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Marine Spatial Data Infrastructure in Greece Challenges and Opportunities

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Abstract.

This paper analyses the opportunities and challenges for establishing a National Marine Spatial Data Infrastructure (MSDI) in Greece, according to the recommendations of the International Hydrographic Organization (IHO) and by reviewing evolutions in standards, technology and implementations of similar projects worldwide. The MSDI platform is proposed to follow the best practices provided by EU, such as the European Interoperability Framework for public sector e-Services. Moreover, a suitable architecture for implementation is also proposed similarly to the concept of Maritime Connectivity Platform, the recent initiative of IMO's e-Navigation program. For end users evaluation, a short questionnaire was sent to key Greek marine and maritime stakeholders. The results of the survey highlighted the need for a service-oriented MSDI, which would be a key driver for the long-term success of both the public-sector services, as well as the private-sector investments.

Keywords: Greek Marine Spatial Data Infrastructure (MSDI), Marine Spatial Planning (MSP), e-Navigation, Marine Ontology, S-100, European Interoperability Framework (EIF), Maritime Connectivity Platform (MCP).

PREAMPLE

The long relationship of the Greeks with the Sea begins at the pre-historic era[1]. The Greeks, have always been mariners, they love the sea and the development of the Greek Seamanship grew naturally, influenced by the unique landscape, the geographical position, the climate and the enormous coastline of the country. Nowadays Greek ship-owners control over 16% of the world fleet[2,3], shipping sector provides approximately 192,000 jobs to the country GDP and sea tourism is considered one of the major drivers for growth of the Greek economy. Geographically, Greece is surrounded by the Aegean Sea and the Ionian Sea, which is adjacent to the Adriatic Sea and all belong to the Mediterranean Sea basin. In the Aegean Sea smaller pelagos are included, such as the Thracian, Myrtoan, Icarian, Carpathian, the Cretan and the Libyan (HNHS 1992).

[1] https://web.archive.org/web/20120201142936/http://www.greece.org/poseidon/work/articles/polemis_one.html - last accessed 12.02.2019
[2] https://www.naftemporiki.gr/finance/story/1292111/protos-kai-me-diafora-o-ellinoktitos-stolos - last accessed 30.09.2018
[3] https://unctadstat.unctad.org/CountryProfile/MaritimeProfile/en-GB/300/index.html - last accessed 12.02.2019

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Nowadays Blue Economy[4], meaning all economic activities related to seas and coasts, is at the top of the political agenda of the European Commission and the Greek government. Moreover, marine economic sectors, such as sea transportation, coastal tourism, aquaculture, blue biotechnology and other, are in the national and international investment horizon. Especially for the sustainable development and growth of the maritime sector, the e-navigation strategy implementation plan of the International Maritime Organization (IMO) is intended to meet present and future user needs through harmonization of marine navigation systems and supporting shore services to shipboard users and those ashore responsible for the safety of shipping with modern, proven tools that are optimized for good decision making in order to make maritime navigation and communications more reliable and user friendly.

The marine and coastal zones of the world (IHO 2017) host a growing number of overlapping and at times competing uses and activities, including commercial, recreational, cultural, energy, scientific, conservation, defense and security interests. The quality of life on earth is determined in large part by an incomplete understanding of the interacting system that operates in the world's oceans and coastal areas. The implementation of the National MSDI requires a complex and difficult activity, taking into account (Chatziantoniou 2006):

1. the large spread of the coasts of Greece as a whole, continental and insular, is about 7 times the length of the coasts of France and 0.7 the coast of the African continent.
2. the number of islands, islets and rocks are about 9,800 of which 228 are populated, the 1354 bays and coves, the 161 channels and the 520 ports.
3. the extent of about 470,000 km^2 of the Greek maritime area to be surveyed and mapped by the Hydrographic Service which is 3.6 times larger than the land area of the country.
4. the fact that the characteristics of the seabed (flares, shipwrecks, etc) are not visible and accessed as terrain features depicted on maps of land (mountains, roads, rivers, etc.), but requires the identification and accurate fix with measurements made by sea shore with special electronic devices that are equipped the hydrographic vessels.

Greece has available to follow the paradigm of similar countries, especially those within the Pacific, that have marine jurisdictions that are greater than that of their land mass. Australia for instance, has maritime responsibility for twice that of the Australian continental landmass (Kaye 1995) with the ability to increase the size of sea area under Australia's jurisdiction, based on the 3rd United Nations Convention on the Law of the Sea (UNCLOS).

MSDI AND MSP (MARINE SPATIAL DATA INFRASTRUCTURE & MARINE SPATIAL PLANNING)

Geographic Information & SDIs

Today, the availability of Geographic or Spatial Information is considered as basic infrastructure for a developed society (Kavouras 2002), as people considered in the past water supply, electricity, fixed telephony and more recently the wireless communications. Moreover Geographic information is vital to making sound decisions at the local, regional, and global levels (GSDI 2004). Spatial information is used today for emergency response, business development,

[4] https://en.wikipedia.org/wiki/Blue_economy - last accessed 13.01.2019

wildlife prevention, land use planning and many other activities in which decision-makers are benefiting from geographic information.

The term "Spatial Data Infrastructure" (SDI) as defined by the Global Spatial Data Infrastructure Association (GSDI 2004) is used to denote the relevant base collection of policies, institutional arrangements, standards and technologies that facilitate the availability of and access to spatial data. The SDI provides a basis for spatial data discovery, evaluation, and application for users and providers within all levels of government, the private sector, the non-profit sector, the academia and the citizens in general.

Marine Spatial Data Infrastructure

More specifically, MSDI is "the component of an SDI that encompasses marine geographic and business information in its widest sense" (IHO 2011). Typical data content includes marine boundaries and limits, protected areas, marine habitats, oceanography, bathymetry, geology, marine infrastructure, wrecks, offshore installations, pipelines, cables and many others.

Moreover, along the coastline, there are measurements related to climate change that indicate sea level change, incidence of storm events, higher wave energy and surges that have an impact on fixed structures, and significant beach erosion and flooding inundation. Controllable and equitable use of coastal resources for urban planning, renewable energy, tourism, conservation, and preservation of natural habitat, are within the scope of an MSDI developed framework.

In general the information provided through a MSDI can be used for safe and efficient operation of maritime traffic, exploration and exploitation of marine resources, marine spatial planning (MSP), integrated coastal zone management (ICZM), environmental protection, naval and maritime security. MSDI could provide benefits such as promoting data and information sharing and exchange, enable the wider use of field data and information, facilitate development of new products and services, improve organizational decision making, reduce duplication of activities.

National MSDI benefits

In addition to the above stated benefits the MSDI implementation at a National level could increase co-ordination and co-operation of activities and processes across stakeholders, ensure more effective use of public funds, stimulate commercial and scientific activity and ensure a safer operating environment.

Marine Spatial Planning

One of the most important uses of MSDIs is to facilitate Marine Spatial Planning (MSP), which is the planning about when and where human activities take place at sea – to ensure these are as efficient and sustainable as possible. MSP involves stakeholders in a transparent way in the planning of maritime activities (EU 2012).

With Marine Spatial Planning, several benefits could be realized, such as reduction of conflicts between stakeholders, creation of synergies between different economic activities, encouragement for investments by instilling predictability, transparency and clearer rules, increased coordination between administrative bodies, through the use of a single instrument to balance the development of a range of marine activities. Moreover, increased cross-border cooperation on cables, pipelines, shipping lanes, wind installations, etc. as well as protection of the environment through early identification of impact and opportunities for multiple use of space.

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According to IHO (IHO 2011) the benefits of MSP are improved decision making, coastal zone management, coastal inundation and flood plain modeling, climate change adaptation, conflict management in use of sea space, conservation, fisheries management, ecosystem approach to managing sea space, monitoring, assessment, management and control.

MSDI PILLARS

Although the SDI concept was initially been used to describe land related spatial data and information, very soon the relevant concepts were examined if they were applicable and desirable to improve marine administration and preserve the ocean nature, with the structured definition of components to describe marine and coastal spatial data and information.

According to OceanWise (2013),[5] a MSDI consulting company, the four 'pillars' of MSDI are policy and governance (people), domain standards, information systems (technology) and geographic content (data and metadata). These 4 pillars (figure 1) are discussed in detail in the next chapters, especially in the perspective of how these pillars would affect the National MSDI implementation in Greece.

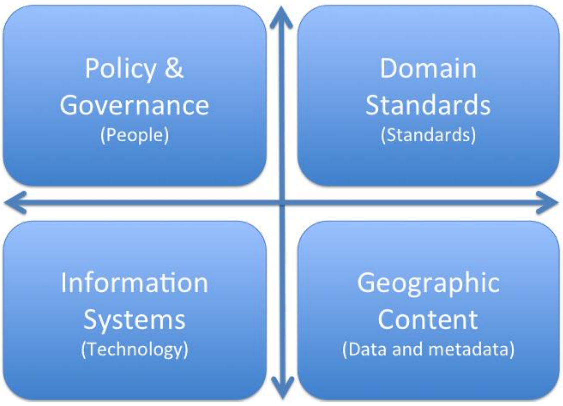

FIGURE 1. MSDI 4 Pillars (OceanWise 2013)

POLICY & GOVERNANCE

Policy

Policies are influenced by international best practices in spatial data management and exchange (Strain et al. 2006). MSDI policies have been developed initially in United States and Australia. In US, the National Oceanic and Atmospheric Administration (NOAA) has developed a policy for Coastal NSDI that aimed to link the coastal management community with the National SDI. In Australia, the Marine Science and Technology Plan established a policy for marine spatial data management, which defines methods for avoiding duplication, data consistency, improved access to data and coordinated data management.

In Europe, the Policies for the establishment of MSDIs at national and regional level are mandated mainly by the EU Directives and Communication documents, that are initiated by the DG for Environment and the DG for Maritime Affairs.

[5] IHO, MSDI Open Forum, Copenhagen, 30 Jan 2013

Marine Strategy Framework (DG Environment)

In June 2008, the European Union's Marine Strategy Framework Directive (2008/56/EC) was adopted, aiming to protect more effectively the marine environment across Europe. The Directive aimed to achieve good environmental status of the EU's marine waters by 2020 and to protect the resource base upon which marine related economic and social activities depend.

The Marine Strategy Framework Directive establishes European Marine Regions on the basis of geographical and environmental criteria. Each Member State, cooperating with other Member States and non-EU countries within a marine region, are required to develop strategies for their marine waters. The marine strategies to be developed by each Member State must contain a detailed assessment of the state of the environment, a definition of "good environmental status" at regional level and the establishment of clear environmental targets and monitoring programs.

Blue Growth (DG Maritime Affairs)

In 2012 the Commission adopted a Communication on Blue Growth (EU, 2012) showing how Europe's coasts, seas and oceans have the potential to be a major source of new jobs and growth that can contribute to the Europe 2020 strategy and improve the way we harvest the planet's resources. In early 2014, another communication published on an Action Plan on “innovation in the blue economy". The general aim of this communication is to realize the potential of Blue Growth. It proposes a series of initiatives to gain better knowledge of the ocean, improve the skills needed to apply new technologies in the marine environment, and strengthen the coordination of marine research.

In March 2013 (EU 3013), the Commission proposed legislation to create a common framework for maritime spatial planning and integrated coastal management. While each EU country will be free to plan its own maritime activities, local, regional and national planning in shared seas would be made more compatible through a set of minimum common requirements.

More recently the Commission (EU 2014) drafted the «Marine Knowledge 2020 Roadmap» a document that sets the objective of establishing a sustainable process where marine data would be easily accessible, interoperable and free of restrictions on its use.

Governance

Relevant to policies, governance, which can be seen as organizations and partnerships, is one of the most important aspects of MSDI. The organizations in MSDI are the data providers and the data users (Strain et.al. 2006). In the marine environment these organizations may be from government at local, regional and national levels, as well as from private industries such as shipping, defense, aquaculture and conservation.

In addition, in a memo of the EU Integrated Maritime Policy for better maritime governance in the Mediterranean (EU 2009), the term for maritime governance introduced that refers to the manner in which authorities and other stakeholders, influence, direct, guide, or regulate sea-related and coastal activities, such as maritime transport, offshore energy development, gas pipelines, port development, fisheries, aquaculture, etc. Governance should enable stakeholders to participate fully in this process, and should ensure that decision-making is transparent and that the agreed rules are implemented fairly.

Similarly, SDIs (GSDI 2004) require a consensus process to properly define, document, and manage the standards framework in order to ensure that the needs of the many constituents are properly represented. A structured and open process that facilitate dialogue, approval of the SDI framework and future revisions, and effective life cycle management. In this context, there was an effort tried to identify the major stakeholders of the National MSDI in Greece, either as providers or as users. In the next paragraphs these organizations are presented, classified under the supervising ministry.

Ministry of Defence

Hellenic Navy Hydrographic Service (HNHS)

The Hellenic Navy Hydrographic Service (HNHS) [6] was established in 1919 and is an agency of the Ministry of Defense (MOD). Its core mission, besides operational support of the Navy, is the hydrography of the Greek seas, issuing navigational charts, aids and notices to mariners, with main objectives, the safety of navigation, the protection of the marine environment and the support of the economic development of the coastal areas and the islands.

The responsibilities of HNHS are the collection and processing of hydrographic, oceanographic and maritime data, the issue of navigational charts in paper and digital form, the issue of navigational aids (Sailing Directions, Lights list, etc.), the provision of notices to mariners, the advisory on matters related to the foreshore, marine works, aquaculture, etc., the coverage of public and private sector requirements related to its responsibilities and the cooperation with other local or foreign bodies for research projects associated with its responsibilities.

HNHS is legally the only national body, which produces cartographic products certified for official use by mariners (navigational charts and publications) and provides services to mariners in order to ensure maritime safety, protection of the marine environment and in extension of the human life at sea.

In 2006 (Information Society SA[7] 2006), HNHS commenced the development of an integrated Marine Geographic Information System (MGIS) that will form the basis for the management of information collected and provided by HNHS, the version of its products, providing services to third parties, but also for any study related with marine and maritime activities (figure 2).

MGIS aimed to contribute to the improvement and modernization of methods of information dissemination and provision of HNHS products, in order to support mariners in Greek and adjacent seas and the operational needs of HNHS and the Navy in general. The project aimed to achieve effective management of information, increased safety for navigation, effective marketing, minimize time for services provision, efficient exchange of Geographic Information with other entities with similar purpose (HMGS, HCMR, IGME, etc), cost reduction for processing, production and distribution of products and efficient data exchange with bodies and services abroad

Hellenic National Meteorological Service (HNMS)

The Hellenic National Meteorological Service (HNMS)8 was founded in 1931 under the Ministry of Aviation and its mission was to cover all the meteorological and climatological needs of our country. Today, HNMS is a National Service under the subordination of MoD and the auspices of the Hellenic Air Force General Staff. The mission of HNMS is to provide meteorological support to National Defense, National Economy and Safety of life and property.

[6] http://www.hnhs.gr
[7] https://www.gcloud.ktpae.gr/wps/portal/gcloud/ktp/ - last accessed 12.02.19
[8] http://www.hnms.gr/hnms/english/index_html

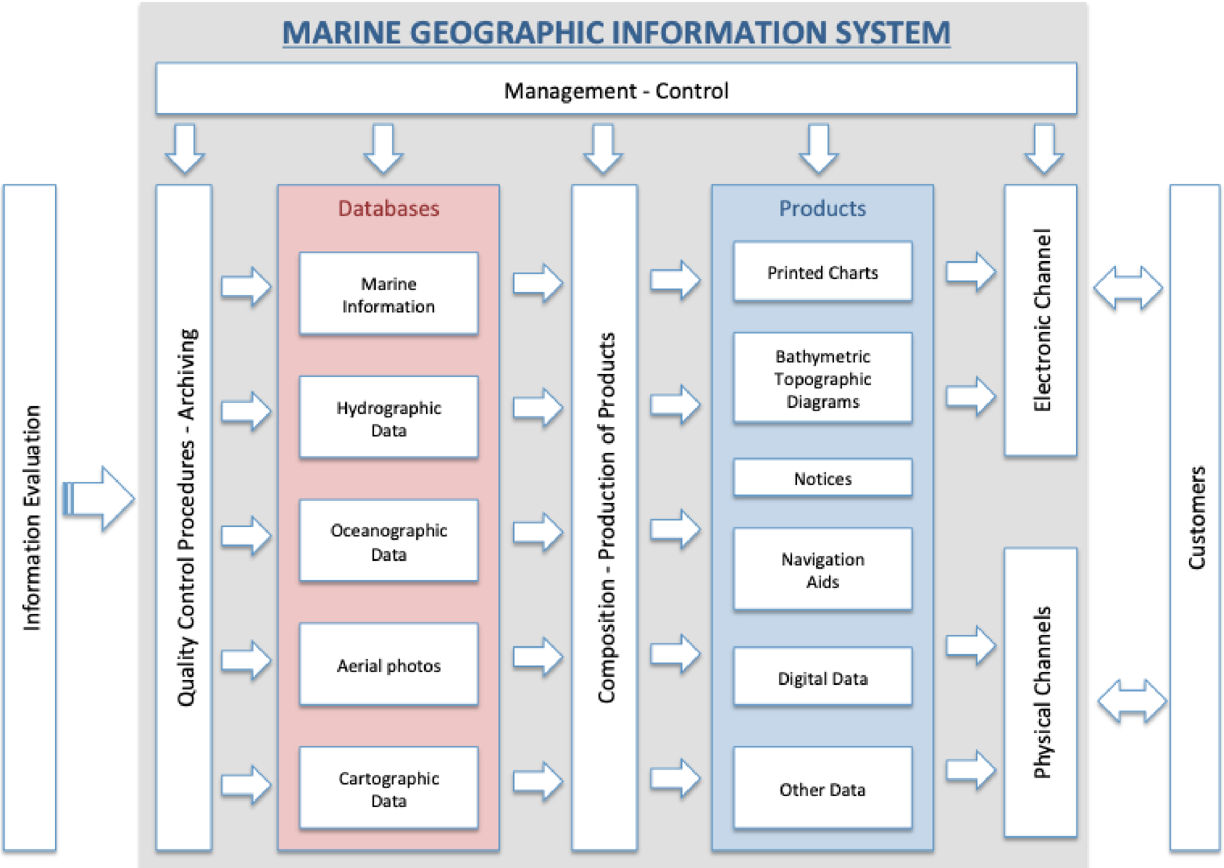

FIGURE 2. HNHS Marine Geographic Information System
(Adapted in English from Information Society S.A. 2006)

Ministry of Education

Hellenic Centre for Marine Research (HCMR)

The Hellenic Centre for Marine Research is the national laboratory of Greece on oceanography and marine research. HCMR work covers the entire spectrum from basic science to technological research. We do large scale experiments in the ocean, measure environmental parameters, explore the seafloor, find ancient wrecks and submerged cities, help the State with tsunami hazard mitigation, protect our beaches, study the evolution of fish populations, develop feed for fish, train graduate students and disseminate information to the public. We invite scientific collaborations from anywhere in the world, and we charter our oceanographic ships for specialized studies.

Other Research Institutions and Academia

Almost all Research and Academic Institutions have been involved in the past in research projects related to marine and maritime activities. Naming a few, without the list being complete,: NCSR "Demokritos", Athena, University of Piraeus, University of Aegean, National Technical University of Athens, University of Crete and many more.

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Ministry of Environment, Energy and Climate Change

The Ministry of Environment, Energy and Climate Change (M.E.E.C.C.),[9] formulated in 2009, is responsible for the protection of the natural environment and resources, the improvement of quality of life, the mitigation and adjustment to the implications of climate change and the enhancement of mechanisms and institutions for environmental governance. The Ministry has been established in order to confront the continuous environmental problems and to adopt a new development model–the model of Green Development- that will secure a better quality of life for every citizen. The Ministry of Environment, Energy and Climate Change in order to achieve its mission, has developed a strategic plan based on 4 pillars:

- tackling climate change by switching to a competitive low-carbon consumption
- preservation and management of natural resources in a sustainable manner
- upgrading the quality of life while respecting the environment
- strengthen mechanisms and institutions of environmental governance

The Ministry is responsible for the General Framework for Spatial Planning and Sustainable Development and supervises the implementation of the National Spatial Data Infrastructure (EYGEP) and the efforts to adhere with the INSPIRE Directive. The public consultation on the project: "National Interoperability Framework for Geoinformation and Services and the National Geoinformation Policy" has initially started in 2011 but the project did not continue until recently.

Hellenic Cadastre.

The Hellenic Cadastre is a legal entity of public law and its mission is the study, development and operation of the cadastre. The sole shareholder of the entity is the Ministry of Environment and Energy. The entity initially was called Ethniko Ktimatologio AE and was founded with a joint decision of the Minister of Economy and Finance and the Minister of Environment in 1995 as an agency of private law.

Special Secretariat for Water

The Special Secretariat for Water is responsible for the development and implementation of all programs related to the protection and management of the water resources of Greece and the coordination of all competent authorities dealing with the aquatic environment. The implementation of the Water Framework and the Marine Strategy Directives as well of the related child Directives fall within the scope of the activities of the Secretariat.

The Secretariat, in collaboration with the Regional Water Authorities, formulates and, upon approval by the National Council for Water, implements the River Basin Management Plans and the national monitoring program. More specifically the Secretariat is responsible for the coordination of all agencies and state institutions, related to water issues and the regional Water Directorates and the implementation of the:

- Water Framework Directive
- Marine Strategy Directive
- National Monitoring Program
- Floods Directive
- Urban Wastewater Directive and reuse programs
- Nitrates Directive

[9] http://www.ypeka.gr

- Bathing Waters Directive
- Transboundary and international water issues

Institute of Geology & Mineral Exploration

The Institute of Geology & Mineral Exploration (IGME)[10], founded in 1952, as core mission has the research and study of the geological structure of the country, the identification and assessment of mineral and energy raw materials, research and exploitation of groundwater resources, the risk from natural disasters, always aiming to improve the quality of life and environmental protection. It is a Legal Entity of Private Law, supervised by the Ministry of Environment and is the official adviser of the State on geo-science, minerals and energy raw materials.

Centre for Renewable Energy Sources and Saving

The Centre for Renewable Energy Sources and Saving (CRES) is the Greek national entity for the promotion of renewable energy sources, rational use of energy and energy conservation. CRES is active, in the frame of the national and EU policy and legislation, for the protection of the environment and sustainable development and implements projects for the promotion and market penetration of new energy technologies.

Ministry of Maritime and the Aegean

Hellenic Coast Guard

Hellenic Coast Guard founded in 1919 and its manpower amounts to 7,500 people and continually expanding in the face of increasing demands of policing the country's ports. Its main mission includes border surveillance, ports policing, assistance and rescue, protection of the marine environment and the elimination of illegal action. It has well-trained personnel and equipped with special vessels, lifeboats for sea and helicopters for air surveillance.

Hellenic Chamber of Shipping

Hellenic Chamber of Shipping, being established in 1936, is the official advisor to the government on all shipping matters. It carries out its work in close co-operation with, and under the supervision of, the Ministry of Maritime. Members are all vessels under the Greek flag represented by the following ship-owning unions:

1. Union of Greek Shipowners
2. Hellenic Shortsea Shipowners Association
3. Greek Shipowners Association for Passenger Ships
4. Union of Coastal Shipowners
5. Panhellenic Association of Tug Boats & Salvage Vessels (St. Nicolas)
6. Shipowners Association of Tug Boats and Salvage Vessels
7. Panellenic Union of Shipowners of Coastal Cargo Vessels
8. Hellenic Professional Yacht Owners Association

The major functions of the Chamber include offering opinion on draft legislation proposed by the Ministry of Merchant Marine or other government departments, carrying out research and studies on shipping related matters, following developments in international maritime legislation, offering expert advice on specialized shipping issues, proposing measures for the protection and

[10] http://portal.igme.gr

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welfare of seafarers, attending meetings of international shipping organizations, monitoring all legal and technical developments in the shipping field and conducting arbitration on maritime disputes.

Ministry of Tourism

The Ministry of Tourism is the government department in charge of tourism in Greece. In the recent Common Ministerial Decision the National Planning for Tourism has been revised and defines four (4) marine tourism priorities, (i) cruise, (ii) yachting, (iii) fishing and (iv) diving tourism.

In the recent years there is a steady growth trend, both in cruise tourism, and tourism with yachts. It is imperative need that the upward trend in the marine tourism should be supported by spatial policy organization for the sustainable improvement of sector competitiveness. For instance the organization of marine space in Sailing Zones under common geographical features, weather conditions, preferred sailing routes etc. The Sailing Zones, as shown on the map of the Tourist Ports Network (figure 3), are as follows:

Zone 1: Thermaikos-Northern Sporades-Pagasitikos-North Evvoikos, Zone 2: Thracian Sea-North Aegean, Zone 3: Central-Eastern Aegean, Zone 4: Southeastern Aegean - Dodecanese, Zone 5: Crete, Zone 6: Cyclades, Zone 7: Southern Peloponnese, Zone 8: Argolis - Saronic - South Evvoikos, Zone 9 Ionian Sea, Zone 9a: Corinthian (subsystem Zone 9).

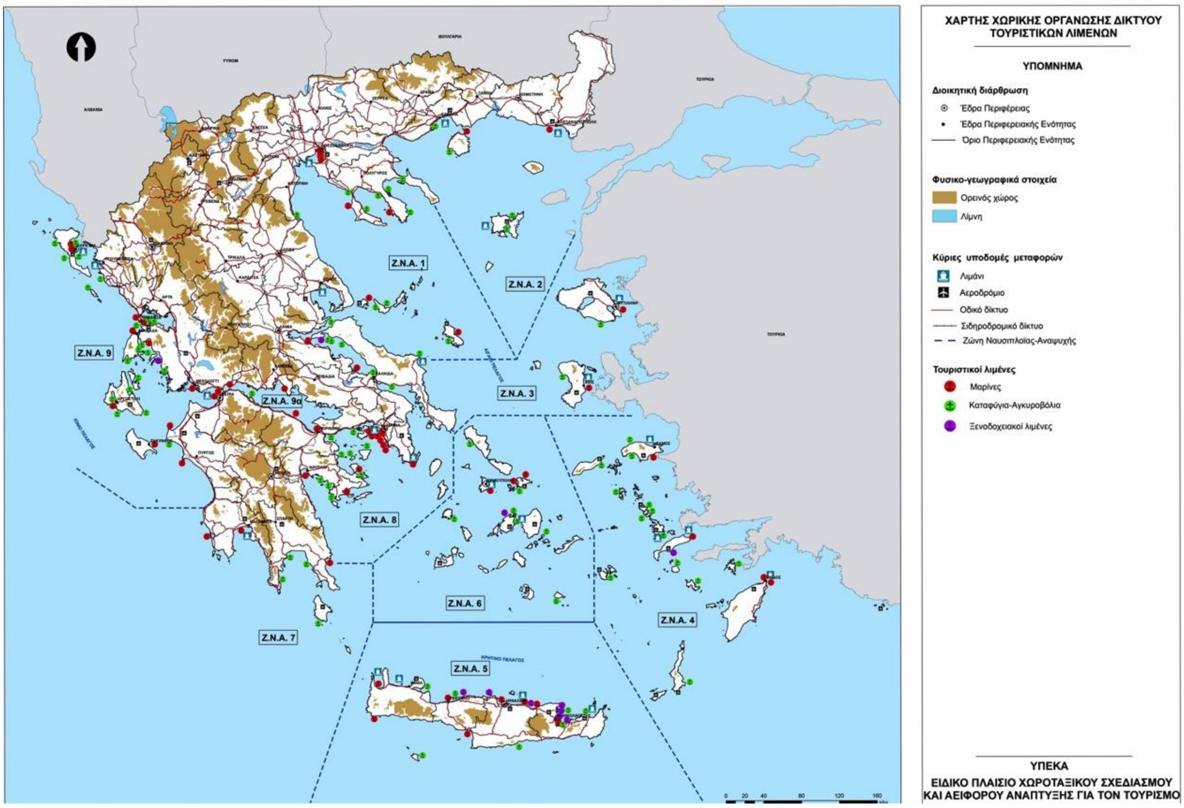

FIGURE 3. Revised Sea Tourism National Spatial Planning (Ministry of Tourism 2013)[11]

[11] http://www.greenagenda.gr/wp-content/uploads/2013/12/KYA_TOURISMOS_anath_LIMANIA_11_2013_mintour-2200x1552.jpg

Ministry of Rural Development and Food

The General Directorate of Fisheries[12] is the administrative sector of the Ministry of Rural Development and Food, who manages sectors collectors fishing, aquaculture processing and marketing of fishery products. The general purpose of the General Directorate of Fisheries is to ensure those fisheries and aquaculture activities that create long-term sustainable economic, social and environmental conditions, which are a prerequisite for the establishment of an economically and socially sustainable fisheries sector that will contribute to food availability.

Federation of Greek Maricultures

Aquaculture, the world's fastest growing food production sector[13] according to the Food and Agriculture Organization of the United Nations (FAO), will expand the coming years. Total fish supply is projected to increase to 186 million tones in 2030 with fisheries and aquaculture contributing equal amounts. However, aquaculture is expected to provide close to two thirds of global food fish. Mariculture[14], is a specialized wing of aquaculture that is undertaken in marine environments. It involves cultivation of marine organisms in the open ocean or in an enclosed section of the ocean or in ponds, tanks filled with seawater.

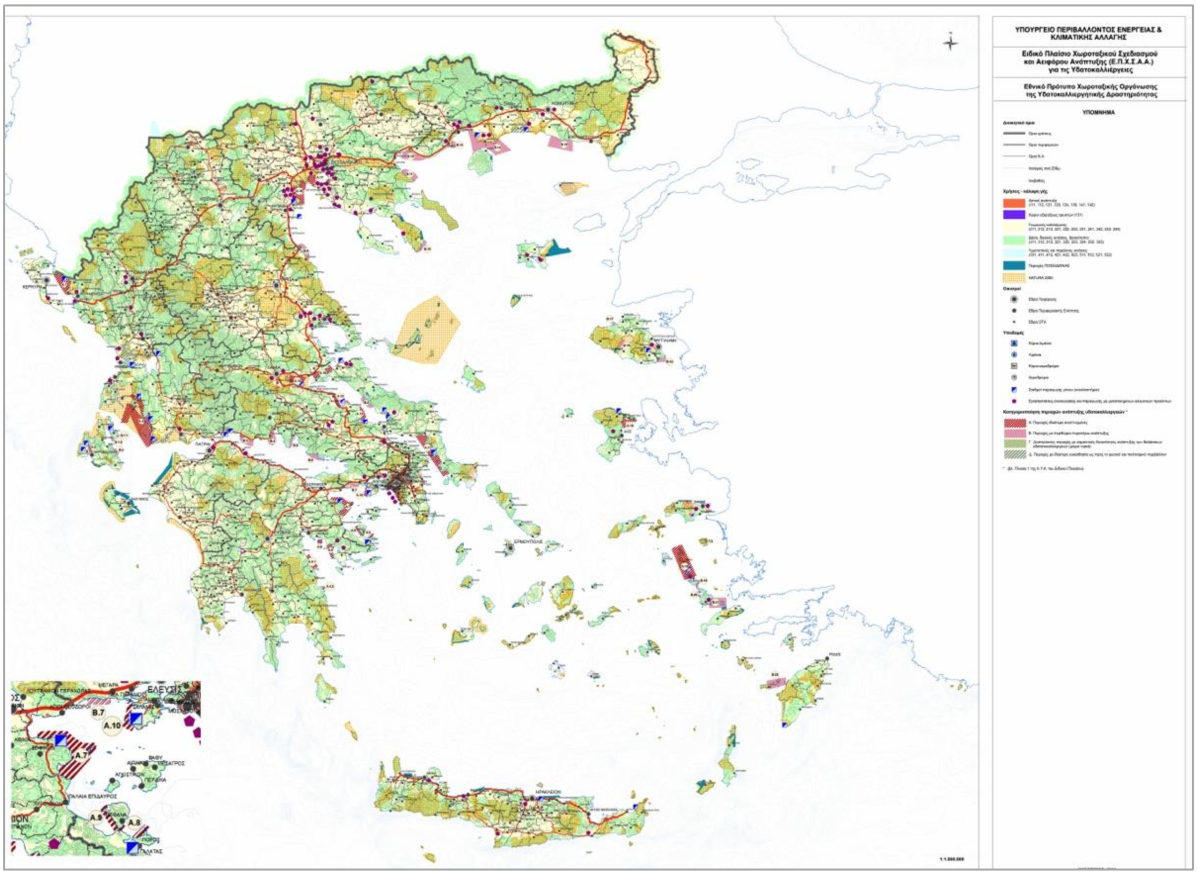

FIGURE 4. Aquaculture National Spatial Planning (FGM 2011)[15]

[12] http://www.alieia.minagric.gr
[13] http://www.fao.org/post-2015-mdg/14-themes/fisheries-aquaculture-oceans-seas/en/
[14] http://www.differencebetween.net/miscellaneous/difference-between-aquaculture-and-mariculture/
[15] http://www.ypeka.gr/LinkClick.aspx?fileticket=KqnN2BWqAKo%3d&tabid=513&language=el-GR

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The Federation of Greek Maricultures was established in 1991. Since 1991 FGM is focusing in the promotion and establishment of the successful development of the Greek Mariculture Industry. The companies - members of FGM - represent the 80% of the total production capacity in sea bream and sea bass. The successful production and rapid development of the sea bass and sea bream in marine cages represents a popular production model in the international mariculture industry.

Aquaculture has a specific plan for the sector development coordinated by the Ministry of Environment (see FIGURE 4)

(DOMAIN) STANDARDS

Domain Standards are used to ensure interoperability of the provided datasets from the various organizations and specify regulations for content, metadata, data access, and exchange. In the traditional SDIs there are many different standards used, often set at international and national levels. Working within a common framework of standards and tools based on these standards maximizes the impact of the total available resources for SDI creation through future co-operation. Although the core SDI concept does not includes within its scope the original data collection activities or the applications built upon it, the infrastructure provides the environment to connect application services to data – influencing both data collection and applications const

uction through appropriate standards and policies.

International Hydrographic Organization (IHO)

The International Hydrographic Organization[16] (IHO) is an intergovernmental consultative and technical organization established in 1921, to support the safety of navigation and to contribute to the protection of the marine environment. One of its primary roles is to establish and maintain appropriate standards to assist in the proper and efficient use of hydrographic data and information. Realizing the potential of MSDIs, IHO appointed a specialized Marine Spatial Data Infrastructure Working Group which prepared a workbook, the C-17 - Spatial Data Infrastructures: The Marine Dimension – Guidance for Hydrographic Offices (IHO 2017), which outlines the benefits of developing spatial data infrastructures (SDIs) to reinforce coordination among maritime authorities and describes a complete framework for implementation.

S-100 Framework Data Structure for Hydrographic and Related Data

Moreover IHO, in conjunction with the International Hydrographic Bureau, have developed a framework standard for digital hydrographic data the S-100 series. S-100 provides a geospatial data standard that can support the variety of hydrographic-related digital data sources, products, and customers. S-100 specifies methods and tools for data management, processing, analyzing, accessing, presenting and transferring data in digital form between different users, systems and locations. By following this set of standards users are able to build constituent parts of an S-100 compliant product specification.

Its main features include:

- separating the data content from the carrier (file format).
- manageable flexibility that can accommodate change.

[16] http://www.iho.org

- alignment with the series of current geospatial information standards adopted by the International Organization for Standardization (ISO 191xx).
- an ISO-conforming web-based registry containing registers for feature data dictionaries, portrayal and metadata.

S-100 supports imagery and gridded data, high-density bathymetry, seafloor classification, 3D and time-varying data (x,y,z and time), dynamic ECDIS, Marine Information Overlays (MIOs), Marine Mapping, web-based services and other maritime data applications. Besides the IHO, other organizations are involved in maintaining domains within the S-100 Registry such as:

- the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA)
- the Inland ENC Harmonization Group (IEHG)
- the Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM) of the Intergovernmental Oceanographic Commission (IOC) and
- the World Meteorological Organization (WMO)

Intergovernmental Oceanographic Commission (IOC) of UNESCO

The UN and UNESCO, through the activity of the IOC (Intergovernmental Oceanographic Commission) (Kousiopoulos 2011), has recently dealt with Marine Spatial Planning. In 2009 IOC published a definite guide (IOC 2009) that describes in a step-by-step approach the concept of MSP.

The guide aims at providing understanding what marine spatial planning is about, insight in the consecutive steps and tasks of setting up a successful marine spatial planning initiative that can help achieving ecosystem-based management and awareness of what has worked and what has not in marine spatial planning practice around the world

The 10 steps for marine spatial planning include:

- Step 1 Defining need and establishing authority
- Step 2 Obtaining financial support
- Step 3 Organizing the process (pre-planning)
- Step 4 Organizing stakeholder participation
- Step 5 Defining and analyzing existing conditions
- Step 6 Defining and analyzing future conditions
- Step 7 Developing and approving the spatial management plan
- Step 8 Implementing and enforcing the spatial management plan
- Step 9 Monitoring and evaluating performance
- Step 10 Adapting the marine spatial management process

Oceanographic Data Exchange

Related to data exchange standards, IOC established in 1961 the programme "International Oceanographic Data and Information Exchange"[17] (IODE). Its purpose was to enhance marine research, exploitation and development, by facilitating the exchange of oceanographic data and information between participating Member States, and by meeting the needs of users for data and information products. The IODE system forms a worldwide service oriented network consisting of DNAs (Designated National Agencies), NODCs (National Oceanographic Data Centres),

[17] http://www.iode.org

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RNODCs (Responsible National Oceanographic Data Centres) and WDCs (World Data Centres – Oceanography). During the past 50 years, IOC Member States have established over 80 oceanographic data centres in as many countries. This network has been able to collect, control the quality of, and archive millions of ocean observations, and makes these available to Member States.

More recently the Ocean Data Standards and Best Practices Project (ODSBP)[18] initiated with main objective to achieve broad agreement and commitment to adopt a number of standards and best practices related to ocean data management and exchange. The project is a continuation of the Ocean Data Standards Pilot Project (ODS), established and implemented jointly between Joint WMO-IOC Technical Commission on Oceanography and Marine Meteorology (JCOMM)[19] and IODE.

European Union – INSPIRE Directive

On the EU level, the INSPIRE directive aims to establish an infrastructure for spatial information in Europe that will help to make spatial or geographical information more accessible and interoperable for a wide range of purposes supporting sustainable development. INSPIRE Directive entered into force on 15 May 2007 and provides a general framework for a Spatial Data Infrastructure (SDI) for the purposes of European Community environmental policies. It is based on the infrastructures for spatial information established and operated by the member states of the European Union and the directive addresses 34 spatial data themes of features needed for environmental applications. The following four may be considered as more closely related to marine data.

Ocean Geographic Features (OF)

The Ocean Geographic[20] Features include the measurable physical conditions of oceans e.g. salinity, oxygen, other chemical components, currents. Relevant observational data include (i) remote-sensing of sea surface temperature, dynamic topography, synthetic aperture radar winds, ocean colour, (ii) drifting buoys provide surface velocity, temperature, atmospheric pressure, (iii) ships-of-opportunity and regular voluntary observing ships provide temperature (bathythermograph) profiles and (iv) argo floats provide temperature and salinity profiles.

Sea Regions (SR)

The Sea Regions[21] Features includes Seas and saline water bodies divided into regions and sub-regions. Each region with common characteristics, concerning water flow/ circulation, adjacent river catchments, bio-chemical or temperature of water, based on scientific criteria. Both ‘Oceanographic geographical features’ and ‘Sea-regions’ are concerned with physical conditions of marine water-masses.

Meteorological Geographical (MF)

The Meteorological Geographical[22] Features includes weather conditions and their measurements; precipitation, temperature, evapotranspiration, wind speed and direction.

[18] http://www.oceandatastandards.org
[19] https://www.jcomm.info
[20] http://inspire.ec.europa.eu/theme/of
[21] https://inspire.ec.europa.eu/theme/sr
[22] http://inspire.ec.europa.eu/theme/mf

Elevation (EL)

The Elevation[23] Features includes terrestrial elevation, generally represented as (i) the terrain data, ground surface topography, called Digital Terrain Model (DTM) describing the three dimensional shape of the Earth's surface, (ii) the surface data, named Digital Elevation Model (DEM), including the three dimensional shape of every feature placed on the soil (buildings, bridges, trees, etc) and (iii) bathymetry, e.g. a gridded bottom model.

International Maritime Organization - e-Navigation

In addition to the information that nautical charts traditionally depict, the electronic chart systems usually contain additional navigation data. However, even the term "navigation" does not fully describe the fact that many other types of information, usually found in many other sources, can also be included in an electronic chart system. The IMO's e-navigation strategy specifically addresses the harmonized collection, integration, exchange, presentation and analysis of such marine on-board information using the electronic chart as a key technology (IMO 2008).
IMO established a correspondence group led by the Norwegian Coastal Administration to advise the various IMO committees to develop the strategic implementation plan. The task of the Contact Group was to examine appropriate data structures and stated in a report at the beginning of 2011 that the S-100 Geospatial Data Model should be used as a guiding principle when designing the e-Navigation initiative (Ward 2011). In this context, the S-100 plays a key role in organizing hydrology and other marine industries in the present time as well as in the future.

Interoperability Standards

Interoperability standards have been matured to promote the exchange, integration and use of marine data through enhanced data publishing, discovery, documentation and accessibility. The following ISO and OGC standards are proposed by GSDI (GSDI 2004):

SDI technology standards

- OGC Web Map Service 1.3
- OGC Web Feature Service 2.0/ISO 19142
- OGC Filter Encoding 2.0/ISO 19143
- OGC Web Coverage Service 1.1.2
- OGC Geography Markup Language 3.3
- OGC Catalogue Service 2.0.2
- ISO 19115 and ISO/TS 19139
- OGC KML 2.2 and OGC WPS 1.0 + corrigenda

SDI supplemental standards

- OGC Styled Layer Descriptor 1.1
- OGC Web Map Context 1.1/Corrigendum 1
- OGC® WCS 2.0 Interface Standard- Core: Corrigendum, Version 2.0.1, 2012-07-12, and KVP, XML/POST, XML/SOAP, and GeoTIFF extensions
- GeoRSS-Simple, GeoRSS GML

[23] http://inspire.ec.europa.eu/theme/el

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INFORMATION SYSTEMS

Maritime Connectivity Platform

Based on the IMO's e-Navigation Strategy, the idea of the Maritime Cloud, or recently the Maritime Connectivity Platform (MCP) (Figure 5), has emerged as "a framework for communication that enables efficient, secure, reliable and uninterrupted electronic information exchange between all authorized shipping operators on all available communication systems". The vision goes beyond IMO's strategy, combining the objectives of the EU e-maritime initiative and other[24].

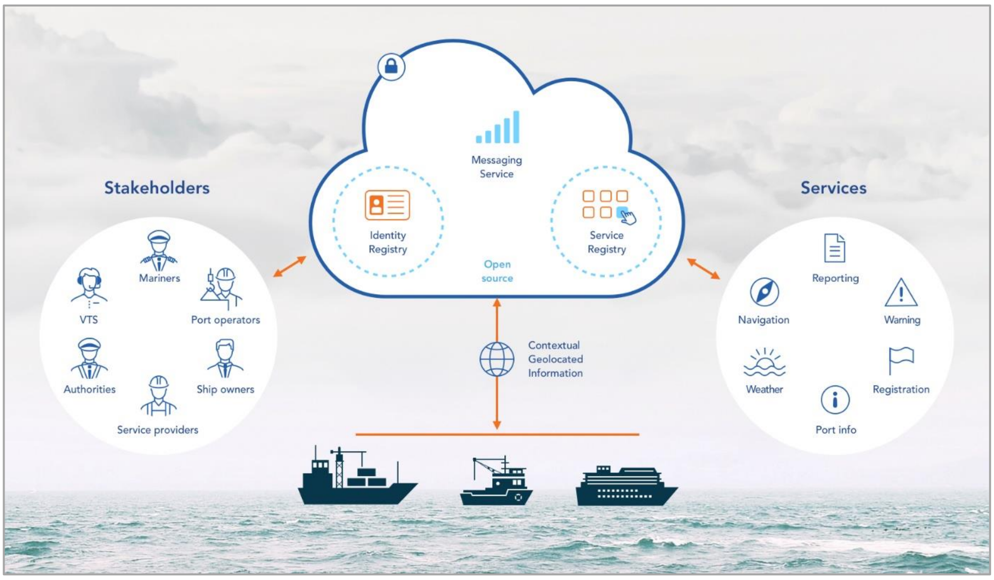

FIGURE 5. - Maritime Connectivity Platform[25]

MCP's mission is to enable an open and neutral shipping platform that facilitates the exchange of information easily and securely across various communication channels, such as the Internet, satellite or digital wireless interfaces. It will allow the interconnection of heterogeneous software systems on the different types of ships, on offshore platforms or on land, including specially approved systems (e.g. ECDIS) as well as most personal devices such as smartphones, tablets according to standardized interfaces, protocols and permissions for access control. MCP has three main elements:

- a register of identities
- a services register
- a messaging service

MSDI High Level Logical Architecture

A marine SDI is more than a single database as it hosts geographic data, entities attributes, metadata, processes to discover, visualize, and evaluate the data, catalogues and web mapping

[24] https://ec.europa.eu/inea/en/horizon-2020/projects/h2020-transport/waterborne/efficiensea-2 - last accessed 13.02.19

[25] https://efficiensea2.org/solution/maritime-connectivity-platform/

services and methods to provide access to the geographic data. Beyond this there are additional programs and software to support SDI services. For the actual implementation of the MSDI there are currently many open source technologies for implementing Spatial Data Infrastructures (Mpezati 2010). Building upon the MGIS project principles, a logical architecture of the MSDI is proposed as depicted in the Figure 6.

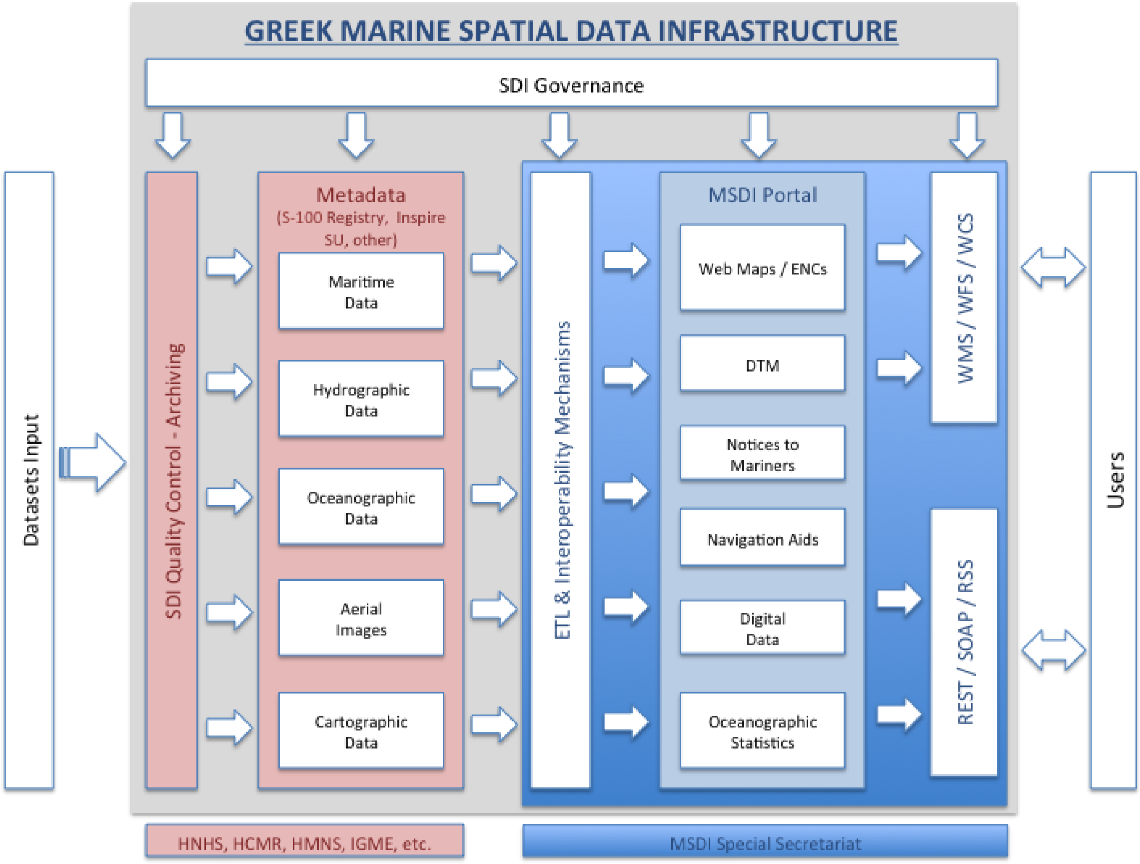

FIGURE 6. MSDI Logical Architecture Diagram

On the left hand side (red area), the various data owners are providing either their datasets as network locations and/or their web services definitions. Initially, a control process will perform quality assessment of the inputs, then a classification process incorporates the necessary metadata and following the directory data and the metadata are loaded into the infrastructure. On the right hand side (blue area) all the various technical mechanisms for providing the services to the end users are provided through a common MSDI portal.

MSDI DATA

The marine environment is dynamic and multi-dimensional, featuring a difficult area for data collection and updating. Data is usually collected on a project-based approach and is rarely shared between different organisations. A key issue is the availability of data. There is a substantial amount of data collected about the marine and coastal environments, but it is often not available to all users. The other issue is that if it is available, it may not be interoperable.

To resolve this problem in the land environment often an SDI will include 'fundamental datasets', those that will be needed to support most business processes, with a designated custodian responsible for maintaining them. Respectively, according to IHO (IHO 2017) and the BLAST project[26], marine spatial fundamental datasets would be as follows:

- Coastline (MHW, MLW): The mean position of the incidence of mean high water and land as observed and measured over many tidal cycles.
- Maritime Baseline: The line from which maritime zones and limits are measured and monitored internationally.
- Offshore Cadastre: The land management system extending from the baseline to the extent of national jurisdiction.
- Climate: The modeled and observed spatial and temporal data characteristics of the atmosphere, hydrosphere and land surface system.
- Bathymetry: The datum to which sea level is measured and maintained to support nautical charting, engineering and construction projects and to model the seabed.
- Seabed Character and Bedform: The complexion of the seabed in terms of its surface geology and sediment composition.
- Flood Hazards: National Flood Insurance Programs maintain flood hazard information around a nation.
- Maritime/National Boundaries: Sovereign seabeds defined by specific legislation and / or usage (e.g. 12 nautical mile limit).
- Offshore Minerals: Minerals and hydrocarbons occurring on or under the seabed.
- Marine Transportation: Commercial, Defense, and Recreational in terms of surface navigation aids controlling where vessels might traverse.
- Obstructions: those features that exist on the seabed (e.g. shipwrecks, well-heads).
- Physical Oceanographic features: Those temporal elements in the water column that describe the condition of the oceans (e.g. salinity, light attenuation, currents, waves).
- Marine Gazetteer: A geographical dictionary or directory and reference for information about places and place names.
- Shoreline Constructions (e.g. pontoons, piers)
- Tidal Elevations (surfaces)
- Natural Shoreline and Seabed Topography (marine landscapes)
- Offshore Infrastructure (e.g. oil & gas installations, cables, fish cages)
- Land ownership: Information and descriptions of property including title, estate or interest of the federal government (or other owner) in a parcel of real and mineral property.
- Licensed Development and Activity Areas

These data can be categorized in the following categories (IHO 2017):

- Reference Data (e.g. Bathymetry, Structures, Borders)
- Application Data (e.g. Managed Areas, Natural Resources)

[26] http://www.blast-project.eu/

- Business Data (e.g. Environmental Statistics)
- Personal Data (e.g. Supplier Contact Details)
- Internal or Working Data (e.g. Product Schemes)
- Publications and Services (e.g. Thematic Chart)

European MSDI Platform - EMODnet

The European Marine Observation and Data Network (EMODnet) is a long-term marine data initiative of EU's DG MARE[27]. EMODnet is also a network of organisations supported by the EU's integrated maritime policy. These organisations work together to observe the sea, process the data according to international standards and make that information freely available as interoperable data layers and data products.

EMODnet provides access to European marine data across seven discipline-based thematic Portals:

- Bathymetry
- Geology
- Seabed habitats
- Chemistry
- Biology
- Physics
- Human activities

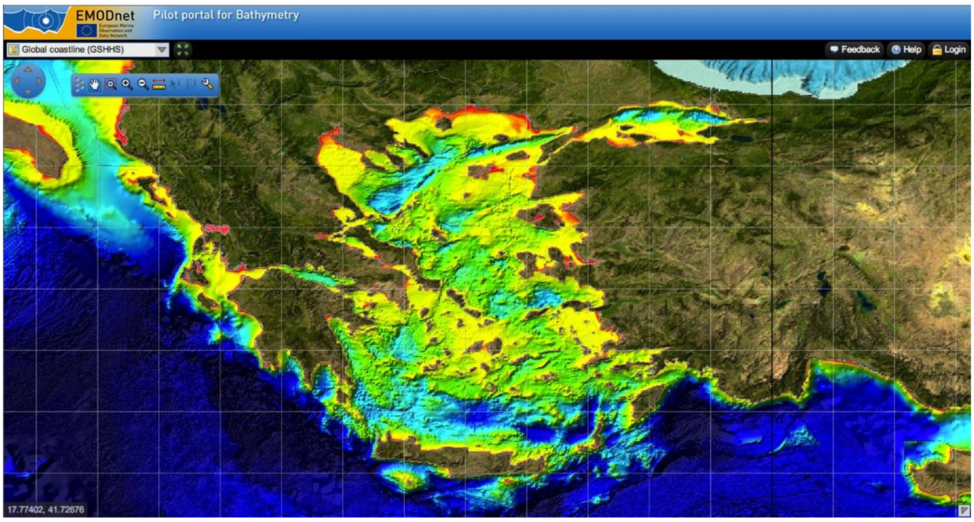

FIGURE 7. EMODNet Bathymetry Portal

For each of these themes, EMODnet has created a gateway to a range of data archives managed by local, national, regional and international organisations. Through these gateways, users have access to standardized observations, data quality indicators and processed data products, such as basin-scale maps. These data products are free to access and use.

[27] http://www.emodnet.eu/

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In addition to the thematic portals EMODnet initiated a project for sea-basin portals, and commenced with the Mediterranean Sea. The project sets out a methodology to collect existing data, analyze them for seven areas of application or 'challenges' and to make the outputs available through a web portal. The application areas of the MedSea portal are wind farms siting, Marine Protected Areas, oil platform leaks, climate and coastal protection, fisheries management, marine environment & river inputs.

Regional MSP Projects

ΘΑΛ-ΧΩΡ project

At the south-east part of Greece (Figure 8) a strategic project called "Cross-border Cooperation for Development of Marine Spatial Planning" with acronym "ΘΑΛ-ΧΩΡ"[28], aims to determine a methodology that will then gradually pilot implemented in regional planning projects in selected areas in Greece and Cyprus taking account the principles of MSP. The Lead Partner of the project is the Ministry Communications and Works - Department of Merchant Shipping of Cyprus.

Eligible project areas are the regions of Crete (Heraklion, Lasithi, Rethymno and Chania), North Aegean (prefectures of Lesvos, Samos and Chios) and Southern Aegean (Dodecanese Prefecture) in Greece, and the entire Cyprus (Figure 8). The project idea was developed taking into consideration the developments in the EU compared with the MSP and the fact that the Greece - Cyprus is built around a marine border. In addition, the project partners are the operators, which will implement the national policies for MSP. The proposed project incorporates both national and European requirements for the development of MSP and focuses on development of a common methodology and MSP process and pilot application for development of marine spatial plans in selected areas.

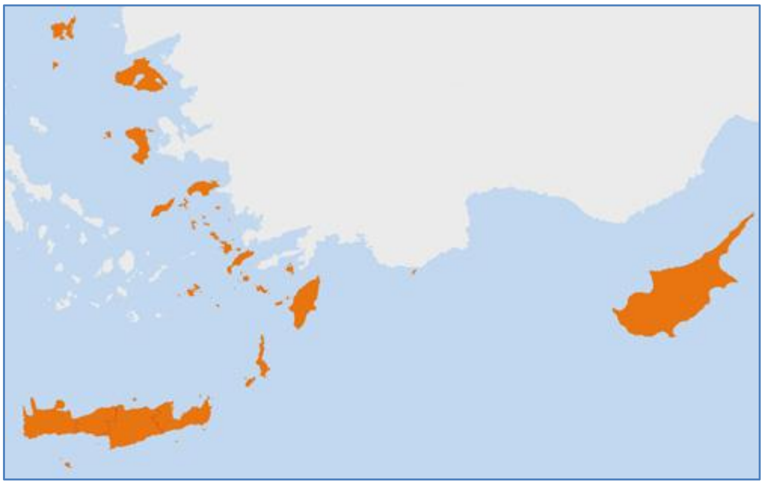

FIGURE 8. Eligible Areas of the ΘΑΛ-ΧΩΡ project[29]

[28] http://mspcygr.info
[29] http://mspcygr.info/wp-content/uploads/2014/05/Grislands-kypros.jpg

ADRIPLAN

On the north-west side of Greece, ADRIPLAN[30] project, that stands for ADRiatic Ionian maritime spatial PLANning, is funded by the European Commission – DG Maritime Affairs and Fisheries (DG MARE) under the theme "Maritime Spatial Planning (MSP) in the Mediterranean sea and/or the Black sea".

The ADRIPLAN project promotes the harmonized implementation of the EU Strategy for the Adriatic and Ionian Region (EUSAIR) and will improve the ongoing process to develop MSP in the region. The study area is the Adriatic - Ionian Macroregion, zooming into two focus areas, one in the Northern Adriatic Sea and the other in Southern Adriatic Northern Ionian Sea.

FIGURE 9. ADRIPLAN Project Focus Areas

The analysis carried out at the Macroregion scale will produce results of strategic relevance, also supporting the Action Plan of the Macroregion Strategy.

Moreover, such spatial scale is the right scale to develop MSP for elements such as transport and cruise traffic, ecosystems, fishery and aquaculture, oil & gas, energy and to provide adequate boundary conditions to the analysis on the two Focus Areas.

Local Marine related Portals

"POSEIDON" Network

The POSEIDON network[31] has been realized by the Hellenic Center of Marine Research (HCMR) in collaboration with the Hellenic Navy Hydrographic Service (HNHS) and the

[30] http://adriplan.eu/

[31] http://poseidon.hcmr.gr/weather_forecast.php?area_id=gr

Hellenic National Meteorological Service (HNMS). It aims in the continuous observation of the sea state of Hellenic waters and it contributes in the prognosis of sea state. It is comprised of a network of oceanographic mooring buoys (POMS) that are located in different areas of the Aegean Sea.

Each buoy belonging to the network carries a wide variety of sensors such as telecommunication systems, a system for data processing and storage, a data gathering system, a system for transmitting the data, etc. The boys operate on a 24-hours base. The measurements are sent to HCMR which resends the data to HNHS and HNMS. The above bodies exploit the data in different ways. The reliable and continuous operation of the boys is assured by continuous maintenance of the network and by the dissemination of the results in a national scale. The data that is collected is used in many different applications such as the wave field prognosis.

MSDI QUESTIONNAIRE

In the context of research activities of the Cartography Laboratory of the National Technical University of Athens, a short questionnaire regarding the collection of data regarding the creation of the National MSDI was drafted in order to receive end users perception. The questionnaire was circulated to over 300 key Greek marine and maritime stakeholders in October 2018. The results of the survey emphasized the need for a service-oriented MSDI, which would be a key driver for the long-term success of both the public-sector services, as well as the private-sector investments.

The questionnaire was sent to bodies related to maritime activities such as the Ministry of Shipping, Hellenic Navy Hydrographic Service (HNHS), National Centre for Marine Research (HCMR), Hellenic National Meteorological Service (HNMS), Centre for Renewable Energy Sources and Saving (CRES), Institute for Geological and Mineral Exploration (IGME), the Federation of Greek Maricultures (FGM), National Tourism Organization (GNTO), Hellenic Coast Guard (HCG), Hellenic Chamber of Shipping (NEE), Port Authorities, Universities, Shipping Companies and other relevant organizations. The questions aimed to capture the perspective of each organization regarding the development of the National MSDI and the conclusions of the survey, after the relevant responses were processed, showed with great emphasis that a relevant infrastructure will be useful both for public bodies and for shipping companies. More particularly the participants declared by:

- 71% that they have heard about the term MSDI.
- 100% that a National MSDI will help Greece for various reasons (e.g. for marine spatial planning, maritime service, environmental protection actions, etc.

Regarding MSDI benefits the participants declared by (Figure 10):

- 58% that MSDI will assist the cooperation of their organization with the public authorities.
- 58% that the MSDI will assist their organization for the compliance with national and EU directives (e.g. Open Data).
- 52% that MSDI will improve their organization services to citizens and businesses.
- 45% that MSDI will assist their organization for the promotion of their services.
- 39% that MSDI will benefit for the extroversion of their organization.

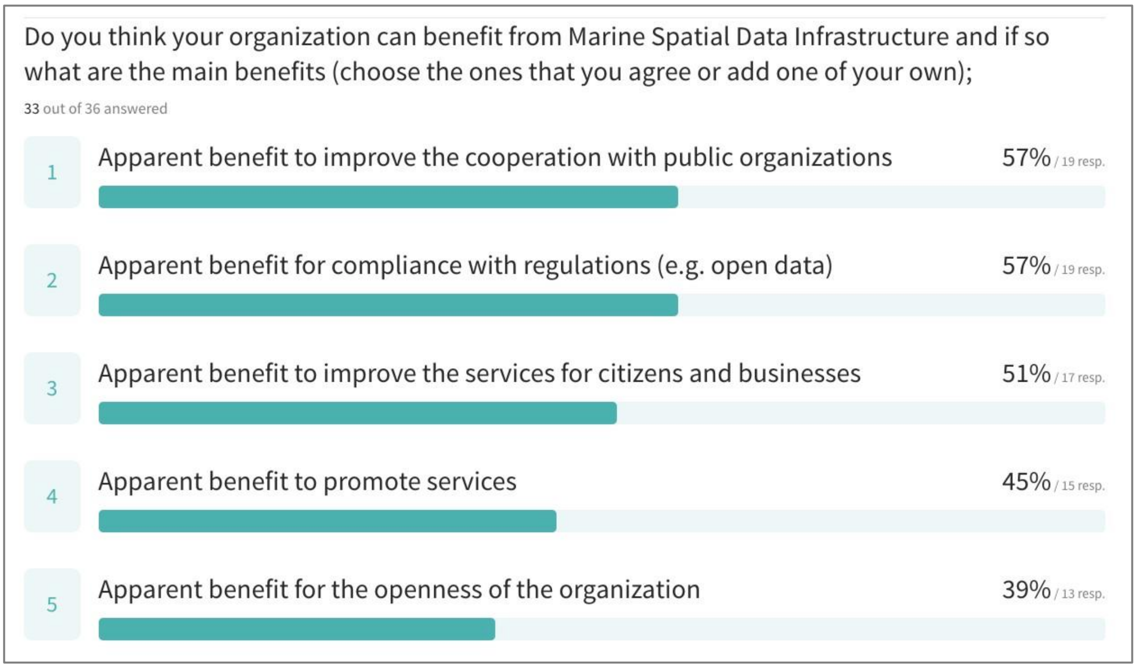

FIGURE 10. Questionnaire result for the MSDI benefits (Adapted in English)

Regarding MSDI implementation strategies the participants declared by:

- 53% that they knew about the Interoperability of Electronic Services Framework[32], that defines standards and rules for interoperability of information systems of the Public Sector.
- 48% that they knew about the European Interoperability Framework[33], that defines standards and rules for interoperability of e-services provided within the European Union.
- 54% that they knew about S-100[34], the new IHO Standard, that is a data model that covers a wide range of maritime related activities such as safe navigation of ships, protection of the marine environment, etc. and which adopts best practices and international standards for geospatial information of the ISO 19100 series.
- 63% that they were aware of e-Navigation[35], the IMO-International Maritime Organization strategic initiative, that aims to optimize interconnection and co-operation of ships with land-based stations and adopts the S-100 standard for the development of relevant services.
- 54% that they knew about the Maritime Connectivity Platform[36], which aims to develop relevant services to implement the e-Navigation strategy.
- 74% that they believe that a Greek MSDI, which in a context similar to the Maritime Connectivity Platform, will act as a central hub and will operate successfully to:

[32] http://www.yap.gov.gr/index.php/e-gif-menu/eggrafa-plaisiou-egov.html - last accessed 13.01.2019

[33] https://ec.europa.eu/transparency/regdoc/rep/1/2017/EL/COM-2017-134-F1-EL-MAIN-PART-1.PDF - last accessed 13.01.2019

[34] https://www.iho.int/iho_pubs/standard/S-100/S-100_Info.htm - last accessed 13.01.2019

[35] http://www.imo.org/en/OurWork/Safety/Navigation/Pages/eNavigation.aspx - last accessed 13.01.2019

[36] https://maritimeconnectivity.net/ - last accessed 13.01.2019

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a) develop the necessary infrastructure to support interoperability between the Marine Sector information systems as well as applications for the provision of e-services from a central point
b) collect and organize the services offered by all Marine Sector Operators and their availability on the Internet for the reliable service of citizens / businesses and their interaction with the Public Sector
c) digitally authenticate public sector officers, business users & citizens for secure access to these online services

MSDI IMPLEMENATION

The key to success in SDI initiatives is partnerships within and between organisations involved in marine administration and spatial information. EU policies are highlighting the need for better coordination and integration between and within levels of government to improve coastal zone management.

In Germany (Rüh, Korduan, Bill, 2013) the development of a marine data infrastructure takes place with the aim to integrate existing technical developments like NOKIS (North Sea and Baltic Sea Coastal Information System) – a metadata database – and the spatial data infrastructure of the German Federal Maritime and Hydrographic Agency as well as merging information concerning the fields coastal engineering, hydrography and surveying, protection of the marine environment, maritime conservation, regional planning and coastal research. The funded parties and their sub projects (SPs) in this project (funded by BMBF, the German Federal Ministry of Education and Research) are:

- Federal Waterways Engineering and Research Institute (SP1 - "coastal engineering and coastal water protection"),
- German Federal Maritime and Hydrographic Agency (SP2 - "protection of the marine environment"),
- German Federal Agency for Nature Conservation (SP3 - "maritime conservation")
- Professorship for Geodesy and Geoinformatics at Rostock University (SP4 - "scientific accompanying research").

The following are 'lessons learned' from the international arena of SDI developments according GSDI Cookbook[37]:

- Build a consensus process: build on common interests and create a common vision
- Clarify the scope and status of the SDI
- Exchange best practices locally, regionally and globally
- Consider the role of management in capacity development
- Consider funding and donor involvement
- Establish broad and pervasive partnerships across private and public sectors
- Develop clearinghouses and use open international standards for data and technology

MSDI Roadmap

For MSDI to be successful, it must be based on clear, broad-based goals that define the desired outcomes to be achieved. Muto et al (2012) put forward the following MSDI implementtation Roadmap:

[37] http://www.gsdidocs.org/GSDIWiki/index.php/Chapter_9

Phase A - Framework and Basic Principles

1. Establishment of Governing Board
2. Coordination of Data Policy
3. Standardization of Data and Metadata
4. Provision of most-updated Data
5. Partnership with Private Sector

Phase B - Required Information and Data Items

6. Definition and Consolidation of National Marine Spatial Data Infrastructure
7. Provision of Multi-dimensional Data
8. Seamlessness between Marine Data and Terrestrial Data
9. Spatially Enabled Platform linking all the related Non-spatial Marine Information

Phase C - System User Interface

10. Simple User Interface open to all the People
11. Availability of Output Data

MSDI Services Governance

The provision of public services requires Public Sector Organisations to work together to better meet the needs of end-users. When multiple organizations are involved, there is a need for coordination for optimal design, implementation and operation of services, which need to be managed (Figure 11) to ensure integration, uninterrupted execution, reuse and development of new services, as proposed in the Implementation Strategy of the European Interoperability Framework (EC 2017). The Governing Organisation is proposed to be a Special Secretariat at the Ministry of Maritime, coupled with the support of the Information Society S.A. and building upon the experience of the ΘΑΛ-ΧΩΡ project.

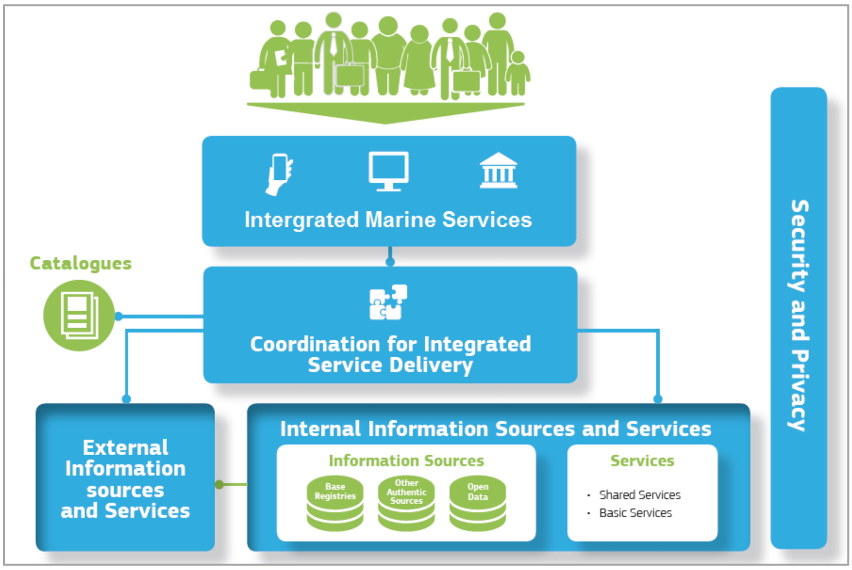

FIGURE 11. Integrated Marine Information Services Governance Framework

CONCLUSIONS – PROPOSALS

The continued advances (GSDI 2004) in remote sensing, mapping and geospatial technologies, including an increasing variety of data acquisition capabilities and low cost and more powerful computing capacity have enabled and increased the demand for geographic information. As the importance of geographic information in addressing complex social, environmental, and economic issues facing communities around the globe is growing, the establishment of a Spatial Data Infrastructure to support the sharing and use of this data locally, nationally and, in some cases, transnationally makes increasing sense.

The last 20 years has prevailed in the international scientific community the belief (Margaritou 2013) that the basic sciences of the Earth, systematically studying the atmosphere, the oceans, the earth's crust, flora and fauna, they can not explain everything that happens in our physical environment, but must cooperate closely in the field of physico-chemical interaction of the atmosphere with the earth. This notion is supported by the rapid developments in collecting, systematic scientific observations of natural phenomena with the help of satellite technology and informatics. Moreover, the operating costs of these activities and infrastructure that accompany them are a multiple of the required and inversely proportional to the qualitative and quantitative results. After the years of the economic crisis, the development is expected for Greece requires collaborative and gradual disappearance of fragmentation in research and development projects.

Key Drivers for the implementation of a National MSDI are:

- The national digital strategy of Greece[38] and the new development framework
- The establishment of S-100 as a de facto open standard for hydrography and maritime information
- The advancement of open source GIS technologies and interoperability frameworks

As Blue Growth strategy is driven by the DG of the Maritime Affairs in the EU level, it is proposed the coordination body for the realization of the MSDI platform to be either a Special Secretariat at the Ministry of Maritime (YEN) or a special purpose Marine Development Organization, which in close cooperation with the Ministry of Environment, the implementer of the national infrastructure (NSDI), and the Ministry of Development, will coordinate the effort accommodating the needs of the marine and maritime stakeholders, driven by the national interest. In the long term the Greek Marine-SDI will facilitate the efforts for a regional growth, both in the Ionian-Adriatic and the Aegean sea regions, as well as in the greater East Mediterranean basin.

Public organizations with stakes on the marine area, such as the Hellenic Navy Hydrographic Service (HNHS), the National Centre for Marine Research (HCMR), the Hellenic National Meteorological Service (HNMS), the Centre for Renewable Energy Sources and Saving (CRES), the Institute for Geological and Mineral Exploration (IGME), the Federation of Greek Maricultures (FGM), the National Tourism Organization (GNTO), the Hellenic Coast Guard (HCG), the Hellenic Chamber of Shipping (NEE), and most of all their governing bodies, should closely cooperate to achieve the goal of the proposed MSDI platform.

[38] http://www.mindigital.gr/index.php κείμενα-στρατηγικής/220-digital-strategy-2016-2021 - last accessed 14.01.2019

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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.
PACS: 07.05.Hd

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.

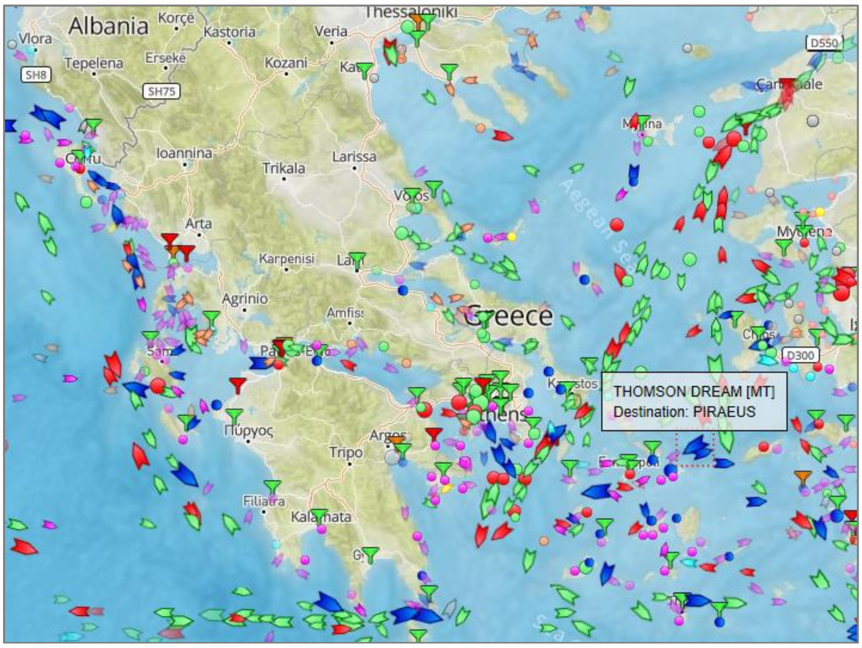

FIGURE 1. Typical AIS image.
From: marinetraffic.com

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.

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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).

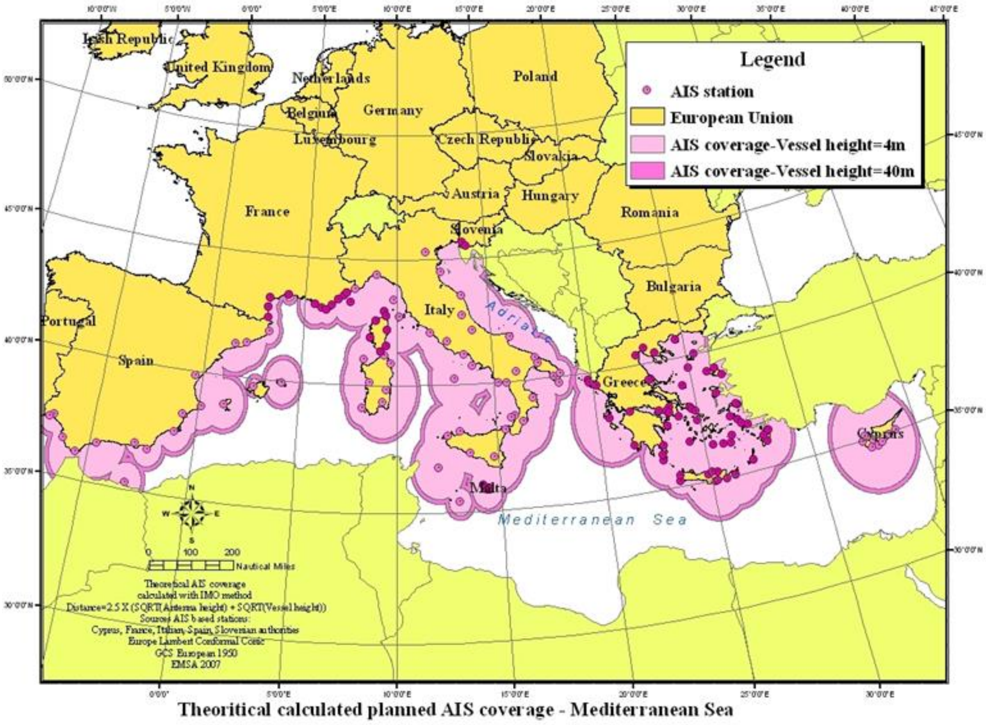

FIGURE 2. A map of the Mediterranean Sea demonstrating the range of the coastal network of AIS stations in the EU Member States that does not cover the entire sea basin.
From: EMSA, Development of an AIS Master Plan for Europe. Lisbon, 2007.

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.

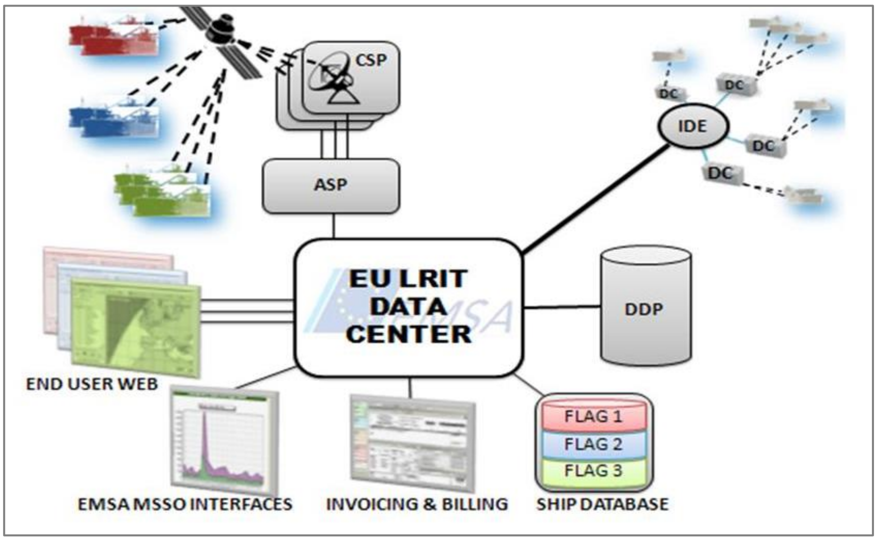

FIGURE 3. LRIT general arhitecture and data flow.
From: http://www.emsa.europa.eu/lrit-home/lrit-home/how-it-works.html7.

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).

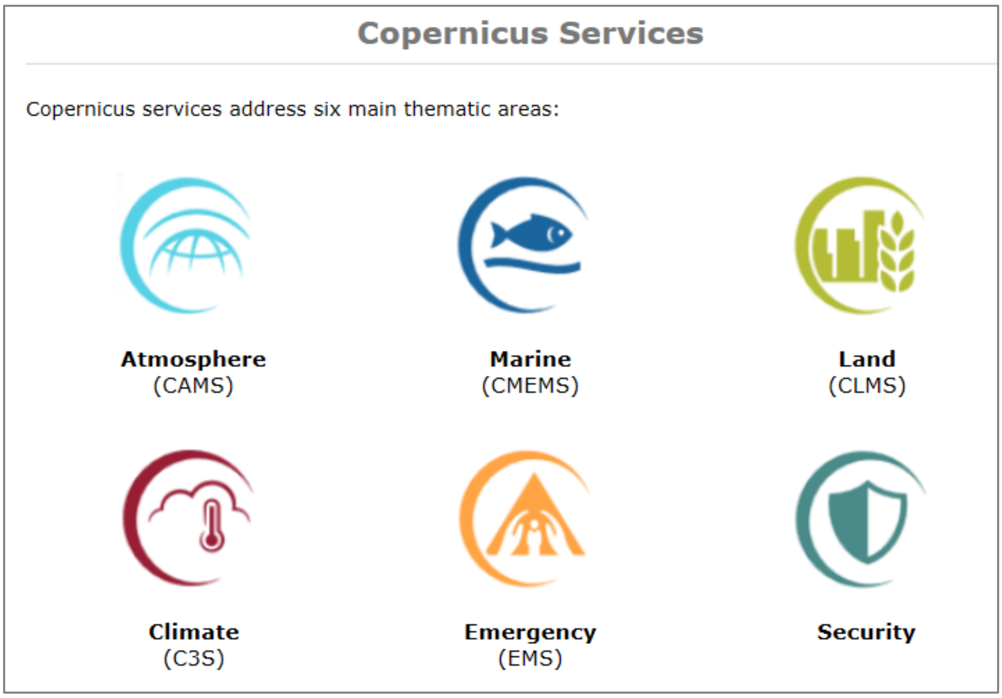

FIGURE 4. The six thematic areas covered by the European program "COPERNICUS"
From: http://www.copernicus.eu/main/services

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

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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.

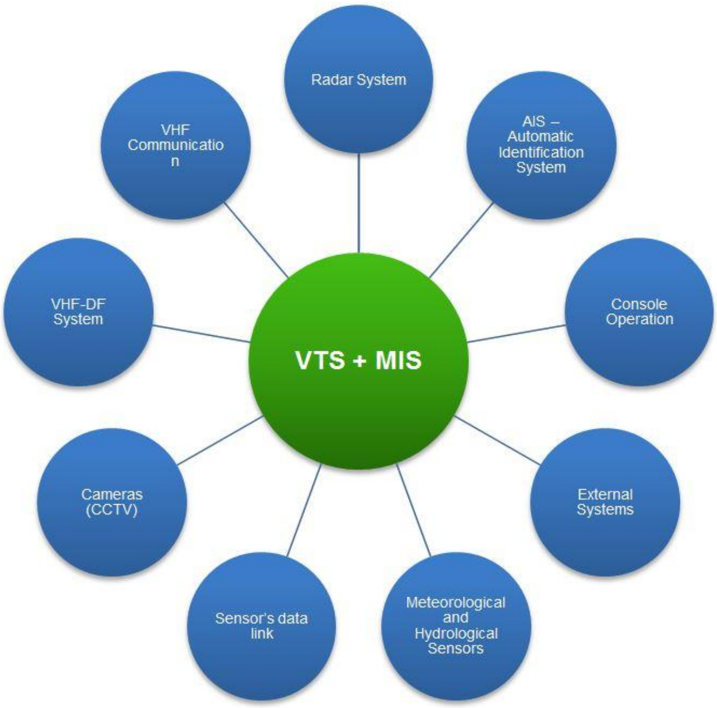

FIGURE 7.
Schematic diagram of the input and output components and subsystems of a VTMIS
From: http://www.sheltermar.com.br/en/vts/vtmis/

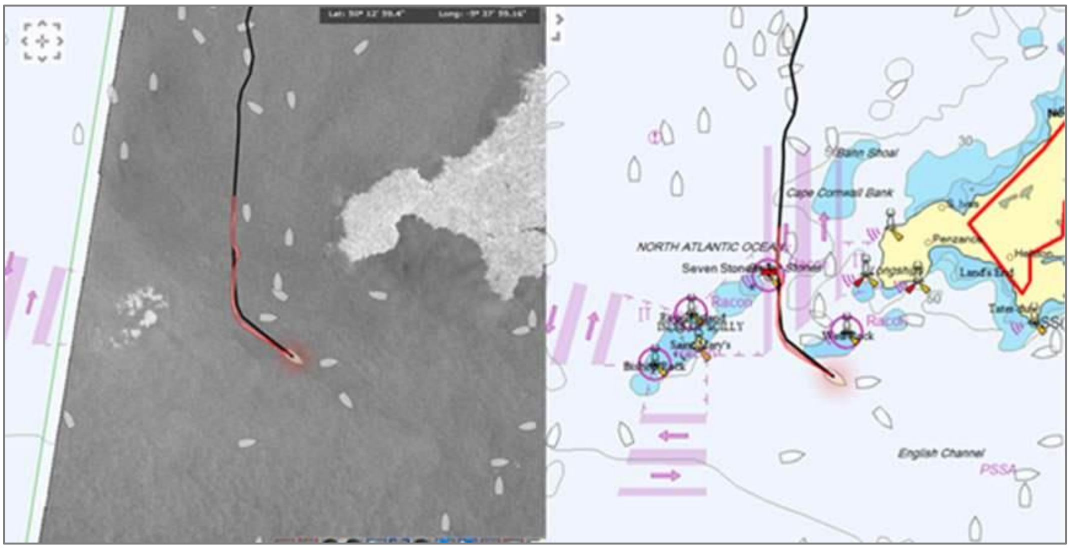

FIGURE 8. On the left, the image shows a satellite radar image with the location of detected oil on the sea surface marked in red. The shape of the spill indicates a possible trailing slick of oily waste from an underway vessel. By combining the satellite image with AIS vessel track information, on the 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

- 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 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.

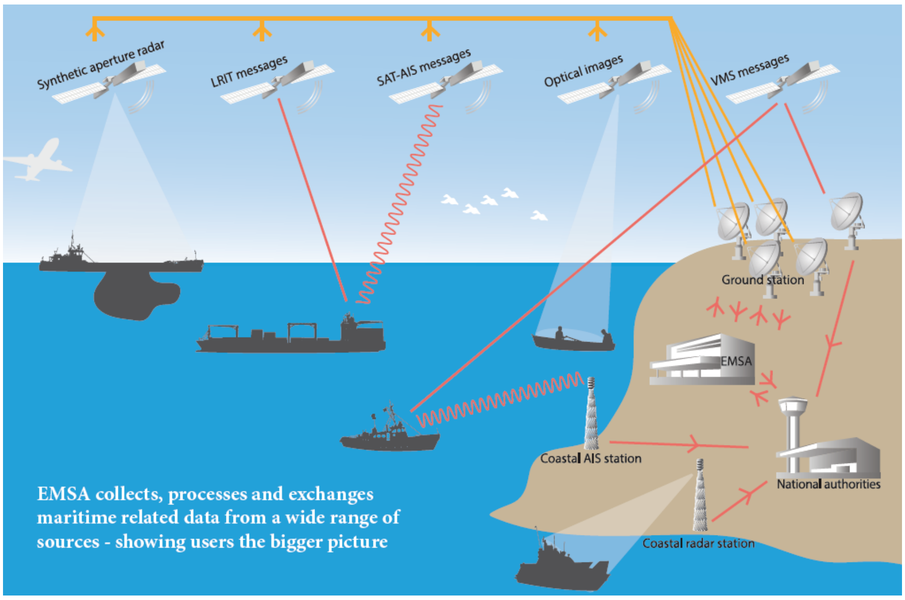

Figure 10. Illustration of the integrated collection and distribution network after SSN-e expansion.
From: https://csndc.emsa.europa.eu/web/imdate

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.

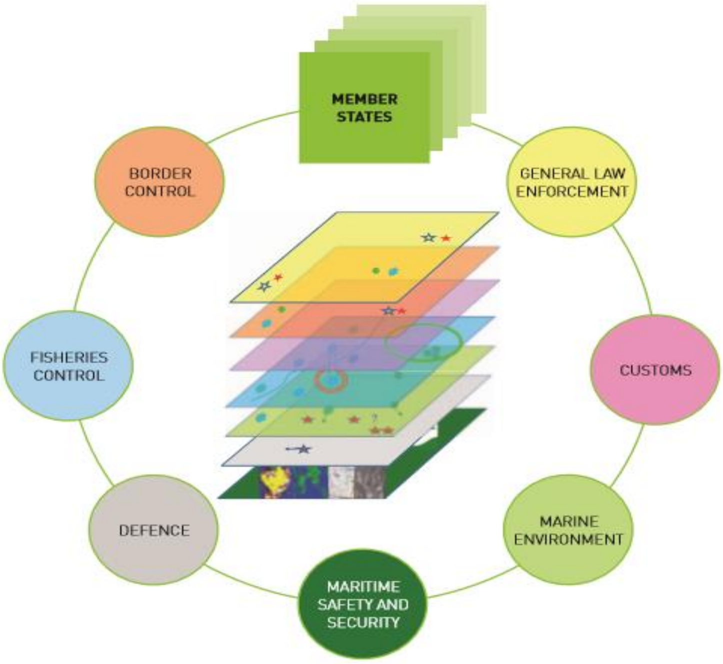

Figure 11. The CISE will serve essentially the 7 broader user communities shown in the portrait.
From: COM(2010) 584 final: « Draft Roadmap towards establishing the Common Information Sharing Environment for the surveillance of the EU maritime domain»

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

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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)

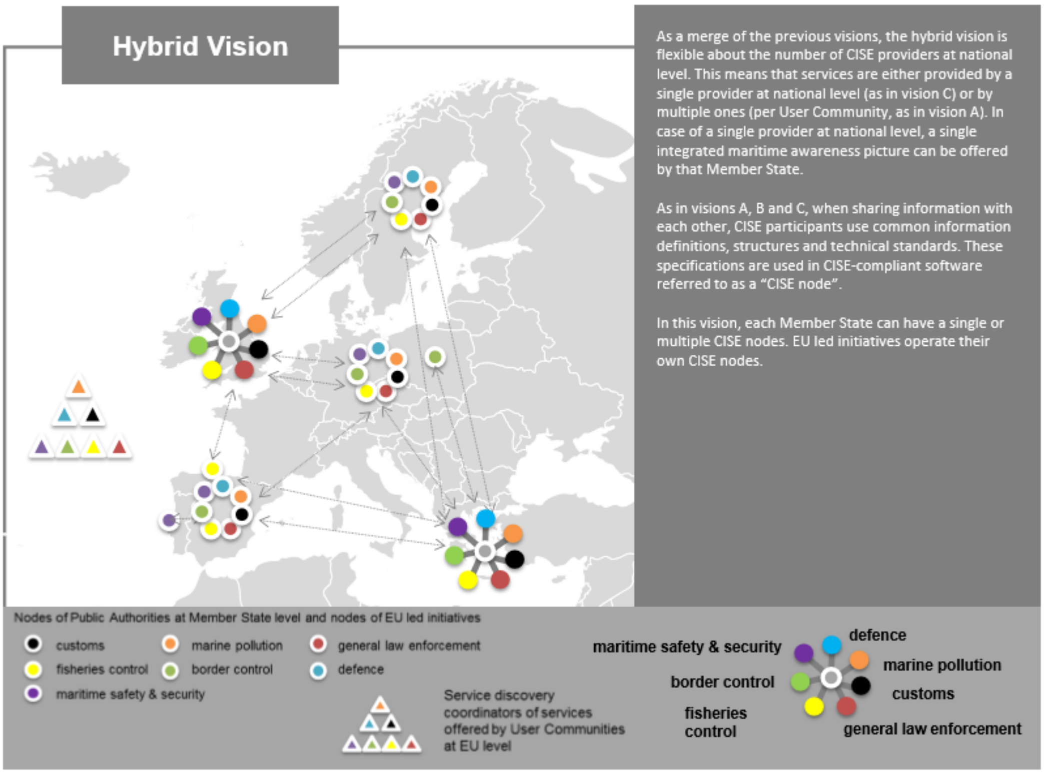

Figure 12. The architecture of the hybrid form is the one chosen for the CISE operation[15]
From: CISE Architecture Visions Document (v. 3.00)

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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