Maritime Anomaly Detection Systems and Automated Behaviour Monitoring

Meeting Minutes

Held in Lisbon on

02 December 2015

Final version
Date:22 December 2015

List of Abbreviations

AIS	Automatic Identification System
ABM	Automated Behaviour Monitoring
AOI	Area of Interest
CSD	Central Ship Database
EC	European Community
EFCA	European Fisheries Control Agency
EMSA	European Maritime Safety Agency
EU	European Union
FRONTEX	European Agency for the Management of Operational Cooperation at the External Borders of the Member States of the European Union
IMDatE	Integrated Maritime Data Environment
IMS	Integrated Maritime Services
LRIT	Long Range Identification and Tracking (vessel position data based on telecommunication satellites)
IUU	Illegal Unreported and Unregulated Fishing
MAOC-N	Maritime Analysis and Operations Centre – Narcotics
MRS	Mandatory Reporting System
MSS	EMSA's Maritime Support Services
SADV	Statistical anomaly detection
SAT-AIS	Satellite Automatic Identification System (AIS data transmitted by satellite)
SSN--EIS	SafeSeaNet European Index Server
VDS	Vessel detection system (vessels identified on satellite images)
VHF	Very high frequency (radio signals)
VMS	Vessel Monitoring System (tracking of commercial fishing vessels based on communications satellites)
VOI/ TOI	Vessel (Targets) of Interest
VTMIS	Vessel Traffic Monitoring and Information System
WUP	Web User Portal, also referred to as web user interface

Background

Anomaly Detection and Automated Behaviour Monitoring (ABM) tools are computer-based systems analysing real or near real time vessel position reports (as made available in EMSA's operational maritime applications) for the detection of abnormal and/or user specific behaviours. The aim is to support the maritime surveillance operators, and to provide an increased maritime situation awareness, by providing automatic tools to detect vessels with suspicious or anomalous behavior.Patterns, such as entering an area of interest, encounters at sea, approach to shore, and deviation from the usual route, are detected and operators are automatically alerted in real time via email or through the graphical user interface.

Meeting programme

1. Opening and welcome

The meeting was opened by Mr Lazaros AICHMALOTIDIS, Head of Unit for Information Services/User Management, chaired by Mr Samuel DJAVIDNIA, Senior Project Officer, and supported by other **EMSA** Project Officers. The EU member states and the EU agency actively using or developing ABMs for surveillance purposes attended the meeting. Delegations attended from: **Ireland, Italy, Malta, Sweden and United Kingdom** as well as from the European Agency for the Management of Operational Cooperation at the External Borders (**Frontex**).

Following the opening, the chairman welcomed the participants and introduced the main objectives of the meeting, which were: to gather and share knowledge on the Anomaly Detection Systems and ABMs practical applications, note new requirements for the related existing and future functionalities and discuss a possible framework for the future. The agenda (**Annex 1**) was presented and adopted without change.

The list of participants is presented in **Annex 2**. All the meeting slides and documents may be obtained at: http://emsa.europa.eu/workshops-a-events/188-workshops.html .

2. National and EU Bodies presentations

Sweden - The outcome of the research project on Statistical Anomaly Detection and Visualisation (SADV) in the maritime domain was presented. The main objective of the project was to improve methods to detect vessels with suspicious behaviours for increasing the ability to make more qualitative risk assessments as well as the ability to take immediate action when necessary. Project organization, developments, general architecture as well as the implementation in the Swedish Coast Guard's system (Sjöbasis), and the operator's interface were presented. The current anomaly detection covers:

- Movement pattern - Detects vessels performing abnormal manoeuvres, in terms of the number of stops and turns;
- Rendezvous at sea - Detects meetings between two vessels at sea, when they are of a type not expected to meet;
- Grounding risk - Detects vessels moving outside of normal fairways towards shallow waters.

Practical examples of the above were demonstrated to the participants. The quality of data used for the analysis and challenges in modelling fishing vessels' patterns were also discussed. The SADV was developed as a module with an Application Programming Interface which can be easily adapted to further surveillance systems and easily extendable to both rule-based and statistical anomaly detection systems. It also covers a number of useful anomaly aspects, with high precision and low false alarm rate. It was highlighted by Sweden that SADV is an actually deployed system, integrated with Sjöbasis, and in use by operators. In conclusion Sweden emphasized the benefits of cooperation in regards of use cases, design ideas and if possible a generic framework and architecture for anomaly detection in maritime surveillance systems (**Action 1**). Following detailed discussion with other participants it was confirmed that the SADV could be also applicable for the other areas of interest, such as the Mediterranean or Black Seas, as the system is generic machine learning solution.

EMSA noted, based on the member states' experience and discussions, that there was a high demand for tools that may assist and support maritime surveillance operators. Knowledge-sharing, coherent implementation, and improvements in the area of Maritime Anomaly Detection Systems and Automated Behaviour Monitoring could be supported at EU level. Options for such cooperation and the related actions will be examined (**Action 2**).

Italy – Italy demonstrated their rule-based operational approach in the existing system PELAGUS, where the identifiers, position reports, course and speed are validated against the reference sources (e.g. SSN EIS, CSD, other external databases, etc.) and where inconsistencies are highlighted. The 'forbidden area' tool was also demonstrated. Italy is also considering the statistical-based approach in further anomaly detection developments.

Malta – The operational experience of Malta in the use of the IMS (IMDatE) based ABMs by the fisheries protection authorities was presented. These algorithms are used for the monitoring of fisheries areas and specific types of fishing vessels. For the moment Malta does not intend to develop additional anomaly detection systems.

Frontex –The use of the data and IMS ABMs delivered by EMSA via a system to system interface in the context of the border protection use cases (e.g. analysis of the historical tracks, use of the vessel detection system [VDS] data)was described. The presentation by the agency covered their operational experience, specific use cases, and limitations or improvements to the existing services. Additional requirements were also presented and included, amongst others, combination of the existing ABMs (e.g. transfer of the vessel between two areas of interest - AOI, detection of the switching-off of the AIS transponder in AOI, ship patterns analysis, etc.). From the **Frontex** operational perspective, the anomaly detection capabilities are mainly used by the personnel accessing online user interfaces (JORA).

Ireland – Ireland described the use of the IMS based ABMs for safety purposes, whereby responsible authorities are notified automatically of vessel entries into the Traffic Separation Scheme. The possibility of alerting off-line users (those not working with the graphical user interface) was considered as significant for Ireland.

UK – The UK provided ideas for new developments linked to the analysis of the ship status (Not Under command – NUC) as transmitted in the AIS messages and the related alerting. It was suggested that the MARNIS (Maritime Navigation and Information Services) project, undertaken in the EU 6th RTD Framework Programme, might be relevant in this context, and should be analysed and taken into consideration during future developments (**Action 3**). From the operational experience of UK users, the filtering of the vessels (targets) of interest for specific anomalies detection was an important feature.

Based on the abovementioned discussion with all participants, detailed proposals for the improvement of existing as well as development of the new anomaly detection services are summarized in **Annex 3**.

Following the roundtable discussions, all participants also agreed that in the rule-based approach implemented in IMS, ships missing specific attributes (selected initially in the filters in the ABMs) should also trigger alerts. In practical terms, for the alerting set for 'tanker' type ships, also the vessels without this attribute (type) would trigger alerts.

3. EMSA's Automated Behaviour Monitoring tools: an operational and technical perspective

EMSA presented the existing Automated Behaviour Monitoring tools operational and technical perspective, focusing on: the rule-based approach applied by EMSA, data flows, configuration features and distribution interfaces. All existing, operational ABMs as well as those which are still being validated operationally were described in detail from the operational and technical perspective. The challenges linked to the specific anomaly detections were also explained. Additionally, the topics of timeliness, precision, availability and alerting policy for the anomaly detection and ABMs were discussed with the participants in order to address the detailed operational requirements linked to the existing and future services.

4. Working Groups – discussion on operational needs and practical use cases for the Safety, Security, Fisheries and Environmental communities

Participants were divided into groups to discuss operational needs and practical use cases for the following domains: Safety, Security, Fisheries/Environment. **EMSA** moderated the discussions and noted requirements. The parallel sessions addressed practical scenarios stemming from the experts' operational experience in using or developing the anomaly detection and ABMs.

5. Results from Working Groups and define objectives for a common framework for the future developments

Following the parallel sessions, the groups met in plenary to summarize the results. **EMSA** moderators presented the outcome of the groups' discussions and mapped common requirements. The outcome of the discussions is reflected in the **Annex 3** (requirements) and **Annex 4**.

6. AOB and Conclusions

During the summary session the following common points were expressed by the participants:

- When developing the Maritime Anomaly Detection Systems and Automated Behaviour Monitoring an 'open source' approach could be considered, so that the outcome of the specific projects and developments can be shared and exchanged between EU member states and agencies (maritime domain users), to avoid duplication and ensure harmonization (**Action 4**).

- Regular meetings of the active Anomaly Detection Systems and Automated Behaviour Monitoring users should be considered in order to plan the mid-term future developments, monitor progress and share experience and solutions (**Action 5**).

- Rule-based and statistical approaches should be further studied to identify common areas and gather additional experience. The modification of existing as well as new requirements, discussed during the meeting, should be analysed. Feasibility and implementation plans should be presented at the next meeting (**Action 6**), while the high-priority Use Cases identified during the workshop should be implemented using the existing ABM framework. Validation campaigns should be further performed with a few member state users (**Action 7**).

- Minutes of the meeting will be prepared by **EMSA** distributed to the participants along with the noted requirements and the action points (**Action 8**).

The related action points are presented in **Annex 4**.

The meeting was closed.

Annexes

Annex 1 – Meeting Agenda

Annex 2 – Participants List

Annex 3 – Vessel anomaly detection and ABM requirements

Annex 4 - Action points

Annex 1: Meeting on Maritime Anomaly Detection Systems and Automated Behaviour Monitoring

Room 1.49, EMSA, Lisbon, 02 December 2015

Wednesday, 02 December 2015

Time	Agenda Item	Speakers
09:00	**Welcome and introductions**	
09:00 – 11:00	National and EU Bodies presentations: operational requirements; developments at technical level; lessons learned; needs for the future; success factors.	Member States & EU Bodies (Plenary format)
11:00 – 11:30	**Coffee break**	
11:30 – 12:00	EMSA's Automated Behaviour Monitoring tools: an operational and technical perspective	EMSA (Plenary format)
12:00 – 13:00	Divide into separate Working Groups to discuss operational needs and practical use cases for the following domains: - Safety - Security - Fisheries/Environmental	All (Parallel session format)
13:00 – 14:00	**Lunch**	
14:00 – 15:30	Continuation of Working Groups: - Safety - Security - Fisheries/Environmental	All (Parallel session format)
15:30- 16:00	**Coffee break**	
16:00 – 17:00	Present results from Working Groups and define objectives for a common framework for the future development of ABM at both operational and technical level	All (Plenary format)
17:00 – 17:30	AOB and Conclusions	All (Plenary format)
17:30	**End**	

Annex 2: Participants list

Shane Dillon, Irish Coast Guard, Ireland
Giuseppe Aulicino, Italian Coast Guard, Italy
Marco Patrick Mincio, Italian Coast Guard, Italy
Christopher P. Sciberras, Dept of Fisheries and Aquaculture Malta
Peter Ryman, Swedish Coast Guard, Sweden
Lennart Dreier, Swedish Coast Guard, Sweden
Anders Linse, HiQ, Sweden
Staff Officer VTM, Maritime and Coastguard Agency, UK
Marcin Pempus, Frontex
Daniel Hernandez, Frontex
Samy Djavidnia, EMSA
Paulo Neiva Fernandes, EMSA
Andrea Pelizzari, EMSA
António Rocha, EMSA
Lukasz, Bibik, EMSA
Dario Cau, EMSA
Justino De Sousa, EMSA
Stephanie Seddon-Brown, EMSA
Lazaros Aichmalotidis, EMSA

Annex 3 – Vessel anomaly detection and ABM requirements

No	Community (ies)	Requirement	Comments/ Additional elements or improvement of the existing services
1	All	The anomaly detection and automated behaviour monitoring should cater for both: (1) back-office, less regular, off-line users, as well as (2) the users accessing the system via on-line interfaces.	New Availability, timeliness and alert policies should reflect different kind of users
2	All	Specific data set access rights should be reflected in the anomaly detection and automated behaviour monitoring.	Existing
3	All	Anomaly detection and automated behaviour monitoring users should be divided into: (1) administrators, setting specific anomaly detections (e.g. Member State or EU level) and (2) clearly defined end-users who are entitled to receive specific alerts.	New
4	All	There shall be a high quality of data ensured in the reference sources of information linked to the anomaly detection and ABMs to avoid false detection and alerting and unnecessary burden to the system.	New Additional validation of data, quality, related monitoring and checks should be applied to the reference sources of data.
5	Environment, All	Monitoring vessels entering and exiting Marine Protected Areas (MPA)	Modification of the existing ABM Allow upload of the MPA areas by the ABM admin.
6	Environment, All	Monitoring traffic in the vicinity of pipe lines/underwater cable lines	Modification of the existing ABM Consider feasibility of the modelling of the areas of interest in the vicinity of the pipe lines/underwater cable lines
7	Fisheries, All	Add another filter level for the definition of the vessels of interest – Length Over All (LOA) in all surveillances	New
8	Fisheries, All	Improve the speed anomaly detection ABM to detect the temporary change of speed to a certain value (e.g. 5 kts)	Modification of the existing ABM
9	Fisheries, All	Combine the existing ABM to reflect new types of behaviours e.g. change of speed with at sea encounter or ‘InArea’ - leaving one area of interest and entering another specified area of interest.	New
10	Security, All	Add exclusion criteria in the existing ABM, i.e. alert for all vessels but exclude specific identification or vessel type	New

No	Community (ies)	Requirement	Comments/ Additional elements or improvement of the existing services
11	Security, All	Alerting for ship coming from a particular port/area and entering areas of interest; Ship heading to a particular port/area and passing areas of interest; Ship leaving one specific port/Area and entering in a another area/port	New
12	Security, All	Include the Terrestrial AIS coverage area	Modification of the existing ABM The Terrestrial AIS coverage areas needs to be provided by MS.
13	Security, Safety, All	Detect when AIS transponder has been switched off. Additional attributes to be considered for the detection are – T-AIS coverage area and no-reporting duration	New
14	Security, All	Improve the detection of the change of heading and speed	Improvement of the existing ABM
15	Security, All	Detection of the identity spoofing	New
16	Security, All	Detection of the geographical position spoofing	New
17	Security, Safety All	Ship Profile changes alerting, for example for the selected vessel alert when additional, vessel related attributes changes are detected, like: change of the owner, flag, PSC report/ data changes, deficiencies, crew, vessel with a certain age, etc.	New
18	Security, All	Detect the deviation of the most used/economic route	New
19	Security, All	Vessel stationed/ idle in the AOI (e.g. close to Port) without entering port for a long time	New
20	Security, All	Change of the voyage related data: ETA, destination,	New
21	Security, All	Improve detection of the at sea encounter, exclude specific vessels/ criteria	Improvement of the existing ABM
22	Safety, All	Lost target – lack of position reports of any kind	New
23	Safety, All	Public media monitoring for the detection of the unreported incidents/ accidents	New

No	Community (ies)	Requirement	Comments/ Additional elements or improvement of the existing services
24	Safety, All	Change of the specific AIS attributes in the transmission	New
25	Security	Apply a combination of several algorithms (e.g. sudden change of heading with rendezvous at Sea) and allow to apply a set of algorithms for vessels of interest.	New
26	Security	Discrepancies between declared voyage and track of a ship, e.g., the vessel track and its current location does not match its destination.	New

Annex 4 – Action points

No	Action	Responsible	When
1	Consider and propose a generic framework and architecture for anomaly detection in maritime surveillance systems.	EMSA	Proposal to be presented during 2016
2	Examine options for supporting the cooperation and developments in the area of the expanded anomaly detection and ABMs.	EMSA	To be consulted with the COM and MS before/during one of the SSN HLSG meetings in 2016
3	Explore and reflect the MARNIS project experience as a reference for the future developments in the anomaly detection and ABMs.	EMSA and UK	To be presented at the next meeting in 2016
4	Examine a possibility of adopting an 'open source' approach for the anomaly detection and ABMs, so that the outcome of the specific projects and developments could be shared or exchanged between EU member states and agencies.	EMSA and MS	Results to be presented at the next meeting in 2016
5	Agree on the next meeting of the active Anomaly Detection Systems and Automated Behaviour Monitoring users.	EMSA and MS	3 months before the next planned meeting, possibly during the first half of 2016
6	The modification of the existing as well as the new requirements discussed should be analysed. Feasibility and implementation plans should be presented at the next meeting.	EMSA	To be presented at the next meeting in 2016
7	To implement some of the high-priority Use Cases identified during the workshop using the existing ABM framework and perform a validation campaign with a few MS users	EMSA	During 2016
8	Prepare and distribute MoM.	EMSA	During January 2016

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