Towards Augmenting Maritime Surveillance Capabilities via Deployments of Unmanned Aircrafts and Autonomous Underwater Vehicles

Conference Paper · October 2020

DOI: 10.5281/zenodo.4399215

Towards Augmenting Maritime Surveillance Capabilities via Deployments of Unmanned Aircrafts and Autonomous Underwater Vehicles

Andrej Mihailovic
Centre for Telecommunications Research, Department of Engineering,
King's College London, London
also affiliated as consultant at Administration for Maritime Safety and Port Management, Bar
MONTENEGRO

andrej.mihailovic@kcl.ac.uk

Nexhat Kapidani
Administration for Maritime Safety and Port Management, Bar
MONTENEGRO

nexhat.kapidani@pomorstvo.me

Enis Kocan
Faculty of Electrical Engineering, University of Montenegro, Podgorica
also affiliated as consultant at Administration for Maritime Safety and Port Management, Bar
MONTENEGRO

enisk@ac.me

Aleksandra Nadziejko and António Brás Monteiro
TEKEVER - Aerospace, Defence & Security, Lisbon
PORTUGAL

aleksandra.nadziejko@tekever.com
antonio.monteiro@tekever.com

ABSTRACT

This paper presents exemplar cases of adjusting the operations and taskings of an existing maritime safety administration in the Adriatic towards the emerging technologies for enhanced patrolling in maritime surveillance. This work derives from ongoing COMPASS2020 project that aims to showcase the capabilities of unmanned systems (aerial, underwater) demonstrated in a novel concept of operation (CONOPS). Results will be presented in: REP(MUS) 2020 – NATO, the largest maritime unmanned systems exercise to be held in Portugal at the end of the project. The Montenegrin Maritime Safety Department reviewed and assessed the deployment of novel assets towards with goal of increased effectiveness (i.e. reduction of costs and responses) of its civilian maritime safety and security missions. This practical approach is presented in two exemplar use-cases: 1) an illicit activity, and, 2) a polluting incident, both with a search and rescue finale. They are presented using the Plan-Do-Check-Act model of analysis together with problem formulations, functional breakdowns for all operational actors (from patrolling boats, maritime operation centre to decision making institutions), and, stages of data deductions. The use-cases are sequentially revealed using the NATO Architectural Framework (NAF), with its glossary and terms, followed by conclusions on the expected results at the operational and tactical levels from COMPASS2020 Mission System.

1.0 INTRODUCTION

Experience from the recent migratory crisis has shown that if border crossings are not appropriately secured, numbers of illegal border crossing can soar to unprecedented numbers. Namely, the crisis of 2015 accounted for 1.8 million illegal crossings [1] across the borders of Europe. Measures applied by the member states of the European Union (EU) were inadequate to address the situation effectively. As a consequence and remedy, the EU introduced a series of measures targeting the effective management of migration, improving internal security and cross-border cooperation between the member states all of which have helped reduce border crossings to a tenth [2] of the number from the 2015 crisis.

External border security threats are still far from being eradiated. Border crossing incidents are dispersed and mutable, with changing critical regions across the whole of Mediterranean (e.g. Western Mediterranean route being critical in recent times). Very importantly, other border security threats are considered as critical: trafficking of narcotics and increased risks of environmental incidents such as various sea pollutions that follow the constant increase of diverse types of vessels at sea. With the new forms of transport including leisure sailing vessels, fishing vessels, merchant vessels and fast speedboats [4], recent channels of narcotics smuggling take routes over Northern and Eastern Africa making Spain and Portugal as the points of entry into Europe [3]. Undoubtedly, operations of border and maritime patrolling remain a permanent and rigorous necessity requiring collaborations, forethought and considerations for applying new innovations and related technologies. A specific focus induced by these necessities and inherent in maritime surveillance objectives is associated with the following challenges [5]:

- *Heterogeneity of the traffic and threats* – detection of non-conformant situations and response to unverified information is challenging as only 90% of the traffic from vessels (merchant, sailing and fishing) report their positions, route and intentions validly.
- *Satellite imagery is incomplete* – satellites usually have limited access time windows in which they are monitoring an area of interest, making the remaining time void of detailed surveillance inspections.
- *Lack of assets by the relevant authorities* – for vast maritime regions under specific jurisdictions, possessing a patrolling fleet large enough for achieving complete coverage and responsiveness is too expensive.

Opportunities for further advancements of maritime surveillance can be found within the above challenges and underpinning requirements of minimising costs of operations and improving the speed of responsiveness at sea. Emerging technologies offer attractive new attributes in the operations of maritime administrations. Generally, this refers to ranges of new unmanned vehicles and augmented powers of data collection and processing. We also note an indicatively low intake of the surveillance technologies and tools such as unmanned vehicles by the associated organisations. This discrepancy between the availability of emerging technology and the actual integrated deployment of it in maritime surveillance remains despite significant investments in the manufacturing segments. The lack of uniformity in the integration of such technological extensions onto existing systems is a strong blockage. Each system comes with own capabilities, interfaces, displays and finally deployment/recovery requirements. Simultaneous deployment of multiple unmanned assets still requires a tool able to extract their full potential and augment surveillance capabilities. Such a tool would be an information system with a strong analytical component, able to gather and assess information arriving from assets and other sources. It is within this context that the EU collaborative project COMPASS2020 was envisaged [6].

Content of the paper is as follows: Section II gives an overview of the COMPASS2020 EU project; Section III present the specific maritime surveillance situation in Montenegro; Section IV present a methodological approach for integrating the new technologies in operations of the Montenegrin maritime safety; Section V concludes the paper.

2.0 OVERVIEW OF THE COMPASS2020 PROJECT

Project COMPASS2020 aims to demonstrate scenarios which use unmanned vehicles in maritime surveillance. Alongside this drive, the project builds an implementation framework, operational guidance, options for the use of technologies and instructions on the incremental deployment of demonstrated solutions as part of the functional and operational capabilities of the project partners. The demonstration as the conclusive project event will be conducted in Portuguese waters by Autoridade Marítima Nacional agency in Portugal conducting surveillance activities in domains of policing and security duties. The scenario event will consist of pre-organised situations of narcotics smuggling and the search and rescue (SAR) of irregular immigrants. Besides academia, large and small industry as project members, the consortium includes several other maritime surveillance (government) agencies as end-users including the Maritime Safety Department of Montenegro (MSD). These end-users attempt to convey the experience from the focal demonstration event and inform the actions taken while building towards it. This will enable integrating the unmanned vehicles and accompanying technologies into their operations as extended capabilities for maritime surveillance. In a wider context, these results are directed towards further potential users: (EU) European border guards (both maritime and land-based), law enforcement agencies, and potentially defence entities.

For the demonstration case, deployments of unmanned vehicles occur from regular patrolling vessels called Offshore Patrol Vessels (OPVs) and in support of their regular patrol missions. As such the intention is to:

- Extend OPV coverage by means of aerial and underwater unmanned vehicles;
- Increase cost effectiveness of maritime surveillance missions;
- Complement the satellite imagery;
- Increased detection accuracy and autonomy for patterns, behaviours and threat risk analysis.

Besides the mentioned pivotal demonstration event in Portugal built around the mentioned use-cases, other end-users in the project also indicate their specific use-cases. Hence, the Maritime Safety Department of Montenegro formulates these as presented in the remainder of the paper. This process offers a unique opportunity within the project for calibrating the operational procedures at sea and at the maritime surveillance control units, or, as trainings for personnel dealing with the situations.

A summary of the project objectives can be stated as: "*COMPASS2020 aims at demonstrating an operational solution involving both manned and unmanned vehicles to ensure long range and persistent surveillance, increasing the situational awareness of maritime authorities, and, thus, increasing the cost-effectiveness, availability and reliability of the operations.*" From this, we specifically extract the objectives of: a) propose an innovating Concept of Operations (CONOPS); b) deploy an information system called Mission System (MS) that enhances the existing platforms for maritime surveillance with project specific add-ons; c) assess and improve the capabilities of unmanned vehicles used in the project.

2.1 Concept and Approach

Upon introspecting many use-cases provided by the involved maritime surveillance authorities in Europe, it becomes evident that there are ever-present limitations and deficiencies in availability and comprehensiveness in incident responses. These are numerous and subject to situations and can include: i) elusive targets at sea and hampered interceptions; ii) insufficient details for proper situational awareness; iii) lack of information for appropriate decision making; iv) inability to assess risks for patrols and/or incident response action; v) ultimately, slow response.

The project converged on the following approach:

1. Combination of usage of manned asset (OPV), and, four distinct unmanned assets (three Unmanned

Aerial Vehicles and one Unmanned Underwater Vehicle – AUV/UUV).

2. Performing rigorous analysis, practical and real-environment tests, simulations and ultimately demonstrating this layered approach of combining the assets, coverage and characteristics, as depicted in Figure 2-1.

3. Developing a functional composition of the features to be integrated in the existing systems as enablers of the use of the assets. A functional architecture is developed spanning from the assets (i.e. manned and unmanned) to maritime surveillance operational centres at land. Hence, MS is built and distributed to include from Data Fusion to complex Artificial Intelligence (AI) features such as Risk Analysis etc.

4. Applying the findings to the benefit, use and extensions of maritime surveillance capabilities and wider usage (e.g. standards, commercialisation, research, manufacturing etc.) in terms of how the assets and accompanying functionalities can be utilised and endorsed follows a modelling termed Concepts of Operations (CONOPS). In simple, CONOPS reveals the operational implications and uses of assets per situations in all use-cases.

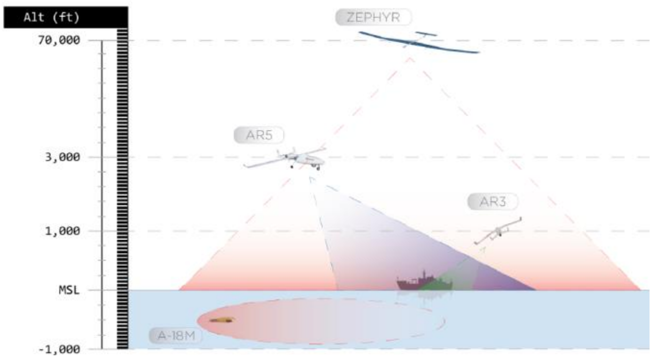

Figure 2-1: A layered approach to deployment of unmanned vehicles.

2.2 Assets

COMPASS2020 unmanned assets include aerial and underwater, technologically mature and available, commercial platforms. The combination of these remotely piloted surveillance platforms, together with manned assets, will provide the enhanced and virtually continuous situational picture to authorities responsible in the maritime domain:

- TEK AR-3 – 'Net Ray' small size Unmanned Aerial Vehicle (UAV) aircraft platform: high endurance, long range (10 h, 150 km), launched on board OPV by catapult and recovered by net or parachute, up to three sensors, payload (also include optional sensor), identification and positioning features.
- TEK AR-5 – 'Life-Ray' medium size UAV aircraft: needs a runway, greater range, endurance and payload, five sensors in gyro-stabilised gimbal (Electro-Optical (EO), Infra-Red (IR) and thermal laser illuminator as baseline); it also has: Emergency Position-Indicating Radio Beacon (EPIRB), Automatic Identification System (AIS), Automatic Dependent Surveillance – Broadcast (ADS-B) and Mode S Radar, Synthetic Aperture Radar and Laser Range Finder (LRF). Detects large vessels up to 15 km with EO/IR cameras, up to 60 km with RADAR or 100 km with AIS sensors. For aerial targets with ADS-B, detections can occur with a range of up to 200 km.

- 'Zephyr' medium size High Altitude Pseudo-Satellites (HAPS) aircraft: needs runway, solar-electric, stratospheric, beyond-line-of-sight control, real-time mapping, offers internet, imagery and a number of surveillance opportunities. Considered only for system concepts and design in the project, not in demonstrations.
- 'A-18M' Autonomous Underwater Vehicle (AUV) is used in military sector for ranges of missions, typically launched from a ramp system attached to a host vessel, with 300 m depth, 2 km2/h coverage rate. It hosts: Synthetic Aperture Sonar (SAS), Video, Forward Looking Sonar (FLS), Multi-Beam Echo Sounder (MBES), CTD, ADCP, Turbidity, and others. Note: at the time of the writing and preparation of the paper, COMPASS2020 project also considered another AUV/UUV as the alternative option for the demonstration event to be held in Portugal and with unchanged operational implication: ASEMER by Thales. For simplicity we only mention A-18 in the remainder.

3.0 BACKGROUND TO MARITIME SURVEILLANCE IN MONTENEGRO

3.1 Area and Environment in Montenegro

Montenegro's relatively short coast belongs to the south-eastern part of the Adriatic Sea with the following basic specifics: costal total length of 294 km; sea border length of 148 km; surface area of inland sea of 362 km^2; surface area of the territorial sea of 2.099 km^2; and, surface area of the epicontinental shelf 3.885 km. There are quite numerous shipping movements in the Adriatic Sea all year round, but with significantly high intensity during summer seasons, with lots of small fishing and tourist pleasure boats. Border regions and territorial waters are shared with Italy, Albania and Croatia. The climate is hot and dry in the summer, and cold and highly humid in the winter: temperatures can be as high as 25 °C, with peak summer temperatures over 40 °C. The sea surface temperature varies from 14 °C in winter to between 22 °C and 28 °C during summer, where winds can reach up to 40 knots. The Adriatic Sea has particularly high salinity. Its deepest point is in Montenegro (1240 m) while the shallowest is in Bay of Trieste in Italy (25 m).

3.2 Brief Overview of Maritime Safety Department in Montenegro

Current system at use in MSD is briefly described:

- Vessel Traffic Monitoring Information System (VTMIS) is comprised of the primarily positioned main VTMIS centre in Dobra Voda, near the city of Bar, with three additional remote VTMIS sensor sites scattered along the coast.
- VTMIS system information and data are "mirrored" via Web service monitoring system Pelagus for improved awareness of maritime traffic. All network level communications are done via Internet Protocol (IP).
- At data exchange level, VTMIS is configured to utilise the IVEF standard (Inter VTS Exchange Format) via XML (Extensible Markup Language) for exchanging data (AIS, radar) with other systems.
- Equipment at VTMIS Centre in Dobra Voda: VTS Software, VTS servers, Database servers, Record and Playback Servers, Very High Frequency (VHF) Radio Servers, VHF Dispatcher Software, Voice over IP (VoIP) Interface module, VTS Operator Consoles, Uninterruptible Power Supply (UPS), Diesel Generator, Microwave Links and interconnections, VHF Operator Terminals. Each remote VTMIS site has similar equipment as the main centre.
- Coastal radio station – BARRADIO
- The Maritime Rescue Coordination Centre (MRCC) in Bar is assumed as operationally integrated with the Maritime Operations Centre (MOC) being physically collocated to conduct tasking of the assets using the appropriate communications means. The MRCC, as a part of MOC, uses VTMIS, while MRCC additionally uses GMDSS - Global Maritime Distress and Safety System based on VHF, MF

and Inmarsat C satellite.

– MSD has five boats for SAR actions and the variety of response equipment for emergency intervention at the sea.

At its disposal, MSD gathers its own personnel coordinated together as a joint working team with the Navy and Border Policy at its disposal. According to National plan for SAR at sea, and National Contingency Plan for oil spills prevention at sea, MSD could involve other national institution from Montenegro (Army, Police) and their equipment and assets (e.g. boats) to participate in SAR actions or exercises. In cases of operations such as SAR and/or protection of sea from pollution such as oil spills, MSD coordinates activities at the sea, and the rest of the institutions' assets are at the disposal, command and coordination of MSD's Director.

3.3 Operational Actors

All component that play a part in the composition of the MSD use-cases are listed below:

– **Inter-ministerial Body consisting of: (1) Maritime Safety Department (MSD), (2) Ministry of Defence represented through its Montenegrin Navy (MN), and (3) Ministry of Internal Affairs (MI) represented through its Police Directorate (PD) and Maritime Border Police (MBP)**: it is a focal governing body assembling various national institutions responsible for making executive decisions in situations of national security threats and risks. Such decisions are realised and executed as individual tasks executed by institutions identified as responsible, related and involved in alleviating the threats and risks.

– **Police Directorate (PD) and Maritime Border Police (MBP)**: running regular policing activities at sea, such as border control, detection of vessels, pursuits, launching patrolling missions, also, requests and invokes supporting sea actions by MSD.

– **MSD (Maritime Safety Department):** performs VTS, VTMIS and SAR at sea and assists and extends the activities of the PD in maritime affairs and situations. Responds to decisions made by the Inter-ministerial bodies or requests by PD. The activities can include: SAR, identifications of situations at the sea, vessels monitoring, recognisance missions etc.

– **Maritime Operation Centre (MOC)**: on-shore scentralised base in city of Bar shared by all actors where the high level strategic planning occurs; equipped with own VTMIS systems which collects all operational data from three sensor sites along the Montenegro coast equipped with X-band solid state radars and AIS. The MOC is coupled with the MRCC and is capable of tasking assets in operation (sending requests through VHF, Terrestrial Trunked Radio (TETRA) or phone calls).

– **Offshore Patrol Vessels (OPVs)**: combination of many vessels used and deployed by MSD, Navy or PD that can have the capabilities of COMPAS2020 OPV with COMPAS2020 MS components running. OPVs are engaged in emergencies and patrolling scenarios, e.g. a patrol boat from port of Bar with Special Operations Team (SOT) embarked in case of interceptions of suspicious vessels.

– *to be incorporated*: **Unmanned Aerial Vehicles (UAVs):** options to be considered for sutilisation of COMPASS2020 UAVs: AR3, AR5 and/or Zephyr are related to extending the coverage, speed and targeted search and identification tasks in support and coordination with OPV manoeuvres and activities. The requirements and capabilities for launching the UAVs will determine the most fitting UAV for each task.

– *to be incorporated*: **Autonomous Underwater Vehicle (AUV):** A18-M is launched and recovered from the OPV; it is equipped with several payloads including a set of hydrophones, SAS, Video, FLS, and MBES.

4.0 COMPOSING TWO USE-CASES FOR AUGMENTED MARITIME

SURVEILLANCE IN MONTENEGRO

MSD generally seeks cheaper means of reaction during the emergency occurrences at sea. This basically means reducing costs and resources during the deployments of personnel, high-cost vessels, patrol boats and consumption of petrol. Hence, usage of UAVs/AUVs promises to fulfil these requirements and enable faster responsivity and versatility in operational capabilities and manoeuvring.

In order to reveal and solve gaps in operations and opening for the usage of technologies such as the COMPASS2020 introduced assets, a methodology is applied for defining the two MSD use-cases: one on intercepting narcotics smuggling, and another on risks of pollution at sea. This explanation of the two use-cases is preceded by description of the two general situations in the Adriatic sea. The particular methodology is intended to revel: a) engagements of UAVs/AUVs in extending the capabilities in specific stages of incidents tacking; b) extending of the monitoring and deduction capabilities through in data gathering [8] (anomaly detection, level 2 - L2) and analysis of capabilities (risk analysis, level 3 – L3) of the COMPASS2020 system and the functional architecture to be fully compiled in the project; c) raised awareness and means of operations due to usage, trainings and experiences with UAVs/AUVs deployments in the project.

4.1 Use-case 1: Narcotics Smuggling followed by Search and Rescue

4.1.1 Narcotics trafficking situation in Montenegro

Illegal transportations of cannabis are a regular occurrence between the borders of Italy, Albania and Montenegro in the Adriatic Sea. The authorities from all three countries are constantly vigilant and engaged in destroying the plantations and the illicit transport. The cannabis is often transported by the smugglers using high speed boats. A joint task force composed by Albanian, Italian and Montenegro authorities is created to stop these activities. Only on one occurrence in 2017, Montenegrin authorities led by Montenegro police caught 1.2 tonnes of cannabis transported in two high speed boats. One boat was intercepted while the other escaped dumping its cargo during the pursuit. MSD was contacted to provide support to police with VTMIS system for maritime surveillance in order to track smugglers boats.

4.1.2 Methodology: Plan-Do-Check-Act (PDCA) Cycle

Relationship between the operational actors for Use-case 1 are shown in Figure 4-1 using the NATO Architectural Framework representation, glossary and terms [7].

1. Plan (Prior mission planning):

- The sea borderline of Montenegro is covered by Coastal Surveillance System (VTMIS). L2 alarms can be generated by boats/persons merely carrying out a legal activity and sent to COMPASS MS and MOC. OPVs regularly patrol sea border areas or are in reasonable proximity.
- Information received from the Montenegro PD is that suspicious speedboat(s), loaded with a significant amount of illicit narcotic bundles are coming from Albania (heading westwards) towards the Montenegro coast with more than 2 tons of illicit drugs.
- L2 data fusion verification of an illegal border crossing.
- Inter-ministerial body called up an emergency meeting to respond urgently to the situation and consequently issues individual tasks to each institution.
- Upon receiving the VTMIS data, COMPASS2020 MS at MOC calculates the interception point with the two speedboats.

– PD requests support from MSD for detecting and tracking the speedboats.

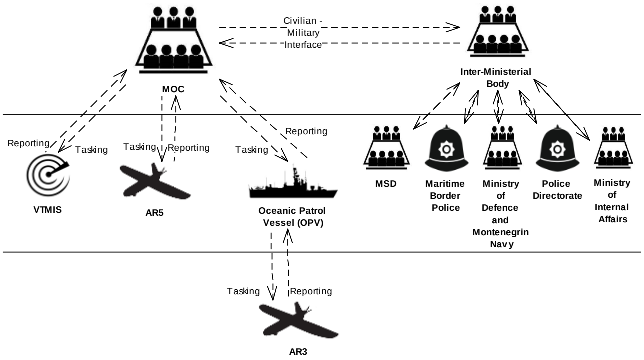

Figure 4-1: NATO Architectural Framework (NAF) C3 diagram showing the relationship between the Use-case 1 actors

2. Do (Initial response):

– OPV is invoked with a SOT.

– The OPV patrol boat approaches the calculated interception point (that was calculated using VTMIS system) and detects with radar and visual contact the suspicious speedboat(s).

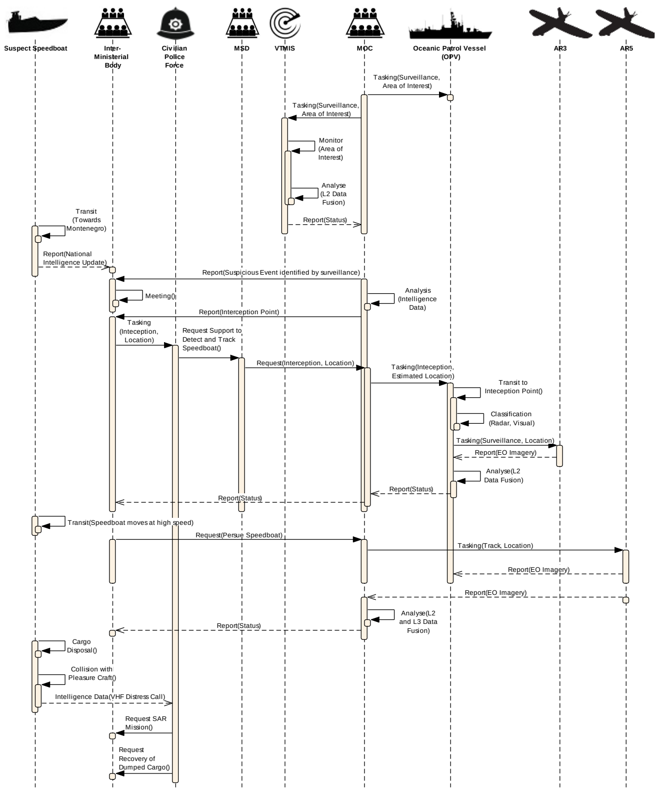

Figure 4-2: NAF L6 diagram of the complete storyline for Use-case 1

- L2 data fusion verifies that the objects are speedboats with crew and with suspicious cargo on board.
- In addition, a UAV (or other Legacy System) can also verify that there are suspicious movements in a specified point (e.g. several speed and course changes) and notifies the
- COMPASS2020 MS, this point is also an L2 data fusion stage.
- The second speedboat is trying to escape and approaches the coast at high speed (> 25 kts).

3. Check (Monitoring and Analysis):

- Inter-ministerial body decides to deploy a UAV platform in order to detect the second runaway speedboat that escaped the calculated interception point and is heading fast towards the coast.
- Video Analysis supports the sensors in a way that unwanted incidents/alarms can be filtered out by the proactive filter function, and personal verification
- Object detection: verifies that the suspect speedboats are carrying suspect packages.
- COMPASS2020 MS could use L3 data fusion to assess risks of both speedboats in terms of cargo, collisions with other (civilian vessels at the sea), fires, oil spillages etc. in relation to state of the current OPVs deployment at the sea and other vessels.
- Two further events occur with both speedboats requiring further actions

4. Act (Final response):

- Upon the detection of an event, the system should be able to send a real-time alert to the COMPASS MS and MOC including the following information regarding the location of event; Time of event, Type of event and Pictures and/or video and: i) Plan mission operations; ii) Initiate mission with other systems; iii) Manage Mission Data; iv) Make Distribution to Unit level/Rescue team.
- The first event is the dumped cargo by one of the speedboats during the "hot pursuit" by PD OPV. Since the L3 was not deployed to predict the situation/risk, the action that can follow the occurrence is: L2 identification of the situation from OPV; L3 estimation of the affected areas and location of the cargo; and, deployment of UAV to confirm cargo left behind and potential further illegal border crossing (L2) and guides the cargo recovery/clean-up action (L3 supported)
- The second event is the collision with a pleasure yacht with 25 people on board that was identified by the distress call to MRCC in Bar that can be associated as L2 information. Similarly, L3 data fusion could have predicted it. Once it occurred, L3 data fusion could identify further risks associated with the collision (e.g. persons in distress, vessels, environment, other vessels etc.). UAV can be deployed to assess the situation (L2) by verifying that the objects are there (i.e. yacht and speedboat) and support the SAR operation.

4.2 Use-Case 2: Polluting incident followed by Search & Rescue mission in Montenegro

4.2.1 Sea polluting situation in Montenegro

There is a high presence of mega pleasure yachts that come for bunkering fuels in Montenegrin ports, Port of Bar or Porto Montenegro, as there is tax exemption on fuel for some yachts. According to this increase in traffic density and MSD's previous experiences, there is a real danger of the marine pollution incidents or oil spillages detection. MSD has implemented and is using EMSA Clean Sea Net (CSN) system to detect potential oil spills. Owing to CSN System, we had experiences when the polluter was detected and Port State Control (PSC) inspection was performed. Particularly, in 2016 similar event happened close to the Albanian Port of Duress, where collision between a cargo vessel and a ferry took place. Three crew members were missing from cargo vessel.

4.2.2 Methodology: Plan-Do-Check-Act (PDCA) Cycle

Relationship between the operational actors for use-case 2 are shown in Figure 4-3.

1. Plan (Prior mission planning):

– On entering and leaving Montenegro's VTS areas yacht(s) send entering/leaving report according the Montenegro VTS procedure.

– After entering in the VTS area, VTS operators inform the pleasure craft about weather condition, traffic density on the waterway and other maritime safety information.

2. Do (Initial response):

– According the COLREG it is mandatory for the cargo vessel to avoid the pleasure craft, but in this case, it did not follow the rules.

– Upon the collision, a distress call is sent to MRCC Bar, L2 data fusion information is fed to COMPASS2020 MS and MOC.

– MRCC Bar/MOC activate the national SAR plan and send two SAR patrol boats (OPVs) to receiving position.

– L2 data fusion verifies that the object is a life raft with 14 persons on board and 5 shipwrecked people at the sea – Object Detection

– After 20 minutes, the SAR recovers 14 persons from the life raft and five persons in the sea.

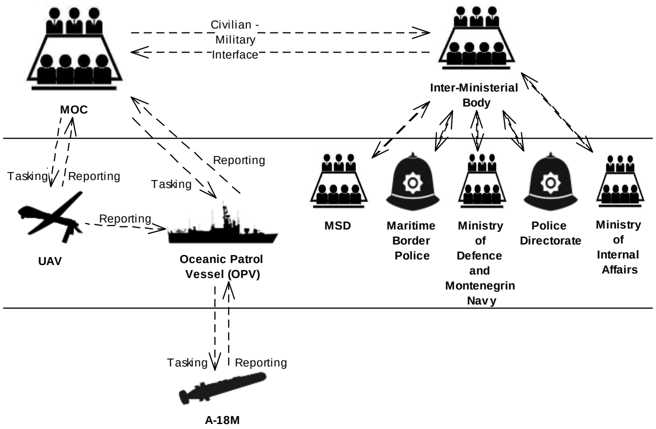

Figure 4-3: NAF C3 diagram showing the relationship between the Use-case 2 actors

3. Check (Monitoring and Analysis):

– COMPASS2020 MS and MOC can predict further risks of spillages, scattered persons in the sea, fires, other boats.

– 3 persons are still missing at the sea as identified by SAR patrol boats when they conducted the rescue.

– UAV (or other Legacy System) verifies that there are persons and an object at sea and notifies the COMPASS2020 Mission System.

– A large oil spill is also detected by the SAR crew. On-scene commander suspects that the pleasure craft's tank releases fuel. The depth of the water is about 120 meters.

– Video Analysis supports the sensors in a way that unwanted incidents/alarms can be filtered out by the proactive filter function, and personal verification.

– MRCC information is sent on both events. L2 information contains spillage confirmation, number of persons at the sea

– L3 is updated by the information from the collision scene and can calculate further risks

4. Act (Final response):

– Upon the detection of an event, the system should be able to send a real-time alert to the COMPASS MS and MOC including the following information regarding the location of the event; Time of event, Type of event and Pictures and/or video and: i) Plan mission operations; ii) Initiate mission with others systems; iii) Manage Mission Data; iv) Make Distribution to Unit level/Rescue team.

– MRCC Bar/MOC decides to send a UAV to search the area and try to detect the persons in the sea

– Inter-ministerial body activates National Contingency Plan (NCG) and sends ECO-1 pollution boat with equipment to recover the oil spill.

– Because of the impossibility to check damaged fuel tank an AUV is used to explore any leakage.

– All activities of the Inter-ministerial team are coordinated in MOC and observed in real time.

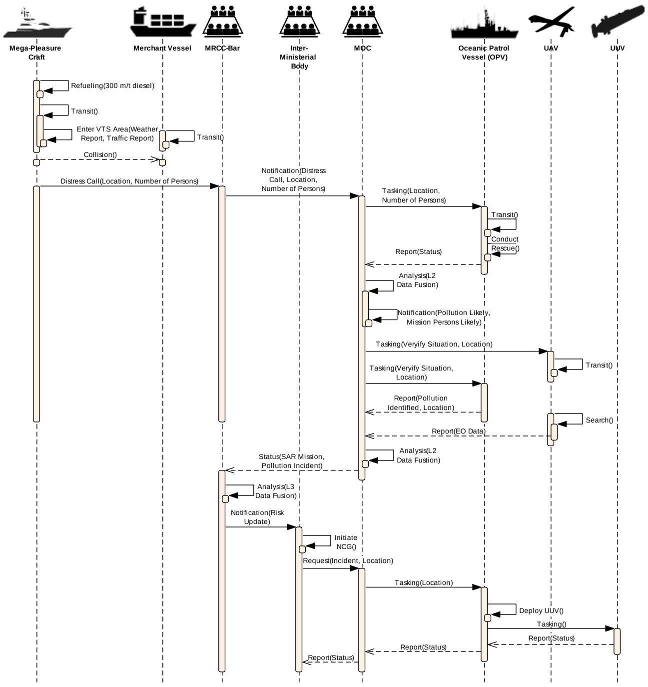

Figure 4-4: NAF L6 diagram of the complete storyline for Use-case 2

4.3 Expected Results using COMPASS2020 solutions

4.3.1 Operational Level (MOC):

- Anomalous behaviour detection (vessels' behaviour at sea), for example: significant change of course and/or speed, no AIS associated with radar contact, speed exceeds 30kts.
- Send and receive anomalies detection, with position, course, speed and date-time-group near real time (to boat/OPV and UAVs/AUVs operators).

- Capability of optimised planning of a mission and tasking UAVs/AUVs (definition of initial mission, activate an asset, send new waypoints, define a new area of interest, etc.)
- Capability of tasking deployment of AR5 UAV platform (which requires a runway to take-off and landing phases).
- Have a dedicated chat to make the link between MOC and boat/OPV for mission control.
- Send and receive contacts of interest in terms of position, course, speed and Distance-To-Go (DTG) near real time; Send and receive areas of interest including water space management.
- COMPASS2020 MS to show the data acquired by UAVs/AUVs.
- Capability of COMPASS2020 MS receiving additional AIS information from Montenegro VTMIS system.

4.3.2 Tactical Level (OPV/boat):

- Anomaly behaviour detection (same as above) and it crosschecks the data with MOC.
- Send and receive anomalies position, course, speed and DTG near real time (to MOC).
- Capability of deploying and recovering AR3; Capability of tasking and re-tasking UAVs.
- Have a dedicated chat to make the link between MOC and OPV for mission control.
- Send and receive contacts of interest; Send and receive information within the areas of interest.
- COMPASS2020 MS to show the data acquired by UxVs.
- OPV to report its own and UxVs' positions, course, speed and DTG in near real time to the MOC.
- Send all AIS and Radar data to MOC.

5. CONCLUSIONS

All stakeholders in comprehensive maritime industry, governance and research are constantly exposed to emerging advances in technologies and their capabilities. It is of unique importance that such opportunities are reviewed and assessed before being considered for deployments in real-life situations at sea and as components of the overall maritime surveillance systems. This practically oriented approach is shown in this paper by explaining the whole process of adjusting the maritime surveillance operations and capabilities of an existing Montenegrin maritime safety authority in the Adriatic Sea. As there are many possibilities for integrating the unmanned assets, either aerial or underwater, as well as different types of them, the COMPASS2020 project performs the whole process of integrating two specific types of UAVs and one AUV in maritime surveillance operations and fits the operational aspects from these in existing functionalities used in maritime surveillances.

ACKNOWLEDGEMENTS

This work was supported by the European Union’s Horizon 2020 Framework Programme for Research and Innovation under grant agreement No. 833650 (COMPASS2020 project).

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