in a database. The files will be produced for each area, vessel type[1] and time period (pre-defined).

[1] The vessel types are defined in accordance with the ship codes adopted by the PARIS MoU for PSC community purposes.

Annex 2

Examples of Traffic Density Maps

Applying the proposed methodology, EMSA created the sample TDM shown here:

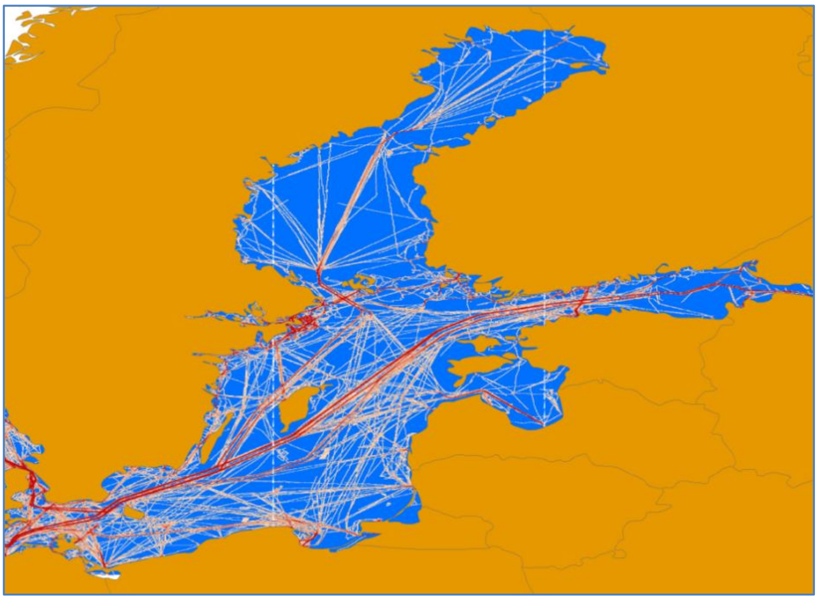

Figure 10: Overall traffic density in the Baltic Sea

Figure 11: Traffic density in the Baltic Sea by ship type (cargo)

Figure 12: Traffic density in the Baltic Sea by ship type (passenger)

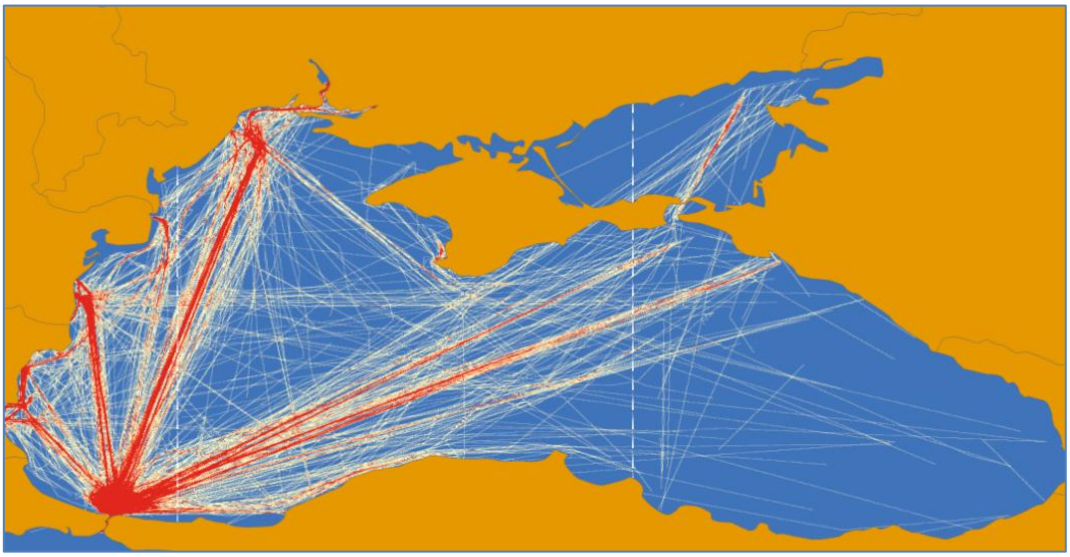

Figure 13: Overall traffic density in the Black Sea

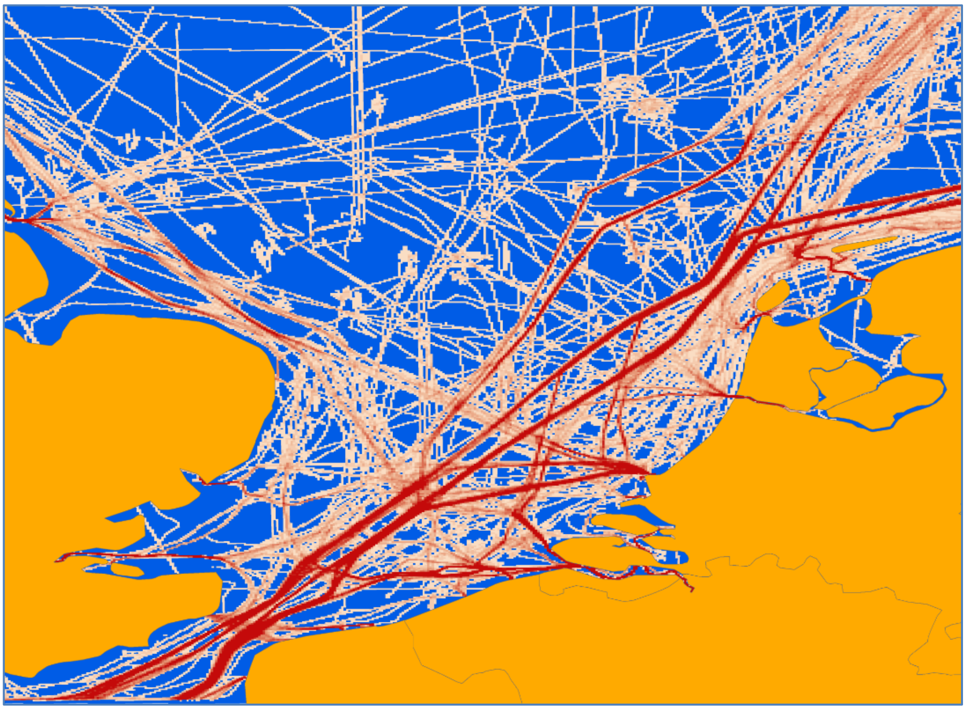

Figure 14: Overall traffic density in the southern North Sea

The above maps are constructed using the available T-AIS and S-AIS data collected on 11th August 2017 (data from one full day), except the Black Sea TDM, which shows the traffic density using one week of data from 11-17th August 2017).