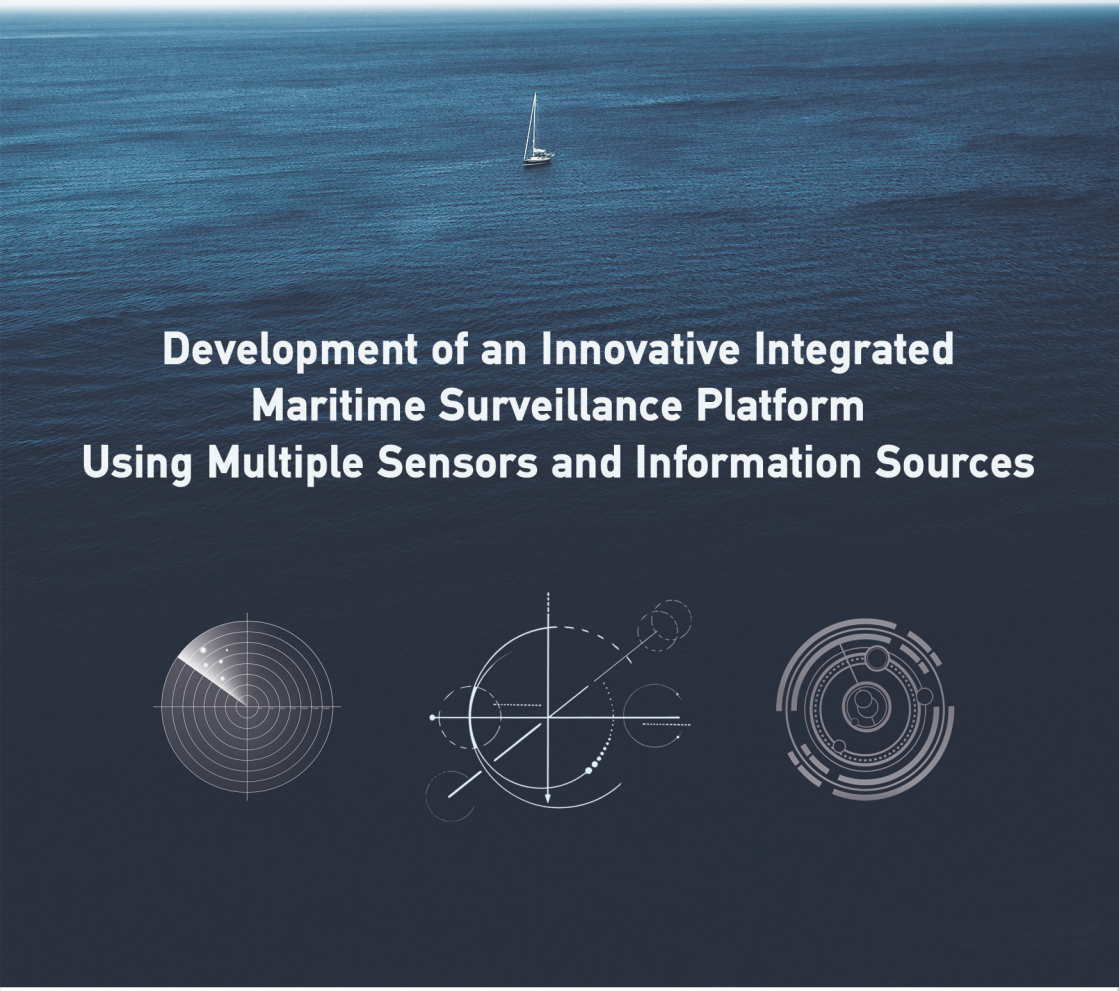
BORDERSAFE

Κωδικός Έργου: **T2ΕΔΚ-00232**



Development of an Innovative Integrated Maritime Surveillance Platform Using Multiple Sensors and Information Sources

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INTRODUCTION

Maritime surveillance is carried out by national authorities, mainly to detect and prevent regulatory violations and security threats. Surveillance is a key element in the exercise of national sovereignty at sea and is carried out for various reasons such as, fisheries control, environmental protection, maritime transport security, border control, illegal immigration control, etc. (Bosilca 2016) Today, maritime surveillance can be implemented using a variety of methodologies and tools, using either cooperative systems (in which ships themselves report their identities and positions), such as the Automatic Identification System (AIS), Long Range Identification and Tracking (LRIT) and Vessel Monitoring System (VMS), or non-cooperative systems, which do not demand any action from the side of the ships. The latter typically use cameras or radars installed on platforms (e.g. ships, airplanes, satellites) (Serco Italia SPA 2018). Although many systems have been implemented to date for maritime traffic surveillance (VTMS, SAFESEANET), fishing vessels surveillance (VMS), and collision avoidance (AIS) (European Maritime Safety Agency 2021; Wawruch 2017), there is no provision for interoperability between them. At the national level there are many different systems that are a source of information for the Hellenic Coast Guard about activities at sea, but without any integration/interoperability among them (KEMEA 2013). Within this context, the paper presents a single multi-layered platform for monitoring various parameters, threats and events, gathering the overall picture of the maritime domain on a single platform.

The Border Safe Platform is based on the research effort of the Border-Guards system, which aims to find alternative affordable options, able to offer fast and low-cost reliable solutions, to meet the imperative needs of surveillance of the national maritime space. Thus, the guiding principle of the present research effort is focused on the reasoning that the multifaceted nature of the study area requires the use of an ever-growing and expanding network of multiple sensors and information sources. The sensors supporting the system can include any useful types (e.g. radar, AIS receivers, cameras, drones, etc.), should be low cost (purchase and operation) and easily replaceable (off-the-self). The system will be interconnected via the internet, without excluding other forms of interconnection, such as Wi-Fi, radio links, etc. The system should also monitor developments in the field of Earth Observation (EO) and develop its ability to exploit information derived from satellite data. Finally, it uses any online sources of information capable of enriching the situation awareness picture (e.g. meteorological and oceanographic data, historical statistical data, etc.). The functions of the platform will be the real added value in research and

technological development, in all stages of risk management-event detection, alarm warning, data fusion-continuous tracking (e.g. weather conditions, fires, environmental pollution on land and sea, refugee flows, shipwrecks, criminal activities, etc.), and notification of persons in charge, with applications to surveillance technologies.

In this paper, the following sections discuss the design of the platform and its main features and functions. More specifically, after an introduction to the study area and the existing maritime surveillance systems, the Border Safe platform is described in detail. Finally, future research steps and conclusions are summarized in the last sections.

Current Situation and Needs in Maritime Surveillance

The surveillance of the national maritime space, which is also the EU's external maritime border, close to the destabilized Middle East and North Africa, is undoubtedly a difficult and complex task. Especially today, as the region is under extremely high pressure, from the large wave of migration flows to the EU. The extensive coastline, about 18.400 kilometers, both continental and that of the numerous islands and islets (about 9.000) which are scattered in the seas surrounding the country, create the most favourable conditions for border violations. This is not only related to migrant smuggling, but also includes other smuggling activities, such as smuggling and trafficking of fuel, cigarettes, drugs and weapons. The maritime trafficking and border violations observed in the region are unfortunately complex, compared to other Mediterranean regions. This is due to the fact that distances between the point of departure and destination vary, from very close (e.g. Eastern Aegean Islands-Turkey), where they allow the use of dinghies or other small vessels, to long where larger vessels of almost all types are involved. These conditions create the need for systematic surveillance of the extensive maritime border zones, far exceeding the capabilities of the limited patrolling means of the Hellenic Coast Guard. The situation becomes even more complex, due to the intense international and local shipping activity that takes place in the area (Fig.1). The first concerns international maritime transport with ships of all types crossing the Greek seas. At least 50.000 ships pass through the Aegean Sea every year, as it is a corridor between the Mediterranean and the Black Sea (Pavlakis 2006). The second concerns coastal shipping connecting the islands to the mainland and to each other, as well as intensive fishing and recreational activity including cruise ships, yachts and pleasure boats.

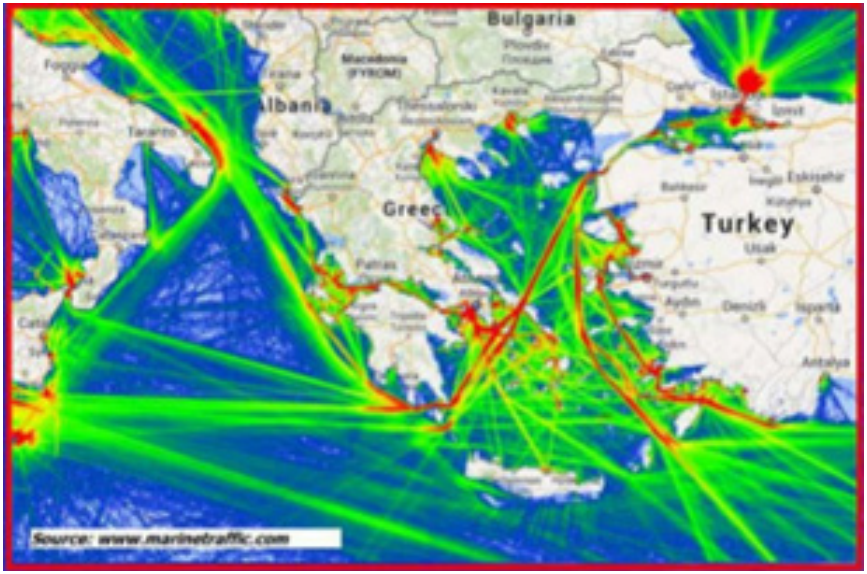

Figure 1. Shipping density based on AIS data
Source: MarineTraffic 2023

Thus, the particularities of the area require, as a key element of an integrated surveillance system, the ability of distinguishing between non-cooperatives and cooperative vessels, i.e. those that comply with AIS signal transmission requirements and those that do not transmit or transmit with long interruptions. It is obvious that in order to achieve this goal, in addition to an extensive network of AIS receivers covering the area, which already exists to a large extent, the ability to detect ships moving in the area is also required, through independent sensors such as radars. This refers to an integrated system such as VTMIS (Vessel Traffic Monitoring and Identification System). In 1996, the development study of the national VTMIS system was completed, for the development of VTS (Vessel Traffic Service) centers in the wider Greek maritime area. Based on this study, an international tender was announced in 1998 for the implementation of the first phase of the national VTMIS (Dalaklis, Siousiouras, and Nikitakos 2009; PoliceNet 2014). Although the first phase of the national VTMIS has been implemented, it only covers the Saronic Gulf, South Evia, a small part of the Central Aegean Sea, the Gulf of Patras and the sea zone between Corfu and Igoumenitsa (Fig.2).

Figure 2. National VTMIS system.
Source: PoliceNet, 2014

Unfortunately, the second phase, which is planned to cover areas of the Eastern Aegean Sea and the straits of Kythira and Karpathos has not yet been implemented. However, as shown in Figure 2 even when second phase is implemented, extensive areas of Greek seas will remain unmonitored, continuing to be a fertile ground for illegal activities.

System Concept & Vision

Border-Safe platform is being developed in a continuum perspective to cover the border security of Greece both in the terrestrial and maritime domain, in an open architecture and with prospect to be expanded in the future, over the entire national border space. However, for the purposes, of designing and development, in the frame of the project, it will be focused over the Eastern Aegean Sea and Evros Region.

Telecommunication technologies: To support Border Safe border security services, the telecommunication network is based on (a) space communications broadcast techniques, using the Digital Video Broadcasting (DVB) standard and Single Channel Per Carrier (SCPC) transmission mode, (b) mobile communication in a local area scale if available through Global System for Mobile Communications (GSM) based transmission mode and (c) on terrestrial communication using any Internet Protocol (IP) based wired connection.

Secure Operational Interface: Several applications will be integrated into the system including - Video tool for UCB - Video conferencing, which is a real time multimedia application for conferencing over IP internet. The video conferencing and (visual and thermal) camera data reception is designed with a flexible and extensible architecture to support heterogeneous environments and configurations. Real time feed will also be able to be transmitted to the border control units of the Border-Safe solution at their mobile devices (pdas, mobiles, tablets).

Audio conferencing and streaming applications allow users to participate in audio conferences over network. These can be between two participants directly, or between groups of participants on a common group. This functionality requires no special user (patrol, command unit) configuration for point-to point communication, just a network connection and a soundcard or a respective mobile phone enabled device (GSM or satellite).

For irregular border crossing analysis or patrol crisis situation management all parties involved are called to assist in delivering effective solution (command, patrol, experts, and political supervisors). They are called on the command center premises and they operate through the Border-Safe system. Different applications are stored into two different displays for ease of use.

The main purpose of the generic interface is to launch applications and ser-

vices used in the Border-Safe project for collaboration and communication between the border sea and land units. The main characteristics of this application should be:

- Support for all platforms used in the Border-Safe project (PC, mobile and tablet devices).
- To accommodate this feature, platform independent technologies like internet technologies have been used for the development of the system.

Technical Description

Border Safe platform covers a wide range of functions, mainly interoperable with advanced technology systems, in order to display complex geographical information. The core of the system is the online GIS (Geographic Information System) database to provide static, dynamic and real-time information. Earth observation (satellite imagery), georeferenced imagery and analysis are included as part of the overall performance. The system can also connect to existing available infrastructure services and sensors (e.g. AIS, LRIT, VTS, radar, cameras, weather stations, etc.) and other available monitoring sensors (mobile or fixed IR and thermal sensors, etc.). It is therefore an open architecture system where all sensors can be connected to detect data, information, alarms and hazards, either in real time or near real time, to support decision making. Additionally, it enables alerts to be detected, and real-time decisions will be made for local patrols, emergencies and other risk issues that affect border security decisions. Available information can be relayed by two-way communication with local patrols, ships, and other relevant personnel. The architecture of the system is such that it allows the connection of any sensor (radar, AIS, fixed camera, drones, etc.) so that any arrangement of any number of sensors is possible at any time. Figures 3, 4 and 5 show the main functions/interfaces of the platform. Google maps are used as the main cartographic background.

Figure 3. a) Map type selection (left), b) Meteorological data processing/visualization options (right)

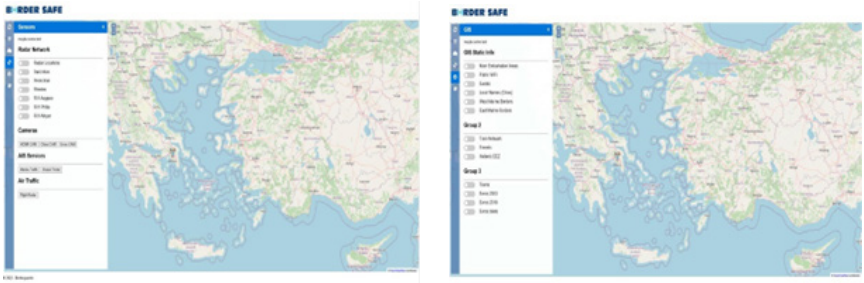

Figure 4. a) Data processing/visualization options from radars, cameras and AIS services (left), b) GIS geospatial data processing/visualization options (right)

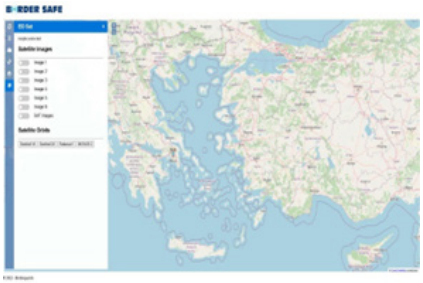

Figure 5. a) Satellite data processing/visualization options

A key element of the developed system is the real-time radar image transmission (Fig. 6a). This allows independent perception of shipping traffic so that potentially suspicious vessels that do not comply with the obligation to transmit an AIS signal can be detected. Through the "Sensor" tool, users can display the green menu, where they can choose the sensor they want to view in the system interface (Fig. 6a). In this phase of system development, the radar image

is experimentally obtained only from the Saronic Gulf, through a radar installed at HCMR (Hellenic Centre for Marine Research) central facilities in Anavyssos (Greece). It is a simple navigation radar, (FURUNO type), whose signals are channeled to the internet through independent digitization. This type, in combination with any other type of radar (e.g. more accurate), it can also be placed in other coastal locations. Thus, this original and alternative system can be systematically expanded and extend the surveillance coverage of marine areas with more sites.

The system also provides the options to display AIS information, either from an independent receiver (e.g. installed at the radar site) or from other providers (e.g. Marine Traffic, Vessel Finder, etc.) (Fig. 6b). Display options are also completed by displaying real-time images from cameras of any type (Fig.6c).

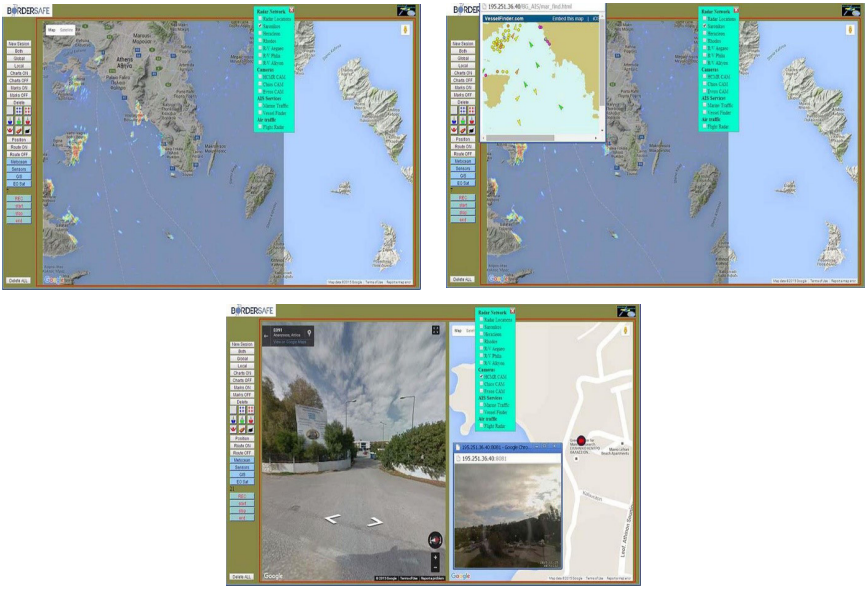

Figure 6. The Border Safe interface: a) Real-time radar image from the Saronic Gulf (left), b) Real-time radar image and AIS information from Vessel Finder (right). c) Real-time image from a camera placed at the entrance of the HCMR facilities (center).

The system is simple in its design to allow for continuous improvements and additions. It is also designed to operate autonomously, without dependencies on special commercial softwares, so that periodic upgrades and additional costs are required. Most of it is based on open source software, e.g. the central server runs in the freely available UNIX environment and implements indus-

try standard OGC (Open Geospatial Consortium) protocols such as Web Feature Service (WFS), Web Map Service (WMS), and Web Coverage Service (WCS) for sharing geospatial data (Open Geospatial Consortium 2023a). It has a user-friendly interface and no specialized computer skills are required. Authorized users will be able through the interface to import, search, edit and export data, as well as import and export metadata using the Keyhole Markup Language (KML) coding standard, so that metadata can been transferred among systems of different suppliers. KML is complimentary to most OGC standards, including GML (Geography Markup Language), WFS and WMS (Open Geospatial Consortium 2023b).

It is based on Service Oriented Architecture (SOA) principles (Wikipedia 2023a). More specifically, the subsystems that constitute the platform can interoperate through web services and share their information with other subsystems. For example, the meteorological station data sharing subsystem can receive data via API (Application Programming Interface) from various meteorological stations but also send processed data from Border Safe to meteorological centers, provided that they can interoperate through their own APIs with the Border Safe API. The term API defines the set of web services than an application uses to interoperate with other applications (Wikipedia 2023b). The Border Safe API consists of web services per subsystem and will be developed as a ReST API that will use JSON (JavaScript Object Notation) format to transfer information.

The system administrator can manage users of the database, in particular, create new users or groups of users and assign them access rights, as well as modify data or rights of a user or group of users. Finally, regular backups are provided through a scheduled process to ensure proper system functioning in case of error (e.g. cyberattack, etc.).

Additions and Improvements

The extensibility of the system, which was also the strategic goal of the platform, as well as the other visualization options it provides, make it a central core, to which other functions can be added or connected. Such an example, is the Decision Support System, through communication and information display, between surveillance and patrol units. As already mentioned, the system is simple in its design to allow for continuous improvements and additions. These features allow easy adaptation to user requirements, as well as modular attachment of new functions. Such functions include the option to display nautical charts as a cartographic background (in progress) (Figure 7a). This function is

activated through the "Charts On" tool on the left of the screen. By bringing the cursor over the map display (right) and using the "Charts On" tool, users can display the local nautical chart of an area. Figure 7b shows the course display option, in the case that a user is in motion (e.g. boat) and the device being used (e.g. laptop, tablet, etc.) supports GPS location. This function is activated and de-activated through the "Route On" and "Route OFF" tool respectively on the left of the screen.

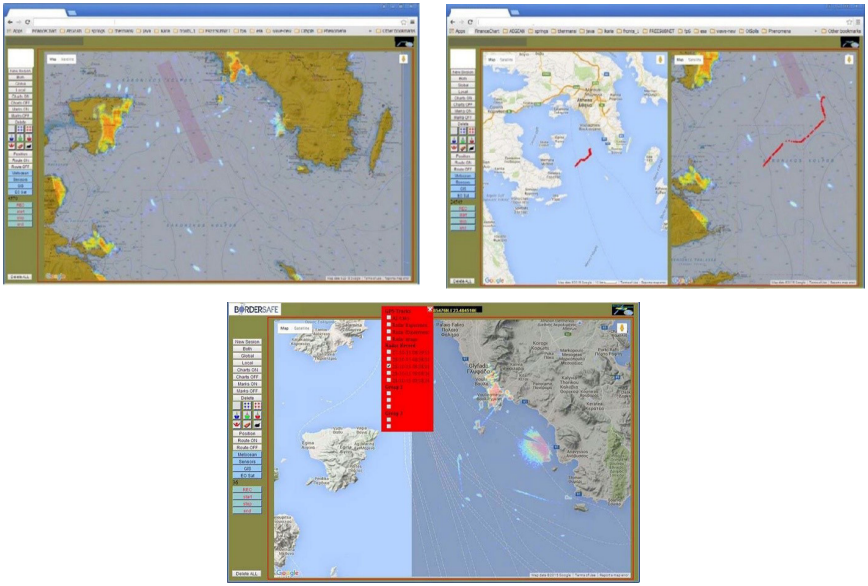

Figure 7. a) Radar image on nautical chart background (left), b) Course display option (right), c) Radar image playback & Aircraft movement through FlightRadar24 app (center).

A similar, but more complex function was also developed for the case of radar images. Thus, users can record and replay for review all maritime activity of the surveillance area as captured by the radar sensor and saved on digital devices. It should be noted that due to the large volume of data produced by this function, it is necessary to have sufficient capacity for archiving radar images (e.g. Universal Serial Bus-USB, Hard Disk Drive-HDD, etc.). Figure 7c shows such a snapshot from the Saronic Gulf. This function is activated by users, through "Rec" tool on the left of the main screen. Finally, the option to monitor the movement of aircrafts, through the FlightRadar24 app, was also integrated into the platform (Figure 7c).

CONCLUSIONS

This paper presented an innovative maritime surveillance platform that gathers the overall picture of the maritime domain into a single platform, with the aim of finding alternative affordable options, capable of delivering fast and low-cost reliable solutions, to meet the overriding needs of the national maritime surveillance. Existing surveillance systems (e.g. VTS, VTMIS, AIS, etc.) meet some of the requirements of user needs, while also facing maintenance issues, but remain (some of them) operational. The border control process should come from a system not only of surveillance and control but also of identification. This function is very important for making the right decisions as the system gathers many sources of information. The system is simple in its design to allow for continuous improvements and additions. It is also designed to operate autonomously, without dependencies on special commercial softwares, so that periodic upgrades and additional costs are required. The Border Safe platform will be developed in two versions: Master platform (full version) for national authorities and organizations and Specific platform with several application for regional authorities etc. Through Border Safe platform, it is expected that a large group of people, such as national, regional and local authorities (e.g. Port Authorities, Coast Guard, Armed Forces, Fire Service, Local Government Organizations, etc.), scientists, decision-makers and management as well as other involved groups will have access to high-resolution and easy-to-understand geospatial data for continuous tracking of terrestrial and maritime objects in their area of responsibility.

Acknowledgments

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Με τη συγχρηματοδότηση της Ελλάδας και της Ευρωπαϊκής Ένωσης

Ευρωπαϊκή Ένωση
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