Concept of the Integrated Maritime Data Environment as a framework for European integrated and comprehensive shipping monitoring data exchange system

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ABSTRACT

Effectiveness of the contemporary maritime transport depends largely on already implemented intelligent shipping- and maritime environment monitoring systems, which are simultaneously responsible for improvement of the maritime transportation process, management and widely understood safety and security. Recently noticed, diversification of existing shipping monitoring systems is based on a different range of covered areas, direct benefits for end-users as well as technical specifications of modern maritime sensors. Nowadays, a totally new approach has been developed as a response to growing demand for integration of all existing maritime systems and building a common platform for maritime data exchange. This solution is expected to be a cost-effective tool in gathering, transforming and dissemination of an integrated and comprehensive recognized maritime picture and relevant maritime data. This paper represents the holistic approach to identification of important factors having impact on possible implementation of such a system. The working hypothesis stating that there are systematic reasons for implementation of a single, common and integrated platform of maritime data exchange has been positively proved. As an example of efforts already taken by European Maritime Safety Agency (EMSA) on the EU seas, the experimental Integrated Maritime Data Environment (IMDatE) solutions have been presented.

Keywords: Integrated Maritime Data Environment, shipping monitoring systems, maritime data exchange

1. Introduction

Since ages maritime trade has been fundamental for the functioning and living of numerous nations and societies. Maritime transport has always been a driving force for many national economies. This can be proved by the fact that nowadays about 90% of all goods in the world are carried by maritime transport. The significance of maritime transport is additionally emphasized by another fact: about 70% of the human population in the world, live in the coastal belt of 60 km in width. Modern maritime transport is maritime shipping and its supporting port operations that are performed with the use of strict technological and operational standards. All these activities are subject to severe time pressure, the imperative of cost cutting and the most important principle of all: providing these operations with the highest possible level of safety and security. Safety and freedom of navigation come as "constitutional" rights of all maritime states, and nowadays they

have become one of the main determinants pertaining to economic efficiency of maritime transport processes [11, 5].

Considering all these facts, the problem of providing safety and security of maritime shipping by efficient counteraction becomes crucial. It is no longer just a local or even a continental question; its character has become global and international [14].

The pragmatics of operations realised to minimise the potential results of hazards in maritime transport (by supporting processes of safety management) involves systemic solutions concerning maritime shipping monitoring systems based on Galileo Satellites Constellation [6,8] (e.g. systems of VTMIS class), applications supporting maritime operators in logistic process management (systems of SPINNAKER class) and applications for monitoring and tracking maritime containers (systems of AVANTE class). The awareness of anthropopression of maritime shipping and its related hazards has also resulted in the implementation of tools for controlling and assessing risk related to emission of greenhouse gases (GHG – CO_2 in particular) as well as pollution reports [11].

During last two decades all contemporary maritime monitoring systems have been developed. The most important are [1, 2, 13]:

- AUTOMATIC IDENTIFICATION SYSTEM (AIS) - is a maritime broadcast system, based on the transmission of very high frequency radio signals; ships over 300 GT are obliged to send reports with ship identification, position, and course, as well as information on cargo;
- LONG RANGE IDENTIFICATION AND TRACKING (LRIT) - global ship identification and tracking system based on communications satellites; all passenger ships, cargo ships over 300 GT and mobile offshore drilling units on international voyages send mandatory position reports;
- SATELLITE AIS (AIS-S) - new system (under development) enabling satellites to receive AIS position messages; this feature extends the geographical range from horizontal to global;
- ADDITIONAL SHIP AND VOYAGE INFORMATION - countries also exchange a range of additional data, including: port notifications (e.g. ETA, ETD arrival and departure times), hazmat notifications (for dangerous and polluting goods), ship notifications (to be sent in mandatory reporting areas), and incident reports (e.g. pollution reports);
- SYNTHETIC APERTURE RADAR SATELLITE IMAGES - independently of weather and sunlight conditions satellite radar sensors measure the roughness of the sea surface; on the satellite image oil spills appear as dark areas and vessels and as bright spots; this is used in vessel detection systems (VDS) as well as pollution monitoring systems;
- OPTICAL SATELLITE IMAGES - Earth observation imagery from satellite sensors operating in the optical spectrum, providing high resolution images of vessels or coastal areas;
- METEOROLOGICAL-OCEANOGRAPHIC DATA – consists of a range of fields such as wind speed and direction, wave height and direction, wave period, etc.

Other data sources from national systems can also be utilized [4, 13]:

- VESSEL MONITORING SYSTEM (VMS) - uses communications satellites for tracking commercial fishing vessels;
- COASTAL RADAR - vessel traffic services constantly track vessels movements along their coastline with the aid of local radar systems;
- USER SPECIFIC DATA - other varied forms of national data provided by users including encrypted position reports from patrolling vessels, position reports from leisure crafts, and additional meteorological- oceanographic data provided by buoys at national system level.

The concept of maritime shipping monitoring systems understood in that way is presented in Figure 1. These systems co-exist but not always cooperate with each other.
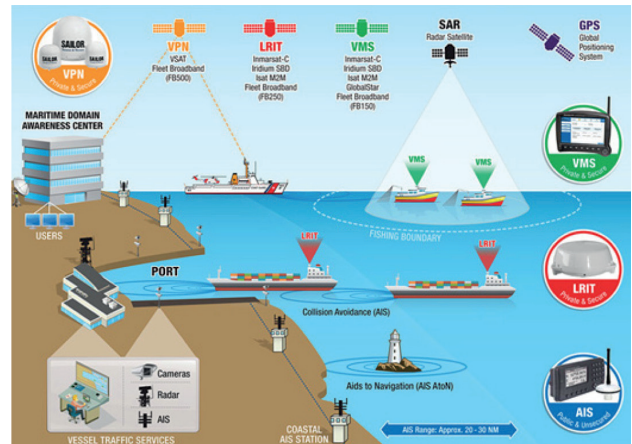

Fig.1. **The architecture of multi-system concept of maritime shipping monitoring [3]**

The experience gained during the recent years has indicated that there is a lot of massive pressure exerted by maritime business community to create a unified monitoring system for analysing and exchanging information concerning maritime shipping. To create such a system, it is necessary to identify the conditions of the system and its technical and organisational assumptions, which determine its expected functioning.

2. Identifying the conditions of the system to create a unified platform of maritime shipping data exchange (construction of a model)

2.1. Capabilities of integrated maritime data system

Integrated maritime services should deliver relevant, complete and up-to-date information at the right time to the right end user. New developments in the field of maritime systems should facilitate data exchange and distribution through the promotion and implementation of both common standards and semantic services. In such a system information and all relevant data

should be shared easily and selectively based on a set of unique capabilities [10,12]:

- Ability to process technically differentiated types of data - different types of maritime data acquired from different sensors and different information formats should be processed, integrated, correlated and finally distributed through the user tailored services;
- Capability to operate on a diversified scale and geographical coverage – different levels of detail should be shared at different geographical scales to satisfy different types of users;
- Use of data for serving different functions - integrated maritime services should respond to the need of wide range of different functions e.g. maritime security and safety, fisheries control, law enforcement and environmental protection at least;
- Open architecture to facilitate direct use of data from users - users could also provide their own data which can be correlated (enriched) with data from other sensors and then sent back;
- Access rights management - distribution policies should be set up by the data and information owners, complying with complex landscapes of access rights management.

A model of the integrated maritime data system is depicted in the Fig. 2
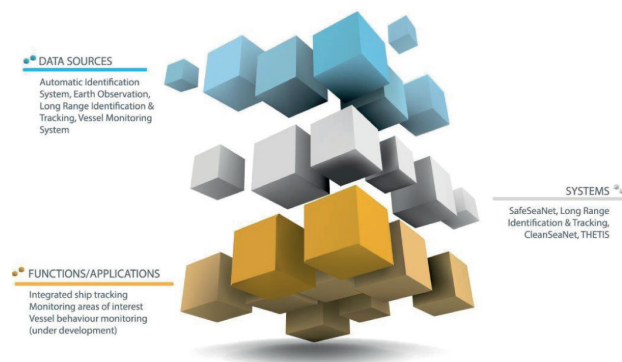

Fig. 2. Integrated maritime data system (model) [1]

The construction of this model will make it possible to obtain a detailed stream of data which will meet the requirements of a particular situation and expectations of a particular recipient (the end-user), (see: Fig.3). Undoubtedly, this will be a significant step in the implementation of Maritime Domain Awareness (MDA) 1 doctrine.

This model approach is presently being implemented within the frames of an experimental EU project, which aims at providing an integrated platform for maritime shipping data exchange among the member states.

Following the adoption of the EU Integrated Maritime Policy (IMP) in 2009, EMSA has embarked on the project of integrating its maritime systems into a powerful and flexible operational platform called the Integrated Maritime Data Environment (IMDatE)[5].

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[1] Maritime Domain Awareness (MDA) is defined as the effective understanding of anything associated with maritime activities that could impact the security, safety, economy, or environment.
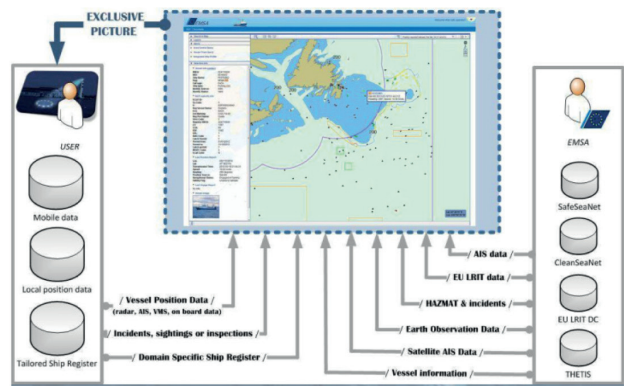

Fig. 3. Maritime Awareness through a tailor-made picture [12]

3. The Integrated Maritime Data Environment (IMDatE) project as a technical framework for integrated platform

3.1. The IMDatE concept and components

At present, the existing maritime shipping monitoring and vessel tracking systems provide us with a possibility to access the key information, which is essential for maritime safety. However, each of the presented applications provides only partial information that is directly connected with the operation of a particular system. Therefore, there has appeared a necessity to create an integrated system, which could combine and process data obtained from all the systems implemented so far, in accordance with the assumptions of the MSA concept [10]. It refers first of all to systems handled by EMSA and some external sources. Considering its potential and its open architecture, the system has been named: Integrated Maritime Data Environment (IMDatE). Its main task is to provide the system users with more comprehensive and complex information adjusted to their requirements and to support the data exchange between particular system users [14]. The scheme presenting the architecture of the IMDatE system is depicted in Fig.4.
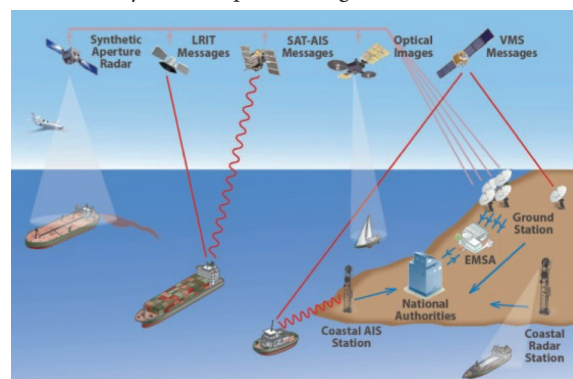

Fig. 4. Basic architecture of the integrated IMDatE system [4]

IMDatE integrates data and services from four critical maritime applications – the main ones that EMSA is tasked to host and operate, namely [12]:

- SafeSeaNet (SSN) – the European coastal system of over 700 shore-based AIS receiving stations which automatically tracks all ships navigating within 100 Nautical miles (Nm) from the EU coastline, and receives and stores information concerning the cargo and voyages of vessels;
- EU LRIT DC (LRIT) – is the European Long Range Identification and Tracking Data Centre using communication satellites to track all ships (around 10,000) under EU flags all over the world, as well as any ship, irrespective of its flag, within a maximum 1,000 Nm from the EU coastline [7];
- CleanSeaNet (CSN) – the EU satellite-based system for detection of oil spills and vessels at sea using Satellite Aperture Radar (SAR) images;
- THETIS – is a web-based application providing ship inspection related information and reporting support to all European Port State Control officers.

The IMDatE is being developed as a complex technical integrated system aiming to provide an enhanced MDA to all EU member states (MSs). The system is based on state-of-the-art technology and set-up on the principles of flexible and configurable Service Oriented Architecture (SOA) and Integrated Product Development (IPD). These may be delivered via a user-friendly web interface or distributed automatically to authorised external systems such as [2]:

- Integrated Ship Profile Service - will provide a combined view of all information related to a ship or fleet based on information available in the different systems which are connected to the IMDatE,
- Area Centric Service - will provide a complete maritime and oceanographic picture of a selected area, built-up from different layers of information;
- Maritime Surveillance Service - will allow users to analyse all available ship traffic information in order to identify activities of interest for the purposes of Maritime Surveillance activities;
- EU Common Maritime Space Monitoring Service - this specific service will support the implementation of EU Common Maritime Space (CMS) applications; particularly the service is being developed in order to monitor ships engaged in EU coastal

trade (ferries and coasters in scheduled/regular services between EU ports).

IMDatE Concept and Components under Marsurv-3 High Level Architecture is depicted in the Fig. 5.
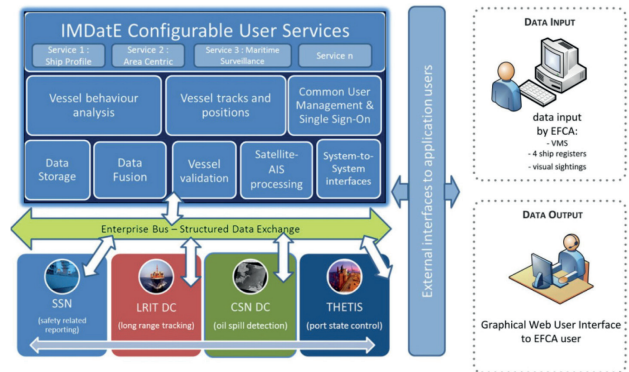

Fig. 5. IMDatE Concept and Components under Marsurv-3 High Level Architecture [13]

3.2. The new features of the Integrated Maritime Data Environment platform (and added value)

The IMDatE is a technical framework currently under development. In future, it will combine and process data from EMSA's maritime applications and other external sources to provide more comprehensive and configurable services to users, as well as supporting the relay of data between the applications themselves. It will directly lead to significant change of existing configuration from separate systems to integrated customisable services (Fig. 6) [10, 12].

Configured in that way, the platform for integration, visualisation, analysis and processing data obtained from various sources has already provided us with additional functions based on analytical potential. These are the tools referred to as [10]:

- graphical "time slider",
- „Timeline".

A graphical "time slider" allows visualization for ship movement replay and correlation inspection (Fig. 7).
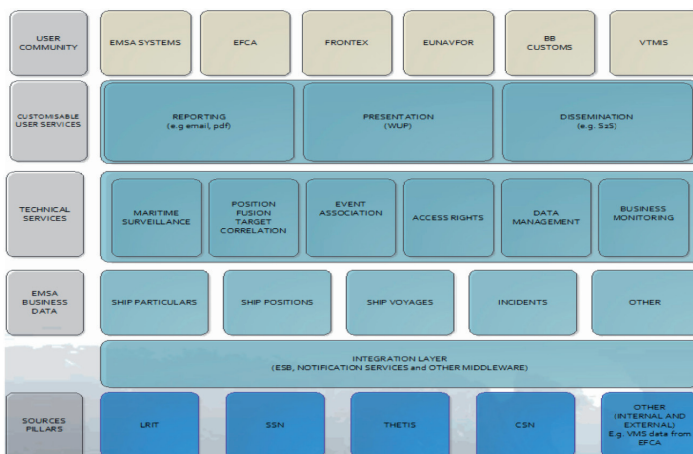

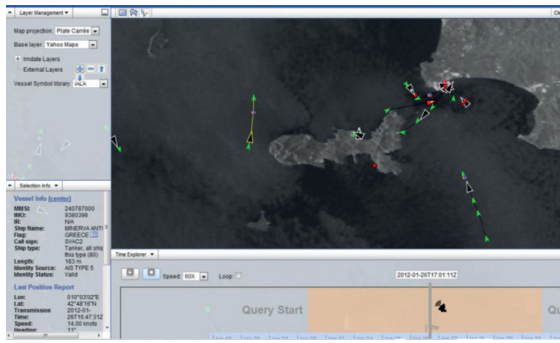**Fig. 6. IMDatE Matrix: From Systems through Data Centre to Customisable Services [13]**

Fig. 7. "Time slider" as an IMDatE platform new tool [10]

Another new IMDatE platform feature, a „Timeline" tool, in addition to the map view provides better awareness of time related events/information. Clicking on an element in the timeline refocuses on the relevant part of the map (Fig. 8)
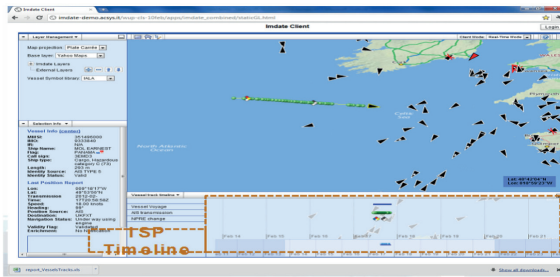

Fig. 8. "Timeline" as an IMDatE platform new tool [10]

Despite the fact that the platform is still at the stage of experimental development, it is possible to observe the first results concerning central processing of images obtained from various sources.

3.3. Examples of IMDatE new possibilities

The new functionalities will enable users to benefit from improvements to current services, such as more options for data visualisation, a single sign-on process, new machine-to-machine interfaces and automated vessel behaviour monitoring. Verification of data will also improve the quality of data across the systems, for example through the confirmation of vessel details across different vessel registries [1, 4].
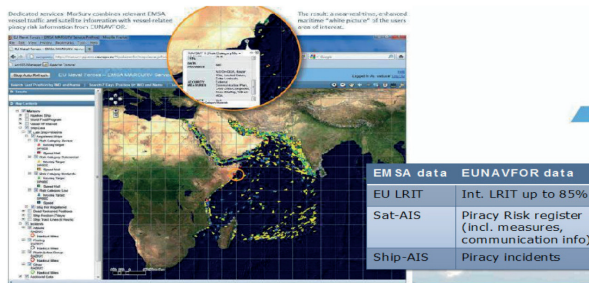

Fig. 9. IMDatE Anti-piracy support for merchant fleet monitoring [12]

Users, who combine functions, for example vessel traffic monitoring and marine pollution control, if they have the necessary access rights, will benefit from being able to obtain an overview of maritime activity in their area of interest, integrating data, which would otherwise only be available through a range of different individual applications. This integrated data can be delivered via a user-friendly web interface or distributed automatically to authorised external systems in accordance with the access rights applicable to each data set [2]. As good examples of such as new features of the IMDatE platform the Anti-piracy support (Fig. 9) and illegal fishing monitoring and analysis (Fig. 10) mechanisms can be called.
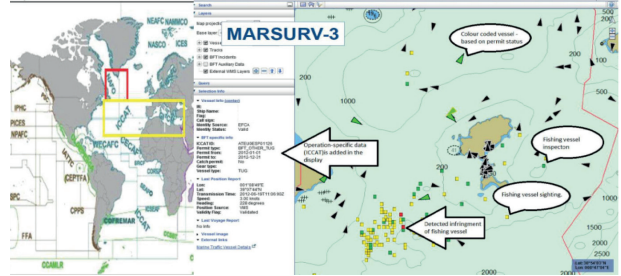

Fig. 10. IMDatE Illegal fishing monitoring (EFCA) [12]

4. Conclusion

Despite a lot of effort taken so far, the way to the final implementation of an efficiently operational, integrated maritime shipping monitoring system with considerable analytical potential is still long ahead. The most advanced solutions have been presented and are being implemented by EMSA within the frames of the IMDatE project in the EU sea regions. The IMDatE comes as a representative example of an integrated platform for maritime data exchange. It is not intended to replace the existing systems, but it creates new databases (VMS Data and satellite data AIS-S Data Processing Centre). It is also to facilitate data processing and distribution of data coming from all the new sources, which can appear in the future. This solution (in the context of other platforms developed on this model) offers a number of advantages, however, it is also exposed to many threats and must face numerous challenges, among which the following can be listed [10, 12, 13]:

- A complete and integrated maritime picture at the regional level provides substantial added value for a better Maritime Domain Awareness in the area of interest, where neighboring countries share the same maritime interests;
- whilst the focus is on parallel technical development of the existing systems and the new integrated platform, governance and clarity of objectives is equally important when dealing with complex multi- disciplinary issues;
- prototyping, incremental deliveries and iterative design reviews should allow quick wins to be achieved whilst lowering possible projects risks, however there is always a risk (political, economical, financial, managerial, operational) linked to the new platform development project which should not be underestimated;

- such integrated system (platform), from its definition, relies on other maritime applications that are under constant evolution, that is why coordinated parallel development is absolutely required;
- it seems to be a logical choice to give the inter-dependency with construction of some applications to the involved parties, however it rises the need for a roadmap of coordinated changes as well as advanced management system based on critical path methods (e.g. PERT), Concurrent Engineering (CE) and agile software development approach;
- the full life project cycle demands user requirements, propagating early conceptual designs, running computational models, creating prototypes, developing and delivering early products, testing and re-analysing needs and performance, incremental development and feedback to be widely integrated in to design process.

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