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SCANMARIS

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ABSTRACT

The SCANMARIS project is a software workshop conceived to develop and evaluate solutions of prevention and monitoring the maritime borders. It relies on tactical picture exploitation tools, known as enriched for resulting from the continuous treatment of important volumes of heterogeneous data gathered in real time and differed time. SCANMARIS allow supervising the permanent evolutions traffic on a global maritime zone in order to follow the flow of transported goods (bulk, containers, energy, chemical....) according to various routes (corridor, coastal traffic...) and to automatically detect criminal traffics of illicit products.

SCANMARIS uses data treatment tools to merge ship's data kinematics and other information to establish and maintain a global enriched tactical picture compilation of the traffic, the training methods and the models which exploit the tactical picture. This increase a permanent knowledge of the goods flows, to improve its follow-up, and the rules of investigation organised to detect irregularities like the illicit products flows, disasters, regulation violations, etc.

SCANMARIS project involves functions that improve the effectiveness of a global surveillance of the contraveners. They will contribute to set up optimal answers and intervention means well fitting the struggle against terrorist threats, illicit activities and maritime violations.

CONTEXT

Maritimes activities, and more generally sea-related issues, are of the utmost importance for the European Union (EU). As a matter of fact, its shoreline is approximately 150,000 km long (even

more than that of United States) and the maritime regulated zones under Member States' jurisdiction is larger than their terrestrial territory. As maritime spaces are more and more exploited and maritime activities move further from the coast, management and surveillance of territorial waters (up to 12 nautical miles) are not sufficient anymore. Member States have now a vital interest in their Exclusive Economic Zones (EEZ) which extends to 200 nautical miles (370 km) from the coast. However, vessel traffic monitoring is currently unable to be extended efficiently to such a range.

This priority can be explained by the fact that over two thirds of EU's borders are coastal and that 90% of the EU foreign trade and 43% of its internal trade are transported by sea. This represents 3.5 billion tons of cargo and 350 millions of passengers per year. The map below (Figure 1) establishes a comparison between trade by road and by sea. A blue line represents, in tons of freight, for the same size, twice as much as a red line, thus revealing the importance of maritime freight transport.



Figure 1: European ocean and short sea shipping routes

OBJECTIVES

Maritime terrorist threats and criminal activities become more and more organised. So, future solution should be set up for illicit activities such as clandestine immigration, terrorism, and trafficking of drugs, weapons and illicit substances. Indeed, maritime traffic is peculiarly well suited to the development of illicit activities. For example, illegal migrant prefer maritime routes because they can enter through long sea borders where they can hardly be detected. Around 500.000 people enter the EU illegally every year, with few entry points: the Strait of Gibraltar, Italy and Malta islands, etc. The economy based on illegal migrants has generated \$10 billions per year, placing it just after weapons and drug traffic.

Moreover, EU has no coordinated security approach on this matter as yet and is not currently able to track and monitor every ship in order to detect abnormal or illicit behaviour. This is why a common surveillance solution allowing Member States to track and fight illicit behaviours on a wide maritime area is imperatively needed.

Then, technical objectives of the SCANMARIS project are to provide a new generation of maritime surveillance solution allowing:

- Overall and permanent coverage of the Exclusive Economic Zone (EEZ).
- Continuous collection and fusion of heterogeneous data provided by various types of sensors and external data sources.
- Supervised automatic detection of illicit behaviours.
- Compliance with the relevant national and EU legal requirements (privacy, data storage, proof gathering...).

No equipment deployments and data exploitation systems are currently able to answer all these requirements. However, progress has been made in long range sensors, heterogeneous data fusion and compartmental behaviour that could be usefully merged to build an innovative maritime surveillance solution for security applications.

SCANMARIS project will study, develop and experiment advanced algorithms to learn various vessel compartmental behaviours (Learning Engine) and to automatically extract abnormal behaviour (Rule Engine), such as terrorist thretas

and illicit activities, from a global enriched operational tactical picture compilation of the vessel traffic over a wide area.

TERRORIST THREATS AND IMPACTS

Immediately after the devastating September 11th World Trade Centre attacks in New York, governments around the world scrambled to assess their vulnerability to highly organised terrorist groups willing to sacrifice thousands of lives to achieve their aims. The risk of mega terrorism, once a spy novel fantasy, suddenly became very real, and maritime transport system loomed large in eyes of securities agency worldwide as a prime target and/or vehicle for future attacks.

In EU foreign and internal trading, one of the principal special concerns is bulk liquid shipment (ranging from crude oil, distilled oil derivatives and liquefied natural gas to molasses and vegetable oil). While the destructive potential of these cargos is great, terrorist attacks could have strong direct effects on critical transport infrastructures such as shipping lanes, vital energy procurement and thus highly disruptive consequences on EU states business.

Policy makers also frequently cite passenger ferries and cruise as attractive to terrorist because such attacks are easy to execute, may kill many people, would likely draw significant media attention, and hence, high public awareness and strong psychological impact.

As an example of potential terrorist actions, these previous dangers highlight the combined potential for a bulk liquid shipment to be used as a weapon in a terrorist attack against ferry or cruise just as jet aircraft were used in 2001 World Trade Centre attacks. These combinations of targets, then, would cause as much as possible loss of life and at the same time would disrupt worldwide national energy procurements by threatening vulnerable trade routes.

As we face the varied threats of terrorism and other lucrative criminal activities, future and innovative solutions shall be set up to permanently track and monitor critical ships and vulnerable trading lanes in order to early detect abnormal or illicit vessel behaviour. These new generations of maritime surveillance solutions will allow:

- Overall, permanent and all weather coverage of wide maritime areas.
- Continuous collection and fusion of heterogeneous data provided by various types of deployed sensors and external information sources.
- Supervised automatic detection of abnormal vessel behaviours (track and activity).
- Analysis of the nature of suspect event suite of spatial and temporal abnormal behaviours.

Again, no equipment and information system deployments are currently able to answer all these requirements. However, significant technical progress has been made in wide maritime area coverage by different sets of sensors, heterogeneous data processing and fusion, and detection of abnormal behaviours that could be usefully merged together to built an innovative ocean and short shipping routes surveillance solution for efficient security applications.

DETECTION OF ABNORMAL BEHAVIOR

The SCANMARIS solution is based on the assumption that illicit behaviours are very often hidden behind a law-abiding facade: fishing boats involved in illegal immigration for example. SCANMARIS's approach consists in defining official licit objectives, and then applying an Adaptive Multi Agent System (AMAS) method to determine how activities will have to be organised to better answer these objectives (shortest itinerary, safest route, etc.). By deduction, activities that cannot be explained by the will to better achieve an official licit objective will be considered suspicious, and be labelled abnormal by the system.

Fused data acquired from deployed sensors over a large maritime zone (conventional coastal radar, AIS, HF long range radar, etc.) are combined with auxiliary information coming from on line databases (TRAFFIC 2000, LLOYDS, EQUASIS, SATI, etc.) or intelligence, to built an enriched traffic picture where track for each detected vessel are associated to auxiliary information (name, flag, type, operator, owner, tonnage characteristics, etc.).

Then, both the Learning Engine built on the AMAS (Adaptive Multi Agent System) theory and a Rule Engine access these data. The Learning Engine will process these data and assess the behaviour of

each ship indicating three states: licit behaviour, abnormal behaviour and unknown. The Rule Engine uses both this assessment and the direct result of the data fusion process and analyse them using defined rules established to detect abnormal behaviour. For example these rules allow defining transshipping, coupling, shifting of speed/course, etc. Also, systematic coherence tests on all the acquired data are undertaken by the Rule Engine, for example, AIS code discrepancy with similar information in the LOOYDS data base, etc. The Rule Engine issues alerts to the Man Machine Interface. The operator manages each alert, provide a feedback to the Learning Engine, and precise if the behaviour having triggered an alert is ultimately to be defined as "licit", "illicit" or "unknown", possibly after enquiry to experts.

HFSW RADAR

Current systems are based on a non permanent multi-sensor coverage, encompassing networked coastal radars that cover 50 to 70 km, mobile radars or IR cameras on surveillance boats or aircrafts, etc. The EEZ is never entirely and permanently observed, and the zones that are partly covered necessitate a costly deployment of numerous mobiles sensor platforms (boats & aircrafts). The SCANMARIS project intends to experiment cost-efficient sensor coverage, introducing set of complementary sensors with improved ranges. The goal is not to replace the entire sensor cover currently in use: that would be an unnecessary and unrealistic financial waste. But the SCANMARIS project aims to propose add on sensors, that serve to improve detection range and release currently monopolised mobile sensor capacities that could be better used elsewhere or otherwise (surveillance aircrafts are better suited to specifically targeted recognition missions for example).

ONERA deployed during the first quarter 2007 a promising long range HFSW (High Frequency Surface Wave) radar in the Bay of Biscay. The HFSW radar is composed of an omni-directional transmitting antenna and an array of reception of 16 passive antennas. The transmission and the reception system are entirely numerical. The design allows focusing the reception beam in several directions inside a domain with an aperture of +/- 45 degrees.



Figure 2: ONERA HFSW radar

During the project, the HFSW radar at Biscay is run to realise various trials in order to obtain data usable for the multi sensor (HFSW and conventional radars, AIS, etc.) data fusion process to built representative traffic picture over wide maritime area.

SCANMARIS ARCHITECTURE

The SCANMARIS system is structured in three data processing layers. Each of them elaborates value added traffic picture up to the detection of abnormal behaviour.

The figure 3 provides the architecture of the SCANMARIS system.

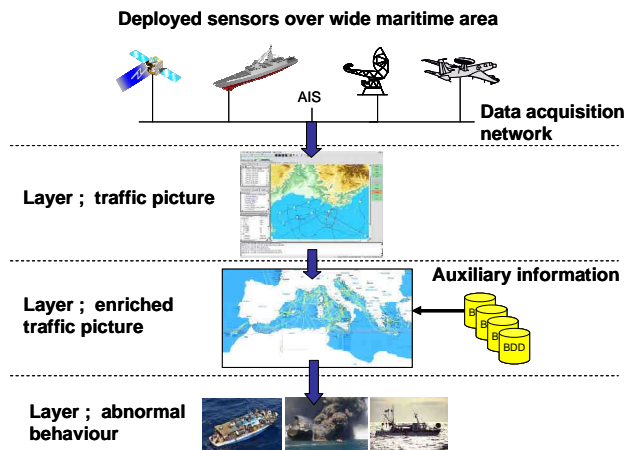


Figure 3: SCANMARIS architecture

The SCANMARIS solution is made up from data treatment tools to cross and amalgamate the measured ships' data kinematics in a global traffic picture, and auxiliary information in order to establish and to maintain a global enriched tactical picture compilation of the sea traffic, the training methods and the models which exploit these pictures. This is organized in order to acquire a better permanent knowledge of the flows of transported goods, with an aim to improving its follow-up, and the rules of investigation to detect

irregularities like the flows of illicit products, disasters, violations of regulation, etc.

This system and transverse approach of the maritime safeguard at the borders (Homeland Safety and Protection against actions of the malevolent type) calls upon multi-field competences which are capitalized in a grouping of complementary partners. The partners are industrialists (DCNS, SOFRESUD, and ECOMER), academics (IRIT, ENMP, ONERA, Centre of Maritime Law and Transport) as well as operational actors of the maritime safeguard (Prescriber and Operators of the Maritime Businesses Direction of the Ministry for Transport).

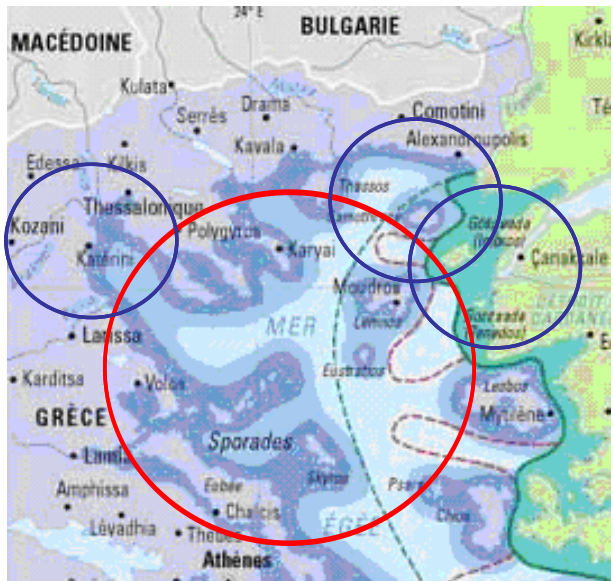
For the enriched traffic picture compilation, the heterogeneous data treated, crossed and amalgamated are:

- The geo referenced observations performed in real time by deployed sensors (coastal radar, long range radar, AIS, satellite imagery, etc.).
- The information extracted in differed time from the on line data bases as TF2000, LLOYDS, EQUASIS, TROCS, SATI, Paris Mou,etc
- The zoning of maritime space (territorial water, contiguous, economic exclusive, ecological protection, surface of seasonal fishing, opens sea, etc.).
- The weather conditions (visibility, nebulosity, wind, etc.) and the oceanographic parameters (wave height and direction, sea surface temperature, surface current, etc).

TESTING SCENARIO (TERRORIST THREAT)

To illustrate the future SCANMARIS outputs, a fictive terrorism threat scenario is presented. The goals are to demonstrate that fused data from different sources contribute to detection and expertise of abnormal behaviours.

The maritime zone is the Aegean Sea where numerous ferries and tankers are navigating. The figure 4 provides the possible deployment of the conventional coastal and HF radars to observe the entire area.



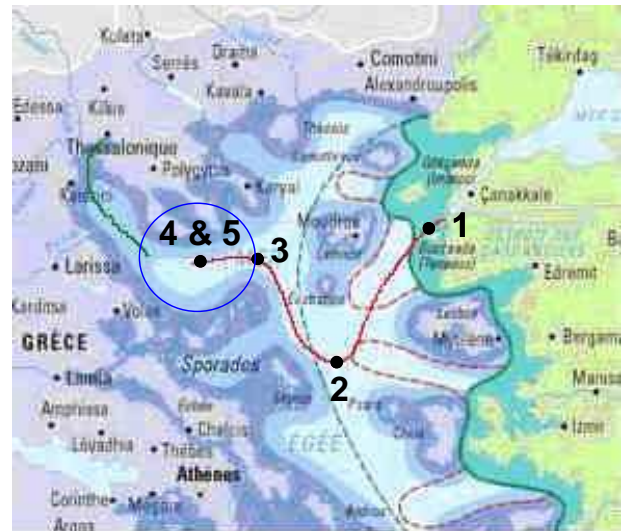
-  Conventional coastal Radar coverage
-  HFSW Radar coverage (located on Piperi island)

Figure 4: Radar coverages of Aegean Sea

The successive abnormal behaviours detected are:

- N°1; Southern mouth of the Bosphorus; tanker boarding by a fast boat (after the return of the pilot boat).
- N° 2; 5 hours later significant tanker change of course of the tanker in open sea.
- N°3; 2 hours later another tanker significant change of course in open sea.
- N°4; 3 hours later tanker stops at the limit between the open sea and Greek territorial water.
- N°5; 1 hour later tanker shifting of speed and course while entering into Greek territorial water.

The chart below gives the tanker's route history, including localisation of the anomalies and the ferry's itinerary.



-  Tanker track
-  Ferry track
-  Tanker radar coverage

Figure 5: Tanker track and anomalies

In the timeline of the events, data are acquired to provide auxiliary information in order to expertise the encountered anomalies and upgrade the alert level until decision for intervention. These information are:

- The Ataköy marina (650 harbour berths), destination of the fast boat, is located near the Atatürk international airport.



Figure 6: Ataköy marina

- From the LLOYDS on line data base is downloaded the tanker file.



General Information

Name : XX
 IMO : 65348703
 Flag : Bahamas
 Type : Combination
 Subtype : Bulk/Oil Carrier
 MMSI : 308954333
 Callsign : C6SH4
 Operator : XX
 Owner : XX
 Manager : XX

Tonnage Characteristics

Deadweight tonnage : 80394
 Gross tonnage : 100232

Engine Characteristics

Engine type : Motor Diesel
 Engine number: 2
 Service Speed : 18/25

Structure Characteristics

Length overall/Draft : 243/17.62
 Beam/Depth : 32.25/20.10
 Sea way : Odessa to Arzew

Liquid Capacities

Liquid : 86345
 Tanks : 11

Figure 7: Tanker descriptive file

- The ship-owner of the tanker is contacted and gave the information stating that the oil tank is empty. The last report communicated by the captain, nothing to declare, is date one day before.
- The sailing conditions in the vicinity of the Gulf of Thermaikos are goods with a maximum wave height of 1.5 meter.

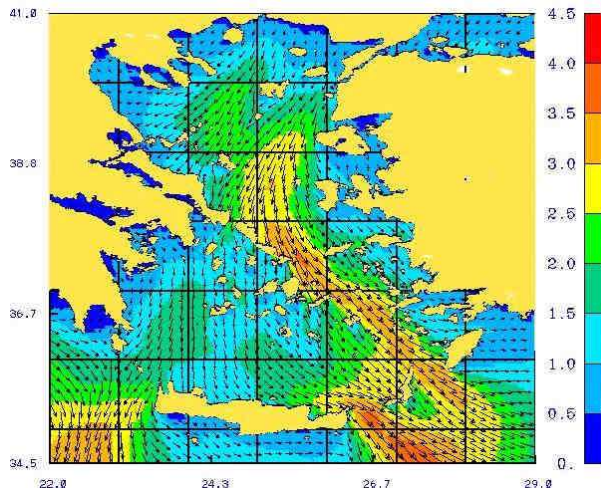


Figure 8: Wave height and direction

- Port of Thessaloniki is contacted and informs that the ferry has onboard 1350 passengers and 238 vehicles.

As soon as the second anomaly had been noticed, the Hellenic Merchant Navy Ministry and the Turkish Ministry for Transport have been informed to activate their terrorism reaction plans.

The chronology and the nature of the detected abnormal behaviours of the tanker present the following profile:

- Boarding of the tanker by pirates/terrorists at the Southern mouth of the Bosphorus.
- Diversion of the tanker in open sea.
- Threat of collision, attack/destruction by night, while approaching the Gulf of Thermaikos (Greek territorial water) of the ferry and its 1350 passengers while ensuring the regular night connection; Thessaloniki to Spokelos.

After the detected fifth anomaly the alert is granted top level, then, recommendations formulated by the decisional authorities are:

- Combined immediate action recognition and air intervention.
- Support by the navy and installation of backup facilities at sea for passengers in distress.
- The tanker is empty and the environment risks (pollution by oil) are very limited.

CONCLUSION

The SCANMARIS project is the result of a deeply analysis of the needs and requirements of EU member States in terms of maritime security pursued by the partners consortium on the basis of various publicly available pieces of information, such as for example the EU Green Paper or the ESRAB Report. Following this analysis, the consortium has come to the conclusion that an efficient solution in the field of surveillance of wide maritime area would have to encompass the following features:

- New sensors capabilities provided by long range high frequency radar (HTSW) in order to permanently monitor vessel traffic over wide area.
- Innovative data fusion tools to generate continuously enriched operational traffic picture.
- Innovative compartmental behaviour learning and detection of anomaly based on Adaptive Multi Agent System (AMAS).

Then, the technical components studied, developed and evaluated within the SCANMARIS project shall allow improving the effectiveness of an overall monitoring and detection of the contraveners in the frame of increasing and complex vessel traffic. They will thus contribute to set up optimal solution well adapted to the struggle against disasters, terrorist threats, illicit activities and violations to the regulations.

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