Integrating Maritime Surveillance Systems within the European Union

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Abstract. This article aims to describe and analyze the various data collection systems in the maritime surveillance domain and will identify the steps which have been taken towards the integration of the maritime surveillance activities within the European Union. Initially, it will present each existing data collection system separately; the specific sensors involved, the structure of the system, its operational mode, its management and finally the impact that this system has on maritime surveillance. Then, it will introduce the concept of the integration of those systems into wider information platforms. How they incorporate those systems in their design, the actors involved and the contribution of those platforms to an integrated information exchange framework are discussed. The article indicate that the uncoordinated utilization of standalone systems causes duplication of effort and overlapping, but it also leaves gaps on information exchange demands. As a result, the necessity to develop systems with enlarged capabilities in data collection and information sharing will be highlighted. Finally, the article will conclude that the EU has already been in the final stages of the development of such a system of systems, namely CISE - Common Information Sharing Environment. The most important finding is that CISE will essentially constitute the prime tool for implementing the European Integrated Maritime Policy. Thus, through the collaborative processes incorporated in it, CISE will contribute substantially to cheaper and more effective maritime surveillance services across Europe.

Keywords: maritime, surveillance, integration, information, security, sea, marine.
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1. INTRODUCTION

The European Union consists of 28 Member States, 23 of which are coastal countries and 26 are flag states of merchant vessels. 85% of its external borders are coastal, with a total length of about 142,000 km. Altogether, the Member States have more than 1.200 commercial ports, more than 8.100 flagged vessels (over 500 GT), 4.300 registered shipping companies, 764 large ports and more than 3.800 port facilities (EUROPEAN COMISSION 2014).

The 90% of the EU external trade and the 40% of internal trade is carried out by sea. European ship-owners manage 30% of the world's vessels and 35% of world shipping capacity - including 55% of container ships and 35% of tankers, accounting for 42% of the value of world maritime trade. More than 400 million passengers are transported via EU ports each year. More than 20% of world’s shipping capacity is registered in EU Member States and more than 40% of

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the world fleet is managed by EU shipping companies. About 300 public authorities are active in the domain of maritime surveillance in the EU and it's Member States (EUROPEAN COMISSION 2018).

The facts and figures above show the enormous role that sea basins play in the EU's economy and security. They clearly highlight the need for maritime surveillance to be carried out in an effective and coherent manner in order to ensure unimpeded maritime transport, cleaner and more secure seas. The purpose of this article is to study the maritime surveillance and its various aspects, in the light of the fact that it is an indispensable tool for promoting the European Integrated Maritime Policy and so crucial for the prosperity of European citizens.

The text unfolds the steps that have been made from standalone surveillance systems to highly integrated platforms. Initially, information for each autonomous maritime surveillance system is given, then, a description of the more integrated systems follows and finally the article closes with the progress achieved in providing integrated maritime surveillance services and the prospects for further integration within the EU framework.

2. AUTOMATIC IDENTIFICATION SYSTEM (AIS)

The Automatic Identification System (AIS) was designed in principle to help avoid ship-to-ship collisions and to support port authorities in achieving better maritime traffic control. Although simple to capture, it is an advanced system in the radio communication.

The AIS device includes a global navigation system receiver (for example GPS or Glonass), which calculates the coordinates of the vessel's position, its speed and course. It also includes a VHF transmitter that transmits vessel-related information. This information includes two basic types of data: dynamic data and static data. Ad dynamic data is considered to be the position of the vessel, the speed, the course and the speed of turn. These are automatically entered into the AIS software via the vessel's sensors. As static data is the vessel's name, IMO[1] number, MMSI[2] number, the vessel's size, and vessel-specific information such as destination, estimated arrival, draft, etc. These data are manually entered into the system by the vessel's personnel during the installation (IMO 2003).

All of the information above is automatically broadcast to those having an AIS receiver, such as other vessels, land stations and radio navigation aids. By means of special software processing the data, the positions of the transmitting vessels and the related data are displayed on computer screens or chart plotters, showing the other vessels' positions in a much similar way as a radar display. Thus, the recipient of this information is capable of a very adequate monitoring of the marine traffic in the area. A prerequisite for this information to reach the recipient is for the receiver to be within the range of the AIS transmitter, usually up to 50 nm, and that no physical obstacles interfere (IALA 2016).

In figure 1, a typical AIS image around Greek coastline is illustrated. Coastal AIS stations are depicted with green and red symbols in the shape of a filter, while ships are shown with colored darts, the direction of which indicates the course of the ship. It is evident the increased shipping traffic on the Dardanelia - Kafireas - Kythira - Western Mediterranean route.

1 The International Maritime Organization (IMO) number is a unique seven-digit number for each ship, dictated by the International SOLAS Convention and is essentially the identity of the vessel.

2 The Maritime Mobile Service Identity (MMSI) number is a unique number for each radio device, dictated by the ITU (International Telecommunication Union) and is essentially the identity of each device.

AIS improves shipping safety and environmental protection, combining the following functions (IMO 2003).

a. Communication between vessels to avoid collision.
b. As a means for littoral states to collect information about the vessels off their coasts and the cargo they carry.
c. As a VTS[3] traffic management tool.

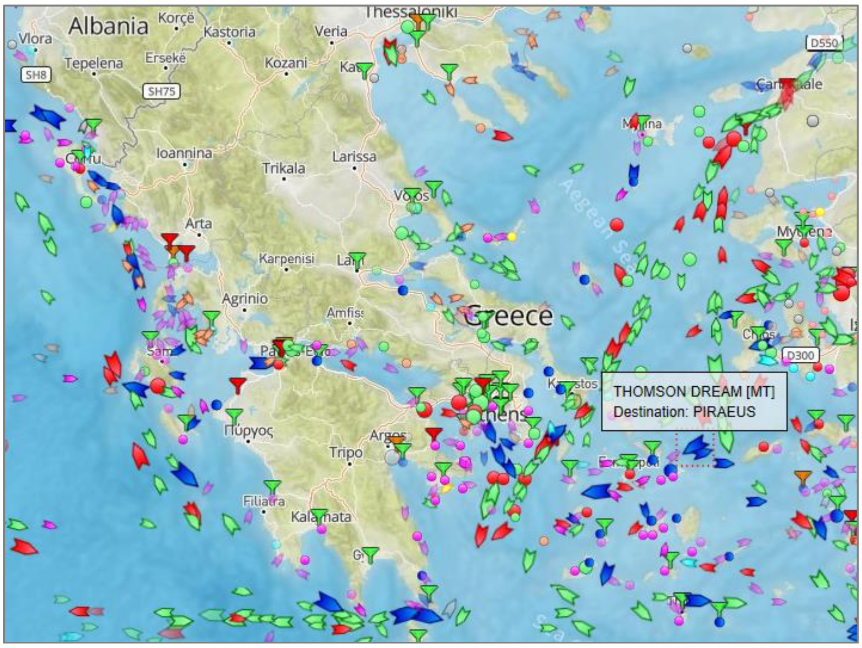

FIGURE 1. Typical AIS image.
From: marinetraffic.com

By means of that, AIS contributes to increase the situational awareness of the marine area of interest, enabling this way, those appointed to handle situations, to respond better to emergencies such as search and rescue or environmental pollution incidents.

Though, terrestrial AIS has some inherent weaknesses that limit its operational function. The largest of these is its limited range, due to the curvature of the earth, and does not allow the exchange of data beyond 50 nm. The position, height and design of the AIS antenna also affect the extent of the coverage area. Increased data flow from a multitude of vessels in the area of interest may also overload VHF channels and cause delays in obtaining critical information. Figure 2 shows the sea area covered by the AIS network of the Mediterranean Sea.

Most of these limitations have been limited with the satellite AIS, as it has the capability to provide service for any given area on Earth. Micro-satellites and nano-satellites, properly tuned, receive VHF ship signals, decode them and forward them to ground AIS stations for further processing and distribution. These satellites are designed for faster message delivery, larger message sizes and better coverage at higher latitudes, while they increase network capacity. The SAT-AIS satellite program is implemented by the European Space Agency (ESA) in cooperation

[3] Service implemented by a Competent Authority that monitors and controls vessel movements when approaching or departing from ports in order to regulate the inbound and outbound traffic and provide navigational safety.

with the European Maritime Safety Agency (EMSA) and with parallel public-private partnerships. SAT-AIS is a sub-program of ESA - ARTES[4] program, involving 9 countries from the EU, Norway, Switzerland and Canada. The ARTES program encompasses the detailed design, manufacture, assembling, testing, and qualification of the SAT-AIS microsatellites and payloads, as well as the development and implementation of innovative SAT-AIS applications and services. The SAT-AIS sub-program is in its final phase of implementation and it is scheduled to be completed within 2019 (ESA 2018).

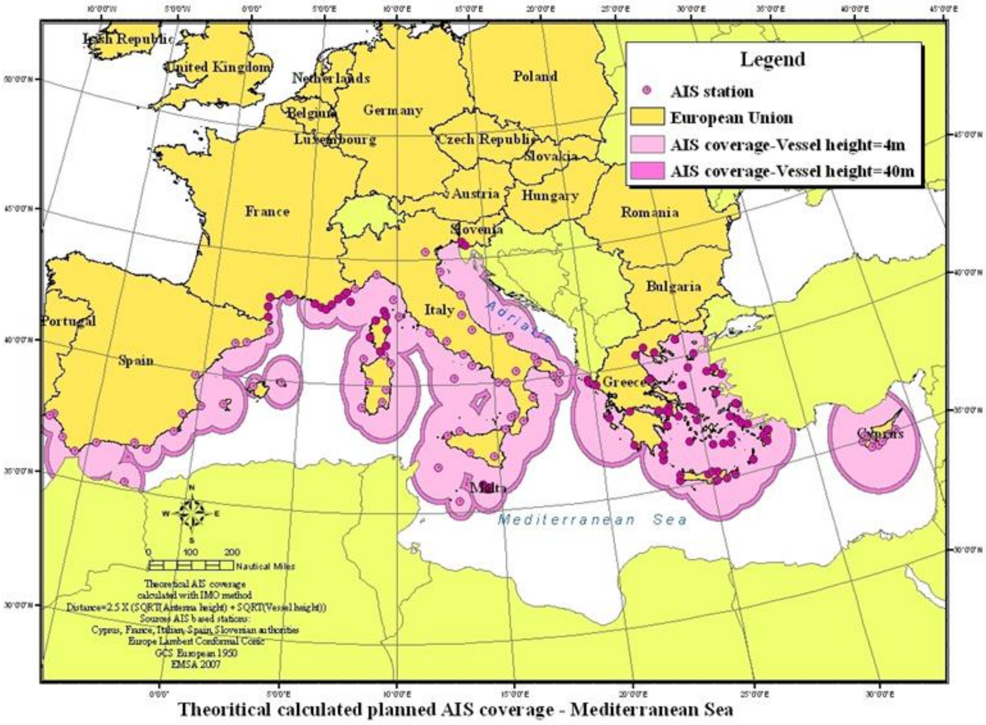

FIGURE 2. A map of the Mediterranean Sea demonstrating the range of the coastal network of AIS stations in the EU Member States that does not cover the entire sea basin.
From: EMSA, Development of an AIS Master Plan for Europe. Lisbon, 2007.

3. LONG RANGE IDENTIFICATION AND TRACKING (LRIT)

The main purpose of the Long Range Identification and Tracking System (LRIT) is to enable the contracting states to recognize the identity of vessels sailing off their coasts as well as to obtain information about their location in a timely manner so that they can assess possible vessel-related risks and take the necessary actions in order to reduce them. (IMO 2017)

The system was originally created for the purpose of maritime security but was soon used in other domains too, such as Search and Rescue (SAR), maritime safety and the protection of the marine environment. To accomplish the above, vessels send LRIT automated location reports every six hours, which are then received by satellites and securely transferred to data processing centers. In turn the processing centers manage this information on behalf of the vessel's flag states. The system is in operation from July 1, 2009 (EMSA 2018).

[4] Advanced Research in Telecommunications Systems

The LRIT network is composed of the Data Centers (DCs), whose task is to collect and disribute the vessels' position reports, and the LRIT International Data Exchange (IDE), which serves as a network hub and interconnects all individual DCs[5]. DCs collect, store and provide LRIT information (vessel position reports) to users worldwide, via an Internet-based network. IDE routes the messages between DCs and makes it possible for the system users to request and receive vessel reports in an efficient and timely manner. IDE is also responsible for the monitoring of the proper functioning of the LRIT network components.

IDE routes the messages to the appropriate destination using the address information contained in the Data Distribution Plan (DDP), a document maintained by the contracting states, setting rules and access rights for users (ie. who can receive data and what kind of data). DCs are the IDE users. To be connected to the IDE they should be included in the DDP. Fifty six (56) Data Centers worldwide, covering a hundred and twenty-one (121) signatory countries and regions, are currently using the EMSA-based IDE in Lisbon. The alternative emergency IDE is located at the United States Coast Guard (IMO 2017).

The system works in the following way. The vessel at sea broadcasts a message through its LRIT equipment. The message shall include the identity of the device carried by the ship, the position of the ship and the date and time of transmission. The system specifies that flag States should ensure that a minimum of four position messages per ship per day (every 6 hours) is sent. The frequency of sending messages can reach the maximum limit which is every 15 minutes, under a user request.

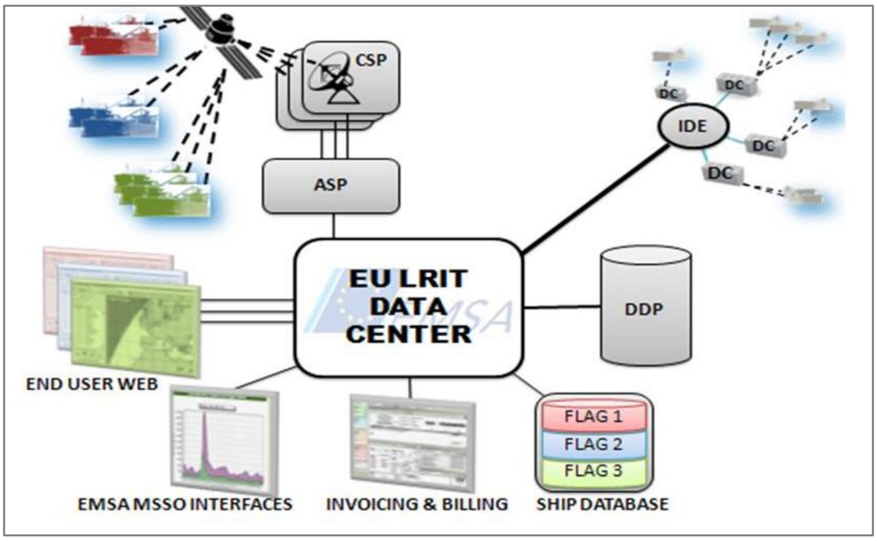

FIGURE 3. LRIT general arhitecture and data flow.
From: http://www.emsa.europa.eu/lrit-home/lrit-home/how-it-works.html7.

The message is received by a telecommunication satellite. The communication networks used for LRIT is the Iridium and Inmarsat (C and D+) satellites. The satellites are managed by a Communication Service Provider (CSP), which provides the necessary infrastructure and the functions required to interconnect the various LRIT components, using communication protocols

[5] DCs are distinguished at different levels, depending on the range of users to whom they provide data. There are DCs national, regional, cooperative - like the EU - and international.

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to ensure the end-to-end secure transfer of information. Thereafter, the data is forwarded to the Application Service Provider -ASP- (IMSO 2018).

ASP completes the information of the LRIT message provided by the vessel by adding the IMO identification number and MMSI number as well as the date and time that the vessel's message was received and forwarded by the ASP. The new extended message created by ASP is then passed to the EU LRIT CDC or other linked DCs, which in turn adds the vessel's name. ASP also ensures that LRIT information is routed in a reliable and secure manner. Figure 3 provides an illustration of the LRIT system architecture.

The objective of the EU LRIT CDC is to identify and monitor the routes of European-flagged vessels sailing around the globe and to integrate them into a wider International LRIT Data Center (IDC). At the last stage of information flow, the EU LRIT CDC collects and disseminates data to contracted states according to the DDP.

4. “COPERNICUS” SATELLITE SYSTEM

At the initiative of the European Commission and in cooperation with the European Space Agency (ESA) the European scientific program "COPERNICUS" started in 2014. It is essentially a continuation of the Global Monitoring for Environment and Security program (GMES).The “COPERNICUS” program aims to develop information services, based on data coming from satellites and ground stations (in situ data). Huge amounts of data on a global scale are collected by satellite, terrestrial, air and sea stations to deliver information to service providers, public authorities and other international organizations, with the ultimate goal of improving the lives of European citizens. The information is free and accessible to anyone (ESA 2018).

The services provided by “COPERNICUS” cover six main themes as depicted in figure 4. These are: atmosphere monitoring, marine environment monitoring, land monitoring, climate change monitoring, security, emergency management[6]. In this context, the services of "COPERNICUS" can be used by end users for a wide range of applications in a variety of areas. These include urban area management, sustainable development and nature protection, regional and local planning, agriculture, forestry and fisheries, health, civil protection, infrastructure, transport and mobility, as well as tourism (EUROPEAN COMMISSION 2016).

The program is coordinated and managed by the European Commission. The development of the observation infrastructure is performed under the auspices of the ESA for the space component, the European Environment Agency and the Member States for the in situ component. EMSA has been appointed as Entrusted Entity of the Copernicus Maritime Surveillance Service, in charge of the technical and operational functioning of the program. Consequently, EMSA has integrated "COPERNICUS" in its data sources to create integrated maritime services. (EMSA 2018).

From a technical point of view, the “COPERNICUS” program is supported by the following systems. Its core is composed of fourteen specialized satellites code-named "Sentinels". These are categorized into six satellite families (Sentinel 1 to 6), depending on their mission. It is anticipated that all of them, almost twenty, will be operational until 2030. So far, seven of them have

[6] Copernicus Atmosphere Monitoring Service (CAMS), Copernicus Marine Environment Monitoring Service (CMEMS), Copernicus Land Monitoring Service (CLMS), Copernicus Climate Change Service (C3S), Copernicus Emergency Management Service (EMS), Copernicus Security Service.

been set to orbit[7]. The next supporting scheme consists of some existing third-party orbit satellites which are either state-owned or privately-owned, of European or international origin. These are known as contributing missions, and have provided satellite data for the program since its inception[8]. Finally, the information collected by the "COPERNICUS" program is supplemented by in situ systems such as ground stations, which deliver data acquired by earth, aerial or marine sensors. These include sensors placed on the rivers' banks, carried through the air by weather balloons, pulled through the sea by ships, or floating in the ocean. In situ data are used to calibrate, verify and supplement the information provided by satellites, which is essential in order to deliver reliable and consistent data over time (Copernicus 2018).

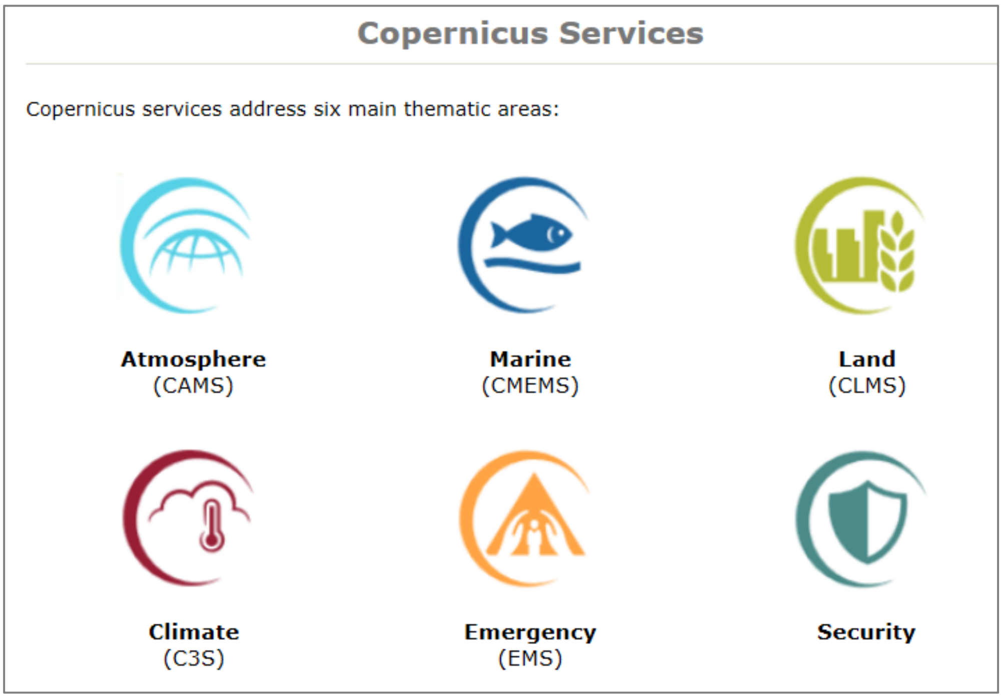

FIGURE 4. The six thematic areas covered by the European program "COPERNICUS"
From: http://www.copernicus.eu/main/services

Data from satellites is downlinked to a network of earth stations, processed into images, and analyzed. These images and their analysis are finally sent to the Earth Observation Data Center - part of EMSA - for operational exploitation. After these images have been correlated with the current marine traffic and supplemented with other information of maritime nature, then are distributed as complete information to the end-users of the EMSA Integrated Maritime Services. The Agency provides radar and optical satellite images in near-real time, delivered regularly to its end-users in a user friendly format, particularly in response to specific operations at sea or in support to emergencies (EMSA 2018).

The earth observation data collected by the above mentioned satellites offers a unique view of the oceans, seas and coasts. The satellites, combined with their high-tech sensors, provide day-to-

[7] Detailed information on the equipment of each satellite and its specialized mission can be found at the following website: https://sentinels.copernicus.eu/web/sentinel/missions

[8] Third-party contracting parties to the COPERNICUS program can be found at the following website: https://spacedata.copernicus.eu/web/cscda/missions

day, systematic, efficient and extensive surveillance over all marine areas. Alternatively, they can focus on a specific location, monitoring specific operations, or gathering data in response to intelligence information. In addition, satellites have access to remote areas (e.g. polar), and are not subject to air traffic control and other restrictions, in comparison with the manned aircraft.

The images created by the satellites can be derived either from active sensors[9], e.g. the Synthetic Aperture Radar (SAR)[10], or passive sensors[11]. The SAR provides coverage day and night regardless of the weather, e.g. presence of fog or cloud cover, whereas the passive sensors can depict the surface of the earth only during clear cloud daylight. However, when environmental conditions permit remote sensing, they provide very high-resolution images, with colored depiction of ports, coasts and targeted sea activities (Perakis 2015).

Radar satellite imagery is obtained with a resolution ranging from 100 m up to <1 m, depending on the extent of the area depicted. Images composed of passive sensors -visual images- have a resolution of even less than 30 centimeters. In any case, there is always a trade-off between the size of the area depicted and the available resolution. Images depicting large areas are suitable for general surveillance of the area, but can distinguish features up to a certain size. If operational reasons require a more detailed image to be displayed, then the area being captured should be much smaller (Aggarwal 2004).

Figures 5 and 6 show how the resolution of the satellite imagery varies according to the scale of the portrayed area and the type of the sensor used.

FIGURE 5. SAR satellite image section depicting Attica, with the original image covering an area of 250 x 250 km. Vessels of over 100 m in length look like bright dots at the anchorage of Salamis. *From:* http://copernicus.eu/main/Brochure

[9] Active sensors have the ability to emit their own radiation, the signal of which is reflected, diffracted or diffused into the earth's surface or atmosphere and record it on its return.

[10] This is a special radar technique that allows users to receive high-resolution radar images over long distances. In this way, objects can be distinguished against the background (ESA 2018).

[11] Passive sensors do not emit radiation themselves, but they detect and record reflected solar and thermal radiation in the visible and infrared wavelengths of the electromagnetic spectrum (Perakis 2015).

FIGURE 6. Part of a visual satellite image with 30 cm resolution. Any feature of the ship of this size, it becomes noticeable. The original image covers an area of 50 x 50 km. *From: http://copernicus.eu/main/Brochure*

5. VESSEL TRAFFIC SERVICE

The Vessel Traffic Service (VTS) are implemented by the National Competent Authorities, with its ultimate objective to improve the safety and efficiency of navigation and to protect the environment. VTS task is to effectively manage maritime traffic in its area of responsibility so that these goals are achieved.

The operation of the VTS is dictated by the International SOLAS Convention and is governed by the IMO guidelines and specifications laid down by IALA. According to SOLAS, the contributing states shall install VTS systems where the density and character of maritime traffic or the degree of risk justifies the existence of such services. However, VTS control areas should be limited to the territorial waters of the coastal States. The Directive 2002/59/EC of the European Parliament sets the requirement for the establishment of a vessel traffic monitoring system within the EC.

A clear distinction need to be made between a Port VTS and a Coastal VTS. A Port VTS provides the required instructions and necessary information to vessels for safe entry and exit to and from ports, while a Coastal VTS is mainly concerned with vessel traffic passing through the area, providing useful information of navigational nature. A VTS could also be a combination of both types (IMO 1997).

Although the primary purpose of the VTS system is the maritime safety through effective maritime traffic management, an additional benefit deriving from its operation, is that it uses information to raise the situational awareness at the service area, this way contributing to better maritime surveillance. The VTS service can use a number of sensors to compile the picture of its area of responsibility. There are the primary sensors of the VTS system, such as the typical radar and the radio communication, but there are also more modern ones such as electro-optical devices. In this list, the AIS, the LRIT and satellite images from “COPERNICUS” can be added, to form the integrated VTMIS coastal monitoring system.

VTMIS is an extension of the VTS in the form of an Integrated Maritime Surveillance, which incorporates other telematics resources to allow allied services and other interested agencies in the direct sharing of VTS data or access to certain subsystems in order to increase the effectiveness of port or maritime activity operations as a whole.

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Figures 7 and 8 demonstrates the input and output components and subsystems of a VTMIS, such as radar, AIS, VHF communication, etc.

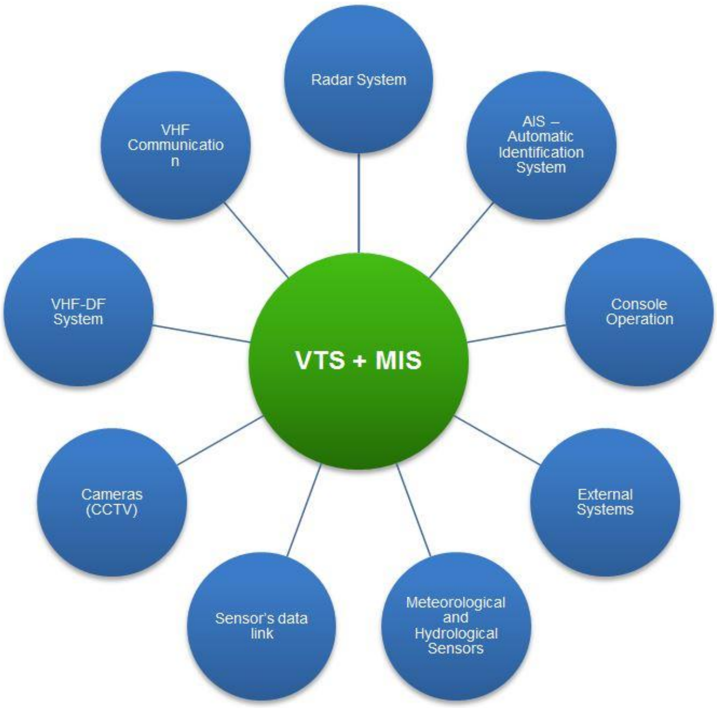

FIGURE 7.
Schematic diagram of the input and output components and subsystems of a VTMIS
From: http://www.sheltermar.com.br/en/vts/vtmis/

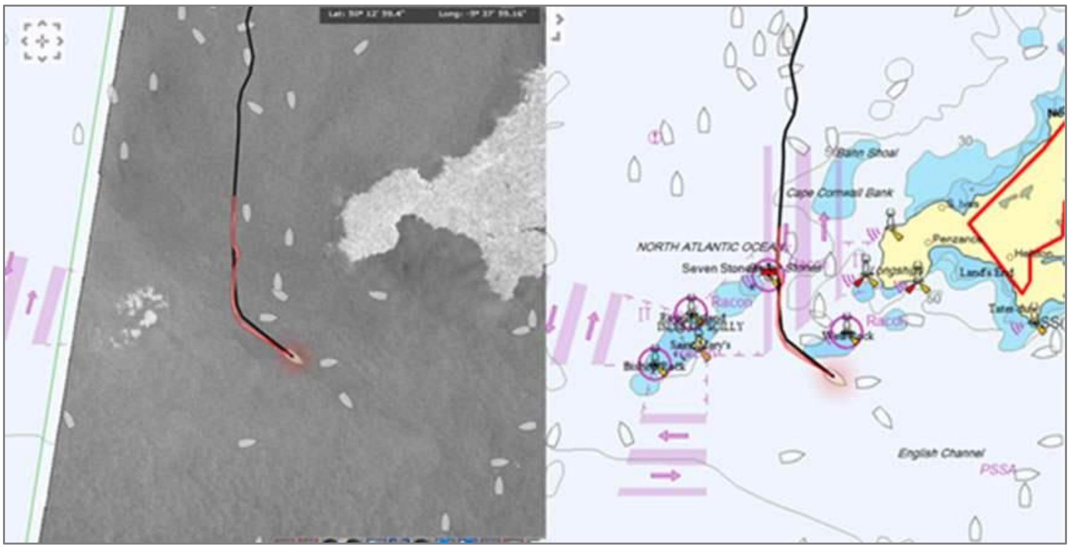

FIGURE 8. On the left, the image shows a satellite radar image with the location of detected oil on the sea surface marked in red. The shape of the spill indicates a possible trailing slick of oily waste from an underway vessel. By combining the satellite image with AIS vessel track information, on the right, the identification of a tanker discharging waste is possible.
From: http://www.emsa.europa.eu/csn-menu/csn-service/oil-spill-detection-examples/

VTMIS is a first attempt to integrate maritime surveillance systems and has emerged from the need for better awareness of the maritime environment. It has been implemented at a state level, since the beginning of the last decade and the system is managed by the states' port authorities (D. Dalaklis 2016).

6. CLEAN SEA NET

CleanSeaNet (CSN) is a European service aimed to detect of vessels and oil spills based on satellite systems. It provides assistance to the participating States in the following issues: identification and trace of intentional pollution coming from vessel's waste, monitoring of accidental pollution during emergencies, identification of polluting vessels. CSN is run by EMSA and has been operational since April 2007 (EMSA 2017).

The CSN service is based on satellite images, produced by Synthetic Aperture Radars (SAR) carried by orbiting satellites. As mentioned before, SARs has some outstanding capabilities and can detect oil spills floating on the sea surface of tenths of a millimeter thick, day and night, regardless the fog or cloud cover, affording worldwide coverage of maritime areas. Data from these satellites are processed into images, and analysed for oil spill, vessel and meteorological variables. Extracted information includes among others: spill location, area, length and confidence level of the detection. This system also estimates the wind and swell obtained from the SAR data. Optical satellite images can also be acquired upon request, depending on the situation and user's needs. Figure 8 shows how the CSN service contributes to the detection of potential polluters, through the correlation of satellite imagery with AIS information.

Each coastal State has access to the CSN service through a dedicated user interface, which enables them to view images on order. Users can also access a wide range of supplementary information through the interface, such as oil drift modelling (forecasting and backtracking), optical images, oceanographic and meteorological information.

Coastal states initially place their requests towards EMSA, via the EMSA website, on issues related to the CSN service. EMSA, after assessing and prioritizing the requests, orders satellite imagery to meet these requests. Then, satellite data is acquired through a network of terrestrial satellite imagery stations. Detailed images are then available to national authorities within 30 minutes after the acquisition of the image. The service includes the identification of potential polluters by combining the image taken by the satellite with vessel traffic information. After receiving the enriched information, the national authority decides on the appropriate operational response, for example, sending an asset such as an aircraft to check the area and verify the spill, or requesting an inspection of the vessel in the next port of call. Almost 3,000 images are acquired and analyzed each year (EMSA 2017).

7. SAFE SEA NET

SafeSeaNet (SSN) is a European maritime information exchange system, that was set up with the main objectives of improving safety, port and maritime security, as well as protecting the marine environment and improving the efficiency of the maritime traffic and the maritime transport (EMSA 2014).

SSN interconnects the port authorities of the participating States[12], allowing them to exchange information about vessels such as:

[12] EU Member States plus Norway and Island

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- Port of departure and destination
- Estimated and actual time of arrival and departure in ports
- Details of hazardous and polluting cargoes
- Information on marine incidents and accidents
- Information on the exact number of persons on board
- Location of vessels based on AIS reports.

SSN is essentially the first stage of integration of maritime surveillance at EU level. SSN integrates both services and systems. On the one hand, it interconnects the maritime surveillance services of the Member States, by enabling them to exchange relevant information directly. On the other hand it combines effectively the AIS and the VTS communication facilities in order to collect the necessary data.

The process of setting-up SSN was initiated in October 2004. The procedure had passed several stages, and the system finally became fully operational in 2009. At a European level, the development, evolvement and operation of the system has been entrusted by the European Commission[13] to EMSA.

SSN products are being delivered to its users through a web-based graphical environment based on electronic charts. This workspace makes the SSN system user-friendly and easy to understand, enabling users to quickly get the information they need. Users have the capability to zoom in and out on the map to get the image they want, in a scale ranging from European continent extent to individual docks in ports. They can also view the history of vessel positions and obtain selected vessel-related information. This information is presented on high-quality nautical electronic maps, containing a range of useful maritime information (EMSA, How SafeSeaNet Works 2018).

8. SAFE SEA NET ECOSYSTEM

After that of the SSN, the SafeSeaNet ecosystem (SSN-e) constitutes a further step towards the integration of EU maritime surveillance systems. SSN-e consists of SSN, CSN, LRIT and THETIS[14], which will be referred to as subsystems, and the IMDatE (Integrated Maritime Data Environment) platform that integrates them operationally. Thus, it is considered to be the EU "ecosystem of systems" concerning the exchange of information among authorities, organizations, approved entities and vessels. Its main objectives are maritime safety, port and maritime security, marine environment protection, as well as the efficiency of maritime traffic and maritime transport. Figure 9 portrays SSN-e as a wider system comprising many sub-sytems (GMV 2014).

SSN-e brings together and combines the data collected by its subsystems and makes them available to use by its authorized users. However, the data is not recorded in a single database, but each user's community is the publisher of its own information, as well as a subscriber to information published by other user's communities on a "need to know" basis. With IMDatE, users can combine functions - e.g. maritime traffic and maritime pollution control - and benefit from getting a full picture of maritime activity in the area of interest, having access to integrated data, which without the IMDatE would only be available through different standalone applications. This integrated data is available through a user-friendly web interface or distributed auto-

[13] Directorate - General for Mobility and Transport

[14] THETIS is a central, web-based information system that supports the new Port State Control inspection regime (NIR).

matically to external approved systems, in accordance with the access rights assigned to each category of data. So, the SSN-e, by combining the information available in its core systems, is a very flexible system able to provide its users with a fully featured "integrated maritime awareness picture". This picture can be tailored to the end users demands and it is based on tools that harmonize and enhance its presentation. These tools provide to the first ones the ability of sharing data for safety, security, the identification of risk, environmental protection and improve logistics management.

Figure 9. SSN-e is not a new stand-alone system; it is the conceptual view of EMSA's systems and information networks as a whole, with a single function and common purpose, that of maritime surveillance.
From: GMV Innovating Solutions: Study to assess the future evolution of SSN to support CISE and other communities

With regard to the SSN-e prospects, pilot projects are already underway considering to integrate data into the SSN-e integrated platform from additional systems such as S-AIS, COPERNICUS and VMS. The implementation of these projects will render EMSA able to deliver Integrated Maritime Services (IMS). These services include vessel traffic monitoring, search and rescue, maritime pollution monitoring, maritime border control, anti-piracy, fisheries monitoring, anti-drug trafficking operations. Figure 10 gives a conceptual scheme of an SSN-e network (EMSA 2018).

Furthermore, users will be able to configure the maritime picture they watch according to their operational needs by adding or subtracting information layers from the full-fledged picture and including focused local information. Finally, technological improvements are being made to allow user's access to Integrated Maritime Surveillance data through all modern electronic devices and networks available. Thus, the internet, laptops, smartphones, tablets, and any similar device invented in the future can be the gateway of the "extended" maritime picture.

9. COMMON INFORMATION SHARING ENVIRONMENT

In 2009, the European Commission decided the creation of a decentralized information exchanging system, interlinking all User Communities both civilian and military, towards the integration of maritime surveillance in the EU. Guiding principles were set out for the establishment of a Common Information Sharing Environment (CISE) for the EU maritime

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domain. The principles that were adopted to create the CISE program (EUROPEAN COMMISSION 2010) are:

- An Interconnection Approach for All Users Communities.
- Building a Technical Framework for Interoperability and Future Unification.
- Exchange of Information between Civilian and Military Authorities.
- Specific Legal Provisions for Confidentiality and Protection of Data.

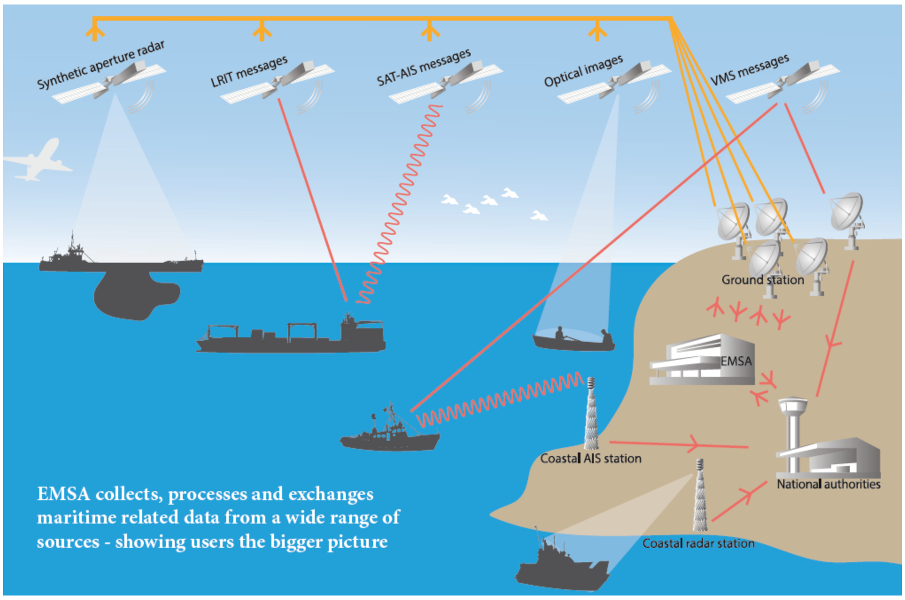

Figure 10. Illustration of the integrated collection and distribution network after SSN-e expansion.
From: https://csndc.emsa.europa.eu/web/imdate

CISE does not mean to replace or overlap existing systems and platforms for information exchange; instead, it uses them in a more efficient way. Its ultimate goal is to increase the efficiency, quality, responsiveness and coordination of surveillance operations in the European maritime domain and to promote innovation, prosperity and security for the EU and its citizens.

Its aim is to ensure that the maritime surveillance information collected by one competent authority and deemed necessary for the operational activities of others, can be shared and be subject to multiuse, rather than collected and produced several times, or be collected and be kept for a single purpose (EUROPEAN COMMISSION 2014).

Therefore, CISE is an ambitious undertaking to further integrate EU maritime surveillance. The need for further integration has been deemed essential, as according to the results of relevant studies a great waste of resources happens. Specifically, by 2014 - when CISE development began - more than 50% of the information gathered was collected solely by two user communities; those of "Defense" and "Maritime Safety and Security". In addition, 80% of the information has remained under national ownership, without further dissemination. Finally, the 45% of the collected information was collected simultaneously by more than one user communities, whereas there was a gap, of between 40% and 90%, between the supply and the demand for additional data exchange across the various user communities depending on the area (COWI 2014).

The integration that is being pursued through the CISE does not only involve the integration of systems and users closely concerned with maritime surveillance, which has largely been achieved by SSN-e. Furthermore, CISE aspires to create a cross-sectoral and cross-border information exchange environment in which participants will be systems, user communities, principles and programs, incorporated in maritime surveillance and its outcomes, directly or indirectly. More than 400 entities are expected to participate in the program (European Commission 2016).

Figure 11 illustrates the broader communities that will benefit from the CISE implementation, which are:

- Maritime Safety, Maritime Security and prevention of pollution caused by ships.
- Fisheries control.
- Marine pollution preparedness and response; Marine environment.
- Customs.
- Border control.
- General law enforcement.
- Defence.

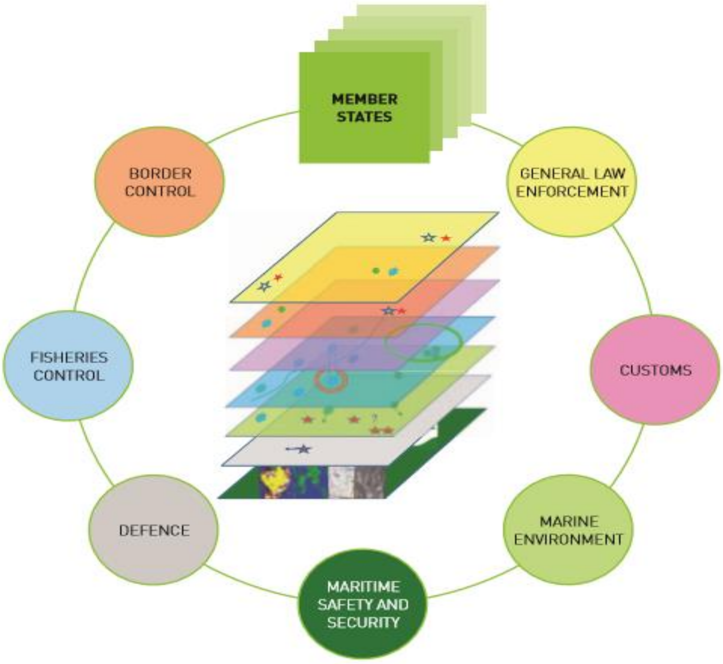

Figure 11. The CISE will serve essentially the 7 broader user communities shown in the portrait.
From: COM(2010) 584 final: « Draft Roadmap towards establishing the Common Information Sharing Environment for the surveillance of the EU maritime domain»

The architecture of the system is one of a hybrid form, which is depicted in figure 12. This form combines two communication schemes among the CISE users. In the first schema, CISE participants share information with each user and communicates directly, without having to contact an intermediate node. Thus, each user creates his own integrated maritime awareness picture by collecting information from any user within Europe. In the second schema, the CISE services are provided within the borders of a Member State by a single state authority or a European led initiative. At Member State level, the provider of these services acts as a node that redistributes information collected from the several public authorities within its borders. Because of this, a single integrated maritime awareness picture can be offered per Member State. This image is then exchanged with the other nodes of the system. As a merge of the two schemas, the hybrid version is flexible about the number of CISE providers at national level. This means that services are either provided by a single provider at national level or by multiple ones. EU led initiatives operate their own CISE nodes (DIRECTORATE GENERAL INFORMATICS 2013).

Finally, regarding CISE function from a technical point of view, it is based on SSN-e, which essentially constitutes the heart of it. SSN-e performs the same operations as CISE - but on a smaller scale - that is, realizes the data exchange between systems and users, it operates on a 24/7 basis, it is accessible to all Member States, organizations and authorities of the EU, meets most of the CISE principles and requirements, and already serves 72% of the total volume of data that CISE hopes to circulate. The key points in which SSN-e falls short of CISE is about information security and information related with the "Defense" sector. As for the first, classified data will be distributed through CISE, which will be protected by special communications protocols, something that is not the case in SSN-e. As for the second point, SSN-e does not draw any information from the "Defense community", something that CISE has the aspiration to do. (GMV 2014)

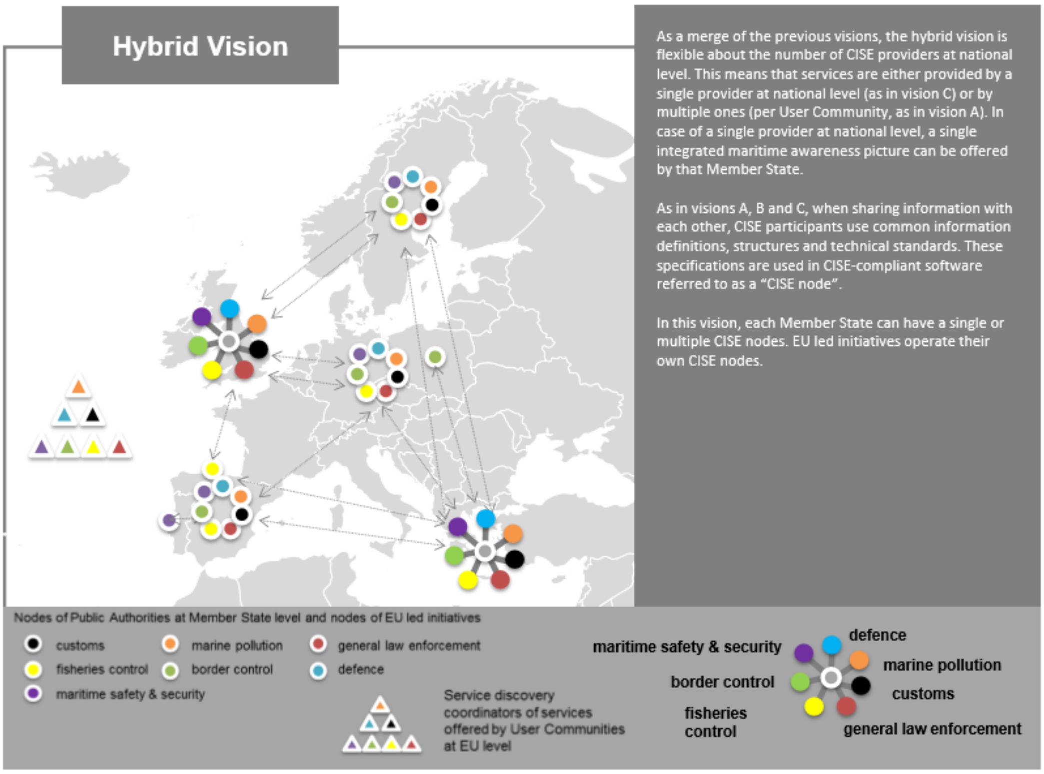

Figure 12. The architecture of the hybrid form is the one chosen for the CISE operation[15]
From: CISE Architecture Visions Document (v. 3.00)

After its completion in around 2020, CISE is expected to serve as a multiplier of the value of maritime surveillance in the European Union. The benefits that are expected to emerge are numerous as well as significant. They have a great impact both on the operational and economic domain of maritime surveillance, as well as on the overall EU economy, prosperity and security of its citizens.

[15] Minutes of Technical Advisory Group (TAG) meeting 23rd of 10.02.2017

Through the collaborative processes incorporated in it, CISE contributes substantially to the economy of the maritime related resources. CISE users will be able to provide European citizens with an improved but also cost-effective service, by avoiding overlapped maritime surveillance tasks, by planning more efficiently the development of surveillance systems and by evaluating accordingly the third party data. With CISE improving overall maritime surveillance, competent authorities will be able to maximize their efficiency, at a higher level and make better use of their operational and financial resources.

According to studies carried out in 2014, maritime surveillance in coastal Member States implies a cost of up to 10 billion € per year. Implementing CISE would cost 10 million € per year over the first 10 years (an investment of just 0.1% of the annual cost), and it would bring direct economic benefits of 400 million € per year, a return on investment of 1:4. Overall, CISE would bring total savings, both direct and indirect, which could rise up to 40 million € per year. (EUROPEAN COMMISSION 2014)

Nevertheless, despite the unquestionable benefits that will arise from the implementation of CISE, many weaknesses remains to be adressed in order for the project to be realized. The diversity of stakeholders, who represent differrent roles and areas of expertise, the lack of a “natural owner” who will act as a central governance body in place, to direct the CISE community and control the programe of work, the voluntary collaborative setting on which CISE is based, are just a few of the project’s potential threats (EUROPEAN COMMISSION 2017).

10. CONCLUSIONS

Enhancing information exchange between maritime surveillance authorities is one of the key strategic objectives of the EU's Integrated Maritime Policy as well as an important building block of the recent Maritime Security Strategy. The EU has vital interest in maritime issues within the EU and around the globe, so it needs to be able to safeguard those interests adequately and efficiently. This cannot be the result of individual efforts by each Member State separately or by fragmented actions of the players involved in maritime surveillance. The EU's objectives in the maritime domain can only be achieved through the efficient monitoring of its coasts and seas in an integrated manner and a holistic approach.

This integration has progressively been phased in over the last years. This results in to reaching very good levels of integrated maritime surveillance in the EU today and its outlook seems to be quite promising, at least in short term. Attempting to give a brief overview of the different phases this integration has gone through so far, one finds that it has been done in four stages.

The first attempt to integrate maritime surveillance systems has been implemented at national level since the beginning of the previous decade with the VTMIS. The second stage of integration, this time at EU level, was implemented through the SSN. SSN integrates both services and systems. SafeSeaNet ecosystem (SSN-e) is the latest state of integration of the EU maritime surveillance systems. It includes the SSN itself, the CSN, the LRIT and the THETIS.

The next stage of integration and the fourth in a row, is that of the Common Information Sharing Environment (CISE) for the EU maritime domain. CISE further enhances and promotes relevant information exchange, in particular between civil and military authorities involved in maritime surveillance. It also ensures interoperability of maritime surveillance systems at EU level, building on existing systems and solutions, without creating a new system. The integration pursued through CISE not only includes the integration of systems and users closely involved in

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maritime surveillance, which has largely been achieved by SSN-e. CISE aspires to create a cross-sectoral and a cross-border information exchange environment in which participants will be systems, user communities, principles and programs involved in maritime surveillance and its outcomes, directly or indirectly.

The conclusion that can be drawn, is that after the full implementation of CISE, maritime surveillance in the EU will have reached such a degree of integration, which will constitute essentially the prime tool for implementing the European Integrated Maritime Policy. This integration is expected to act as a multiplier of the value of maritime surveillance in the European Union. It will ensure secure, clean, productive, sustainable and accessible seas, which means that EU citizens will be able to harness the huge marine potential - in all its forms - and enjoy safely the benefits that the marine environment and the related with it activities can offer.

The CISE program expands over a decade from its political initiation in 2009. Its full operational implementation in order to achieve its overarching purpose remains yet to be verified. The work conducted so far has much focused on preparations at the policy and research levels. Political, executive management, industry, national legal constraints and implementation needs have to be addressed soon, so as they deliver a comprehensive "whole" in support of CISE implementation. A supervising authority entitled with decision-making power, could be the suitable solution to allow for a relevant coordination, monitoring and execution of various CISE ongoing and future developments and deliverables.

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