Planning a Case for Shared Data Retrieval across the European Maritime Common Information Sharing Environment

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Abstract— **This paper outlines an example method and trial scenario phases for extending the existing tools for maritime surveillance across the maritime regions of Europe. There are continuous dedicated efforts throughout European collaborations for advancing the features of Common Information Sharing Environment (CISE), which is a European Union (EU) initiative for ubiquitous information sharing across the maritime and land borders, as well as between the national sectors. The EFFECTOR EU project introduces a novel concept in the information exchange: the data lake, intended for providing a common smart data repository for diverse and comprehensive data analysis and storage that emanates from diverse sources within the local, regional, national, and international scope. Setting up of the data lake facilities and broadened information exchange is established and validated through early trials planned to be conducted in the project. Administration for Maritime Safety and Port Management (AMSPM) is integrating maritime surveillance data from Montenegro in the EU information exchanges and vice versa. The EFFECTOR project's French maritime trial offers an implementation of the broadened scope of uses of advanced data exchanges, analysis storage, and retrieval. A case of retroactive data analysis and deductions is to be demonstrated through collaboration of AMSPM in the French maritime trial with other project partners. The trial scenario planning includes two vessels coming into the French waters near Marseille from distant ports, one via a stop-over in Montenegro and the other from Portugal.**

I. Introduction

Effectively protecting and administering seas using multitudes of maritime surveillance tools has remained a tremendous challenge. This applies both to independent countries as well as in the context of regional border security partnerships as within the European (EU) collaborations. Especially relevant to situations across the EU are its vast maritime regions, long borders, many islands, and unrestrained tourist activities. This makes the EU seas and borders continuously exposed to accidents, criminal and terrorist activities, unlawful immigration, trafficking & trades, illegal fishing, environmental damages etc. The Mediterranean region is the specific focal area in this paper, being generally renowned for intense maritime activities throughout it. In the recent years, the Eastern Mediterranean route including the Adriatic-Ionian Seas route as its branch, has been subject to exalted risks of migration and illegal crossings. Unfortunately, this resulted in increased reports of fatal accidents along the route, with countries like Greece at the route's immediate entry into EU, recording a significant number of fatalities.

Adding to the challenge and the threats in situations of illegal activities is the continuous sophistication of the types of vessels and technologies at the disposal of the perpetrators, as well as general increase in leisure activities at seas. On the other hand, maritime authorities nowadays can choose between a greater set of tools for expedited surveillance capabilities and for comprehensively composing the Maritime Situation Awareness (MSA): i) new types of vessels such as varieties of Unmanned Aerial Vehicles (UAVs) and/or Unmanned Underwater Vehicles (AUVs) [1][2]; ii) improved communications and computational capabilities of maritime surveillance systems; iii) advanced collaborative tools within and between countries for data exchange and interpretations.

In the last decade, the EU has stepped up its drive for advancing the integrated approach for enhanced safety at seas and secure maritime borders. One of the primary objectives of the EU's Integrated Maritime Policy is the enhanced MSA across many surveillance systems deployed in different countries and sectors, carrying various sensory data and meanings, and being represented by many standards. Strategically[1], the EU has recently reaffirmed its role as the global maritime security provider promoting international cooperation amongst the countries as one of the strategic actions. Some of the EU initiatives have been substantiated as operational interoperability frameworks, hence improving the MSA instantiations and have been endorsed across the member states: the Maritime Surveillance Network

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[1]https://www.consilium.europa.eu/en/press/press-releases/2018/06/26/maritime-security-eu-revises-its-action-plan

(MARSUR)[2], the European Border Surveillance System (EUROSUR)[3], and the Common Information Sharing Environment (CISE)[4].

This paper derives its content from the collaborative work in the EFFECTOR EU H2020 project (An end-to-end interoperability framework for maritime situational awareness at strategic and tactical operations) [3], which aims to boost collaborations between maritime stakeholders via an interoperability framework and associated data fusion and analytics services for maritime surveillance and border security. The paper's content is particularly focused on extracting the context and the activities of the Administration for Maritime Port Safety and Management of Montenegro (AMSPM) as a member of the EFFECTOR project. AMSPM is continuously enhancing its maritime surveillance capabilities through formally participating in the EU CISE collaboration projects and as a part of Montenegro's EU accession processes. A specific case of the French Maritime trial is explained in the paper, showing the main features of the EFFECTOR solutions and integrated roles of AMSPM.

The content of the paper is as follows: Section II introduces integrated maritime surveillance, describes a background to the CISE, and briefs main objectives of the EFFECTOR project. Section III then explains the specific position of AMSPM in the CISE integrations and outlines the main steps in the relevant part of the EFFECTOR French trial and particular roles of AMSPM in it.

II. Background to Maritime Surveillance

One of the main deployment incentives when introducing the interoperability frameworks such as the CISE in the domain of maritime surveillance, is to enable a cost-effective platform for filling information gaps and to avoid data duplications. This applies to variety of interconnection scenarios, from cross-border to cross-sectoral data exchange levels, internationally and/or nationally and/or within an organization. The situation is that there is a great multitude of maritime surveillance systems deployed across the EU with both complementary and overlapping features, and means of communications:

1. **Variety of surveillance systems**: depending on the needs of maritime authorities, various systems are implemented either using "known" systems or proprietary solutions: maritime reporting with or without decision support (e.g. AIS, VTS, VTMIS, CleanSeaNet), satellite, radar or telecom, various sensors on-board vessels or used by citizens, UAVs/AUVs, surveillance infrastructures etc.
2. **Diverse types of data**: information conveyed can range from typical vessel data, vessels trajectories, satellite maps to meteorological information, images, documents, videos, voices etc.
3. **Multitude of standards implemented**: data formats, interfaces and communication protocols are related to the systems in use and whether these deployments are using international standards or proprietary solutions. E.g., for a maritime surveillance system at a specific level of communications these can be: NMEA, IVEF, ASTERIX, binary, GeoJSON, .xlsx, XML located at many layers of communications to name a few.

This complexity of technologies and uses across the seas and maritime borders appropriately justifies efforts for advancing interoperability frameworks such as the CISE. The EFFECTOR project develops its solutions from the CISE fundamentals already developed in previous collaborations: its architecture framework composed of CISE Nodes and Adaptors, and the CISE infrastructure already in place at some maritime authorities who are project partners. The project further aims to combine all the various surveillance systems, other interoperability frameworks (e.g. EUROSUR and the eCISE enhancements developed in the ANDROMEDA project [9]), data and standards by advancing data sharing and enhanced MSA at tactical and strategic levels. As its hallmark feature, the EFFECTOR project builds comprehensive data fusion and analytics tool including the implementation of a multi-layered data lake combining the information flows and usage at various levels and scopes across the EU. The project will test its solutions in France (i.e. French maritime trial with AMSPM as a participant), Portugal and Greece involving many of its partners.

A. *A Brief Introduction to the CISE*

The first step when understanding the role and composition of the CISE is that in a technical sense, it is not a system. In fact, as originally envisaged by the EU in 2010, it is an interoperability layer that eases information exchange for enhancing MSA, decision making and many operational capabilities in maritime surveillance sphere. In other words, it is a voluntary decentralised connection platform / network / interfacing tool that adheres to the framework technical specifications and common information sharing principles that are instantiated in the underlying CISE properties. These principles oblige the participants to have responsibility and exercise rights to share and announce information across the CISE network [5].

In a nutshell, the CISE architecture generally consists of a layout of its main entities as shown in Figure 1: CISE Nodes and CISE Adaptors. CISE Node generally performs the functions of connecting the legacy systems for maritime surveillance to the CISE Network composed of CISE Nodes at national and/or Europe-wide levels. In addition, some CISE Nodes share and fuse data about the services being announced across the network. Conventional maritime surveillance systems in the CISE terminology are referred to as legacy systems and their syntax are translated and conveyed to the CISE Network using translatory features that are in CISE Adaptors. Thus, the CISE uses its own services

[2]https://eda.europa.eu/what-we-do/all-activities/activities-search/maritime-surveillance-(marsur)
[3]https://ec.europa.eu/home-affairs/policies/schengen-borders-and-visa/border-crossing/eurosur_en
[4] http://www.emsa.europa.eu/cise.html

and data model vocabulary being mostly generic to the specific and proprietary features in the legacy systems.

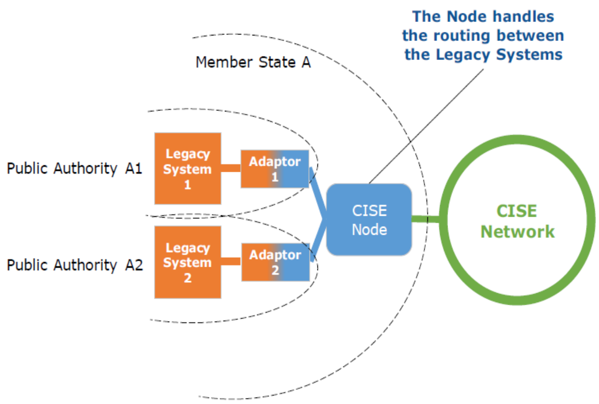

Figure 1. An example layout of connecting to the CISE Network with the CISE Node (copied from open specification in [5])

The CISE specifications include many models for connecting the legacy systems to the CISE Network as one model shown in Figure 1 [5]. This example shows two stakeholders with specific CISE Adaptors using a single CISE Node (e.g. owned by AMSPM in a proposed case of the CISE implementation in Montenegro [6][7][8]) to connect to the CISE Network.

Originally, the CISE was formulated with a data model (it continually gets enhanced [9]) using XSD (XML Schema Definition) or UML (Unified Modelling Language) and comprising seven core data entities [10][11]: Location, Period, Event, Document, Agent, Risk and Object; and associated eleven auxiliary data entities: Action, Movement, Incident, Anomaly, Metadata, UID (Unique Identifier), Cargo, Vessel, Operational asset, Meteo-oceanographic condition, Person and Organisation. The data is defined through relationships and association rules alongside attributes, subclasses, values, and enumerations. Furthermore, the CISE services are defined as models for exchanging information across the CISE Network: *VesselService, CargoService*, *IncidentService, RiskService, AnomalyService* etc [5][7][8][9].

B. The EFFECTOR Concepts

As mentioned previously, the EFFECTOR project aims to facilitate bringing together many maritime surveillance systems, related initiatives and projects outcomes towards advanced interoperability using the CISE infrastructure as the facilitator of interconnections and data exchanges. The core concept being developed is a multi-layered data lake platform for data exploitation and end-to-end interoperability of various maritime surveillance systems with non-integrated and multi-standard data[5], as shown in Figure 2.

In essence, the data lake is a Big Data-like data repository structure6 dedicated to storing and processing various maritime surveillance "raw" data (steams) coming from standardised and non-standardised data sources from and relevant to a country's maritime region. This is shown on the left side of Figure 2 where various data formats are "ingested"7 and stored in the data lake and associated with local, regional and national scope and context. Subject to the way the data is filtered, augmented, transformed and "shelved", then, subjected to expert-formulated data analysis and fusion, the stored data is accordingly distributed or queried (middle of Figure 2) for the use by maritime authorities (End Users) or distributed back to the CISE and EUROSUR networks (right side of Figure 2). For logical and semantical relations between the data stored in the data lake and derivation of more comprehensive and complex reasoning contained the information from the CISE network and legacy systems, expert-formulated relational ontologies are stored and developed (e.g. Rich Data Format - RDF store in the bottom of Figure 2).

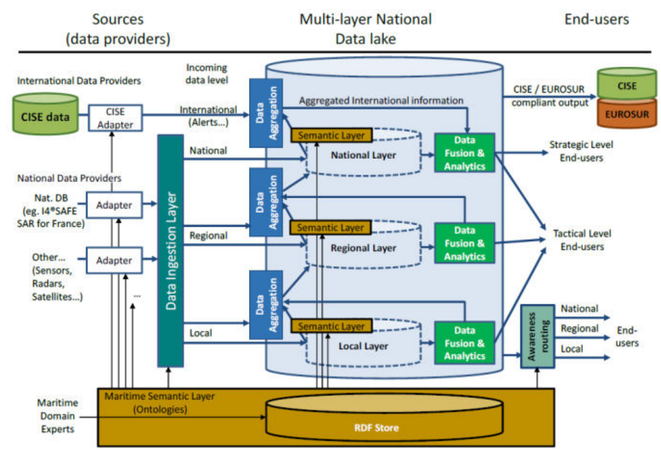

Figure 2. EFFECTOR Multi-layer data lake (copied from the EFFECTOR project's Description of Work document)

III. The EFFECTOR Data Lake Implementation: AMSPM Role in the Effector French Trial

Besides several planned short scale trials at national and local levels for testing the EFFECTOR interoperability features, the project will conduct three joint long trials lasting several weeks in Portugal, Greece, and France. Each trial involves a group of project participants with their National Coordination Centres, legacy systems, and interoperability frameworks. AMSPM's will participate in the French trial supplying high-level intelligence and non-CISE data for the general objective of enhancing Common Operation Picture (COP) at regional and national levels of French maritime surveillance during Search and Rescue (SAR) operations. AMSPM's non-CISE data will be appropriately stored and

[5] Many integrated data repositories from a signal standard are openly available, e.g. AIS data from North Atlantic seas https://doi.org/10.1016/j.dib.2019.104141, https://zenodo.org/record/1167595#.YctG81ko82w], AIS data from Danish Maritime Authority https://www.dma.dk/SikkerhedTilSoes/Sejladsinformation/AIS/Sider/default.aspx etc.

[6] Example software for the data lake implementation: Apache Kudu, Apache Impala, Graph DB, HDFS etc.

[7] Example data ingestions software: Apache Nifi, Kafka etc.

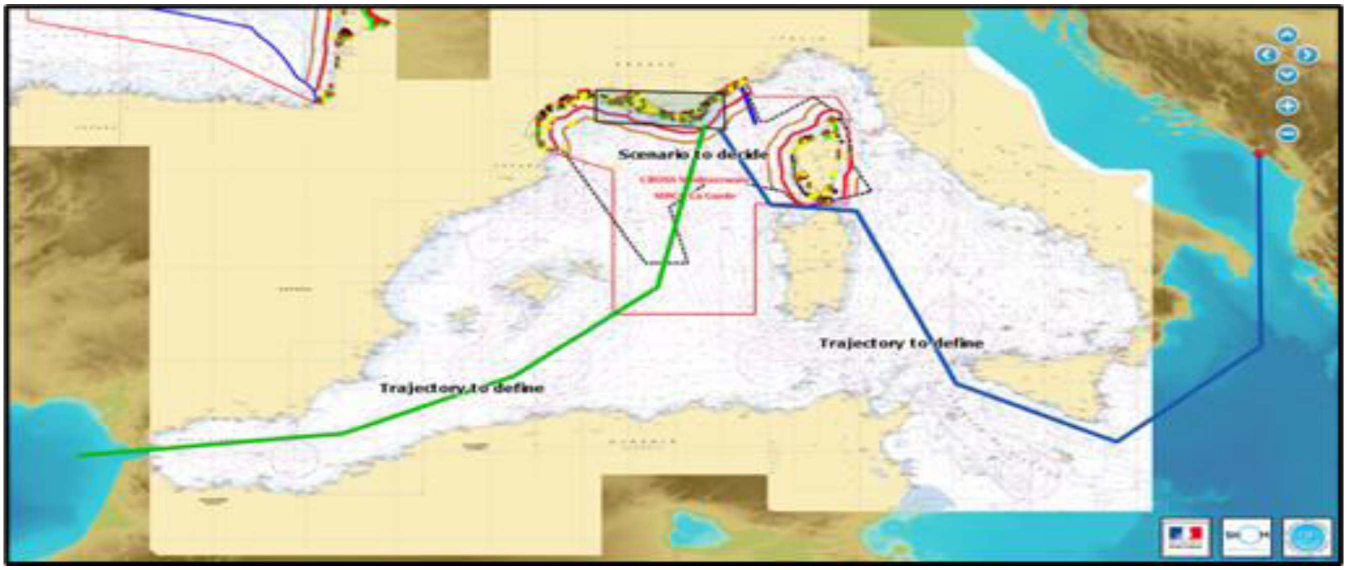

Figure 3. Scenario 1 sketch of planned events and ships' trajectories

fused in the data lake directly or by prior translation into CISE vocabulary by a CISE Adaptor feature.

A. *AMSPM position in the CISE integrations*

AMSPM has participated in many regional cooperation schemes in the maritime affairs, e.g. Vessel Traffic Management Information System (VTMIS) with Albania, South Adriatic connectivity projects also including Italy, installation of National Maritime Single Window (NMSW) in Montenegro ([7][13][14]) and recent H2020 EU projects COMPASS2020 [2] and RESPOND-A [15] on tools for expedited maritime surveillance and responsivity. In fact, AMSPM just completed a participation in EU H2020 project ANDROMEDA [6][7][8] working on enhancing the CISE data and services models (eCISE) and conducting trial implementations. In the ANDROMEDA project, AMSPM participated in the Adriatic-Ionian trial with partners from Greece and Italy (Italian Navy, Greek Maritime Affairs and Insular Policy Ministry, Hellenic Police etc.) through a proxy CISE connection facilitated by GMV, a project partner from Spain being fully integrated inside the CISE Network [7]. The trial implemented several "actions": i) sharing a service amongst the participants (e.g *Vessel Push Service* in a geographical area using, *Location data entity* and *Geometry class*); ii) detecting anomalies with/without rule-based analytics tools (e.g. *UnstableBehaviour* anomaly); and, iii) simulation data for decision support (e.g. *OilSpillSimulationRequest*). AMSPM's data and visibility was provided via VTMIS's IVEF (Inter VTS Exchange Format, VTS – Vessel Traffic Services) protocol for sharing AIS (Automatic Identification System) data on certain locations and vessels in the Adriatic Sea (e.g. IVEF packed AIS data typically streams at 200 kb/s) and was injected into the CISE Network via CISE Adaptor located at GMV [7][8].

B. *Setting up the EFFECTOR French Trial including AMSPM*

In specific terms, the goal of the trial is to enable means of exchanging enhanced information for integrated maritime surveillance amongst the authorities in geographical and timeline situations. End User partners from France, Greece, Portugal, Bulgaria and Montenegro (i.e., maritime authorities such as AMSPM) will work for 2 months including one week for demonstration in France. Scenario 1 of the trial including AMSPM participation will advance cross border information with the following characteristics:

- Detection and apprehension of small boats carrying suspicious cargo.
- SAR Operations.
- Processing of data from very different data sources.
- Data handling: data history (over several months), plus, statistics data correlation in predefined routes / in risky situations / allowing early warnings.
- Exchanging data (contributing to the integrated maritime surveillance) through the CISE Network and facilities.

Scenario 1 summary: The scenario will be "Cross border" and implemented between France, Portugal and Montenegro in a large area planned as "black rectangle" located near Marseille and Toulon with 3 ships as shown in Figure 3:

- WM1: "Western Mothership" coming from Portugal to the French Zone. Flag is Portuguese.
- WF1: "Western Fast Inflatable boat" onboard WM1 carrying suspicious cargo.
- EC1: "Eastern Cargo" coming from Montenegro to the French Zone. Flag is Bulgarian and was previously detained in Montenegro (last Port of Call) detained by Port State Control inspection authority for technical reasons (risky ship/ship known for oil spills…), identified via information system THETIS[8] (https://portal.emsa.europa.eu/web/thetis)

[8] https://portal.emsa.europa.eu/web/thetis

and marked in the ship report information provided by AMSPM. Another Portuguese Navy Patrol Vessel could be optionally deployed for tracking WM1.

Data such as trajectory of ships and various accompanying data will be mostly simulated to save cost and time, with options to include real data in some parts of the scenario. Many data sources can play a part in the scenario including: AIS from several providers, Sat-AIS, (possibly) Radar Tracks, ELINT, CISE & eCISE (report / risk / anomaly / vessel / incident /mission), (possibly) EUROSUR, MAS-Export, METOC data, (possibly) GMDSS alert (tbc for SAR Operation), Ship & Asset information, Reference data (multi-scale charts, maritime boundaries, SAR areas, wrecks & obstructions).

In a nutshell, the main phases of the Scenario 1 are planned as follows:

Initialization

There are two types of communications to be exercised: 1) direct immediate communication between the maritime authorities, and 2) a retroactive data exchange and invocation where a semantically structured set of information that is stored in the data lake is retrieved later or upon a relevant situation is elaborated and allows to find an abnormal behaviour. The former could relate to communications between the neighbouring Portuguese and French authorities on the vessel WM1 heading to "Marseille/Toulon" zone. The latter would relate to EC1 vessel which, while being detained in Montenegro Port on its route to France, would be marked through a formal report by AMSPM as carrying dangerous cargo.

Arrival in French Zone

The French authorities can track and build MSA on the two arriving vessels, WM1 and EC1. Following the setup of the trail, the WM1 would appear to behave suspiciously, e.g., deviate from expected route, stop its AIS communication etc. Relocation attempts can include communications between the national authorities (e.g., AIS data via CISE or EUROSUR), use of satellite data (CLS) and (possibly) observation radar tracks.

Collision Risk, Data Collection

WM1 and EC1 arrive in the monitored zone and are very close to each other. Analytics allow for raising alerts for a potential collision risk between the two vessels with an additional inspection of the data lake for the two vessels in question. Adding to the suspicious vessel indication and behavior on WM1 is AMSPM data/report that EC1 carries dangerous cargo: EC1 with a Bulgarian flag and its last Port of Call in Montenegro.

AMSPM contributes the "stored retroactive" data processed through CISE Adaptor translatory feature: confirming that EC1 was detained by Port State control in Montenegro and contains dangerous goods.

Collision Risk, Situation Analysis

A deeper inspection of the collision risk that might seem avoided at the first instance can reveal further information about a potential meeting event occurring between the two vessels. Such a likelihood of a meeting in fact occurring between the two vessels can be confirmed via data analytics tool (e.g., by a trial participant with relevant data processing capabilities). The French Maritime Coordination Centre (MRCC) operators would them continue tracking the vessels, further inspecting for accidents such as oil spill using satellite data. Of interest here are potential further actions and information on the vessels, e.g., a new vessel appearing such as WF1 being detected, or, one of the vessels moving in an uncontrolled manner (CLS satellite SAR image detection could be available to help further deductions). SAR operations follow this course of events.

IV. Conclusion

Advancement of features of the integrated maritime surveillance across the European waters and borders is continuously being endorsed and conducted via collaborations, tests and deployments of novel sets of data exchange functionalities. One such large-scale effort is the maritime CISE Network facilitations and development, as conducted in the EFFECTOR EU project. AMSPM leads integration of Montenegro into the CISE and through participation in the EFFECTOR project ensures its operational readiness and preparation to become a formally integrated CISE member. This paper shows a case of trial planning to be conducted in the EFFECTOR project, where AMSPM participates in data exchanges using its data models and legacy systems. The French trial conducted in the project offers a specific example of data exchanges between European maritime authorities related to trustworthiness of vessels, that are stored in the multi-layered data lake and retrieved upon a critical situation at sea.

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References

[1] S. Bauk, N. Kapidani, Ž. Lukšić, L.J. Sousa, "Autonomous marine vehicles in sea surveillance as one of the COMPASS2020 project concerns", Journal of Physics Conference Series 1357:012045, October 2019, doi: 10.1088/1742-6596/1357/1/012045.

[2] A. Mihailović, N. Kapidani, E. Kočan, A. Nadziejko, A.B. Monteiro, "Towards Augmenting Maritime Surveillance Capabilities via Deployments of Unmanned Aircrafts and Autonomous Underwater Vehicles", EU Horizon 2020 project COMPASS2020 (No.833650) publication, 14th NATO OR&A Conference, 5-6 October 2020, doi: 10.5281/zenodo.4399215.

[3] EFFECTOR EU Project - "An End to end Interoperability Framework For MaritimE Situational Awareness at StrategiC and TacTical OpeRations", Grant agreement ID: 883374, 2020-2022, https://www.effector-project.eu/

[4] ANDROMEDA EU Project - "An EnhaNceD Common InfoRmatiOn Sharing EnvironMent for BordEr CommanD, Control and CoordinAtion Systems", Grant agreement ID: 833881, 2019-2021.

[5] European Martime Safety Agency (EMSA): CISE Technical Specifications, http://www.emsa.europa.eu/cise/technical-specifications/download/5798/3689/23.html

[6] A. Mihailovic, N. Kapidani, E. Kočan, D. Merino Delgado, J. Räsänen, "Analysing the prospect of the maritime common

information sharing environment's implementation and feasibility in Montenegro", Pomorstvo journal, 35 (2), 256-266, Dec. 2021. https://doi.org/10.31217/p.35.2.8

[7] A. Mihailovic et al., "A Framework for Incorporating a National Maritime Surveillance System into the European Common Information Sharing Environment," 2021 25th International Conference on Information Technology (IT), 2021, pp. 1-6, doi: 10.1109/IT51528.2021.9390138.

[8] Z. Paladin, et al., "Augmenting maritime Command and Control over a regional Common Information Sharing Environment implementation: Montenegro Case," NMIOTC – NATO Maritime Interdiction Operations Journal, Edition: 22, Publisher: NATO Maritime Interdiction Operational Training Centre, July 2021.

[9] ANDROMEDA project Deliverable D3.1 "D.3.1 e-CISE Data Model description", Public deliverable, 2020, https://www.andromeda-project.eu/downloads/index.html.

[10] J. Rajamäki, I. Tikanmäki, J. Räsänen. "CISE as a Tool for Sharing Sensitive Cyber Information in Maritime Domain." Information & Security: An International Journal 43, no. 2 (2019): 215-235, doi: 10.11610/isij.4317

[11] M. Riga, *et al*., "EUCISE-OWL: An Ontology-based Representation of the Common Information Sharing Environment (CISE) for the Maritime Domain", Semantic Web, vol. 12, no. 4, pp. 603-615, 2021, doi: 10.3233/SW-200403.

[12] N. Kapidani, et al., "South Adriatic Connectivity Governance as One of the SAGOV Project Concerns". In: Bauk S., Ilčev S.D. (eds) The 1st International Conference on Maritime Education and Development. Springer, Cham., 2021.

[13] N. Kapidani, E. Kočan, "Implementation of national maritime single window in Montenegro". In: 23rd Telecommunications Forum Telfor (TELFOR) 2015. Belgrade, Serbia; 2015.

[14] N. Kapidani, E. Tijan, M. Jović, E. Kočan, "National Maritime Single Window: Cost-benefit analysis of Montenegro Case Study", PROMET Journal, 23.7.2020. Volume 32, Issue 4, p. 543-57.

[15] RESPOND-A EU project, "Next-generation equipment tools and mission-critical strategies for First Responders", Grant agreement ID: 883371, https://cordis.europa.eu/project/id/883371, 2020 - 2023.