European Maritime Safety Agency

EMSA RPAS SERVICES FOR MARITIME SURVEILLANCE

2017-2023

EMSA

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Executive Summary

The European Maritime Safety Agency (EMSA) has been providing Remotely Piloted Aircraft Systems (RPAS) services since 2017, offering a comprehensive set of capabilities to maritime authorities, including the aircraft system, relevant payload, piloting, communication means, data dissemination, and integration with the Agency's maritime information systems. What was initially a technology intensive pioneering service with an incomplete legal safety framework in the EU has become a regular operational service provided by EMSA to Member States' coast guard authorities.

The provision of RPAS services for maritime surveillance enhances real-time maritime situational awareness for Member States by augmenting the maritime picture with additional sources of data. RPAS services are available to support various coast guard functions and help Member States in performing their coast guard duties at both national and EU levels.

Since 2017, 16 EU and EFTA countries have been able to use the EMSA RPAS service across a total of 7015 operational days, more than 14,700 flight hours and 58 RPAS operations. Up to 13 light RPAS have been maintained ready on stand-by to support pollution response operations and were involved in four emergency response operations.

This report provides a comprehensive overview of EMSA's RPAS services, summarizing key outcomes from 2017 to 2023 and evaluating their use in the maritime domain. This evaluation is informed by feedback from coast guard authorities and aims to facilitate the ongoing development of RPAS Services. Additionally, it seeks to share insights with maritime authorities interested in establishing their own RPAS capabilities for maritime surveillance.

The report is divided in the following chapters:

1. **EMSA RPAS services overview:** EMSA strategy for the use of RPAS and use cases in the period 2017-2023.
2. **EMSA RPAS services model:** Details on the RPAS services EMSA has been offering to its users.
3. **EMSA RPAS services results**: Overview of service results, performance, operational added value for the final users and limitations and challenges stemming from the deployment of RPAS for maritime surveillance.
4. **Lesson learned**: Lessons learned from these first years of RPAS activities at EMSA concerning authorisations to fly, airspace management, communications, and other relevant elements. It also includes a summary of best practices regarding timings, resources, logistics and operational procedures for setting up an RPAS operation for maritime surveillance.
5. **Conclusions and way forward** stemming from the findings in this report for the further improvement of EMSA's RPAS services.

RPAS are now a core surveillance service of EMSA, and several coast guard authorities have since deployed their own RPAS operations, building up on the lessons learned with EMSA's RPAS maritime surveillance services.

Figure 1 - RPAS ahead of 2024 Italian deployment

1 EMSA RPAS services overview

1.1 Background

The objective of the EMSA RPAS Service is to support Maritime Surveillance operations in the civil domain. EMSA started to explore the potential of Remotely Piloted Aircraft Systems (RPAS) for maritime surveillance in 2014. At this time the RPAS market was dominated by military systems and EMSA intended to evaluate to which extent this technology could be used in the civil maritime domain.

The initial proposal to use RPAS in the civil domain was introduced in October 2015 during a dedicated workshop with Member States, the European Commission, the European Border and Coast Guard Agency (Frontex) and the European Fisheries Control Agency (EFCA), and was further discussed with ESA, EASA, and other relevant stakeholders in order to further refine the proposed concept. In parallel, EMSA contracted a user benefit analysis study to evaluate whether RPAS could effectively support operational maritime surveillance and address the operational objectives of Member States. The study concluded that use of RPAS would complement satellite observations and vessel operations by providing more temporal and geographic flexibility with fewer human risks and costs, when compared with manned aircraft systems. RPAS would be able to improve the surveillance and detection capabilities of European Agencies and Member States by complementing the data already available. In early 2017 EMSA contracted an operational demonstration with several state-of-the-art RPAS, providing different maritime surveillance concept of operations (CONOPS) for multipurpose coast guard operations. This demonstration showed EU Member State representatives and other EU authorities that use of RPAS could be an effective support tool to the coast guard tasks of the three EU Agencies: EFCA, Frontex and EMSA.

EMSA RPAS services started operational activities in late 2017 and since then, the Agency has deployed RPAS services for 58 operations to the benefit of 16 countries and two European Agencies.

The prospective areas of operation were all sea areas surrounding the European Union, with an EU or EFTA country as a starting point of the service. Most of the RPAS operations were multipurpose, combining the whole range of maritime surveillance activities, including, for example: large surveillance area for detection of objects of interest; identification of activities on board vessels; support to search and rescue (SAR) operations; environmental observations and vessel emissions measurements. This integrated approach, which is available day and night, increases efficiency and best use of resources, as well as promoting a regional approach by addressing the different needs of multiple stakeholders. The graphic below shows the evolution in number of reported RPAS operations per year in the civil maritime domain in Europe. It distinguishes RPAS operations provided by EMSA from RPAS operations directly financed by national maritime authorities.

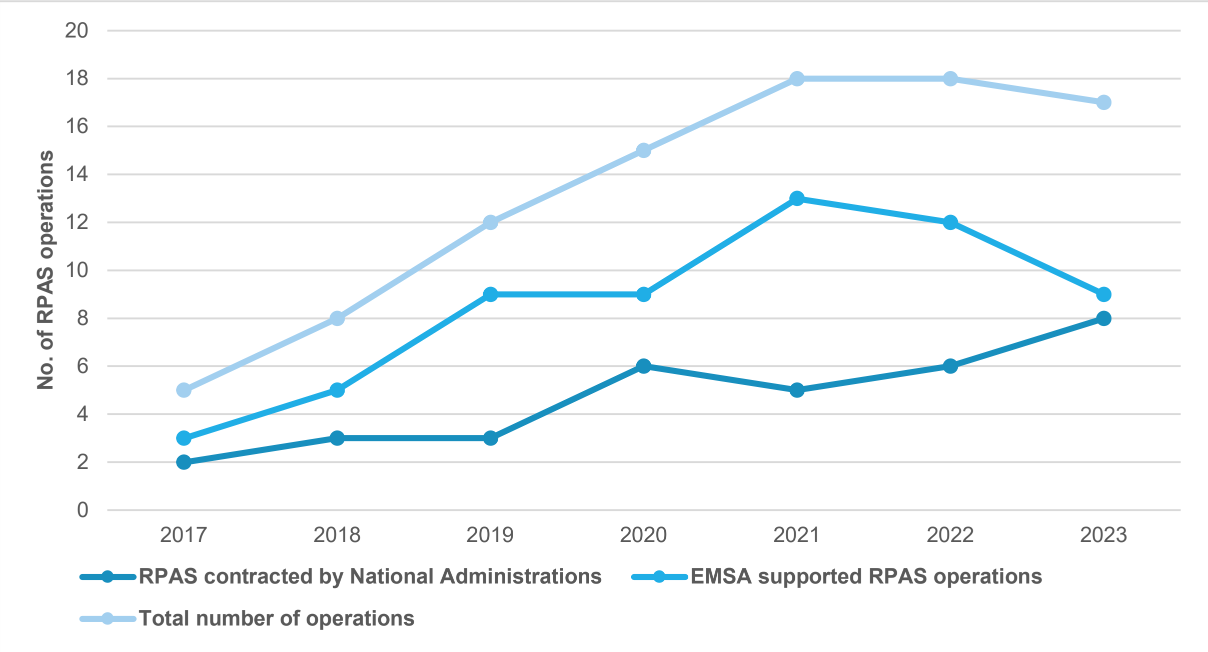
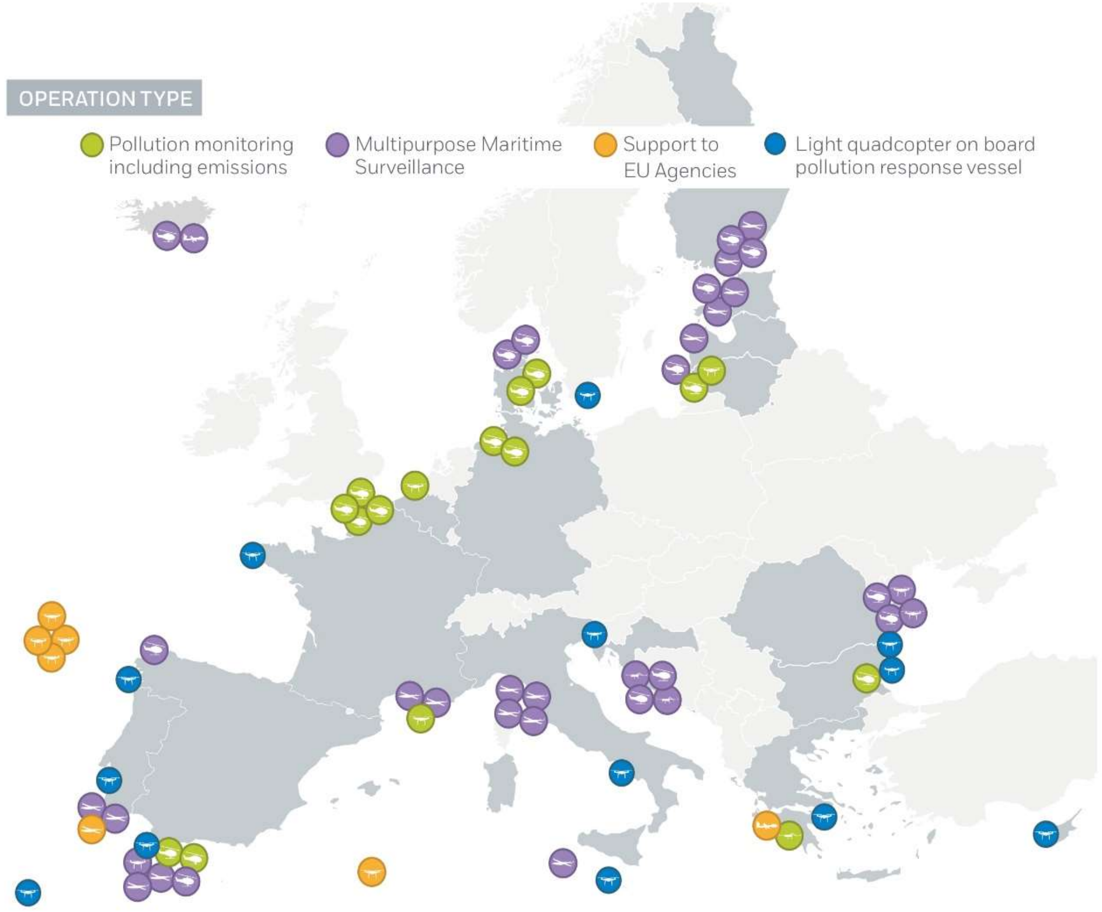


Figure 2 -Number of RPAS operations in the EU Civil domain from 2017 to 2023[1]

According to these figures, the majority of the RPAS operations which took place between 2017 and 2023 in the EU civil domain for EU maritime authorities were supported by EMSA's RPAS services, but from 2020 onwards, these EU authorities started to launch an increasing number of RPAS operations financed and managed by their own resources, some of them building up on the initial experience with EMSA.

The following figure presents an overview of all RPAS services provided by EMSA in the period 2017-2023 including light RPAS on standby on oil pollution response vessels. Further information on these operations can be found in Annex 2.

[1] The number of RPAS operations supported by EMSA were confirmed based on EMSA records, while the number of RPAS operations contracted directly by national coast guard authorities might nor reflect the full extent of RPAS experience at EU level as it counted only those experiences reported by the respondents to the 2023 RPAS survey. Some local authorities might have had other RPAS experience for maritime surveillance that were not shared with EMSA.



BELGIUM
- Pollution monitoring including emissions - 2020, 2021

BULGARIA
- Pollution monitoring including emissions - 2020
- Multipurpose maritime surveillance (Flights from Romania - 2022)

CROATIA
- Multipurpose maritime surveillance - 2017/18, 2019, 2020

DENMARK
- Pollution monitoring including emissions- 2019, 2020
- Multipurpose maritime surveillance - 2022, 2023

EFCA
- Support to EU fisheries control - 2020, 2021, 2022, 2023

ESTONIA
- Multipurpose maritime surveillance - 2021, 2022, 2023

FINLAND
- Multipurpose maritime surveillance - 2020, 2021, 2022, 2023

FRANCE
- Pollution monitoring including emissions - 2020, 2021, 2022, 2023
- Multipurpose maritime surveillance - 2020,2021

FRONTEX
- Multipurpose maritime surveillance: Frontex/Portugal - 2018; Frontex/Greece - 2019; Frontex /Portugal - 2019

GERMANY
- Pollution monitoring including emissions- 2022, 2023

GREECE
- Pollution monitoring including emissions - 2017/2018

ICELAND
- Multipurpose maritime surveillance - 2019, 2022

ITALY
- Multipurpose maritime surveillance - 2019, 2020, 2021, 2022, 2023

LATVIA
- Multipurpose maritime surveillance (Flights from Estonia - 2022, 2023)

LITHUANIA
- Pollution monitoring including emissions- 2021, 2023

PORTUGAL
- Multipurpose maritime surveillance - 2017, 2018, 2023

ROMANIA
- Multipurpose maritime surveillance - 2020, 2021, 2022

SPAIN
- Multipurpose maritime surveillance - 2017/18, 2021, 2023
- Pollution monitoring including emissions - 2022

Figure 3 - Map of RPAS operations from 2017 to 2023

1.2 Contribution to EMSA's multi-annual strategic priorities

RPAS services described have contributed to two of the strategic priorities of EMSA: sustainability and surveillance.

Regarding sustainability, EMSA's RPAS services have supported to the European green agenda for maritime transport by strengthening EU capacity to protect the marine environment. RPAS are now part of a monitoring and response toolbox to top up Member States capabilities to deter, detect and respond to pollution from ships and oil pollution from oil and gas installations. At the end of 2023, the RPAS services were present on board 13 EMSA contracted oil spill response vessels to improve detection and recovery of oil spills in case of a major incident. RPAS deployed by EMSA in EU and EFTA regions for multipurpose surveillance increased the regional capabilities for further verification and monitoring of oil spills detected by satellite imagery through the CleanSeaNet service. RPAS were also used intensively in coastal areas with high volumes of maritime traffic to measure the sulphur content in the plume of the vessels and detect the use of fuel oils with sulphur content above the EU limits, facilitating follow-up of infringements through an inspection at the next port of call.

Concerning surveillance, the RPAS deployed by EMSA have substantially contributed to improving the functionality and efficiency of the EU maritime traffic monitoring and information systems. By progressively strengthening the capabilities of the RPAS in terms of quality of payload, endurance, and reliability, EMSA has provided the maritime authorities with an eye in the sky capable of transmitting live a more complete set of information on activities at sea to the maritime coordination centres, allowing for more efficient decisions and command. RPAS can provide multipurpose maritime surveillance, serving multiple user communities in the same operation, and generating significant benefits to Member States activities at sea. This capability supports Member States in a wide range of functions, including maritime safety, maritime security, fisheries control, customs, and law enforcement. RPAS has also proven to be a useful tool to support search and rescue efforts, at the top of the priorities of Member States' maritime administrations. RPAS support to search and rescue operations, has included the position detection of small vessels in distress, the monitoring of the situation on board until arrival of the manned assets, or the identification of the location of an aircraft crash site at sea. Several Member States have performed exercises to test the RPAS capabilities for search and rescue, either for the detection of persons overboard or for dropping a life raft with capacity for eight persons from an EMSA RPAS.

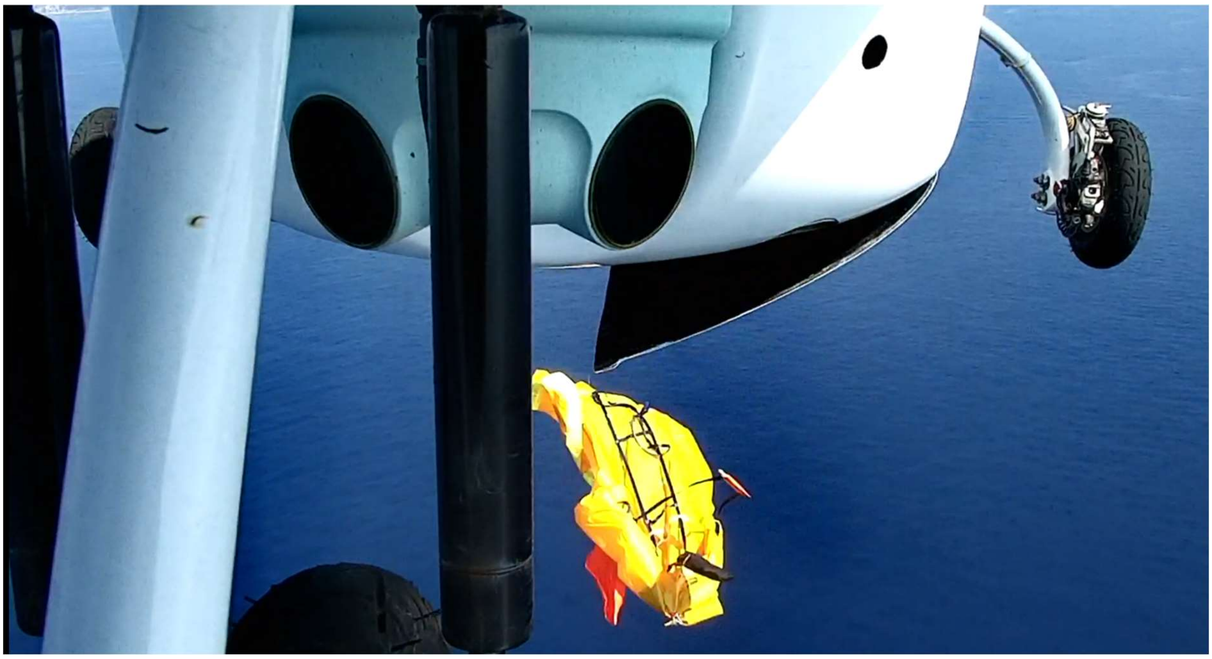


Figure 4 - RPAS dropping a life raft during a SAR exercise, Italy, 2023

EMSA has capitalised on its expertise with RPAS to engage further with the broader EU surveillance community and supported the national and EU maritime authorities by monitoring the emergence of promising technologies, launching market consultations, organising RPAS user groups for exchange of best practices, drafting operational requirements and operationalising the selected solutions while offering a whole portfolio of new RPAS services with the best range of sensors on board.

Finally, RPAS have enhanced EMSA cooperation with the other EU Coast Guard Agencies, EFCA and Frontex, in the framework of the European cooperation on coast guard functions. In 2019 and 2020 EMSA deployed RPAS operations with Frontex and, since 2019, EMSA provided lightweight Vertical Take-Off and Landing (VTOL) RPAS services and satellite communications (SATCOM) internet services on board EFCA chartered fisheries patrol vessel(s). In 2022 and 2023 the EMSA RPAS services participated in the Multipurpose Maritime Operations organised in the Black Sea, the Adriatic, and the Baltic Sea in cooperation with other EU coast guard authorities. Through publications, workshops, and user group meetings, the experience gained by EMSA has been shared within the broad coast guard community.

1.3 Legal Framework

1.3.1 EMSA mandate

The European Maritime Safety Agency (EMSA) was established under Regulation (EC) No 1406/2002 of the European Parliament and of the Council[2], as amended, for the purpose of ensuring a high, uniform, and effective level of maritime safety. Amongst its tasks, the Agency provides technical, operational, and scientific assistance to the European Commission and Member States in the proper development and implementation of EU legislation on maritime safety, pollution by ships and security on board ships. To accomplish this, EMSA's most important supporting task is to foster cooperation with, and between, Member States in all key areas and to build-up capacity of national competent authorities.

Figure 5 - EMSA's headquarters

[2] Regulation (EC) No 1406/2002 (consolidated version) - EMSA - European Maritime Safety Agency (europa.eu)

1.3.2 EU Coast Guard Cooperation

Article 2b of the EMSA founding Regulation as amended in 2016, establishes that EMSA, in cooperation with Frontex and the EFCA, shall support national authorities carrying out coast guard functions at a national and Union level and, where appropriate, at international level. Accordingly, these three “coast guard Agencies”, each within their mandate, support these authorities carrying out coast guard functions by providing surveillance and communication services based on state-of-the-art technology, including space-based and ground infrastructure and sensors mounted on any kind of platform.

The three EU Coast Guard agencies have signed a tripartite working arrangement and annual service level agreements to implement and coordinate this exchange of data, capacities, and experience for the benefit of the national Coast Guard authorities.

Since 2016 EMSA has promoted common initiatives with EFCA and Frontex in the domain of maritime surveillance with RPAS by contracting operational services that could be activated by any of the Agencies or the Member States coast guard authorities for any of the coast guard functions and exchanging best practices and experience in the context of the RPAS user group. EMSA RPAS services have been developed in the context of the coast guard mandate to support any of the categories of coast guard functions at EU or national level, i.e.: maritime monitoring and surveillance; maritime safety, including vessel traffic monitoring; maritime search and rescue; ship casualty and maritime assistance service; maritime accident and disaster response; maritime security; ship emission monitoring (SOx and other trace gases); pollution detection and response (oil spills, other substances); fisheries inspection and control; maritime customs activities; maritime border control; and, prevention and suppression of trafficking and smuggling and connected maritime law enforcement.

Figure 6 - RPAS user group meets at EMSA, June 2024

1.3.3 EU environmental Directives at sea

The EMSA RPAS services were also developed by EMSA to support the implementation of the EU Directives regarding the protection of the seas from ship-sourced pollution.

In September 2005 the European Parliament and the Council adopted Directive 2005/35/EC (since amended by Directive 2009/123/EC) on ship-source pollution and on the introduction of penalties, including criminal penalties, for pollution offences. The Directive tasks EMSA to “work with the Member States in developing technical solutions and providing technical assistance in actions such as tracing discharges by satellite monitoring and surveillance”.

Whereas satellite data can detect oil pollution on a very large scale, Remotely Piloted Aircraft Systems (RPAS) have the enhanced capability to detect and analyse an oil spill on a smaller scale, at any time, and can stay on site during response operations.

Regarding air pollution at sea, ships at European berths have been required to use fuels with a maximum sulphur content of 0.1% m/m (mass by mass) since 2010, and in 2015 sulphur emission control areas (SECAs) were introduced in the North and Baltic Seas, further requiring ships to use fuels with a maximum sulphur content of 0.1% m/m in these areas[3]. In 2020, a further requirement began to be applied globally under the International Maritime Organization (IMO) MARPOL Convention on air pollution prevention from ships. This requires ships trading outside SECAs to use 0.5% m/m maximum sulphur content fuels. This requirement, already established in EU legislation, is expected to reduce SO2 concentrations in ambient air in all other coastal regions in the EU (particularly in the Mediterranean Sea).

RPAS can be used as aerial platforms with gas sensors ('sniffers') to measure the amount of SOx versus the CO2 in a ship's plume, estimating the sulphur content in the fuel being used, enabling comparison with the legal limits. This operational information can be complementary to the emission monitoring activities of Member State authorities to ensure that vessels in transit in European waters comply with the legal requirements.

Figure 7 - RPAS identifies pollution event, Finland, 2021

1.3.4 Regulatory environment for civil RPAS operations in the EU

In 2016, when EMSA started setting up its RPAS service procurements, the legal framework in the EU and EFTA countries was heterogenous, with each Member State having its own national Unmanned Aircraft Systems (UAS) regulations and guidelines (or without any legal reference for UAS operations) resulting in a lack of harmonization at EU level.

The European Commission (EC), through the European Aviation Safety Agency (EASA), developed EU Regulation 2019/947 and EU Regulation 2019/945 in cooperation with multiple stakeholders, which applied progressively in all EASA countries to the operation of civil drones. EU Regulations 2019/947 and 2019/945 set out the framework for the safe operation of civil drones in the European skies[4].

The regulations adopt a risk-based approach, and as such, do not distinguish between leisure or commercial civil drone activities. Instead, they consider the weight, the specifications of the civil drone and the operation to define the operational risk. They distinguish three categories of drone operations depending on their level of risk: "open", "specific" and "certified.

[3] Sulphur directive (Directive (EU) 2016/802)
[4] Civil drones (unmanned aircraft) | EASA (europa.eu)

1.4 Use Cases

1.4.1 Maritime vessel monitoring and general surveillance

EMSA already provides its user community with a service that delivers a permanent feed of terrestrial and satellite Automatic Identification System (AIS) data combined with Long Range Identification and Tracking (LRIT) and Vessel Monitoring System (VMS) data. The service provides integrated vessel track data for individual vessels and the information layers contain the last known vessel positions as well as other ship particulars. Additionally, vessels detected by earth observation satellites (radar and optical) are correlated with vessel reporting systems and made available to users, according to the established data access policy. RPAS sensor data shall complement the already available cooperative vessel position data sets.

Sensors mounted on RPAS can detect and identify vessels of interest, including their type and are also used for monitoring specific ship behaviour. When further details are necessary, RPAS can provide comprehensive information about the vessel, such as type, activity, dimensions (length and beam), estimated speed, course, and associated equipment. Where possible, identification details such as the vessel's name, International Maritime Organization (IMO) number, call sign, external registration, Maritime Mobile Service Identity (MMSI), flag, and home port are also provided.

Parameters collected by the RPAS for behaviour monitoring include, but are not limited to vessel position, course and speed, distance to shoreline, anchorage time patterns, range between vessels, traffic lanes, constraints due to vessel draft, manoeuvring patterns, very low velocity tracks (e.g., under 1.5 knots), and determination of potential landing points or ports through the vessel's course. Sudden course changes and unusual vessel tracks, activities on board or around a vessel of interest (e.g., rendezvous at sea, towage), and vessels entering or leaving specific areas (e.g., areas closed to fishing, restricted areas, marine protected areas) can also be monitored. Identification of blacklisted vessels (e.g., those on the illegal, unreported, and unregulated [IUU] blacklist) is also viable using RPAS.

Figure 8- Aerial view from RPAS for maritime surveillance operations.

1.4.2 Search and Rescue

RPAS have been called to support search and rescue (SAR) calls as a complementary tool to satellite imagery and manned aircraft. RPAS can provide enhanced search capacity through onboard sensors that can be used to detect ships, objects on the sea surface and persons overboard. RPAS are equipped with payloads which make them a flexible and versatile platform. With radio line of sight (RLOS) or beyond radio line of sight (BRLOS) capabilities, and authorization to fly in the area, the aircraft can be directed towards the location of the distress signal to detect the exact position of the vessel or life-raft. The RPAS can maintain sight of the target, assess the situation on board and communicate to the manned assets the information for a better assessment of risk and search and rescue resources required. The RPAS relay this information to national authorities who coordinate the rescue, taking advantage, for example, of a cargo vessel in the vicinity or by sending a rubber boat to tow the vessel to the nearest harbour.

RPAS typically carry onboard a selection of sensors suitable for SAR activities such as:

- Cameras with electro-optical and infra-red capabilities (for day and night operations);
- Maritime radars which include moving target indicators supporting the pilot during the search;
- AIS and emergency position-indicating radio beacons (EPIRB) to identify possible signals of distress being broadcast at sea;
- Optical scanners that automatically monitor the surface of the sea to look for objects of interest;

In 2020, EMSA contracted an RPAS with a capacity to drop an automatically deployable life-raft for eight people, which has already been deployed in search and rescue exercises. In 2023, a SAR exercise using this drone equipped with the life-raft was successfully tested in Italy. The exercise involved the participation of a coastal patrol vessel and a helicopter with rescue swimmers on board provided by the Italian Coast Guard. In the future, technologies such as the mobile phone detector (life-seeker) already installed on board this RPAS will be further developed to enhance their added-value during SAR missions.

Figure 9 - SAR operation in La Manche, 2020

The availability of the RPAS on short notice depends on the contractual conditions, airspace availability, national legislation, and airspace management procedures. When required, EMSA can deploy services that can be mobilised on short notice specifically for SAR operations. In other cases, an RPAS that is already deployed and in operations, can be redirected from its original surveillance purpose to support an ongoing SAR operation.

1.4.3 Monitoring illegal fishing, drug trafficking or other illegal activities

RPAS can be instrumental in supporting the monitoring and enforcement against illegal activities at sea, as well as facilitating intelligence-gathering efforts. Equipped with long-range cameras, RPAS can detect suspicious activities on a vessel's deck. Their capability to operate at high speeds and altitudes enables users to observe onboard behaviour while remaining undetected by the target. Once a target is acquired, the RPAS can track it for as long as its endurance permits. This feature is particularly valuable for gathering evidence and monitoring vessel activities until manned patrols can intervene to seize illegal cargo. These capabilities have multiple applications in what concerns tracking criminals crossing maritime borders and real-time transmission of information to authorities.

Additionally, fisheries control patrols conducted by the European Fisheries Control Agency (EFCA), utilizing RPAS, enhance the monitoring and control of illegal activities such as discarding catches, catching prohibited species, or fishing in restricted areas. RPAS deployed by EMSA on EFCA vessels have also supported the preboarding identification of targets and risks, supporting the safety of the team of inspectors boarding the target vessel and the gathering of evidence while sharing the information in near real time with the command centres on shore. Fisheries Authorities who have used the service have remarked that the quality of the optical features of cameras used are particularly important in detecting illegal fish discards.

Figure 10- Aerial view from RPAS in illegal fishing monitoring operation.

RPAS have been used also to monitor protected areas, including access to a whale sanctuary in the Mediterranean in cooperation with Italy and France. The regular patrolling over the area had a deterrent effect on criminals and provided monitoring of whale activity.

1.4.4 Emissions monitoring

In areas of dense maritime traffic, ship-generated emissions can be substantial. This is mainly due to the burning of fossil fuels and the combustion process for propulsion that cause sulphur oxides (SOx), nitrogen oxides (NOx), carbon dioxide (CO_2) and particulate matter (PM) to be released into the atmosphere. Monitoring the emissions from a ship's smokestack by RPAS can help authorities to monitor and enforce the Directive 2016/802, known as the Sulphur Directive[5], that regulates the SOx emissions from ships.

EMSA's RPAS emissions services are equipped with gas sensors ('sniffers') to take measurements of the amount of SOx versus that of CO2 when flying in a ship's plume. This relationship can ascertain the amount of sulphur content in the fuel being used on board and can then be used to compare the estimated content with the legal limits of the zone where the vessel is navigating. Data related to sulphur fuel content is also shared automatically with THETIS-EU, the EU platform that logs and exchanges information on the results of individual compliance verifications conducted by Member States' competent authorities under the Sulphur Directive. Allowing for a possible targeting for port inspection, at next port of call, of the vessel detected as producing emissions over the limits.

Figure 11: Light RPAS on board a vessel

1.4.5 Marine pollution (monitoring and response support)

RPAS can detect oil spills at any time, providing continuous on-site support during response operations. For 24/7 marine pollution monitoring, long-endurance RPAS complement satellite services and support verification activities of Member States. These systems use automatic navigation to track targets, identify potential polluters, and characterize oil spills (size, thickness, volume estimation, etc.) with appropriate sensors.

RPAS can also assist response operations by launching from vessels, monitoring equipment and personnel deployment at sea, and tracking the spill's spread. The lightweight RPAS on EMSA's Oil Spill Response Vessels (OSRV) use electro-optical and infrared cameras to detect and track oil pollution, supporting OSRV actions and the overall response effort, depending on weather and pollution type.

OSRV are equipped with radar-based oil slick detection systems, but these have limitations, such as false targets from natural phenomena and blind spots near the vessel. They also can't estimate oil film characteristics like type, thickness, or degradation level. RPAS on board the OSRV overcome these limitations, enhancing the detection and characterization of oil spills.

[5] Directive (EU) 2016/802 of the European Parliament and of the Council, 11 May 2016 relating to a reduction in the sulphur content of certain liquid fuels.

Figure 12 - Aerial view of an oil spill from an RPAS.

1.4.6 Monitoring port activities

Keeping ports safe and secure requires a variety of daily activities which can be challenging, especially for large port areas. Large ports may also be close to densely populated areas making it vital to consider the impact of port activities on the surrounding environment. RPAS are particularly useful for port applications, as they can provide a view to areas which are normally not accessible to Port Authorities. RPAS can also be deployed to support the day-to-day monitoring of port operations and rapid response to pollution incidents in large port areas. Several scenarios can be identified such as: estimation of oil spills size and support in cleaning operations, rapid perimeter checks, detections of illegal venting of gasses from cargo (improved detection with the use of IR camera), assistance for berth operations, floating debris detection, check compliance with shore power and dangerous goods regulations.

Flights in port are streamed live to EMSA's RPAS Data Centre where they can be viewed by authorised port users to monitor the situation on the ground and act as and when necessary.

Figure 13 - Light RPAS used for monitoring port activities.

Figure 14 - Aerosonde model on approach during deployment in the Baltic region, 2023

2 EMSA RPAS service model

2.1 Approach

RPAS operations are provided to EMSA users as an end-to-end service. EMSA acts as a facilitator deploying its RPAS service capacity upon request by its users who maintain full operational command. Services are planned on a yearly basis with operations usually taking place from April to September to benefit from better weather conditions.

The service offered by EMSA includes the aircraft, the pilot(s), the transportation of the equipment on site, the data communication from the aircraft to the shore and into the RPAS Data Centre, the tools for visualizing the data live and in replay mode and for communicating with the pilot and other users of the service.

In order to optimize the use of resources and to foster cooperation, EMSA promotes the participation of multiple authorities at national and regional level for each deployed service, establishing multipurpose RPAS operations where possible. Furthermore, to increase the efficiency of operations and operational return, subject to requests from the users, EMSA also revisits the same locations expanding every year the operational areas and number of participant authorities. Returning to the same locations also promotes the consolidation of operational procedures at national level for the use of these new systems which have yet to be fully integrated into the existing procedures of National Authorities.

2.2 Costs to end-users

The EMSA RPAS services are offered free of charge to EU Member States and EFTA Member States. EMSA, with EU and EFTA financed budget dedicated for cooperation in the coast guard domain and for anti-pollution measures, supports and monitors all costs including on-site logistics of the operator. The Member State or Agency requesting the RPAS operation must foresee the human and financial resources necessary to support the activities detailed under the point 2.4 below on "Stakeholders' responsibilities".

2.3 Functional blocks

2.3.1 Aircrafts

Since the inception of EMSA's RPAS operations, maritime authorities recognized the potential of RPAS for maritime surveillance. However, defining an RPAS portfolio to address diverse needs within the available budget posed several challenges. These included a broad range of use cases, the market's relative immaturity at the time, and the complex nature of operations and aviation legal frameworks.

In response, EMSA targeted RPAS services utilizing various RPAS with distinct capabilities. The medium-sized aircraft in the EMSA portfolio currently offer endurance ranging from 6 to 12 hours and weigh between 25 kg and 235 kg. Another critical factor for the suitability of RPAS in specific operations is the lift-off method, which can be from a runway, catapult, or Vertical Take-Off and Landing (VTOL). To meet different operational requirements, EMSA has contracted various types of RPAS, divided between medium size and small size (also designed as "Light RPAS"). Concerning the medium size RPAS:

- **VTOL RPAS for emissions monitoring and maritime surveillance**: With the ability to hover and carry a diverse suite of high-performance payloads, this RPAS is ideal for multipurpose operations, including maritime surveillance. It excels in emissions monitoring, adjusting its speed to match vessels and maintaining position within exhaust plumes to collect samples. Combining a radio range of over 100 km with six hours of endurance, it is highly efficient for monitoring vessel traffic lanes off the coastline. Its vertical take-off and landing capability enables deployment from both vessels and small land areas.
- **Fixed-wing RPAS for coastal monitoring**: Capable of 9-hour missions and a radio range of 140 km, extendable along the coastline with radio relay stations, this RPAS efficiently delivers surveillance over large coastal areas, supporting EMSA's regional approach. Up to 700 km of coast can be covered using antenna relays. Launched from a catapult and recovered with a net, it is deployable in small land areas. It can also operate from two different take-off and landing sites to cover longer distances.
- **Hybrid RPAS for coastal monitoring**: Sharing most of the concepts and performance of the medium size fixed-wing RPAS, this hybrid variant features additional capabilities for deployment and operation from vessels. Its hybrid configuration combines a fixed-wing platform for long endurance with four small vertical rotors to minimize its take-off and landing footprint.
- **RPAS for high seas monitoring**: Equipped with a high-bandwidth satellite communication system and 10 hours of endurance, this RPAS performs missions beyond radio line of sight (around 50 km from the coast), including high seas areas. It supports extensive surveillance operations, carrying a variety of payloads (surveillance sensors and life-rafts for rescue missions). While it requires a runway, it can operate from short unpaved runways

In what concerns the smaller “**light RPAS**”, these are quadcopters with an endurance of 35 to 50 minutes, weighing approximately 3-13 kg. Despite their lighter payload and limited endurance, these RPAS are particularly useful for operations from vessels that have a limited space on deck for take-off and landing or for operations over ports areas where flying larger RPAS is not appropriate from a risk perspective. EMSA has contracted two types of RPAS of this category:

- **Ship-based light RPAS for maritime surveillance and pollution monitoring:** This electrical quadcopter has a very small footprint, enabling easy deployment and operation from vessels with only one operator. It supports pre-boarding tasks and short-range activities and is primarily used on EMSA Oil Spill Response Vessels (OSRV), EFCA patrol vessels, Member State vessels, and for port surveillance. Equipped with optical and infrared cameras, it is well-suited for these applications.
- **Light RPAS for emissions monitoring and multipurpose surveillance:** Capable of hovering, flying beyond visual line of sight, and carrying emissions monitoring sensors, these RPAS are highly effective for monitoring sulphur content in the exhaust plumes of vessels in port areas. They are also used in more restricted port entrance areas for various surveillance tasks, including fisheries control and traffic monitoring.

Figure 15 - RPAS monitoring emissions in the port of Barcelona, 2024

The portfolio with more details on the aircraft used by EMSA for RPAS services is available in Annex1.

2.3.2 Payloads

The payload of each aircraft is adapted to the maritime surveillance activities requested by the user and to the maximum payload capacity of each type of aircraft. RPAS can be used as aerial platforms for sensors, some examples of which are provided below.

- **Electro-optical sensors** in the visible and infrared (IR) spectral range, for night and day maritime surveillance, allowing to:
  - detect, recognise, and identify vessels in the area of interest,
  - identify human behaviour and activity on board,
  - detect, categorise and monitor oil slicks,
  - support in search and rescue operations (e.g. man overboard).

- **Maritime radar** with different operational modes such as SAR and moving target indicator to allow the detection of non-cooperative targets (e.g. vessels that might not be reporting their position, objects adrift) in all weather conditions (cloudy conditions).
- **Optical scanners** for automatic detection of non-cooperative targets in daytime conditions, allowing to cover wide areas.
- **Gas sensors (“sniffers”)**, to measure the amount of SOx in a plume emitted by a ship, to be able to calculate the percentage of sulphur used in the fuel burned by the ship.
- **AIS sensors** to verify onsite that the picture of vessel movements is complete and if a particular vessel is properly reporting is identity and location to the cooperative traffic monitoring systems.
- **Distress sensors (EPIRB) and mobile frequency detectors** to be able to detect vessels in distress and react in emergencies.
- **Liferaft** can be deployed in support of rescue missions.

Depending on the type of mission, RPAS operate closer to shore, i.e., within the Radio Line of Sight (RLOS) or further offshore, i.e., Beyond Radio Line of Sight (BRLOS), which requires special equipment on board to communicate via satellite. All communications and aircraft control are via a Local Ground Control Station, a mobile unit set-up in the area of operation.

Figure 16 - A selection of the latest Sensors used by EMSA for RPAS operations.

2.3.3 Satellite communications

In 2018 the Agency launched the first procurement to directly acquire its own satellite connectivity services. Following the signature of framework contracts with some of the major satellite services providers in the fourth quarter of 2018, the Agency successfully activated several specific contracts for provision of SATCOM services in support of the Agency's RPAS operations. The contracted services encompass the service set-up, equipment leasing and related maintenance, as well as all the necessary space and ground segment infrastructure.

The latest set of SATCOM services was contracted in 2021 to guarantee accessible, secure, and autonomous satellite communication services for next generation of RPAS contracts. These framework contracts cover three different service categories:

- satellite services for beyond radio-line-of-sight communications;
- satellite connectivity services for land-to-land communications;
- satellite services for ship-based RPAS operations.

Framework contracts for RPAS beyond radio-line-of-sight communications have been signed for two different service level categories: 2Mbps and 5Mbps in the return link. These services provide high performance wideband satellite capacity for high data rate applications, including the transmission of simultaneous sensor streams, delivery of high-resolution image/video and a command-and-control link from the RPAS to the shore. EMSA has also signed framework contracts for satellite connectivity services for land-to-land communication services as well as framework contracts for satellite connectivity services for ship-based operations. The wideband satellite internet connection under these contracts, up to 10Mbps, are used to stream the payload data to the RPAS Data Centre allowing end users to follow the RPAS operations remotely.

2.3.4 The RPAS Data Centre

The RPAS Data Centre (RPAS DC) service provides users with access to the RPAS video and other data in real-time or archived. The information is delivered and combined with other EMSA maritime systems, through the same web interface. RPAS DC service has become a tool that is key for remote monitoring of RPAS operations and real-time decision making. Among the most important features are the possibility of watching live or past flights, the use of the common chat, and the possibility to define new tasks or new points of interest in the map.

Users can "control in real-time" the actions of the RPAS in cooperation with the pilot and sensor operator during the flight.

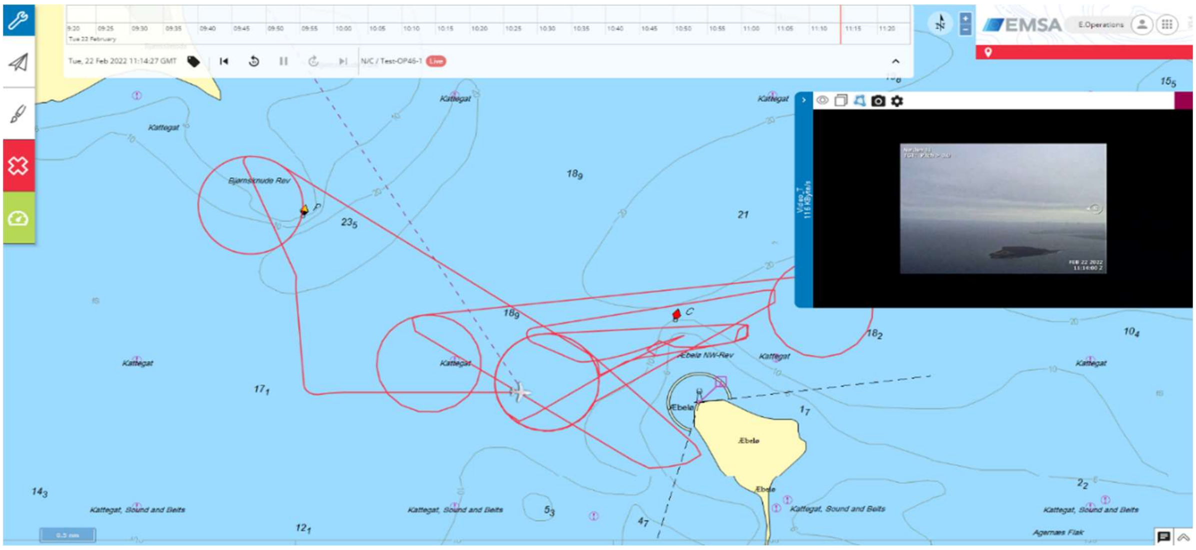


Figure 17 - Screen live view of a flight on the RPAS Data Centre.

2.4 Stakeholders' responsibilities

There are several stakeholders involved in EMSA's RPAS operations, each of which have distinct roles and responsibilities. These include:

- Member State Administrations or EU Agency requesting the service.
- RPAS operator
- EMSA

The Member State administration or EU Agency requesting the RPAS operation will have the following responsibilities:

- Assisting the EMSA RPAS contractor in obtaining the permit to fly, the airspace request procedure and any other authorisations required at national level.
- Supporting the contractor and EMSA in identifying and evaluating the most suitable deployment site for the operation, on a case-by-case basis.
- Financing solutions to respond to the logistical and communications requirements on site (this includes costs for airport fees, office space, storage facilities, utilities including water, electricity, phone line, high speed internet, etc).
- Facilitating the import of the RPAS equipment necessary for the operation.
- Organizing and implementing operational procedures for the coordination and command of the operations in coordination with any other authority involved.
- Providing feedback on the operation to EMSA.

The RPAS operator is responsible for:

- The provision of the technical equipment (aircraft, payload, communications links) and staff necessary for the RPAS service (deployment manager and maintenance manager, RPAS crew including mission chief, pilot, payload operator, technicians, and maintenance crew).
- The production of technical and operational documentation required for the service including that required to submit to the aviation authorities to obtain authorisation(s) to fly
- The safe operation of the RPAS, performing the flight hours following the tasking requested by the user for a specific deployment and flight missions.
- Ensuring the RPAS data sharing, in the agreed format and near real time (payload data; RPAS housekeeping data). The collected data will be streamed into the EMSA RPAS data centre and further distributed to the final users of the services (national authorities of EU and EFTA Member States and/or other EU institutions and bodies).

EMSA responsibilities include:

- Facilitator between the RPAS operator and the final user, being involved in all the phases of the activities (setup, operations, and closure).
- Establishing the necessary contractual frameworks with the RPAS contractor and satellite communications provider.
- Establishing operational procedures that define the roles and tasks of the different stakeholders.
- Managing the RPAS-DC that supports the real time of information between maritime picture between the different authorities involved.
- Monitoring the services, ensuring and controlling the quality of the operational results.

2.5 RPAS User Group

Since 2018 EMSA has organised annual RPAS User Groups with all EU and EFTA maritime administrations interested in discovering more about RPAS technology for maritime surveillance. EU and international agencies and bodies involved in civil coast guard functions such as EFCA, Frontex, MAOC-N, EUNAVFOR, EASA, ESA and EUROCONTROL have been invited to participate.

From the outset, the group became a platform for exchange of knowledge and best practices to boost the successful uptake of RPAS for maritime surveillance. Several Member State delegations visited RPAS operations in other countries to learn more about capabilities, the operational setup and elements linked with deployment RPAS for maritime surveillance.

Figure 18- RPAS user group meets at EMSA, June 2023

Figure 19 - RPAS on board a German Police vessel for emissions monitoring 2024

3 Evaluation of EMSA RPAS services

3.1 Overview of results

In 2017, the Agency began preparations for RPAS services, which were set up and operational from 2018 onwards. Nine different RPAS systems have been contracted since then and made available to support surveillance operations in EU and EFTA waters.

Between 2017 and 2023, EMSA supported deployments for 58 operations, sometimes covering two or three requests in one single regional operation, with 16 different EU or EFTA countries and two other EU Coast Guard Agencies involved. Additionally, light RPAS were rolled out on board the EMSA contracted network of vessels for oil spill recovery, with a total of 13 RPAS installed by the end of 2023.

The services delivered in each year are listed below. A more detailed list of operations and exercises is available in Annex 2, while maps with annual operations are presented in Annex 3:

- In 2017 and 2018, maritime surveillance operations with EMSA RPAS took place in Croatia, Greece, Portugal (partially in cooperation with Frontex), and Spain.
- In 2019, there was a significant surge in services, with operations taking place in Croatia, Denmark, France, Greece, Iceland, Italy, Portugal, and Spain. Moreover, services started on board an EFCA patrol vessel. In addition, exercises for pollution response with Light RPAS were held in France, Portugal, and Germany. In the context of a major maritime emergency, the fire on board of and sinking of the Grande America ship in the Gulf of Biscay, several EMSA pollution response services were requested, including two RPAS on board EMSA chartered vessels to support the response operations coordinated by the French authorities.
- The year 2020, despite COVID 19 lockdowns, saw maritime surveillance operations in Belgium, Croatia, Denmark, Finland, France, Italy, Romania, as well as fisheries control services from the RPAS on board the EFCA patrol vessel. Pollution response exercises were held in Bulgaria, Cyprus, and Estonia, taking place from on board the EMSA vessels.
- In 2021, pollution response exercises from on board OSRV took place in Bulgaria, Cyprus, Finland, and France while maritime surveillance operations were carried out in Estonia, Finland, France, Italy, Lithuania, Romania, and Spain. RPAS services on board the EFCA patrol vessel continued. That year, light RPAS were also mobilised in the context of three maritime pollution emergencies in Greece, Bulgaria, and Cyprus.
- In 2022, there were maritime surveillance operations with RPAS in Denmark, Estonia, Finland, France, Germany, Iceland, Italy, Romania, and Spain, in addition to pollution response exercises in France, Portugal and Germany and the RPAS service on board the EFCA patrol vessel.
- In 2023, continuing its promotion of the regional services, EMSA supported multipurpose RPAS operations in the Baltic (Estonia, Finland, and Latvia), in the North Sea (Denmark), in the Atlantic (Spain and Portugal) and in the Mediterranean (Italy and France). RPAS services with an emissions monitoring component were also deployed in the north of France in the Channel area, from Germany at the entrance of the Baltic and from Lithuania in the Baltic. Finally, two EFCA fisheries patrol vessels were equipped with light RPAS as well as 13 EMSA oil pollution response vessels that participated in two exercises, in France and in Bulgaria.

Overall, there were 7,015 operational deployment days[6] of EMSA's RPAS services delivered to EU and EFTA maritime administrations on their request between 2017 and 2023, demonstrating the large volume of service provided and reflecting significant user uptake. In total more than 14,700 flight hours were achieved in support of EU maritime surveillance activities.

The figure below shows multipurpose coast guard operations and anti-pollution activities (emissions monitoring and support to pollution response services) with RPAS per year.

[6] An operational deployment day is a day when the RPAS operator's staff is deployed on site with the equipment and ready to fly on request by the RPAS users.

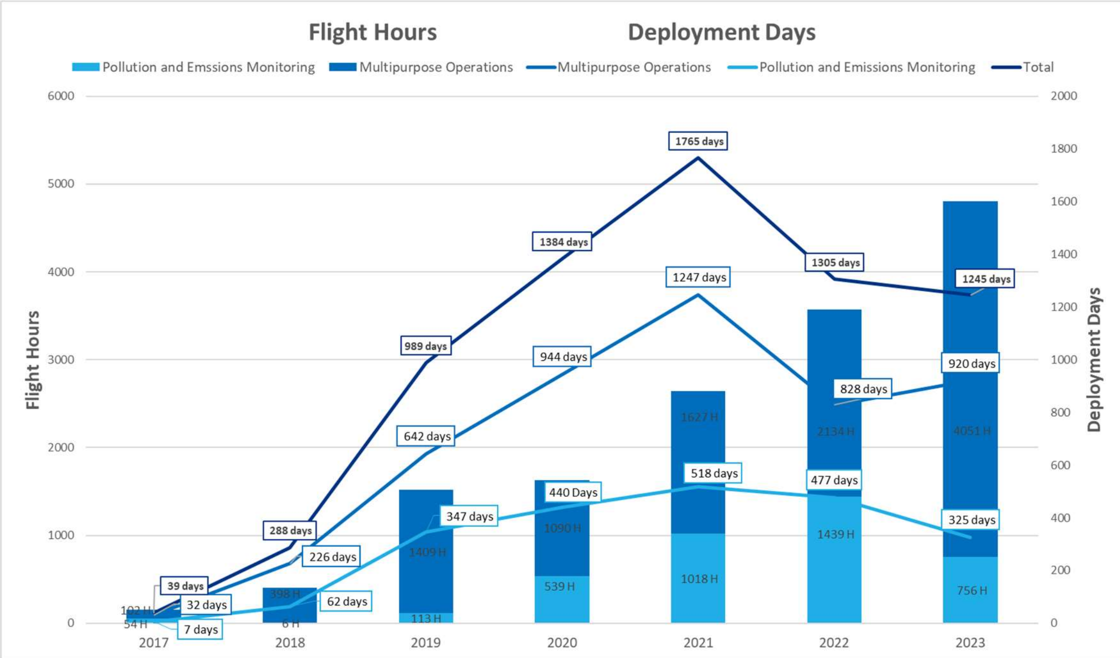


Figure 202: Number of deployment days and flight hours 2017-2023 in EMSA RPAS operational services.

There was a systematic growth in number of flight hours since the start of operations at EMSA, with the maximum being achieved in 2023. Albeit in the last 2 years there was a reduction of the number of deployment days, this is more than compensated by the growth of the number of flight hours available to support Member States activities, achievable by the deployment of more efficient RPAS, with better capabilities in what concerns endurance.

It is important to note that dividing the budget by the number of deployment days per year to determine the cost per day of deployment can be misleading. Various factors influence the budget allocated to each mission, including the complexity of missions, operational requirements, type of RPAS used, weather and seasonal conditions, flight hours requested per day, and the specific needs of beneficiary countries and agencies. These elements all contribute to the overall cost, making simple calculations inaccurate.

In terms of pollution response, the graph below shows also the number of light RPAS installed and ready to fly from EMSA contracted oil pollution response vessels and the number of drills and exercises these RPAS performed to ensure readiness in case of emergency mobilisation.

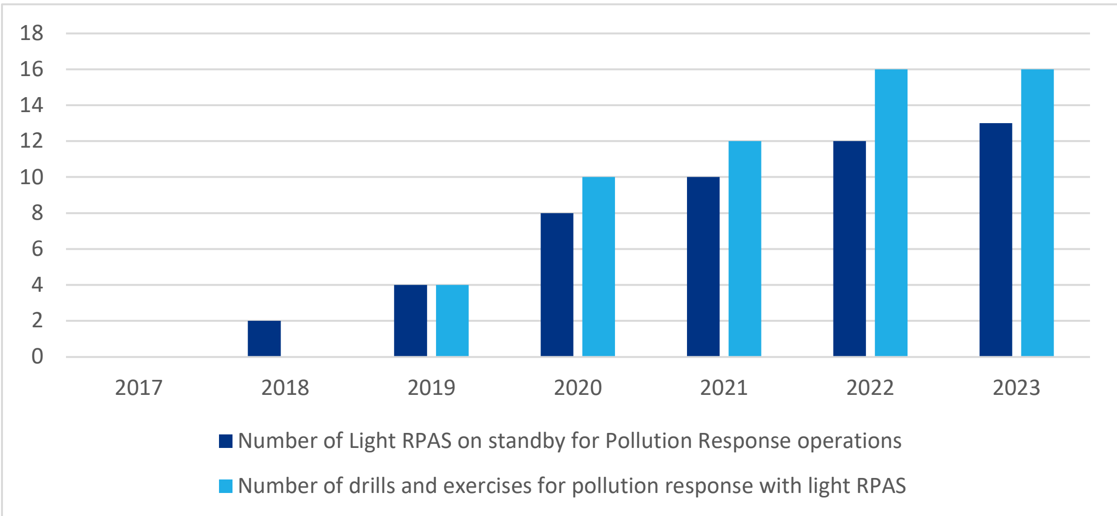


Figure 21 - Evolution of the RPAS service on board of the EMSA charter oil recovery response vessels, drills and exercises.

Light RPAS have been used in the context of mobilizations of EMSA pollution response vessels in accidents such as: fire on board and sinking of the vessel Grande America in the Bay of Biscay, and subsequent oil spill (2019); monitoring and assisting clean-up activities following the grounding on rocks and sinking of the vessel Sea Bird in Greece (2021); stand-by monitoring for an oil spill drifting across from the Eastern Mediterranean towards the coast of Cyprus (2021); and monitoring of hull integrity and potential spills of nitrogen fertiliser following the grounding of vessel Vera SU in Bulgaria (2021).

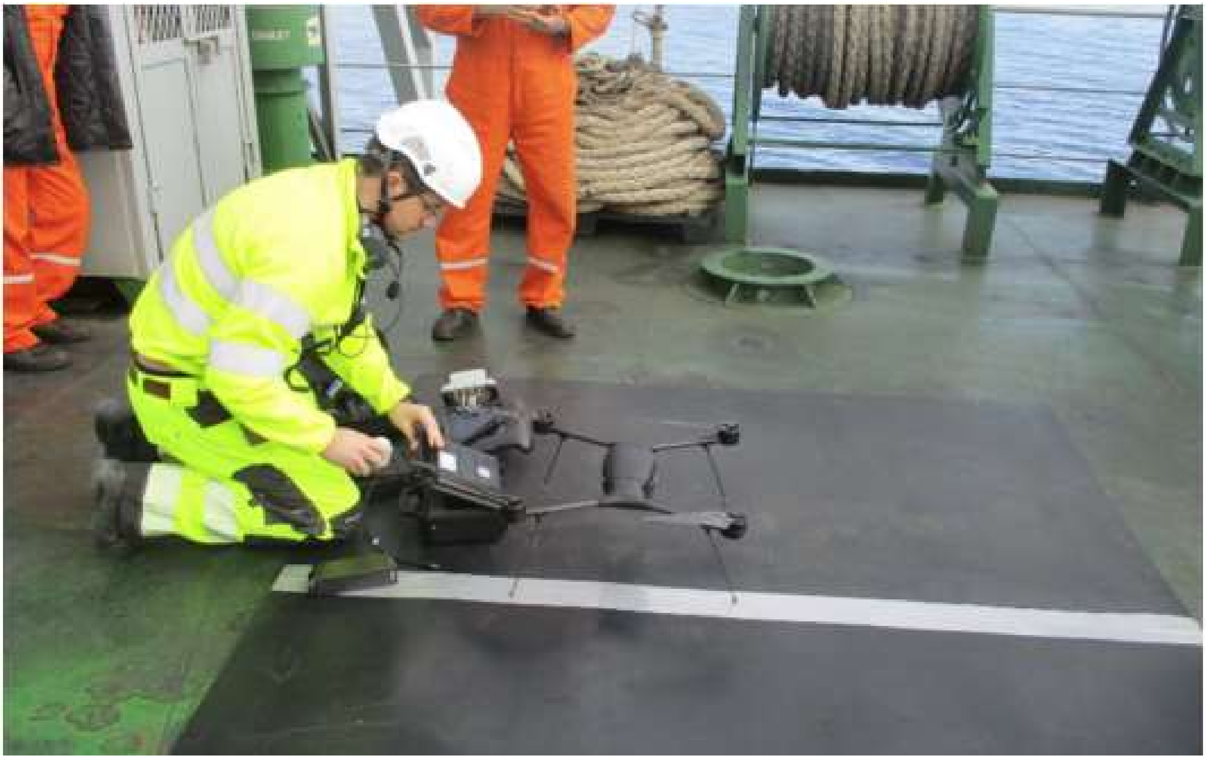


Figure 22 - Pilot preparing the RPAS to take-off from an EMSA pollution response vessel.

In the context of operations with larger RPAS, EMSA RPAS services supported several emergencies, including search and rescue operations. Information about these operations is maintained by the respective maritime authorities. For instance, between 2020 and 2023, the French maritime authorities utilized EMSA RPAS for multiple search and rescue activities in the Channel. Another example is the 2022 search and rescue operation in Latvia, where an EMSA RPAS flew from Estonia to detect debris from an airplane crash in Latvian waters.

EMSA RPAS services also significantly contributed to the emission monitoring efforts of Member States. Between 2017 and 2023, EMSA supported 16 emissions monitoring operations, collecting a total of 2,441 emissions measurements. These measurements were shared with the national authorities overseeing the operations. Measurements exceeding the sulphur content limits established for the area were automatically shared by the RPAS Data Centre with the THETIS EU application, enabling Port State control authorities to target those vessels for inspection at the next port of call.

Additionally, maritime authorities acknowledged that, beyond direct operational support, the EMSA RPAS services and the user group convened by EMSA greatly facilitated the exchange of best practices. This collaboration accelerated the development and sharing of technical specifications and processes. In recent years, an increasing number of Member State authorities have requested RPAS support from EMSA for maritime surveillance or have initiated their own procurements.

3.2 Performance

When EMSA began providing maritime authorities with RPAS services for maritime civil surveillance in 2017, finding operators in the EU or EFTA countries with experience in maritime RPAS operations was challenging. There was a lack of RPAS with the necessary endurance and capabilities to operate in harsh sea conditions. Most tested systems were either expensive medium-sized systems used in the military domain or light RPAS designed for land use. Additionally, there was almost no experience in obtaining permits for flying medium-sized aircraft in the civil domain.

EMSA has consistently worked with its contractors to find technical and contractual solutions to overcome operational limitations (e.g., endurance, spare parts management, weather conditions, etc.). EMSA and the RPAS end users have had to accept an inherent trade-off between endurance, weather resistance and quality of payload on the one hand, and cost, complexity of logistics and permits to fly on the other hand. A Medium Altitude Long Endurance (MALE) aircraft was considered by many Member States "a priori" to be the best solution for regional multipurpose operations covering large areas of interest beyond the coastal areas with more long endurance and high-quality sensors and cameras on board. However, it was recognised, after experience in Iceland with the Icelandic Coast Guard and in Greece with Frontex, that this category of RPAS is very expensive (up to three times more expensive for 10 hours of flight in one day of deployment when compared with flights from a medium size helicopter and up to five times more expensive when compared to a medium-size fixed-wing RPAS). Additionally, the MALE requires large airport runways and involves a very lengthy set-up and authorization procedures. In view of the available budget at EMSA and for the needs of national civil maritime authorities it was therefore decided to target RPAS that would allow sufficient endurance, weather resistance and quality of payloads but would have a lower logistical footprint take-off and landing area, staff required for the operation and cost.

In a maritime environment, the wind resistance was one of the main performance indicators critical for the choice of the RPAS. The wind resistance during flight of the RPAS used by EMSA varies from 26 knots (for a light RPAS of 3.5 kilos) to 35 knots for a medium size helicopter or a medium size fixed wing. An important variable is also the resistance to cross over wind at take-off and landing that is usually significantly lower than the resistance during flight and can reduce considerably the opportunities for flight.

The endurance is an important measure for ensuring added value for operations, but it is also difficult to compare as it depends very much on the weight of the payload carried on board as well as on the flying pattern (with changes of altitude and speed or not) and on the wind strength and direction. The maximal operational endurance per day achieved by different RPAS systems ranges from 18 hours with two flights per day for medium-size fixed wing systems, to 8 hours with two flights per day for medium-size helicopters, or to 4 hours with multiple flights between 35 to 45 minutes for light quadcopters systems. The definition of operational endurance used by EMSA is the endurance of the RPAS fully equipped with all necessary payload and flying in an operational mode (loitering, flying up and down in all directions).

Figure 23 - RPAS during deployment in Denmark, 2024

The range is limited by the endurance, the speed, the flight altitude, and the range of the communication system available for the aircraft (radio with one or several antennas in relay or satellite communication systems). The range varies from more than 1100 km for a MALE, 700 km for a medium-size fixed wing with a relay of antennas, 200 km for a medium size VTOL, and about 5 km for a light RPAS.

In terms of costs, the evaluation of the efficiency of RPAS compared to manned aircraft used for similar surveillance operations is a difficult exercise: the RPAS was and is still a new technology produced in small quantities with only a few manufacturers located in Europe still defining their business model. Manned aircraft have been used for maritime surveillance for over 20 years and are a commodity product. Most of the manned aircraft currently used for maritime surveillance are fully depreciated and any marginal cost per deployment day or hour for the maritime administrations does not include the production cost but mainly maintenance and operational costs. Even some of the RPAS operators started flying for EMSA in 2017-2018 and are still using the same aircraft while new RPAS operators are supporting still some depreciation costs. EMSA has also reinforced its requirements over the years in terms of quality of payloads and redundancy of aircraft, payloads and spare parts on site to reinforce the continuity of services. The costs of EMSA RPAS services across the years are therefore not fully comparable.

Annex 1 provides the portfolio of aircraft used in the EMSA RPAS service between 2017 to 2023 with a more in-depth description of the properties and characteristics of each RPAS.

In 2023, a total of 133 maritime administrations in the EU and EFTA[7] received the invitation to participate in a survey to evaluate the quality of the services provided by EMSA RPAS for their tasks (Annex 4 – Replies to EMSA 2023 survey). A total of 26 responses (19.5% of the administrations contacted) were received from 18 countries and three European Agencies or international organizations. While the results cannot be deemed fully exhaustive, the content of the responses provides a reasonable representation of the experience and interest maritime authorities have with regard to the use of RPAS for maritime surveillance.

The quality of the EMS RPAS service provided to the EU and EFTA authorities who had utilized EMSA RPAS services, was assessed with a median evaluation of 4.2 out of 5. As shown in the figure below, the EMSA RPAS service highest scores where in categories linked with the selected RPAS service provider ("professional, responsive, and prepared service"), the training services provided by EMSA and the contractor, and the overall role of EMSA within the operation.

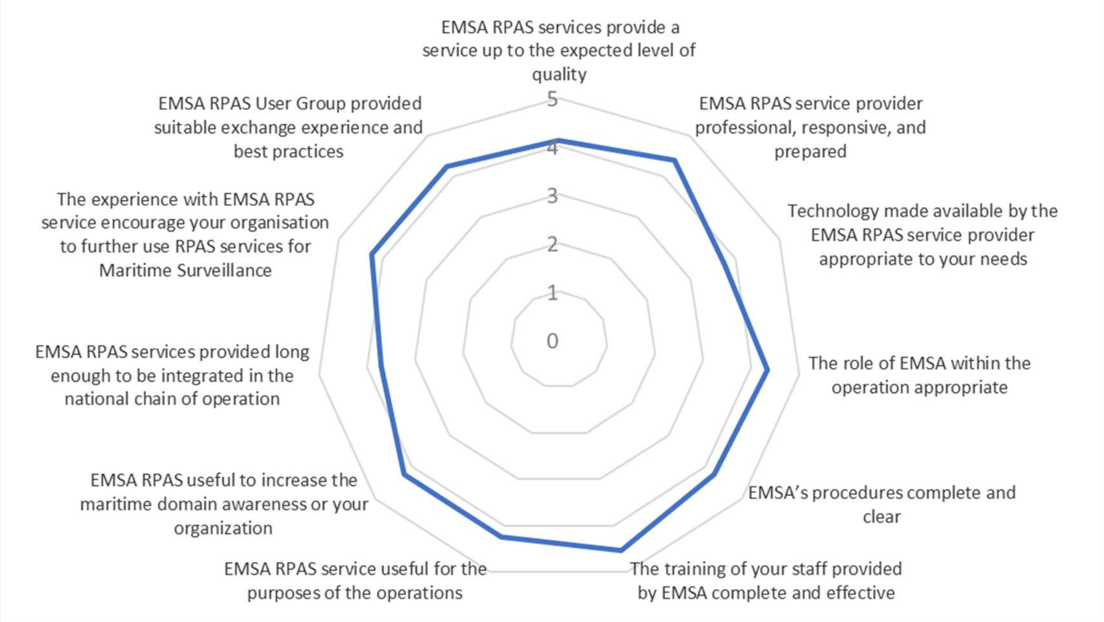


Figure 24 - Quality of EMSA RPAS services in each domain (average marks out of 5 from 2023 RPAS Survey in Annex 4).

[7] The survey was sent to EU/EFTA maritime administrations in EMSA's data base/already in contact with the EMSA Unit 2.2 Maritime Surveillance regarding RPAS operations for maritime surveillance.

3.3 Operational added value

RPAS have proven to be valuable tools in various applications. As originally planned, they offer multiple additional capabilities for enhancing EU-wide maritime surveillance based on their key characteristics: endurance, persistence, discreet approach, on-site measurements, and real-time surveillance through optical video, radar, and infrared, without risking pilots on site. These features enable pollution detection and validation, support illegal discharge detection and response operations, and help detect, track, characterize, and identify non-cooperative targets.

These systems complement other maritime surveillance techniques, such as manned aerial surveillance assets, particularly in high-demand areas or dangerous environments (e.g., flying close to illegal activities or near vessels to take measurements). Compared to manned aircraft, RPAS have low detectability by targets during operations, enhancing their effectiveness. Equipped with high-resolution imagery and video capabilities, they are suitable for pre-boarding verification and gathering evidence both day and night.

RPAS also complement satellite surveillance by bridging the information gap between satellite-based and vessel-based information. While satellite images require prior planning and have limited coverage and revisit opportunities, RPAS can remain on site for extended periods, transmitting live information to command centres, which can dynamically request additional evidence. This capability is essential for combating illegal activities at sea and conducting search and rescue operations.

Real-time data sharing from RPAS also facilitates cross-border cooperation between different coast guard authorities. The coordination of RPAS operations among multiple national authorities leads to multipurpose operations encompassing general maritime surveillance, pollution monitoring, law enforcement (e.g., drug trafficking, customs), fishery control, border control, and more. The information gathered simultaneously serves multiple use cases within a single surveillance operation, optimizing resource allocation.

Figure 25 - Aerial view from RPAS in a fisheries inspection operation.

Based on the responses to the EMSA 2023 RPAS survey, RPAS offer significant value across a broad spectrum of coast guard functions, including law enforcement, fisheries inspection and control, environmental protection, pollution detection and response, border control, multipurpose maritime monitoring and surveillance, search and rescue operations, ship casualty assistance, maritime security, and maritime safety which encompasses vessel traffic monitoring. The survey conducted (see figure below and Annex 4) evaluated the added value of RPAS regarding several use cases, on a scale from 1 (not at all) to 5 (very much). The median of the evaluation of those domains is at 3.23 out of 5. Use cases where RPAS present higher impact include Maritime Safety, Maritime Security, pollution detection, general multipurpose maritime surveillance and fisheries inspection and control.

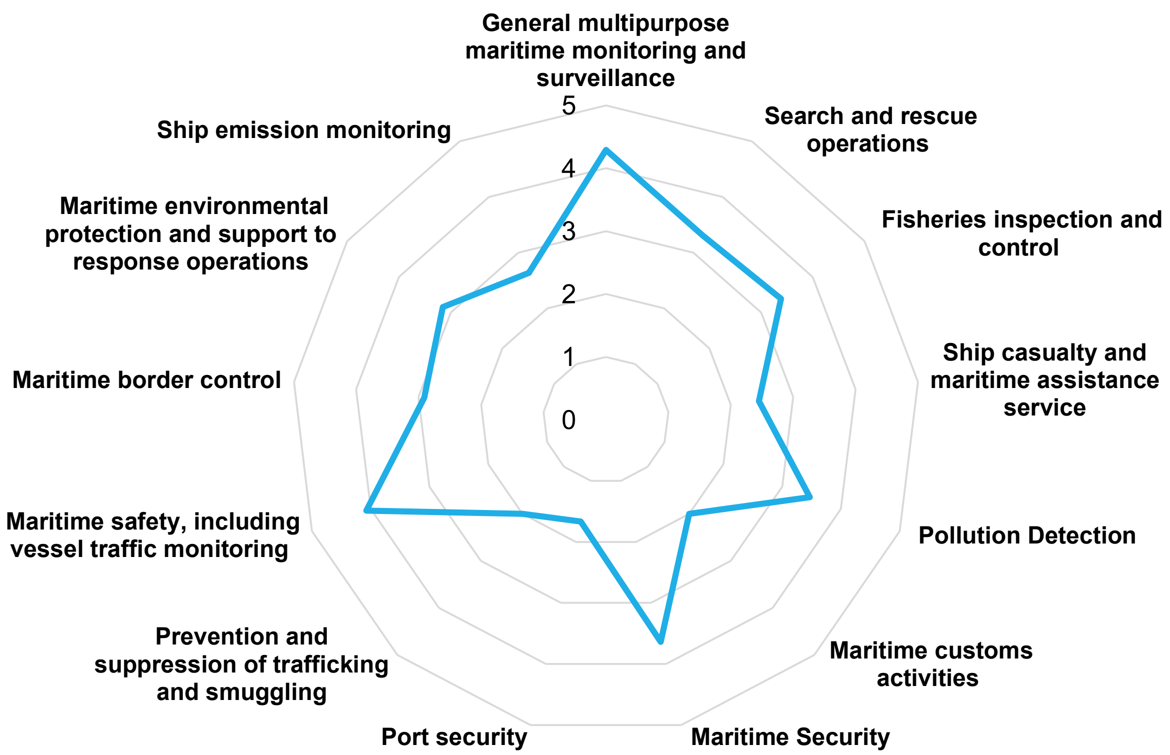


Figure 26 - Average data value of RPAS for maritime surveillance in each domain.

In response to the 2023 RPAS survey, most of the maritime administrations reported a positive experience with RPAS. 23 out of 26 of the respondents plan to further integrate RPAS into their regular maritime surveillance activities to supplement the capabilities of other tools. A significant number, 22 out of 26, expressed interest in EMSA's RPAS services in the future.

3.4 Limitations and challenges

The use of RPAS for maritime surveillance comes with its own set of limitations and challenges. The main issues identified by users in the RPAS user group are summarized below. Further details on how EMSA addressed these challenges are provided in Chapter 4 on lessons learned.

- **Authorization and compliance:** The primary difficulty in deploying RPAS services for maritime surveillance is acquiring the necessary flight authorizations. This involves a complex process to comply with both EU and national regulations, which are often recent or inconsistently implemented across Europe. Chapter 4.1 provides more details on these scenarios and the lessons learned.

- **Flight and airspace restrictions:** RPAS operations are often hindered by flight and airspace restrictions. Many RPAS are not fully certified or equipped with tested detection and avoidance systems, making them a higher risk for safe navigation. Integrating RPAS into airspace shared with manned aircraft is challenging. Consequently, most EMSA RPAS operations require segregated airspace for safety, preventing take-off or landing from high-traffic areas like airports. Chapter 4.2 offers further insights into these challenges and solutions.

- **Limitations of smaller RPAS:** Smaller RPAS generally pose lower risks and have a simplified authorization process. However, they lack satellite communications needed for operations far from the coast and heavier sensors such as radar, limiting their ability to perform precise detection and surveillance. Additionally, light RPAS often cannot withstand severe weather conditions, affecting their reliability in maritime operations.

- **Operational range:** The size of an RPAS usually correlates with its fuel or battery capacity and operational range. Most small and medium-sized RPAS lack onboard satellite communications, limiting their range for high seas flights due to the curvature of the earth and radio communication constraints. Coastal orography can further challenge radio communication, particularly at low altitudes, as experienced in areas like the Adriatic.

- **Vessel-based operations:** While light RPAS are often the only viable solution for vessel-based operations, they come with logistical challenges for take-off and landing, requiring meticulous planning and execution (detailed in Chapter 4.6). Only large patrol vessels with helicopter take-off and landing areas and sufficient open deck space can accommodate medium-sized RPAS and their equipment and operating staff.

- **Data management:** RPAS data management presents several challenges. Integrating different RPAS systems and sensor data for traffic monitoring can be complex. RPAS operations generate large volumes of data that must be efficiently managed and processed by maritime authorities to extract relevant information. Ensuring the quality and security of data for legal admissibility is crucial, and the use of such data as evidence can vary across judicial systems.

Figure 27 - RPAS during deployment in the Baltic Region 2023

4 Lessons learned

With seven years of accumulated operational experience, it is crucial to reflect on the lessons learned to enhance the efficiency and effectiveness of future RPAS activities. These insights will benefit not only EMSA but all EU and EFTA maritime authorities. The information gathered from users of the EMSA RPAS service, including feedback from each deployment, discussions during the RPAS user group, and responses to the EMSA 2023 RPAS Survey, will be detailed below.

4.1 RPAS safety framework and authorisations to fly

In reference to EASA EU Regulation 2019/947 and EU Regulation 2019/945, EMSA RPAS operations are typically conducted within the open and specific categories and have been authorized to fly under the following conditions:

- The operation fell under the open category, with an RPAS below 25kg, flying below 140m, in visual line of sight (VLOS), and did not require prior authorization (only the registration of the operator in the country), or
- The contracted operator held a light UAS operator certificate (LUC) for this type of operation and could self-authorize the operation, or
- The operation was authorized by the National Competent Aviation Authority (NCAA) of the RPAS operator in one EU Member State or EFTA country.

For the latter two conditions, only cross-border recognition by the country of operation was required. In some cases, authorizations were directly granted by the NCAA of the country of operation when the RPAS service was classified as a "State Operation," meaning EASA regulations did not apply.

As noted and detailed further in Section 4.2, most authorizations for EMSA RPAS operations require segregated airspace for safety reasons. Each operation demands a comprehensive safety assessment from the RPAS operator. While safety measures are easier to implement in sparsely populated maritime areas, the process can still take up to 1-2 years. The lengthy process for obtaining a Permit to Fly has been identified as a significant constraint in recent years.

Member State authorities have faced challenges assisting EMSA's service providers in obtaining operational authorizations from Civil Aviation Authorities. These challenges are primarily due to the national aviation authorities' lack of experience with RPAS operations and delays in obtaining authorizations in the RPAS operator's state of registration.

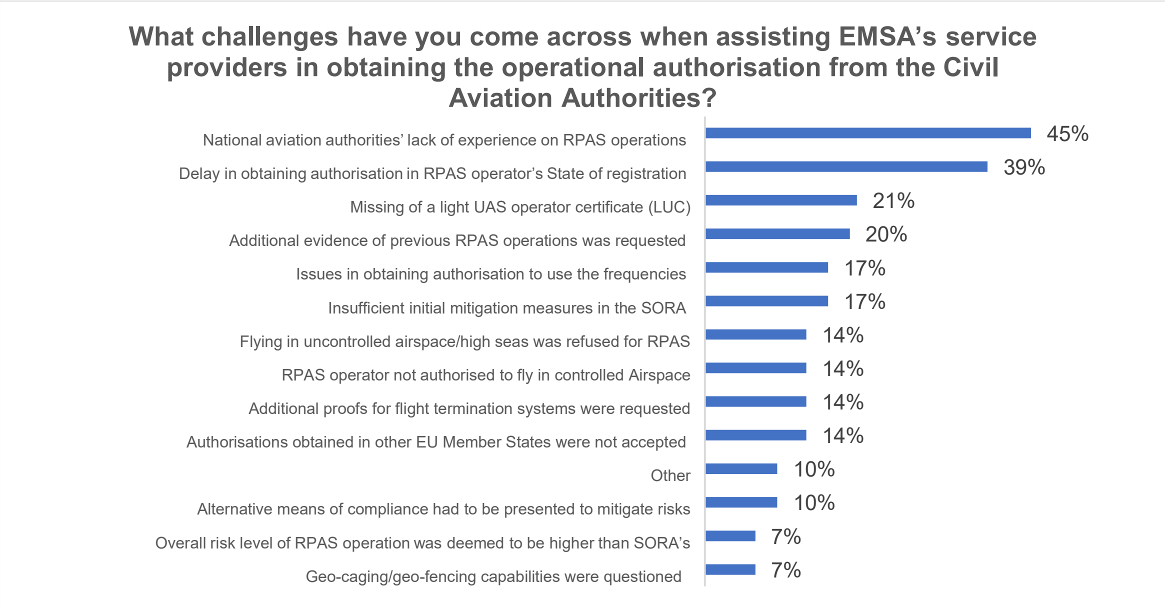


Figure 28- Challenges regarding authorizations to fly. Source: RPAS user group 2022

When EMSA began its RPAS services, the EU and EFTA safety regulatory framework for the operation of civil drones was incomplete and not harmonized. Each national aviation authority had its own process for authorizing RPAS flights, making it difficult for operators, as requested by EMSA services, to work outside their country of registration and to promote regional operations.

However, improvements have been made since 2021 with the introduction of new EASA regulations. The regulatory framework has now been completed, and EU Regulations 2019/947 and 2019/945 establish the framework for the safe operation of civil drones in European skies. National aviation authorities have become more familiar with operators and this type of RPAS operation, increasingly recognizing that flying over the sea poses a lower risk than many other types of RPAS operations. Nevertheless, best practices and standard scenarios for maritime RPAS operations need to be discussed with aviation authorities following the adoption of detailed EU RPAS legislation.

Despite the difficulties in obtaining flight authorizations, Member State aviation authorities, RPAS contractors, and EMSA have made significant progress in familiarizing themselves with setting up RPAS services, obtaining operation certificates, and managing airspace. In areas where operations continued across consecutive years, established protocols for requesting flight authorizations were already in place, and the procedures for registering systems and requesting flight conditions were well known, facilitating the process.

4.2 Airspace: procedures, design, management, and clearance

EMSA operations are mostly based on full segregation of airspace in accordance with the regulation in terms of air risk mainly due to the lack of collision avoidance systems as well as to the lack of full aeronautical certification. To mitigate the consequences of blocking large areas of airspace, the full area of interest is usually divided in sub-areas which are then managed and reserved according to the specific needs for each flight. In addition, in some countries the sub-areas are allowed to be activated/deactivated in real time, minimizing the amount of airspace which is blocked for the RPAS. However, until specific rules and procedures for the integration of RPAS into the airspace are developed, the segregation of airspace will continue to be needed.

As per figure below, the main challenge found when defining the segregated airspace for RPAS operations was that the airspace authorities were not familiar with the process and therefore had lengthy internal decisions before proving feedback. Also, limitations of the RPAS in terms of distance to shore, overcoming orography and need for safe take-off and landing sites had to be taken as a constraint in the definition of the area of operations. Consequently, the process could take longer than planned and the airspace was only allocated just before the service.

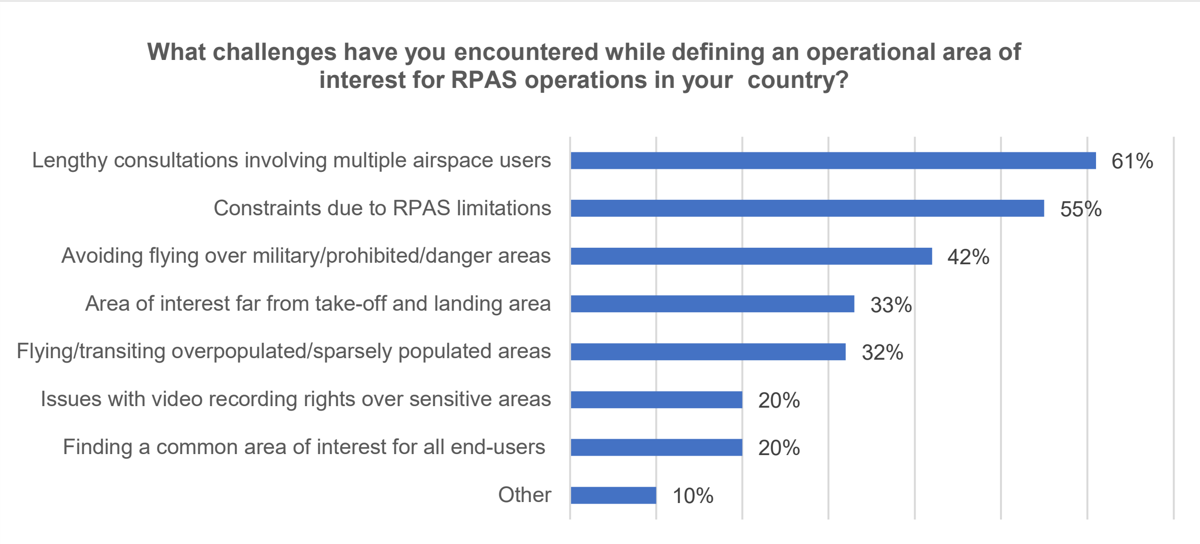


Figure 29 - Challenges when defining an operational aera of interest. Source: RPAS user group 2022

Some Member States had procedures to allocate airspace at short notice for manned patrol aircraft during search and rescue (SAR) events. The possibility of adopting these procedures for RPAS was discussed and agreed upon in some cases. However, this requires significant resources from air traffic control authorities to monitor RPAS flights.
Discrepancies between Flight Information Regions (FIR) and maritime boundaries can complicate cross-border RPAS operations, as air traffic control authorities not involved in the maritime surveillance operation must be consulted. Additional problems include potential conflicts with military airspace users and difficulties maximizing the use of assigned airspace due to conflicts with other manned air traffic in the area.
Establishing communication procedures for RPAS EU operators with local Air Traffic Control (ATC) authorities has also been challenging. ATCs were often unfamiliar with communicating with RPAS pilots on shore or with RPAS that could not be detected by their identification systems. In some cases, language barriers further complicated communication.
The figures below summarize the main challenges encountered by national authorities when defining an operational area of interest, as gathered from a questionnaire addressed to the RPAS User Group in 2022.

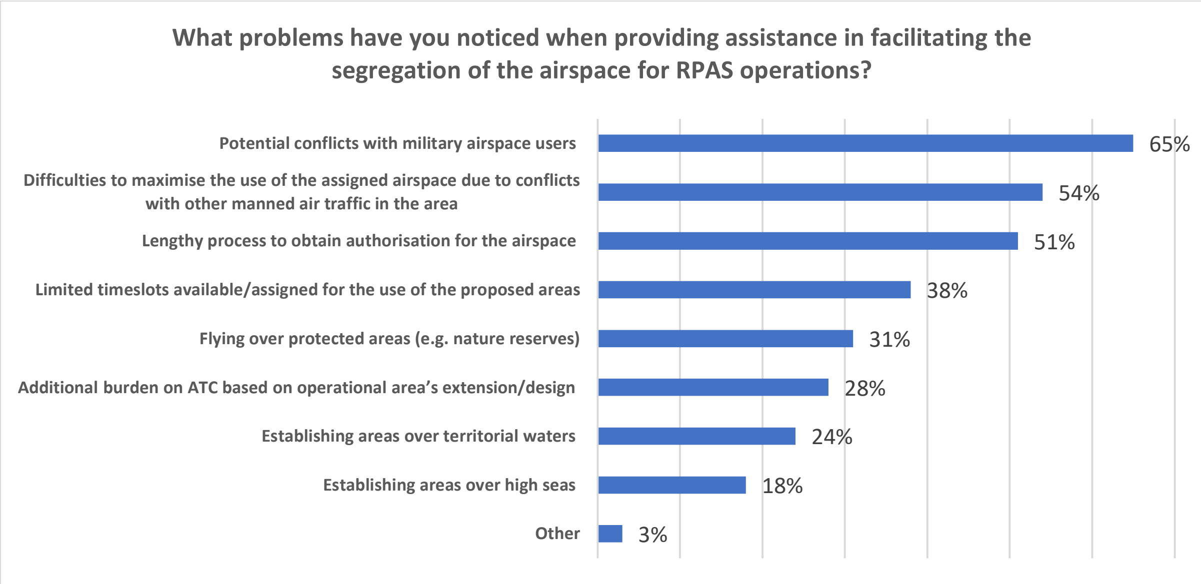


Figure 30- Problems when segregating airspace. Source: RPAS User Group 2022

Feedback and suggestions with regards to airspace design and clearance were obtained through the RPAS survey. For instance, it was suggested to fly RPAS in airport approaches through technologies like IFF (Electronic Identification Friend or Foe) air traffic control recognition systems in order to get more flight authorisations in North Sea and Baltic Sea. Other participants presented a wish to gain flexibility to use RPAS deployments in search and rescue (SAR) operations without necessitating segregated zones, with the possibility that this approach could be anchored within a regional framework. They also proposed regulatory and administrative adjustments to facilitate the integration of these innovative capabilities into the daily shared maritime surveillance operational tools. Finally, it was suggested direct coordination of flight alterations, as opposed to relying solely on Notice to Airmen (NOTAM) publications, to increase operational flexibility.

4.3 Communications

As revealed in the EMSA 2023 RPAS survey results one of the main challenges reported by Member States concerning RPAS operations was the provision of communications from the ground station to the RPAS Data Centre (RPAS-DC).

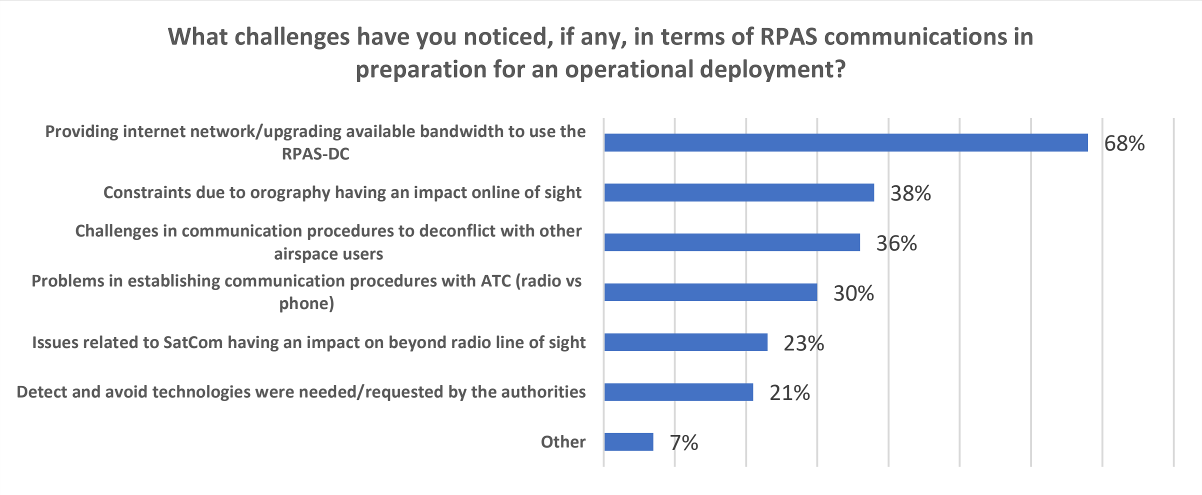


Figure 31- RPAS User group communications challenges when preparing operational deployment. Source: questionnaire 2022

To address communication issues, EMSA contracted reliable satellite communication services across Europe, ensuring sufficient bandwidth to transmit the full set of payload data from the RPAS to shore, and from the ground control station to the RPAS data centre, allowing for monitoring from any command centre.

Radio interference in some areas caused interruptions to the video signal transmission. These interruptions were mitigated by changing the video frequency during flights. However, in some instances, the radio environment was incompatible with the available communication systems, necessitating a relocation of the operation site. Additionally, GPS jamming in operational areas occasionally prevented flights, despite contingency measures such as testing RPAS on the ground with GPS anti-jamming equipment and using GPS, GLONASS, and GALILEO systems.

Regarding Satellite Communications (SATCOM) for operations on board vessels, several considerations and procedures ensure smooth service provision:

- Timing of SATCOM service requests: Request SATCOM services well in advance to allow adequate preparation and planning.
- Site visits: Conduct site visits to identify potential blockages, blind spots, and interference with other electromagnetic equipment. Assess cabling ducts, racks, power supply, and other infrastructure requirements.
- Booking satellite capacity: For maritime surveillance operations far from shore, such as fisheries inspections in the Atlantic, book satellite capacity over areas of interest according to the patrol plan to ensure sufficient resources are allocated.
- Effective communication: Maintain contact with the RPAS pilot or vessel crew for effective communication and prompt escalation in case of technical issues. Follow a clear escalation matrix to streamline troubleshooting and resolution procedures.
- Out-of-Band connection: An Out-of-Band connection for remote troubleshooting enables remote technical support and diagnostics, reducing the need for physical interventions and minimizing downtime during critical operations.

By ensuring timely service requests, conducting thorough site visits, efficient patrol plan booking, effective communication with on-board personnel, and the availability of an Out-of-Band connection, the reliability, efficiency, and effectiveness of SATCOM services can be enhanced in maritime deployments.

4.4 RPAS operations on board vessels

At the end of 2023, EMSA had 15 chartered oil spill response vessels distributed along the European coastline, with 13 equipped with lightweight quadcopter RPAS ready for immediate use in emergencies. It was not technically feasible to equip all vessels. These lightweight RPAS require minimal take-off and landing space, which is crucial given the limited deck area of oil recovery vessels. Since the location of an emergency cannot be predicted, it is vital that these RPAS can be swiftly activated without extensive permit procedures. They can operate in the open category with a Light UAS Operator Certificate (LUC), allowing compliant flights in EU airspace under specific conditions such as altitude, operational area, and weather.

Additionally, EMSA has conducted several RPAS operations from various EU Agency and Member State vessels over multiple months. These operations included deployments of small RPAS from EFCA fisheries control patrol vessels and the Romanian Border Police patrol vessel, as well as medium-sized RPAS from Icelandic Coast Guard vessels and a German Police vessel. Practical experience has shown that the larger the system, the greater the complexity and logistical demands.

In what concerns medium sized RPAS, the installation process is demanding, requiring meticulous planning and coordination to ensure seamless operations. Key factors to consider include limited space and the compatibility of equipment for successful implementation.

Figure 32- EMSA RPAS on-board a vessel.

In summary, while operations from on board vessels are feasible, the complexity and logistical demands are greater with larger systems. The setup process requires meticulous planning and coordination, especially considering the limited space and technical requirements. Satellite communication, as enabled by EMSA, is key to ensuring efficient communication and data exchange, crucial for maintaining connectivity and enabling timely information sharing.

4.5 EMSA RPAS Data Centre

The RPAS Data Centre has been a critical component of the RPAS services provided by EMSA. It allows users to follow live RPAS flights, access mission replays, receive data from various payloads, and exercise command and control. Sharing the live maritime picture between different maritime authorities enables decision-makers to better understand evolving situations at sea and adjust instructions to on-site staff accordingly. The RPAS Data Centre chat tool has served as the primary communication channel between operational actors.

EMSA provides regular training courses for all users in preparation for each RPAS deployment. These courses, delivered by EMSA staff either in-person on-site or remotely to ensure users are well-prepared. Starting in 2023, a fully asynchronous online course accredited by the EMSA Academy is available in EMSA's MaKCs (Maritime Knowledge Centre) on Moodle.

While the RPAS Data Centre interface is considered usable, users have provided feedback and suggestions for improvements:

- The stability of the RPAS Data Centre interface needed improvement in the initial years.
- Some data (RPAS path, metadata, AIS) was missing for certain flights due to incorrect configuration.
- Integrating additional data sources from SafeSeaNet Ecosystem Graphical Interface (SEG) / EMSA Integrated Maritime Services (IMS) would be beneficial. Currently, only RPAS data streams, geographical locations, Earth Observation service frames, and vessel positions and identification are shared within the RPAS Data Centre.
- To fully command operations remotely, users need some form of direct voice communication with the RPAS operator, while command orders would still be published in the written chat.
- The streaming of RPAS data to the RPAS Data Centre interface should be flawless, with a maximum transmission delay of five seconds to be considered live. The quality of the internet connection and setup of the RPAS service provider should be carefully checked before operations to avoid critical service interruptions.

In response to these remarks, EMSA has implemented throughout the years several improvements and initiated the development of a new RPAS Data Centre, leveraging the latest technologies available in the market.

4.6 Benefits of regional and cross sectorial operations

Regional RPAS operations require coordination and cooperation among authorities to overcome challenges and maximize benefits. Successful cross-border flights have demonstrated the potential for seamless operations across different airspace regions. However, one challenge is that aviation authorities treat operational authorizations separately for each airspace, creating complexities and administrative burdens for operators conducting flights in multiple jurisdictions.

In regional operations, a single flight may serve multiple Member States and authorities, necessitating harmonization and collaboration among these entities. Effective cooperation procedures have streamlined processes and facilitated smoother operations, reducing redundancies, and enhancing efficiency.

While shared flight plans and reports are important for information exchange and situational awareness, some operations may require confidentiality due to sensitive information or security concerns. Balancing transparency and confidentiality is crucial for effective regional operations.

To facilitate real-time information sharing, a common live picture is shared with all participants through the RPAS Data Centre. This centralized platform provides up-to-date information, enhances situational awareness, integrates a live communication channel (chat) among participants, and enables informed decision-making. By offering a comprehensive view of the airspace, participants can coordinate their activities more effectively, ensuring the safety and efficiency of operations.

Establishing a weekly flight schedule for all participants can further enhance coordination and predictability. Aligning flight schedules allows authorities to optimize resources and minimize conflicts, leading to smoother operations and reduced disruptions.

By leveraging the benefits of regional operations, aviation authorities can achieve safer, more efficient, and harmonized airspace management. Effective cooperation procedures, shared information, confidentiality considerations, and a unified flight schedule contribute to the success of regional aviation operations. Cooperation and information sharing between different agencies using RPAS can maximize their impact and effectiveness.

4.7 RPAS use for emissions monitoring operations

RPAS operators need to continue enhancing the effectiveness of emission monitoring by refining the best operational procedures for RPAS positioning within emissions plumes. This task currently requires highly skilled pilots, favourable wind conditions, and significant time investment to ensure accurate measurements. Emerging technologies, such as multispectral sensors adapted to the space and weight constraints of RPAS, show promise. These sensors can determine the content of certain gases in the plume by pointing at it from a short distance, eliminating the need for sample extraction, a path EMSA plans to explore further.

Several operations have successfully supported authorities in monitoring the implementation of the sulphur (SOx) limits established by the IMO and in the SECA areas as per EU legislation.

RPAS emission monitoring measurements, like all chemical measurements, come with a variable error, which can be challenging for sulphur inspectors to interpret. EMSA is seeking ways to express or represent this error in a more meaningful and understandable manner for inspectors.

Figure 33- RPAS equipped with an emissions monitoring sensor

It has also been observed that measurements taken by RPAS at different times and locations do not always align with the findings of Sulphur Inspectors at the port. While both RPAS and inspection probe measurements can be accurate, understanding the cause of these discrepancies requires a more in-depth analysis of the processes on board vessels. The performance measurement of scrubbers has gained importance to ensure they are operating correctly on vessels. It is recommended that emission reports specify whether a vessel is equipped with a scrubber. Efforts in emission monitoring should focus on high-density traffic lanes, SECA boundaries, and large ports to maximize the impact of monitoring and enforcement activities due to the significant maritime activities and environmental risks in these areas.

Adopting a multinational approach, even if operations originate from a single coastal state, is crucial. Collaboration and information sharing through the THETIS platform provide a broad perspective and ensure consistent enforcement across borders. RPAS operations, combined with transparent information dissemination by THETIS, create a deterrent effect on non-compliant vessels, reducing the likelihood of non-compliance and promoting adherence to environmental regulations.

Data analysis from the 2021 and 2022 measurements of emissions by EMSA RPAS services, included in the European Maritime Transport Environmental Report (EMTER) 2021, indicates that the likelihood of infringements is significantly higher in areas with more stringent limits (e.g., 0.1%). Therefore, surveillance and inspections in these areas are crucial to ensure compliance with regulations. Combining port inspections, where infringements can be confirmed via accurate lab tests of fuel samples, with remote emission monitoring conducted even in high seas where regular inspections are not feasible, creates a powerful enforcement tool. Aerial systems like RPAS, capable of acquiring observations anywhere, should also be considered for their deterrent effect.

In addition to monitoring SOx values, NOx values are measured in situ but are not yet fully utilized for monitoring purposes. NOx data can provide a more comprehensive assessment of emissions and valuable insights into overall environmental impact. However, current legislation does not consider NOx emission measurements for compliance monitoring. Member States are developing the necessary procedures for this.

The RPAS survey yielded similar or additional recommendations from participants in what concerns environmental emissions monitoring:

- Integrating RPAS flights with EMSA's CleanSeaNet satellite service to improve pollution detection accuracy on-site, and support Member States' verification activities.
- Equipping RPAS with advanced sensors to measure emissions like CO2, NOx, and particulate matter, aligning with the transition towards sustainable ports requiring accurate emissions monitoring of ships using conventional power and onshore electricity.
- Using RPAS to identify ships violating NOx emission regulations, aiding in the enforcement of environmental standards, and reducing maritime pollution.

4.8 Setting up RPAS operations

4.8.1 Timing for operations: Allocating budget, assets and staff

Experience has shown that planning and initial definition for new services takes up to two years. This lead time accounts for various factors, such as obtaining necessary authorizations, airspace design and clearance (often involving complete airspace segregation), and on-site logistics.

Budget constraints initially limited the service duration to about three months, with possible extensions based on available funding. However, uncertainties about extensions can hinder Member States from preparing and allocating staff from the operation's outset. Consequently, many have requested longer service periods and repeated services in subsequent years to fully leverage the experience and incorporate this data source into standard surveillance procedures. By allowing more time for data collection and analysis, end-users can better comprehend the capabilities and potential applications of RPAS. This in-depth understanding facilitates a learning curve for end-users, empowering them to make the most of RPAS capabilities and integrate these services seamlessly into their operational procedures. Longer-term operations offer the opportunity to explore and harness the full potential of RPAS services on board vessels.

Member States and Coast Guard Agencies require certainty about operation durations to plan resources effectively, including budget and staffing. The extensive preparatory work and the uncertainty of obtaining a Permit to Fly can make short missions of only three months less advantageous. Therefore, longer, multipurpose operations are preferred.

Weather conditions, particularly in the first and fourth quarters of the year, necessitate mitigation measures like flexible flight plans, spare parts management, and technical maintenance. These measures address challenges such as endurance, wind, and ice resistance. While operational experience has improved adaptability to local weather conditions, environmental factors remain a primary cause of flight deviations and cancellations.

Some operations saw increased flight hour cancellations due to issues with the Service Provider, such as technical problems or crew issues, possibly linked to insufficient crew rotation and fatigue towards the deployment's end.

Most users highlighted the need for two RPAS to ensure continuity in case of aircraft loss and to minimize the impact of unscheduled maintenance on performance. Since 2020, EMSA has required such redundancy in its subsequent service contracts.

4.8.2 On-site logistics

EMSA RPAS operations have been deployed from various sites, including Maritime Rescue Coordination Centres (MRCCs) with helipads, military and civilian airports, lighthouse properties, training centres, private fields, fire stations, tankers, frigates, ports, patrol vessels, and more.

EMSA and its contractors have gained considerable experience in identifying suitable sites and vessels for RPAS deployments. They take into account security needs, take-off and landing areas, proximity to the area of interest, the need to minimize flights over populated areas or high aerial traffic density zones, ease of agreement with the landing spot owner, and potential interferences with other magnetic or radio equipment. Proper planning and management of fuel needs, transportation, and delivery are also crucial to the success of the operation. Additionally, support from Member State authorities for customs clearance is sometimes required to ensure timely equipment delivery.

The selected areas for flight authorizations are usually far from major airports or restricted to low altitudes, presenting a challenge to find suitable airports with minimal traffic and proximity to the sea. This reduces the risk of overflying highly populated areas and maximizes the RPAS' endurance. Solutions are often found in secondary or military airports, but negotiating terms of use can involve lengthy discussions. One key lesson learned is that operating from an airport not under the requesting users' control might increase risks and delay the project due to conflicting priorities and operational procedures.

Upgrading on-site logistics has been necessary at most take-off and landing areas. This includes installing internet connections for data transmission, runway illumination for night flights, and secure hangars for the aircraft and crew. The selected site can also present operational challenges, such as accommodation difficulties for the crew during the summer season.

4.8.3 Operational procedures

Establishing operational procedures for RPAS services requires intricate coordination among various authorities within each Member State. Typically, 6 to 12 months of preparatory work are needed before deploying RPAS services in response to a request.

To facilitate this planning phase, it is crucial to ensure users are well-informed. Providing detailed checklists outlining service user expectations can help them efficiently allocate resources, prepare and approve necessary documents, and participate in the flights themselves. Additionally, RPAS service providers should be thoroughly briefed on the objectives and operational procedures of the coast guard authorities. This ensures the RPAS targets the correct areas, operates in the required mode, and captures the necessary videos and images to support surveillance tasks.

Figure 34 - RPAS view of vessels in the Atlantic.

Figure 35 - RPAS ahead of take-off

5 Conclusions and way forward

The deployment of RPAS from 2017 to 2023 by EMSA marks a significant period of technological integration and strategic development in maritime surveillance across EU and EFTA nations. This initiative, which started with preparing the ground in 2017, has matured into a robust operational service by 2023, showcasing considerable advancements in the effectiveness and scope of maritime operations. Throughout this period, EMSA RPAS services have been pivotal in enhancing maritime surveillance, pollution response, and safety operations, accruing over 14,700 flight hours in support of various maritime activities. These operations have not only broadened the capabilities of national maritime authorities but have also fostered a collaborative environment for sharing best practices and technological know-how. The integration of RPAS into regular maritime operations has significantly improved operational efficiency and response times to environmental and maritime safety incidents.

The multipurpose nature of RPAS operations increases efficiency by allowing multiple user communities to leverage a single operation. This encourages cooperation among coast guard authorities responsible for various functions within the same areas of interest. Concerning vessel-based operations, deploying RPAS from vessels extends surveillance capabilities beyond the immediate vicinity of the vessel. Previously limited to large naval vessels or light RPAS due to space constraints, there is now a growing interest in developing medium endurance RPAS solutions for broader vessel types.

One of the most noteworthy outcomes of the RPAS deployment has been the enhanced capacity for pollution monitoring and response. High-profile incidents, such as the Grande America have underscored the value of RPAS in providing timely and effective monitoring, which has been critical in mitigating environmental impacts. Moreover, the use of RPAS for emissions monitoring has contributed to the enforcement of environmental regulations, providing a deterrent to non-compliance, and fostering a culture of accountability among maritime operators.

The technical evolution of RPAS, marked by increased endurance and resistance to harsh maritime conditions, has enabled EMSA to deliver more with less—fewer deployment days but more flight hours, indicating a shift towards more efficient and capable systems. This evolution reflects a growing maturity in the operational integration of RPAS, moving from experimental applications to becoming a mainstay in maritime surveillance strategies.

However, the journey has not been without challenges. The complexities of navigating EU and national regulations for flight operations, airspace management, and the technical limitations of smaller RPAS have highlighted areas for ongoing development and regulatory adaptation. The need for segregated airspace and the intricate process of obtaining flight authorizations have been significant hurdles, slowing down the rapid deployment of RPAS services in some cases.

Despite these challenges, the strategic initiatives undertaken by EMSA have been fruitful. The establishment of a multi-annual operational strategy and the continual adaptation of procurement strategies have facilitated the scaling of operations and the achievement of economies of scale. These strategies have not only optimized operational costs but have also ensured that RPAS services are tailored to the diverse needs of member states and regional authorities.

Looking forward, the integration of advanced flight and avoidance systems, alongside the continued dialogue with aviation authorities, will be crucial in enhancing the airspace integration of RPAS. Moreover, the ongoing technical advancements, such as the development of lighter and more effective sensors for pollution monitoring and the exploration of artificial intelligence applications in anomaly detection, are set to further revolutionize RPAS capabilities.

The cumulative experiences and lessons learned over these years highlight the importance of a cooperative approach, both at the regional and EU levels, to overcome operational challenges and maximize the benefits of RPAS in maritime surveillance. As EMSA continues to refine its RPAS strategy, the emphasis will likely shift towards enhancing interoperability among different maritime surveillance systems, including satellite and manned aerial assets, to create a cohesive and comprehensive maritime surveillance network.

In conclusion, the journey of EMSA's RPAS from initial trials to a key component of EU maritime operations is a testament to the potential of innovative technologies in transforming public service delivery. The continued evolution of RPAS technology and its integration into maritime surveillance will undoubtedly play a pivotal role in enhancing maritime safety, security, and environmental protection across Europe's vast maritime domains.

References

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5) EU Regulation 2019/947 and EU Regulation 2019/945
6) European Parliament and Council Directive 2005/35/EC, 7 September 2005
7) European Parliament and Council Directive (EU) 2016/802, 11 May 2016
8) The International Convention for the Prevention of Pollution from Ships (MARPOL)
9) European Maritime Transport Environnemental Report (EMTER) 2021

Figure 36 - Airborne view of RPAS

Glossary and abbreviations

AIS – (vessels) Automatic Identification Systems

ATC – Air Traffic Control

BVLOS or BLOS- Beyond Visual Line of Sight

BRLOS – Beyond Radio line of Sight

CONOPS – Concept of Operations

EASA - European Union Aviation Safety Agency

ECGFF - European Coast Guard Function Forum

EFCA - European Fisheries Control Agency

EMSA - European Maritime Safety Agency

ESA – European Space Agency

EUNAVFOR- European Union Naval Force

EUROCONTROL - European Organisation for the Safety of Air Navigation

Frontex - European Border and Coast Guard Agency

IMO – International Maritime Organization

IMS - EMSA integrated maritime Services

LOS- Line of Sight

LUC - Light UAS Operator Certificate

MALE- Medium Altitude Long Endurance

MAOC-N - Maritime Analysis and Operations Centre - Narcotics

MS – (EU) Member State

NCA - National Competent Authority

NOTAM – Notice to Airmen

OSRVs - Oil Spill Response Vessels

RPAS - Remotely Piloted Aircraft Systems

SATCOM - Satellite Communications

SEG - SafeSeaNet Ecosystem Graphical Interface

SEASAR – ESA's workshops on Coastal and Marine applications of Synthetic Aperture Radar

UAV - Unmanned Aerial Vehicle

VTOL Vertical Take off and Landing

VLOS – In visual line of sight

Annex 1 – EMSA Portfolio of Aircraft used in RPAS Services

Aircraft and Contractors	Main Service	Flight Time	Category MTOM	Take-off	Description
 TEKEVER AR5 Evolution Contractor: REACT (Tekever & Collecte Localisation Satellite)	Multipurpose maritime surveillance	Up to 9h	Medium-size fixed wing 180 kg	Runaway	• Can fly beyond Radio Line of Sight (using Satellite communications) • EO/IR cameras including laser illuminator, AIS sensor, EPIRB, Satcom terminal, Maritime Radar, radar emitter detector, Mobile phone detector • Can be equipped to drop an inflatable life raft for 8 persons
 Hermes 900 (Discontinued) Contractor: Ceiia	Multipurpose maritime surveillance	Up to 12h	Medium Altitude Long Endurance (MALE) 1150kg	Runaway	• Can fly beyond Radio Line of Sight (using Satellite communications) • EO/IR cameras including laser illuminator, AIS sensor, EPIRB, Satcom terminal, Maritime Radar, radar emitter detector, Anti-icing
 OGASSA OGS42 (Discontinued) Contractor: RPASMAR	Emissions monitoring/ Multipurpose maritime surveillance	Up to 7h Up to 10h with electronic fuel injection	Medium-size fixed wing 34kg	Runaway	• Can fly up to 80 km • EO/IR cameras including laser illuminator, EPIRB, AIS receiver. • Emissions monitoring sensor (Sox/NOx sniffer)
 Altus OURANOS UAS (Discontinued) Contractor: Altus	Emissions monitoring	Up to 6 h	Medium-size fixed wing 23kg	Runaway Possible to be configured with a catapult launch	• Can fly up to 100 km • EO/IR cameras including laser illuminator, AIS receiver. • Emissions monitoring sensor (Sox/NOx sniffer)

Aircraft and Contractors	Main Service	Flight Time	Category MTOM	Take-off	Description
 Aerosonde Mk 4.7 Contractor: Nordic Unmanned	Multipurpose maritime surveillance	Up to 10h (with radar) Up to 15h (without radar)	Medium-size fixed wing 36.3 kg	Take-off with catapult. Landing with recovery net in circle area with 20m diameter.	• Can fly for up to 800km along the coast with a relay of antennas. • EO/IR cameras including laser illuminator, maritime radar, AIS receiver.
 Aerosonde HQ Contractor: Nordic Unmanned	Multipurpose maritime surveillance	Up to 9h	Medium-size fixed wing 50 kg	Vertical Take-Off and Landing area < 10mx10m	• Can fly for up to 140km (capability to extend the range with a relay of antennas) • Vertical take-off/land from vessel or land • Payloads : EO/IR with automatic scanning mode, AIS receiver, EPIRB
 Camcopter S-100 Contractor: Schiebel / Nordic Unmanned	Emissions monitoring/ Multipurpose maritime Surveillance	Up to 6h	Medium size VTOL >150 kg	Landing area < 10mx10m	• Can take-off/land from Vessels or land • Emissions monitoring sensor (Sox/NOx sniffer) • EO/IR cameras, laser range finder and illuminator, AIS receiver, EPIRB
 Skeldar V-200 (Discontinued) Contractor: Nordic Unmanned	Emissions monitoring/ Multipurpose maritime Surveillance	Up to 4h	Medium size VTOL 235kg	Landing area < 10mx10m	• Can take-off/land from Vessels or land • Emissions monitoring sensor (Sox/NOx sniffer) • EO/IR cameras, laser range finder and illuminator, AIS receiver

Aircraft and Contractors	Main Service	Flight Time	Category MTOM	Take-off	Description
 Lockheed Martin Indago Contractor: Nordic Unmanned	Support to pollution response (from vessels or in coastal areas)/ multipurpose maritime surveillance	>35 min	Light Quadcopter < 3 Kg	Landing area < 2mx2m (vessels)	• Can take-off/land from Vessels or land • Small logistical footprint • Fast operational readiness • EO/IR capability to transport and drop small objects (samples, USB.)
 Atlas 4 Contractor: Altus	Emission Monitoring (from vessels or in coastal areas)/ multipurpose maritime surveillance	50 min	Light Quadcopter 13 Kg	Landing area 5mx5m	• Can take-off/land from Vessels or land • Small logistical footprint • Emissions monitoring sensor (SOx/NOx sniffer) • EO/IR cameras, AIS receiver

Annex 2 – Operations, exercises, emergencies and OSRVs LRPAS (2017-2023)

Operations

Year	Country/ Requestor	Authority	Type of operation	Aircraft used and endurance	Deployment Days
2017	Denmark	Danish Maritime Authority	Emission monitoring	Skeldar V-200 (5h of endurance)	7
2017	Spain (Huelva)	DMA	Operational demonstration	several	1
2017	Portugal	Coordination committee (CNCM)	Multipurpose maritime surveillance incl. pollution monitoring	Tekever AR 5 Evolution (9h of endurance)	31
2018	Portugal	Coordination committee (CNCM)	Multipurpose maritime surveillance incl. pollution monitoring	Tekever AR 5 Evolution (9h of endurance)	40
2018	Greece	Hellenic Coast Guard Headquarter	Emission monitoring	ALTUS OURANOS (5h of endurance)	4
2018	Portugal	Frontex supporting the Portuguese Garda Nacional Republicana	Support to EU Multipurpose Maritime surveillance	Tekever AR 5 Evolution (9h of endurance)	61
2018	Croatia	Ministry of the Sea, Transport, and Infrastructure	Multipurpose maritime surveillance incl. pollution monitoring	UAVision Wingo Ogassa (6h of endurance)	91
2018	Spain	SASEMAR	Maritime surveillance	Tekever AR 5 Evolution (9h of endurance)	92
2019	Spain	SASEMAR	Multipurpose maritime surveillance incl. pollution monitoring	Tekever AR 5 Evolution (9h of endurance)	68
2019	Croatia	Ministry of Sea, Transport and Infrastructure	Multipurpose maritime surveillance incl. pollution monitoring	UAVision Wingo Ogassa	30

Year	Country/ Requestor	Authority	Type of operation	Aircraft used and endurance	Deployment Days
				(6h of endurance)	
2019	Portugal	Frontex, supporting Portuguese Airforce, DGRM	Support to EU Multipurpose Maritime surveillance	Tekever AR 5 Evolution (9h of endurance)	92
2019	Croatia	Ministry of Sea, Transport and Infrastructure	Multipurpose maritime surveillance incl. pollution monitoring	Schiebel S100 (6h of endurance)	155
2019	Denmark	Danish Maritime Authority	Emission monitoring	Skeldar V-200 (5h of endurance)	81
2019	EFCA	EFCA	Support to EU Fisheries Control	Indago (35min of endurance)	107
2019	Greece	Hellenic Coast Guard/ Frontex	Support to EU Multipurpose Maritime surveillance	Hermes 900 (12h of endurance)	71
2019	Iceland	Icelandic Coast Guard	Multipurpose maritime surveillance incl. pollution monitoring	Hermes 900 (12h of endurance)	119
2019	Italy	Italian Coast Guard	Multipurpose maritime surveillance incl. pollution monitoring	Tekever AR 5 Evolution (9h of endurance)	88
2019	EMSA	Pollution Response vessel	Support to pollution response operations, Grande America emergency RPAS deployed from two OSRVs: Ria de Vigo and VN Partisan	Indago (35min of endurance)	44
2020	Italy	Italian Coast Guard	Multipurpose maritime surveillance incl. pollution monitoring	Tekever AR 5 Evolution (9h of endurance)	294
2020	France	Directorate for Maritime Affairs	Emission monitoring	Schiebel S100 (6h of endurance)	87

Year	Country/ Requestor	Authority	Type of operation	Aircraft used and endurance	Deployment Days
2020	Greece	Hellenic Coast Guard, Hellenic Chemical Laboratory	Emission monitoring	Schiebel S100 (6h of endurance)	18
2020	France	French Navy and Customs	Multipurpose maritime surveillance incl. pollution monitoring	Tekever AR 5 Evolution (9h of endurance)	92
2020	Romania (including exercise with Bulgaria) [8]	Romanian Border Police	Multipurpose maritime surveillance incl. pollution monitoring	Indago (35min of endurance)	144
2020	Finland	Finnish Border Guard	Multipurpose maritime surveillance incl. pollution monitoring	Schiebel S100 (6h of endurance)	150
2020	Denmark	Danish Maritime Authority, Danish Environment Protection Agency	Emission monitoring	Schiebel S100 (6h of endurance)	120
2020	Croatia	Ministry of Sea, Transport and Infrastructure	Multipurpose maritime surveillance incl. pollution monitoring	Schiebel S100 (6h of endurance)	166
2020	EFCA	EFCA	Support to EU Fisheries Control	Indago (35min of endurance)	228
2020	Belgium	Antwerp Port Authority	Pollution monitoring	Indago (35min of endurance)	85
2021	Belgium (Port of Antwerp)	Antwerp Port Authority	Pollution monitoring	Indago (35min of endurance)	60

[8] The Light RPAS also took part to an exercise organized by the Romanian Border Police and the Bulgarian Coast Guard in 2020 in the scope of the Black Sea multipurpose maritime operation.

Year	Country/ Requestor	Authority	Type of operation	Aircraft used and endurance	Deployment Days
2021	Spain	Spanish Maritime Rescue and pollution response authority (SASEMAR), Spanish Customs and Spanish General Secretariat of Fishing	Multipurpose maritime surveillance incl. pollution monitoring	Schiebel S100 (6h of endurance)	158
2021	Italy	Italian Coast Guard	Multipurpose maritime surveillance incl. pollution monitoring	Tekever AR 5 Evolution (9h of endurance)	20
2021	Spain	SASEMAR	SAR and OPR	Indago (35min of endurance)	11
2021	Spain	Dirección General de la Marina Mercante	Multipurpose maritime surveillance incl. emissions monitoring	Schiebel S100 (6h of endurance)	127
2021	Finland	Finnish Border Guard (FBG)	Multipurpose maritime surveillance incl. pollution monitoring	Schiebel S100 (6h of endurance)	91
2021	Estonia	Estonian Police and Border Guard Board (EPBGB)	Multipurpose maritime surveillance incl. pollution monitoring	Schiebel S100 (6h of endurance)	193
2021	France	French Directorate for Maritime Affairs	Emission monitoring	Schiebel S100 (6h of endurance)	153

2021	France	French Navy and Customs	Multipurpose maritime surveillance incl. pollution monitoring	Tekever AR 5 Evolution (9h of endurance)	138
2021	Romania	Romanian Border Police	Multipurpose maritime surveillance incl. pollution monitoring	Schiebel S100 (6h of endurance)	286
2021	Romania	Romanian Border Police	Multipurpose maritime surveillance incl. pollution monitoring	Indago (35min of endurance)	146
2021	Lithuania	Lithuanian Ministry of Environment	Emission monitoring	Schiebel S100 (6h of endurance)	92
2021	EFCA	EFCA	Support to EU Fisheries Control	Indago (35min of endurance)	270
2021	EMSA	Pollution Response vessel	Support to pollution response operations, Sea Bird emergency RPAS deployed from OSRV: Aktea	Indago (35min of endurance)	9
2021	EMSA	Pollution Response vessel	Support to pollution response operations, Cyprus emergency RPAS deployed from OSRV: Alexandria	Indago (35min of endurance)	6
2021	EMSA	Pollution Response vessel	Support to pollution response operations, Vera Su emergency RPAS deployed from OSRVs: Amalthia	Indago (35min of endurance)	5
2022	Romania	General Inspectorate of the Romanian Border Police (RBP)	Multipurpose maritime surveillance incl. pollution monitoring	Schiebel S100 (6h of endurance)	125
2022	Denmark	Royal Danish Navy	Multipurpose maritime surveillance incl. pollution monitoring	Schiebel S100 (6h of endurance)	61
2022	Iceland	Icelandic Coast Guard	Multipurpose maritime surveillance incl. pollution monitoring	Schiebel S100 (6h of endurance)	108

2022	Italy	Italian Coast Guard	Multipurpose maritime surveillance incl. pollution monitoring	Tekever AR5 Evolution (9h of endurance)	173
2022	Finland	Finnish Border Guard	Multipurpose maritime surveillance	Textron Aerosonde (9h of endurance)	74
2022	Estonia (Including access to flights by Latvia)	Estonian Police and Border Guard Board	Multipurpose maritime surveillance	Textron Aerosonde (9h of endurance)	102
2022	Germany	Bundesamt für Seeschifffahrt und Hydrographie	Emission monitoring	Schiebel S100 (6h of endurance)	92
2022	France	French Directorate for Maritime Affairs	Emission monitoring	Schiebel S100 (6h of endurance)	169
2022	Spain	Marina Mercante and Aduanas	Emission monitoring	Schiebel S100 (6h of endurance)	133
2022	France (Port of Marseille)	Direction Interregional de la Mer Mediterranée	Emission monitoring	ATLAS 4 NG (35min of endurance)	88
2022	EFCA (on board Aegis vessel)	EFCA	Support to EU Fisheries Control	Indago (35min of endurance)	15
2022	EFCA (on board Lundy Sentinel vessel)	EFCA	Support to EU Fisheries Control	Indago (35min of endurance)	180
2023	Baltic (Estonia, Finland and Latvia)	Estonian Navy, Finnish Border Guard, Latvian Coast Guard Service	Multipurpose maritime surveillance	Textron Aerosonde (9h of endurance)	170
2023	Atlantic (Spain and Portugal)	Spanish SASEMAR, Portuguese General Directorate for Natural Resources, Safety and Maaritime	Multipurpose maritime surveillance	Textron Aerosonde (9h of endurance)	112

		Services (DGRM/ANP)			
2023	Mediterranean (Italy and France)	Italian Coast Guard, French Navy	Multipurpose maritime surveillance	Tekever AR5 Evolution (9h of endurance)	158
2023	EFCA (on board Ocean Protector vessel)	EFCA	Support to EU Fisheries Control	Indago (35min of endurance)	88
2023	EFCA (On board Ocean Sentinel vessel)	EFCA	Support to EU Fisheries Control	Indago (35min of endurance)	269
2023	Germany	German Federal Maritime and Hydographic Agency	Emission monitoring	Schiebel S100 (6h of endurance)	106
2023	France	French General Directorate of Maritime Affairs, Fishery and Aquaculture (DGAMPA)	Emission monitoring	Schiebel S100 (6h of endurance)	117
2023	North Sea (Denmark)	Royal Danish Navy, Danish Customs and Fisheries Inspection	Multipurpose maritime surveillance	Textron Aerosonde (9h of endurance)	123
2023	Lithuania	Environmental Protection Department under the Lithuanian Ministry of the Environment	Emission monitoring	ATLAS 4 NG (50min of endurance)	102

Exercises

Year	Name of exercise	Country/ Requestor	Vessel	Type of operation	Aircraft used and endurance
2019	ANED POLMAR CALVADOS	Ouisestreham, France	VN Partisan	Pollution response	Indago (Nordic Unmanned)

Year	Name of exercise	Country/ Requestor	Vessel	Type of operation	Aircraft used and endurance
2019	CASCADE	Troia and Figueira da Foz, Portugal	Exercise from shore	Pollution response	Indago (Nordic Unmanned) 35min
2019	ROSTOCK	Rostock, Germany	Exercise from shore	Pollution response	Indago (Nordic Unmanned) 35min
2020	BALEX DELTA	Tallin, Estonia	Norden	Pollution response	Indago (Nordic Unmanned) 35min
2020	BREEZE	Varna, Bulgaria	Galaxy Eco	Pollution response	Indago (Nordic Unmanned) 35min
2020	NEMESIS (Notification Exercise)	Limassol, Cyprus	Alexandria	Pollution response	Indago (Nordic Unmanned) 35min
2021	ATLANTIC POLEX (Notification Exercise)	Algeciras, Spain	Monte Anaga	Pollution Response	Indago (Nordic Unmanned) 35min
2021	BREEZE	Constanta, Romania	Amalthia	Pollution response	Indago (Nordic Unmanned) 35min
2021	BREEZE	Varna, Bulgaria	Galaxy Eco	Pollution response	Indago (Nordic Unmanned) 35min
2021	NEMESIS (Notification Exercise)	Limassol, Cyprus	Alexandria	Pollution response	Indago (Nordic Unmanned) 35min

Year	Name of exercise	Country/ Requestor	Vessel	Type of operation	Aircraft used and endurance
2021	RAMOGEPOL	Bastia, France	Pionnier (vessel of the French authorities)	Pollution response	Indago (Nordic Unmanned) 35min
2021	BALEX DELTA	Kotka, Finland	Norden	Pollution response	Indago (Nordic Unmanned) 35min
2021	ANED POLMAR	Le Havre, France	Argonaute (vessel of the French authorities)	Pollution response	Indago (Nordic Unmanned) 35min
2022	BALEX DELTA	Rostock, Germany	Norden	Pollution response	Indago (Nordic Unmanned) 35min
2022	ATLANTIC POLEX (Notification Exercise)	Viana de Castelo, Portugal	Ria de Vigo	Pollution response	Indago (Nordic Unmanned) 35min
2022	POLMAR LION	Toulon, France	Pionnier	Pollution response	Indago (Nordic Unmanned) 35min
2023	ATLANTIC POLEX	Madeira, Portugal	Mencey	Pollution response	Indago (Nordic Unmanned) 35min
2023	BREEZE	Varna, Bulgaria	Galaxy Eco	Pollution response	Indago (Nordic Unmanned) 35min
2023	ARCACHON	Arcachon, France	Ria de Vigo	Pollution response	Indago (Nordic Unmanned) 35min

Emergencies

Year	Vessel	Date	Cause	Type of support
2019	Grande America	10th March	A fire broke out in containers onboard the vessel, while transiting through the Bay of Biscay from Hamburg to Casablanca.	Support to pollution response operations (detection, identification, monitoring)
2021	Cyprus	24th August	A tank containing 15,000 tons of oil ruptured in Baniyas, Syria, resulting in an oil slick that spread into the Mediterranean.	Support to pollution response operations (detection, identification, monitoring)
2021	Sea Bird	28th August	The vessel's hull was breached after striking rocks in the Aegean Sea, resulting in her rapid sinking. An oil slick over 5 km long was detected.	Support to pollution response operations (detection, identification, monitoring)
2021	Vera Su	20th September	The vessel struck rocks and became stranded on the Bulgarian coastline in a protected area.	Support to pollution response operations (detection, identification, monitoring)

Light RPAS on board EMSA OSRVs (2023)

Port of standby	Vessel	Aircraft used and endurance	Deployment period
Brest, France	VN Partisan	Lockheed Martin Indago - 35min	2019 – 2023
Piraeus, Greece	Aktea	Lockheed Martin Indago - 35min	2019 - 2021
Vigo, Spain	Ria de Vigo	Lockheed Martin Indago - 35min	2019 - 2023
Algeciras, Spain	Monte Anaga	Lockheed Martin Indago - 35min	2021 - 2023
Sines, Portugal	Bahia Tres	Lockheed Martin Indago - 35min	2022 - 2023
Malmo, Sweden	Norden	Lockheed Martin Indago - 35min	2019 - 2023
Canary Islands, Spain	Mencey	Lockheed Martin Indago - 35min	2020 - 2023
Rijeka, Croatia	Kijac	Lockheed Martin Indago - 35min	2021 - 2023
Naples, Italy	SB Borea	Lockheed Martin Indago - 35min	2022 - 2023

Port of standby	Vessel	Aircraft used and endurance	Deployment period
Valletta, Italy	Adelia	Lockheed Martin Indago - 35min	2022 - 2023
Constanta, Romania	Amalthia	Lockheed Martin Indago - 35min	2020 - 2023
Varna, Bulgaria	Galaxy Eco	Lockheed Martin Indago - 35min	2020 - 2023
Limassol, Cyprus	Alexandria	Lockheed Martin Indago - 35min	2020 - 2023
Ostend, Belgium	Interballast	Lockheed Martin Indago - 35min	2023 - 2023

Annex 3 – Maps with location of RPAS Operations per year

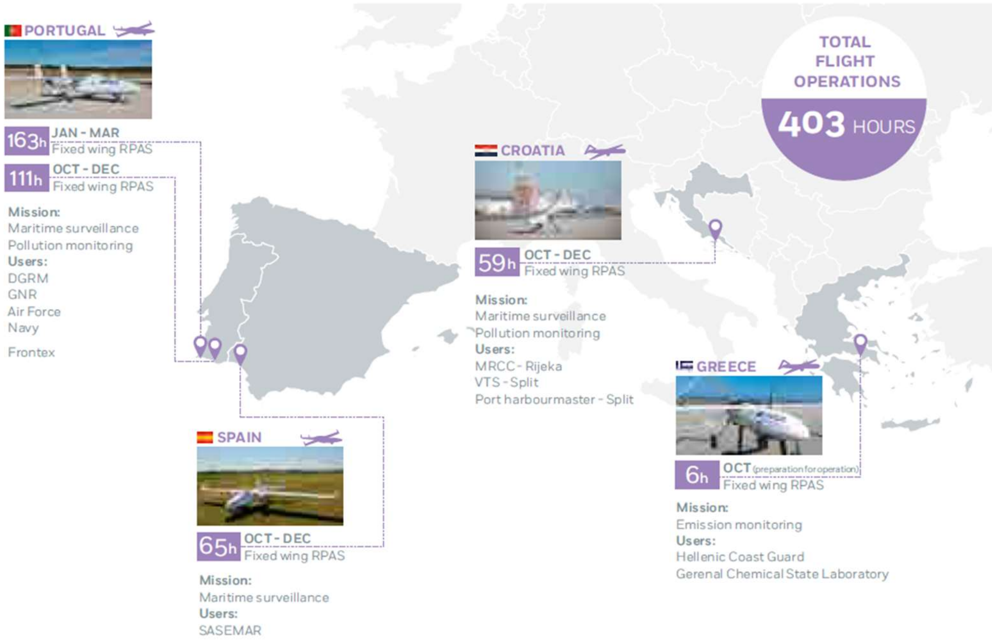

Figure 3.1: RPAS operations in 2017-2018

**A short emissions monitoring operation took place in Denmark in 2017 that is not reflected in this map.*

Figure 3.2: RPAS operations in 2019

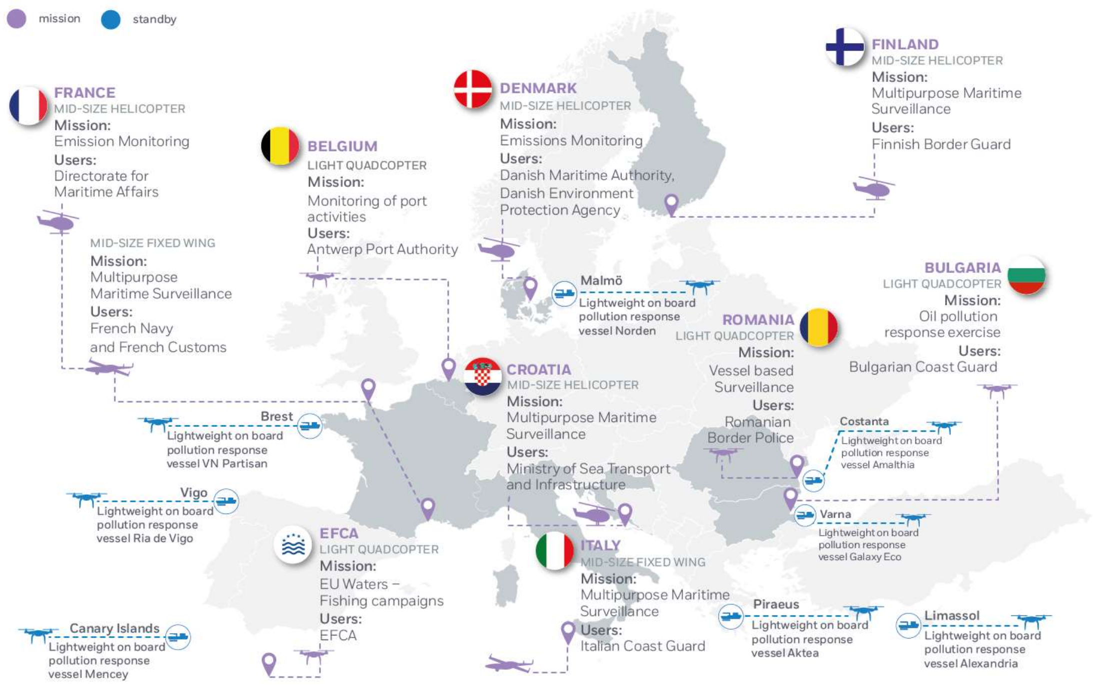

Figure 3.3: RPAS operations in 2020.

Figure 3.4: RPAS operations in 2021.

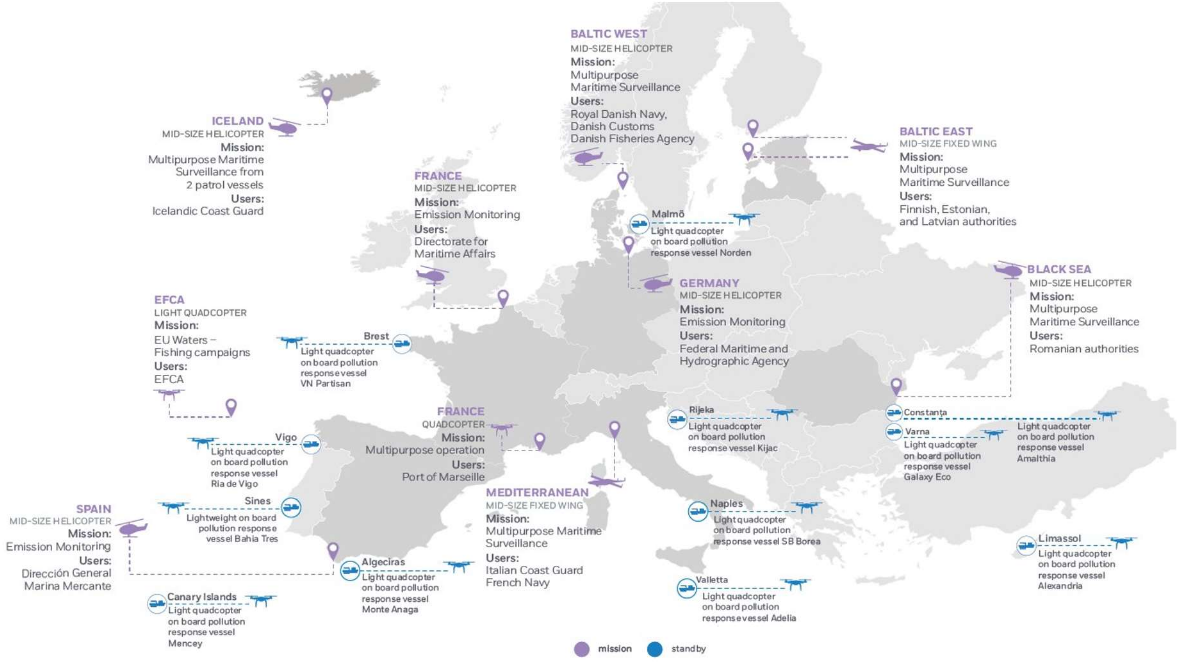

Figure 3.5: RPAS operations in 2022.

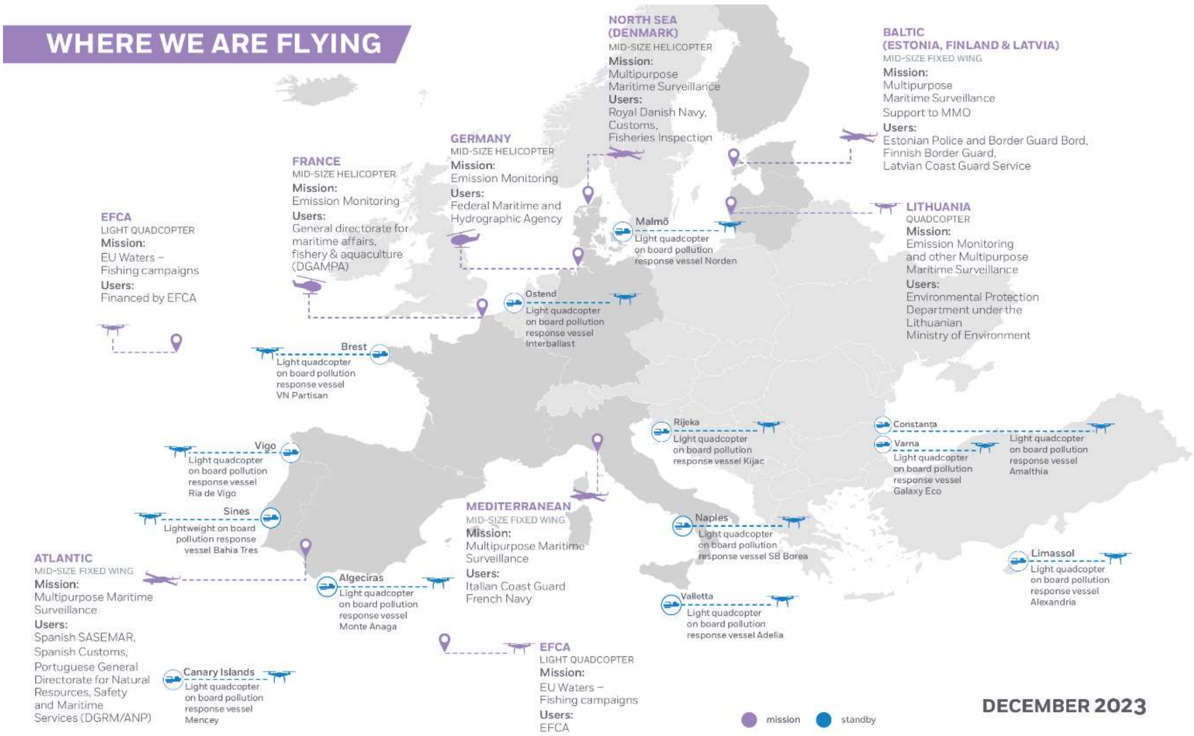

Figure 3.6: RPAS operations in 2023.

Annex 4 – Summary of Results of the EMSA RPAS Survey 2023

Table of Contents

Executive summary

A total of 133 maritime administrations in the EU and EFTA in contact with EMSA received the invitation to participate in this survey. The questionnaire was available online between 18 April and 30 July 2023, published on the page https://ec.europa.eu/eusurvey/runner/rpas-maritime-surveillance. A total of 26 responses were received from 18 countries and 3 European Agencies or international organizations. The number of responses received constituted 19.5% of the administrations contacted. While the results cannot be deemed fully exhaustive, the content of the responses provides a reasonable representation of the experience and interest maritime authorities possess in the use of RPAS for maritime surveillance. The results are outlined below, grouped by question blocks. The figures displayed in the graphics indicate the number of responses received for each answer option.

Based on the responses, RPAS offer significant value across a broad spectrum of coast guard functions, including law enforcement, fisheries inspection and control, environmental protection, pollution detection and response, border control, multipurpose maritime monitoring and surveillance, search and rescue operations, ship casualty assistance, maritime security, and maritime safety which encompasses vessel traffic monitoring.

EMSA's RPAS service was utilized by 17 respondents and received widespread appreciation, with an average rating of 4.2 out of 5 across all questions. Since 2017, this service has facilitated the sharing of experiences in navigating the challenges of implementing these emerging technologies within an evolving legal framework.

Predominant challenges include securing airspace permissions, obtaining flight authorizations, and coordinating with the operational hours of air traffic control towers. While the adoption of RPAS by maritime administrations is still in its nascent stages, an increasing number of these administrations are either using or exploring RPAS to bolster their maritime surveillance capabilities.

The majority of maritime administrations reported a positive experience with RPAS. Of the respondents, 23 out of 26 plan to further integrate RPAS into their regular maritime surveillance activities to supplement the capabilities of other tools. A significant number, 22 out of 26, expressed interest in availing EMSA's RPAS services in the future.

Overall, the survey's results offer insightful perspectives on the operational dynamics, challenges, and advantages of employing RPAS within the maritime sector.

Introduction

This survey aimed at gathering feedback from maritime authorities in the European Union (EU) and European free trade association (EFTA) that used in the past years Remotely Piloted Aircraft System (RPAS) services for maritime surveillance in the civil domain and pollution monitoring or are potential users of those services. In scope are RPAS services provided by EMSA or RPAS services directly contracted by the maritime authorities.

The objective of this survey is to enable EMSA and the maritime authorities to identify opportunities and potential improvements in the quality and effectiveness of the RPAS services. The conclusions of this survey will be reflected in a 2023 publication on Maritime Surveillance with RPAS (2017 - 2022).

Further information about EMSA RPAS services can be found here: Remotely Piloted Aircraft Systems Services (RPAS) - EMSA - European Maritime Safety Agency (europa.eu).

Survey answers

Organizations and their coast guard functions

In total, 26 maritime administrations from 18 countries, along with 3 EU Agencies or International organizations, participated in the survey. The survey received responses from 11 law enforcement authorities, 7 fisheries control authorities, 5 navies, 5 general maritime administrations, 2 customs authorities, and 4 other authorities categorized as 'other'. The following figure presents an overview of coast guard functions implemented by the respondent organizations.

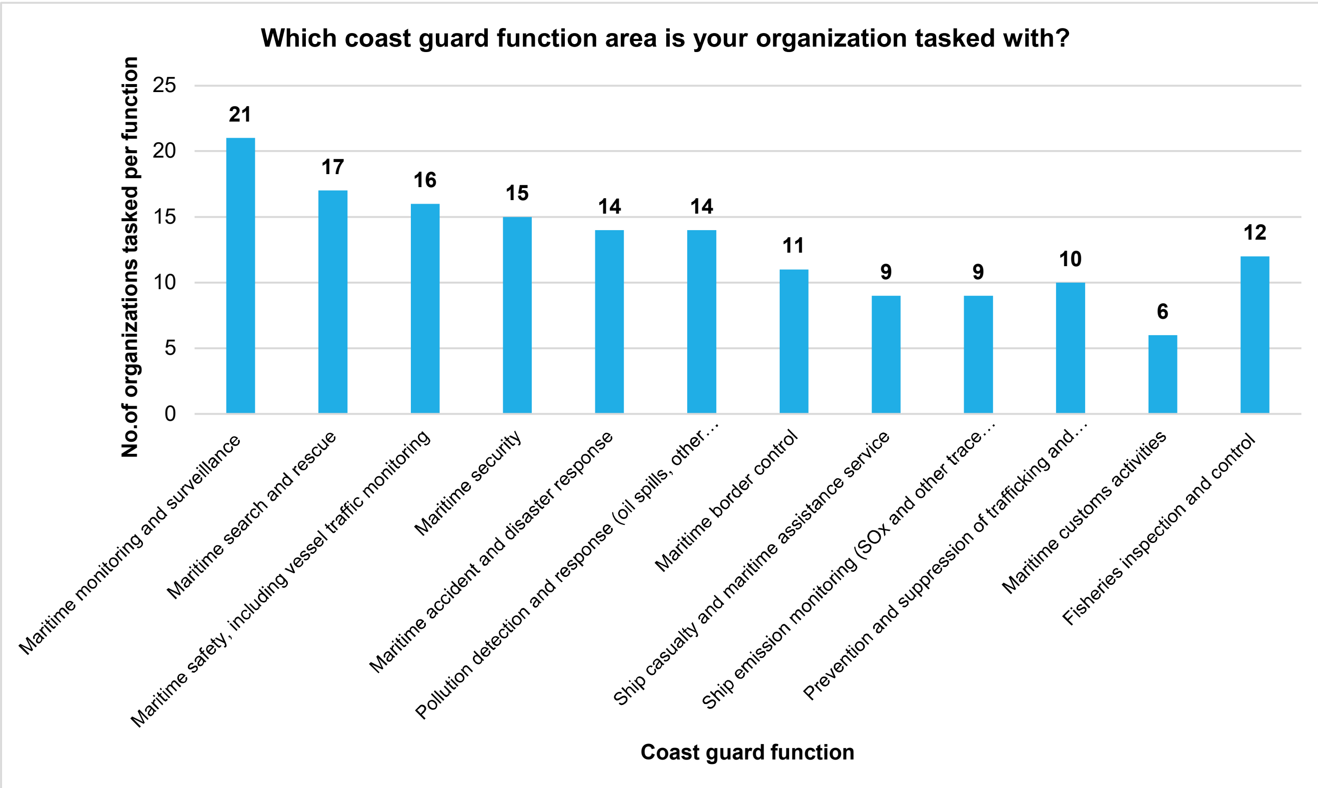

Figure 4.1– Coast Guard Function areas with which each organization is tasked (question 3).

Experience with RPAS for maritime surveillance

Previous experience

77% of the organizations that answered have previous experience with the use or coordination of RPAS services for civil maritime surveillance and pollution monitoring, either with EMSA RPAS services or their own contracted services.

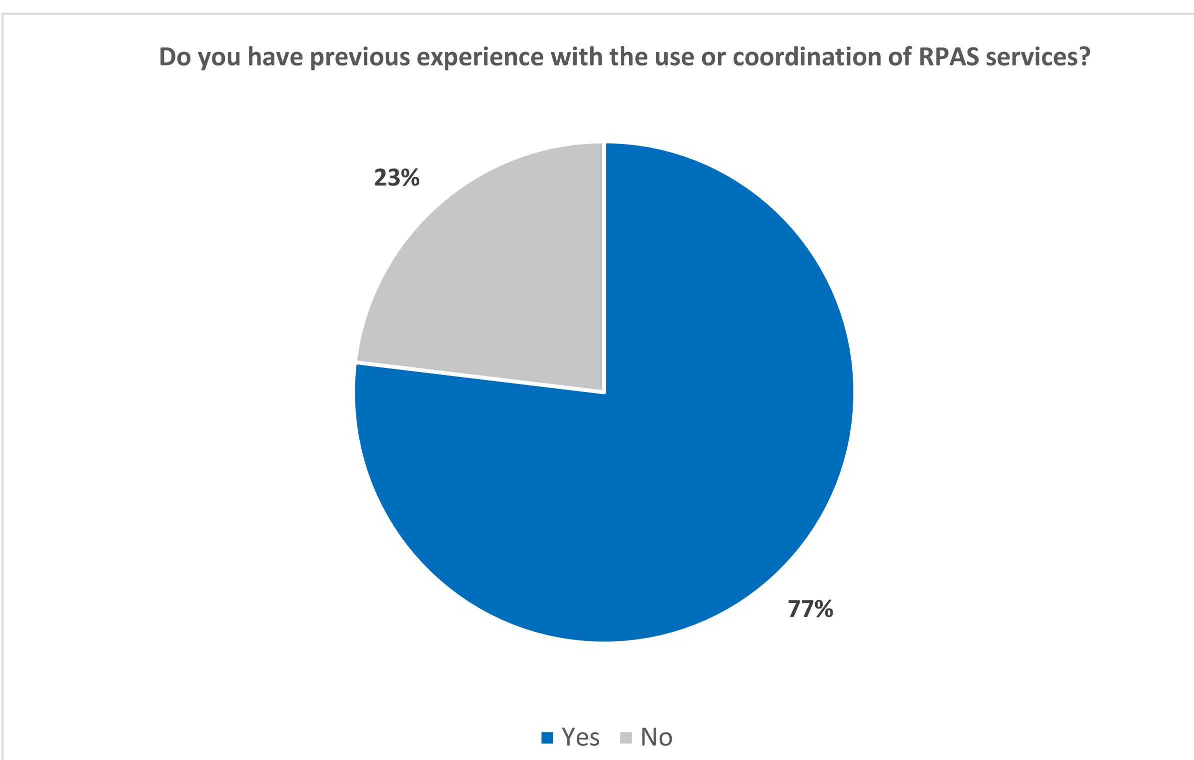

Figure 4.2 - Percentage of participants of the Survey that have experience with RPAS (question 4).

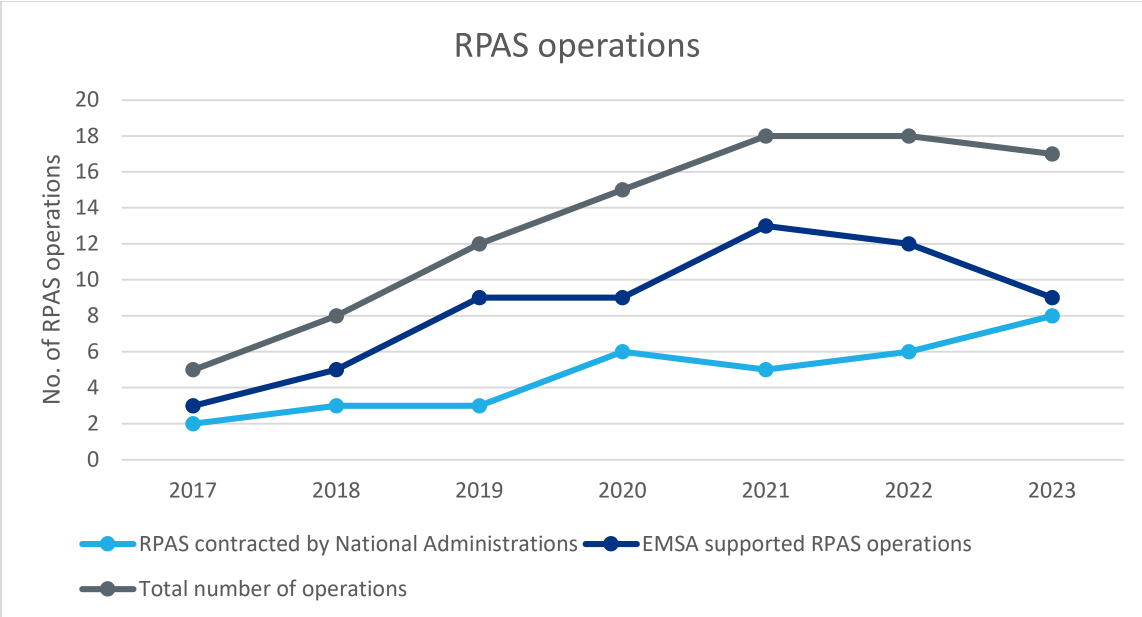

Figure 4.3 - Number of RPAS operations from 2017 to 2023 (question .4.3.2).

The figure above shows that a growing number of administrations experiencing the RPAS as a tool for maritime surveillance since 2017. The number of RPAS operations supported by EMSA were confirmed based on EMSA records, while the number of RPAS operations contracted directly by national coast guard authorities might even nor reflect the full extent of RPAS experience at EU level as it counted only those experiences reported by the respondents to the 2023 RPAS survey. Some local authorities in particular might have had other RPAS experience for maritime surveillance that were not shared with EMSA.

Some of the participants to the survey provided additional insight on their experience with RPAS:

- The **Danish** Fisheries Agency and the Royal Danish Navy Command have benefitted of the EMSA RPAS deployment in Denmark in 2022 and 2023. This western Baltic Operation was called INSIGHT22.
- The **Estonian** Police and Border Guard Board used EMSA RPAS services in 2021-2022 and 2023 and their own contracted RPAS service in 2022 in the East Baltic.
- **The Finnish** Border Guard used EMSA RPAS services from 2020 to 2023.
- **The French** Navy has used a Tekever AR5 RPAS provided by EMSA for operations in the Mediterranean Sea in 2020 and 2021.
- **The French** General Directorate of Maritime Affairs, Fishery and Aquaculture (DGAMPA) had, also with the support of EMSA, campaigns to monitor atmospheric emissions from ships using remotely piloted aircraft from the CROSS/ MRCC Gris-Nez and around the port of Marseille for the past 4 years. They underline the tendency to an increasingly marked multi-mission approach and easier use of segregated airspaces (night flights, activating flight zones, etc.). They conclude on a positive assessment with more than 1,500 ships measured since 2020, one ship subject of an infringement report and prosecuted by the Marseille prosecutor's office. The RPAS deployment for emissions monitoring was also an opportunity to use this asset for search and rescue missions in addition to other existing means, a major tactical gain in order to provide improved situational awareness in the (Channel) area. In 2022, the RPAS was engaged in 90 SAR events, involving 2934 people. The capacities used included the Camcopter S-100 (off the coast of Gris-Nez) and the Altus 4 (in the area around the Port of Marseille).
- An EMSA RPAS service campaign was carried out in Northern **Germany** in summer 2022 for the Federal Maritime and Hydrographic Agency.
- The **Icelandic** Coast Guard managed two RPAS deployments with EMSA support: In 2019 an EMSA RPAS service with the HERMES 900 fixed wing remotely piloted aircraft was deployed from land, and in 2022 the Schiebel S-100 system was deployed on board two of their patrol vessel platforms.
- **The Irish Coast Guard** has equipped 21 of their search and rescue Teams with DJI Matrice 30T Drones. The Coast Guard developed a bespoke SAR Mapping facility for use with their RPAS named DroneSAR. The Irish Coast Guard have worked with 2 Universities in Ireland to develop RPAS in the maritime surveillance area.
- The **Latvian** Coast Service participated to the RPAS operation in the Baltic in 2022 supported by EMSA.
- The Environmental Protection Department under the Ministry of Environment of the Republic of **Lithuania** is in 2023 using EMSA's provided RPAS service from the port of Klaipeda and also used EMSA's provided RPAS service in the spring of 2021.

- **The Netherlands** Coastguard has been working since a couple of years to obtain the permissions to use the EMSA RPAS service, as well as to acquire their own RPAS capacity (see chapter 3.3).
- **The Norwegian Coast Guard** has been using their own RPAS since 2016-2017 for Coast Guard Operations (see chapter 3.3)
- **The Romanian Border Police** used in 2021 and 2022 EMSA's RPAS services for Multipurpose Maritime Operation in the Black Sea, coordinated by Frontex Agency with the support of EMSA and EFCA as well as for the specific mission related to coast guard functions conducted in cooperation with other entities such as the **Romanian Naval Authority and National Agency for Fishery and Aquaculture**. EMSA provided to the Romanian Border Police the Lightweight RPAS service delivered on board of Romanian Offshore Patrol Vessel in 2020 extended to 2021.
- **The European Fisheries Control Agency (EFCA)** referred to the RPAS service received through EMSA on board of EFCA patrol chartered vessels since 2019.

Added value of RPAS for maritime surveillance

The survey evaluated the added value for RPAS regarding several use cases, in a scale from 1 (Not at all) to 5 (very much). The median of the evaluation of those domains is at 3,23 out of 5. Users considered that the RPAS have added value, in decreasing order of added value, for:

1) general multipurpose maritime monitoring and surveillance
2) maritime safety, including vessel traffic monitoring
3) maritime security
4) fisheries inspections and control,
5) pollution detection
6) search and rescue operations
7) maritime environmental protection and support to response operations.

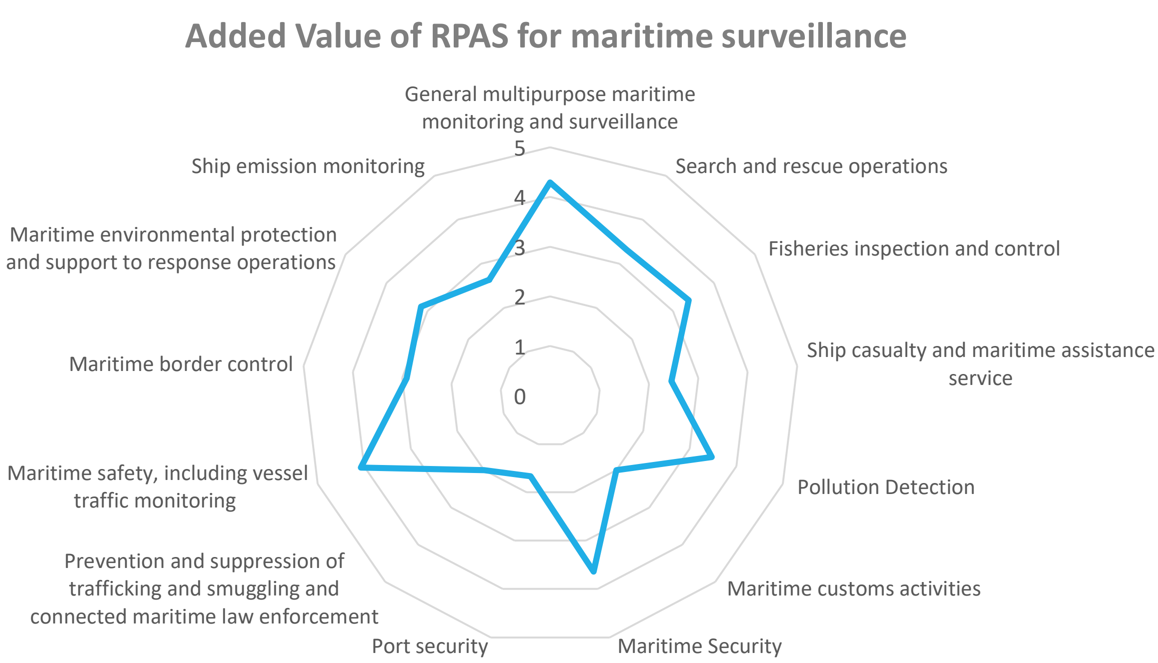

Figure 4.4 - Results regarding the average added value of RPAS for maritime surveillance in each domain (question 4.1).

Maritime administrations were invited to write suggestions to further improve the added value of the RPAS for maritime surveillance and pollution monitoring. Here is a summary of the recommendations and lessons learned shared by the maritime administrations regarding:

a) RPAS Safety framework and authorisations to fly

One participant that had tested the emissions monitoring system proposed enhancing RPAS reliability through the integration of a redundant system. To further improve the effectiveness of emission monitoring and streamline RPAS positioning within emissions plumes, there's a suggestion to simplify the procedures for receiving permits to fly and airspace allowance, requiring a more routine approach within competent airspace authorities when dealing with RPAS. Currently, this task demands highly skilled pilots, favourable wind conditions, and substantial time investment to ensure accurate measurements.

Another participant emphasized the ongoing need for exploring innovative solutions while concurrently offering supportive services to member states to address emerging challenges.

b) Airspace design and clearance

It was suggested to get more fly authorisations to fly in North Sea and Baltic Sea, with a focus on optimizing possibilities to fly RPAS in airport approaches through technologies like IFF (Electronic Identification Friend or Foe) air traffic control recognition systems.

A participant with experience in multipurpose operations presented a wish to gain in flexibility to use the RPAS deployment in search and rescue (SAR) operations without necessitating segregated zones. This approach could be anchored within a regional framework. They also proposed regulatory and administrative adjustments to facilitate the integration of these innovative capabilities into the European coast guard function.

In another case it was suggested direct coordination of flight alterations, as opposed to relying solely on NOTAM publications, was recommended to increase operational flexibility.

c) Emissions monitoring operations and pollution monitoring

Participants suggested coordinating RPAS flights with the EMSA CleanSeaNet satellite service to enhance pollution detection accuracy on-site.

Users of RPAS for emissions monitoring in port areas presented the recommendation to equip the RPAS with additional emissions sensors to measure substances such as CO2, NOx, and particulate matter. This suggestion was prompted by the ongoing transformation of ports into sustainable entities, necessitating precise emissions assessments for ships berthed within ports. Such assessments entail comparing emissions data when ships are powered conventionally versus when they are connected to onshore electricity supplies.

They also proposed to work with RPAS towards targeting of non-compliance with the NOx regulations.

Other recommendations include utilizing RPAS to address environmental concerns through mapping oil field dispersal post-sea or coastline spills and delivering targeted dispersants to oil spill windrows. In addition, RPAS could significantly enhance maritime casualty responses by providing real-time monitoring during ship emergencies, aiding in tracking casualties and managing hazardous incidents like fires onboard vessels.

d) Operations on board vessels and fisheries

Users of RPAS on patrol vessels advised prioritizing the improvement of RPAS endurance for operations from vessels, expanding its operational range, and refining its capacity to track the velocity and trajectory of target vessels.

Participants also highlighted the significance of RPAS reconnaissance during boarding operations and suggests leveraging RPAS for real-time oversight of boarding operations on mother vessels and monitoring catch activities on fishing vessels, contributing to effective fisheries management.

Some recommended enhancing the optical capabilities of cameras utilized in Fisheries Inspection, particularly for the purpose of detecting illegal fish discards through improved video and still image recording.

e) Regional and cross sectorial cooperation

Representatives of national authorities advocated for further identifying collaborative approaches at various levels to foster synergies between coast guard operational centres, facilitated by the exchange of pertinent information through the existing CISE service.

In some regions it was proposed further collaboration between military and civilian sea operations, such as exercises like BALEX DELTA, to optimize flight outcomes.

Challenges in using RPAS

One of the key aspects explored in the survey was the challenges faced by users of RPAS services. The respondents highlighted several key difficulties they encountered. These included obtaining authorization to fly RPAS, securing appropriate airspace, ensuring suitable internet connectivity at deployment sites, and establishing effective coordination procedures among all airspace users at the national and regional levels. These findings help identify areas where improvements and support are needed to enhance the utilization of RPAS technologies.

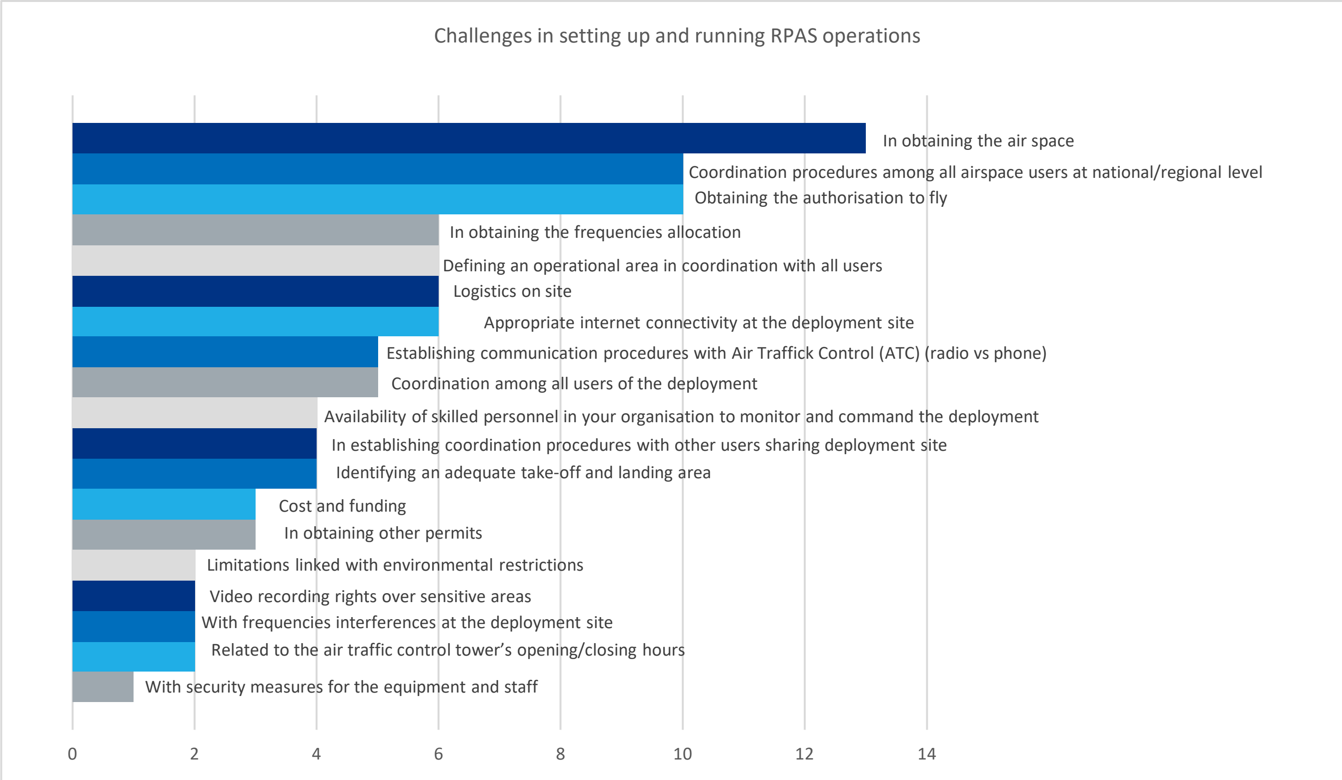

Figure 4.5 - Challenges in setting up and running RPAS operations (question 4.2). The numbers represent how many organizations chose each option.

The survey explored if the users had encountered difficulties linked with the subjects presented in the figure 5 above that presents the areas more frequently quoted as difficult in the setting up of an RPAS operation for maritime surveillance.

According to the results the main difficulties experienced were linked with:

- Obtaining the air space;
- Coordination procedures among all airspace users at national/regional level;
- Obtaining the permits to fly.

This shows that in spite of progress in the harmonization of the EU Safety framework for RPAS flights, the actors (Civil aviation authorities, air traffic control authorities and RPAS operators) still need lengthy processes to agree on a safe operational set-up.

RPAS services contracted directly by the maritime organizations

Out of 26 Agencies and Countries, 11 have directly contracted their own RPAS Services.

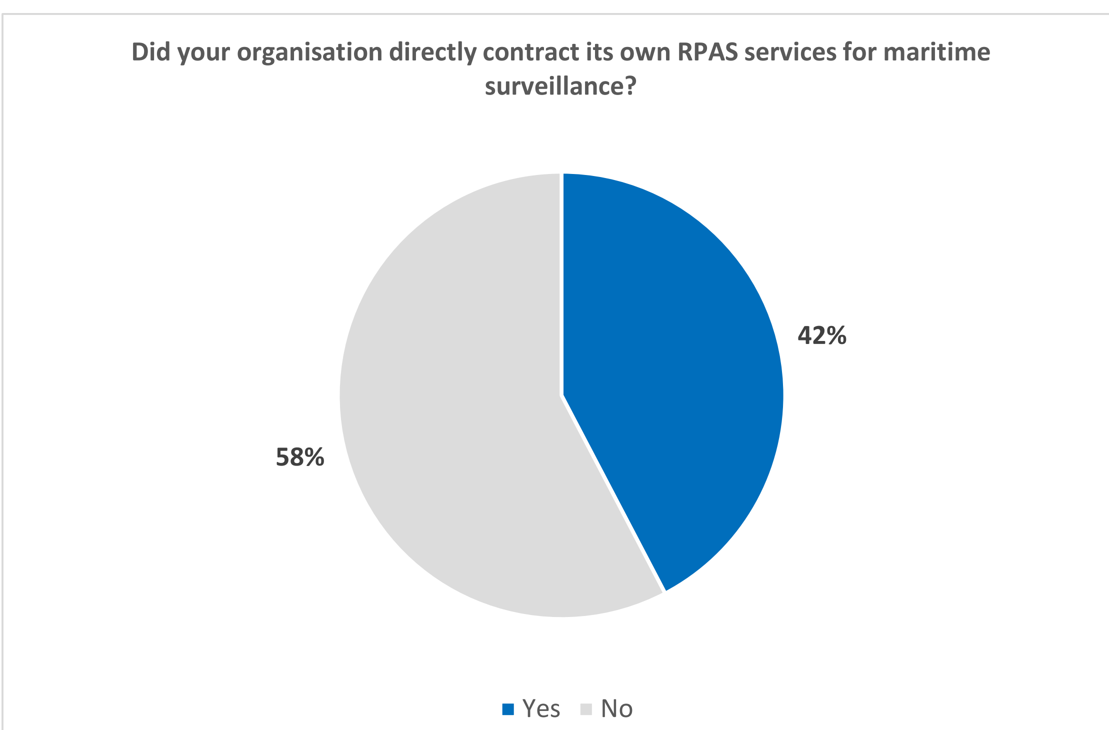

Figure 4.6- Percentage of participants of the Survey that have used their own RPAS (question 4.3).

The utilization of their own RPAS services among various maritime entities highlights a diverse range of applications and operational approaches when contracting their own RPAS:

- **Croatia's** engagement with RPAS services for concept testing in 2020 and 2018 lasted less than a year, employing Large Scale Medium Size VTOL helicopters from airports.
- The Shipping Deputy Ministry of **Cyprus**, since 2020, has been utilizing Medium Size Fixed Wing RPAS for operational tasks within operations lasting less than a year, launched from land.
- The **Estonian** Police and Border Guard Board has adopted Medium Size Fixed Wing RPAS for permanent operational services starting in 2023, taking off from land.
- The **Finnish** Border Guard embraced RPAS since 2020, utilizing Medium Size Fixed Wing drones and Medium Size VTOL helicopters from both land and vessels for operational tasks within the same duration.
- The **French** Navy engaged RPAS services for both test and operational purposes in 2012 and 2020, employing Large Scale and Medium Altitude Long Endurance (MALE) drones, as well as Medium Size Vertical Take-Off and Landing (VTOL) helicopters, launched from airports and vessels.
- The **Irish Coast Guard** employed a Light Quadcopter for operational services before 2017, with multiple take-off and landing sites necessitated by search and rescue missions.
- The **Italian** Coast Guard utilized Medium Size Fixed Wing RPAS for operational tasks in 2012 and 2022, each deployment lasting less than six months and launched from airports.
- The **Netherlands** Coastguard adopted RPAS services in 2023 and 2021, utilizing a Light Quadcopter launched from a vessel to validate concepts and conduct operations within a month's timeframe.
- The **Spanish** Maritime Search and Rescue agency incorporated RPAS into operational frameworks in 2023 and 2019, employing Medium Size VTOL helicopters and Light Quadcopters from vessels, each deployment lasting less than three months.
- The **Norwegian** Coast Guard has maintained permanent RPAS operational services since 2017, relying on Light Quadcopters launched from both land and vessels for surveillance across a fleet of vessels of 47 meters and larger.
- **Frontex**, since 2018, has incorporated Large Scale MALE drones for operational purposes in operations lasting under a year, taking off from airports.

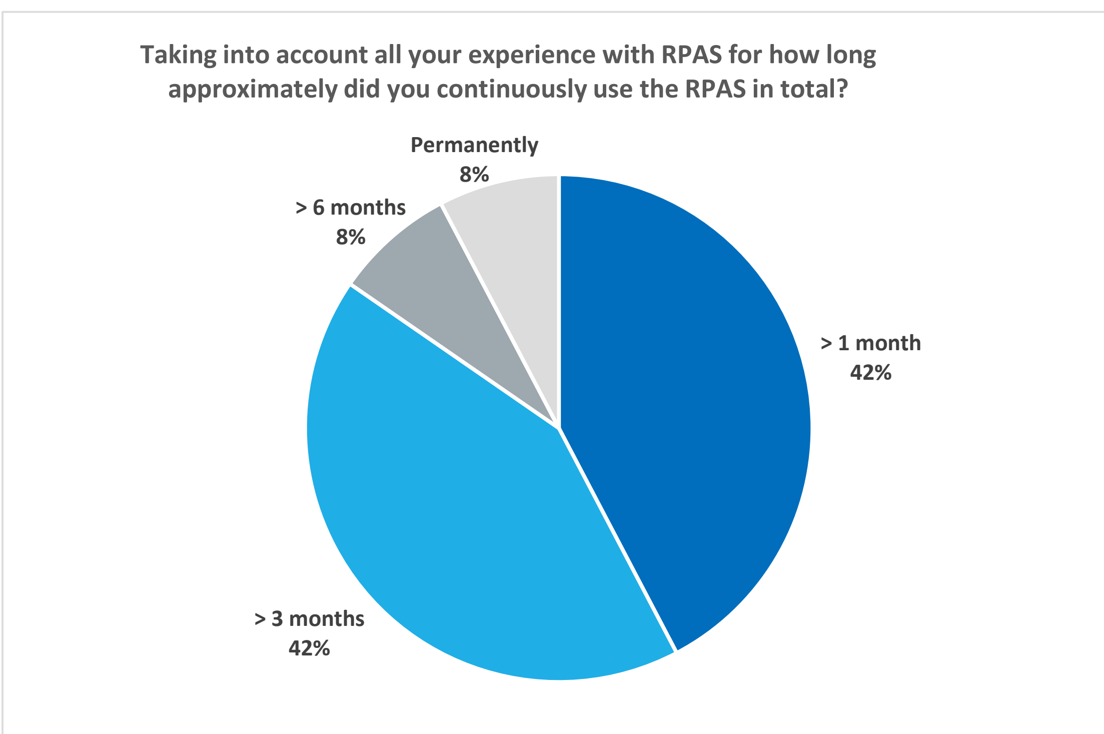

Figure 4.7- Duration of RPAS operations (question 4.3.3).

The graphic above shows that only a limited number of administrations (16%) of the respondents have an experience of using RPAS continuously for more than 6 months, and hence, fully integrating this tool into their Maritime Surveillance procedures. It should also be emphasised that Norway and Estonia considered to have a permanent use of these devices.

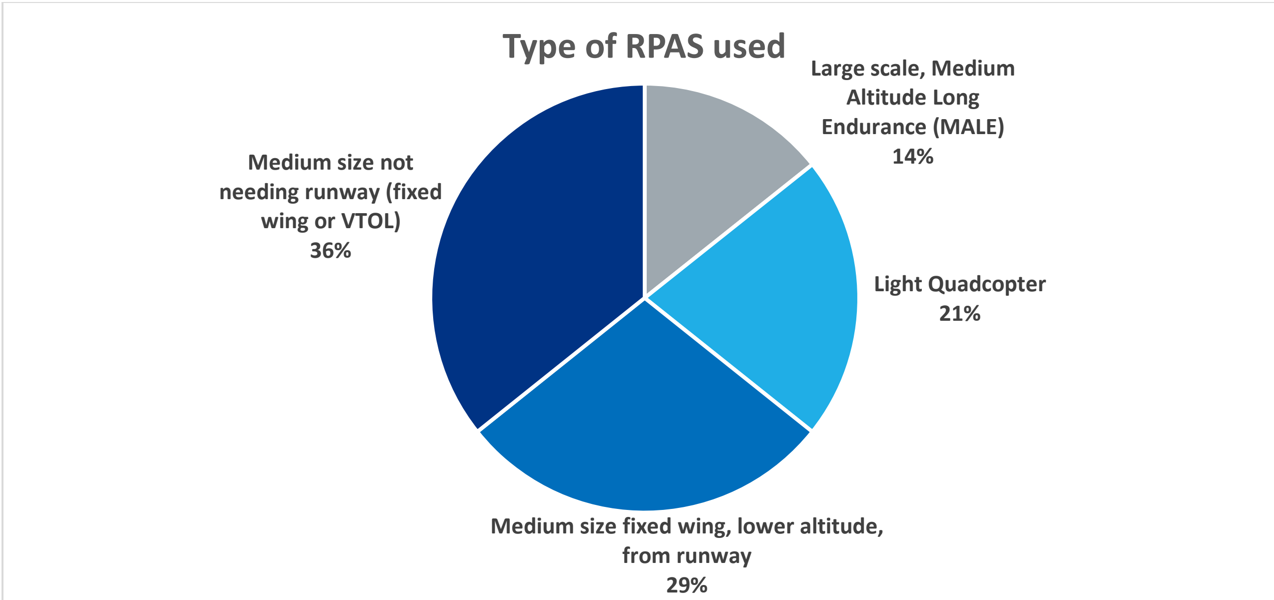

Figure 4.8 - Type of RPAS used in operations (4.3.4).

The RPAS used for maritime surveillance are of a variety of types, mainly medium size but also light weight, and either with take-off and landing systems with a small footprint or needing a runway.

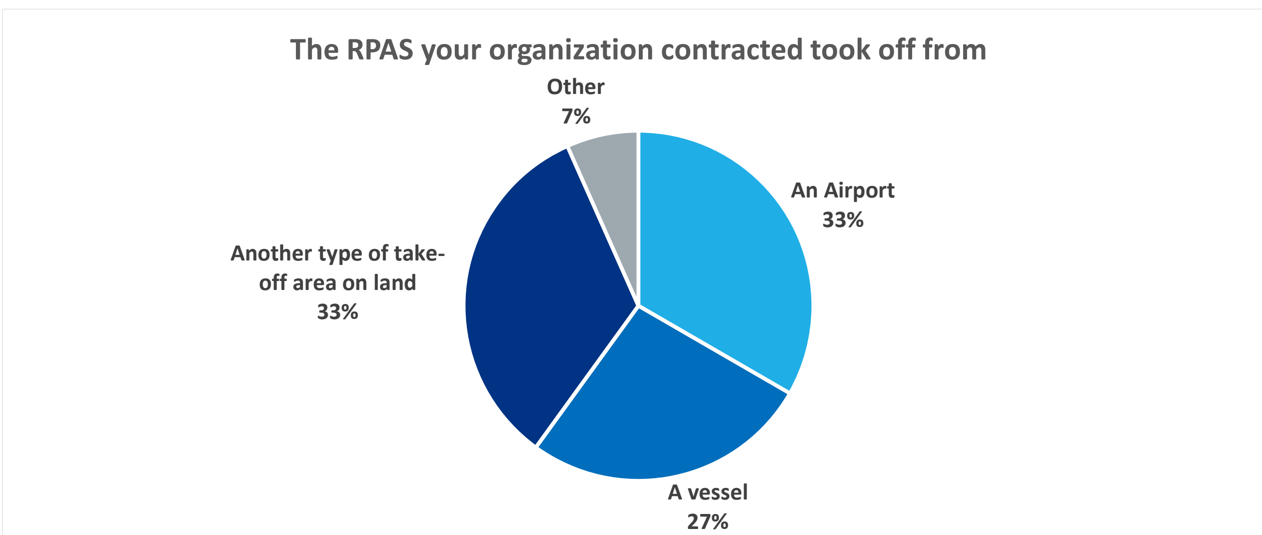

Figure 4.9 - Location where the RPAS took off from (question 4.3.5).

A variety of take-off and landing areas was also used: airports, vessels, secured areas on land far from airport traffic.

EMSA RPAS Services

Out of 26 organizations that answered the survey, 17 have used EMSA RPAS Services.

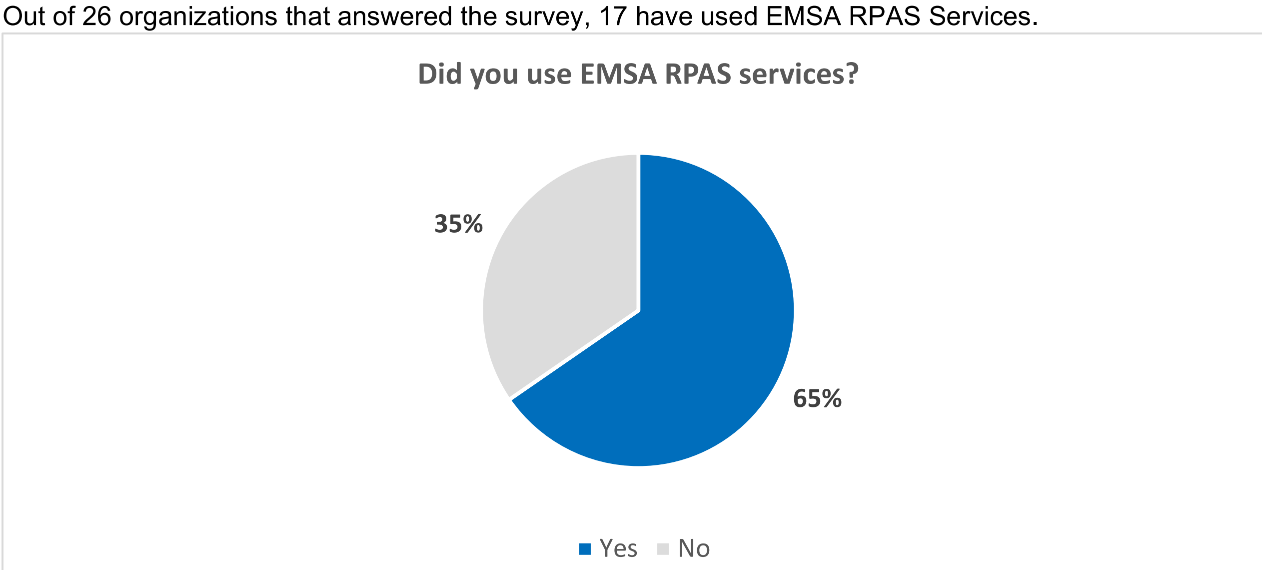

Figure 4.10 - Percentage of participants of the Survey that have experience with EMSA RPAS services (question 4.4).

From the drafted responses it appears that EMSA's comprehensive support has been instrumental in establishing and maintaining the RPAS for maritime surveillance across diverse areas: from defining service requirements and service models to managing procurement processes and financing through EU funds. Facilitating operational setups, including authorization acquisition, and consistently monitoring service quality by RPAS operators have ensured optimal performance. EMSA's provision of near real-time integrated Maritime pictures, coupled with the inclusion of RPAS data streams through the RPAS Data Centre and satellite communications for data transmission, has elevated operational efficiency. Participation in EMSA RPAS regional operations has fostered knowledge exchange and enhanced collaboration within the maritime domain.

The following figure presents the support provided by EMSA that was mostly appreciated:

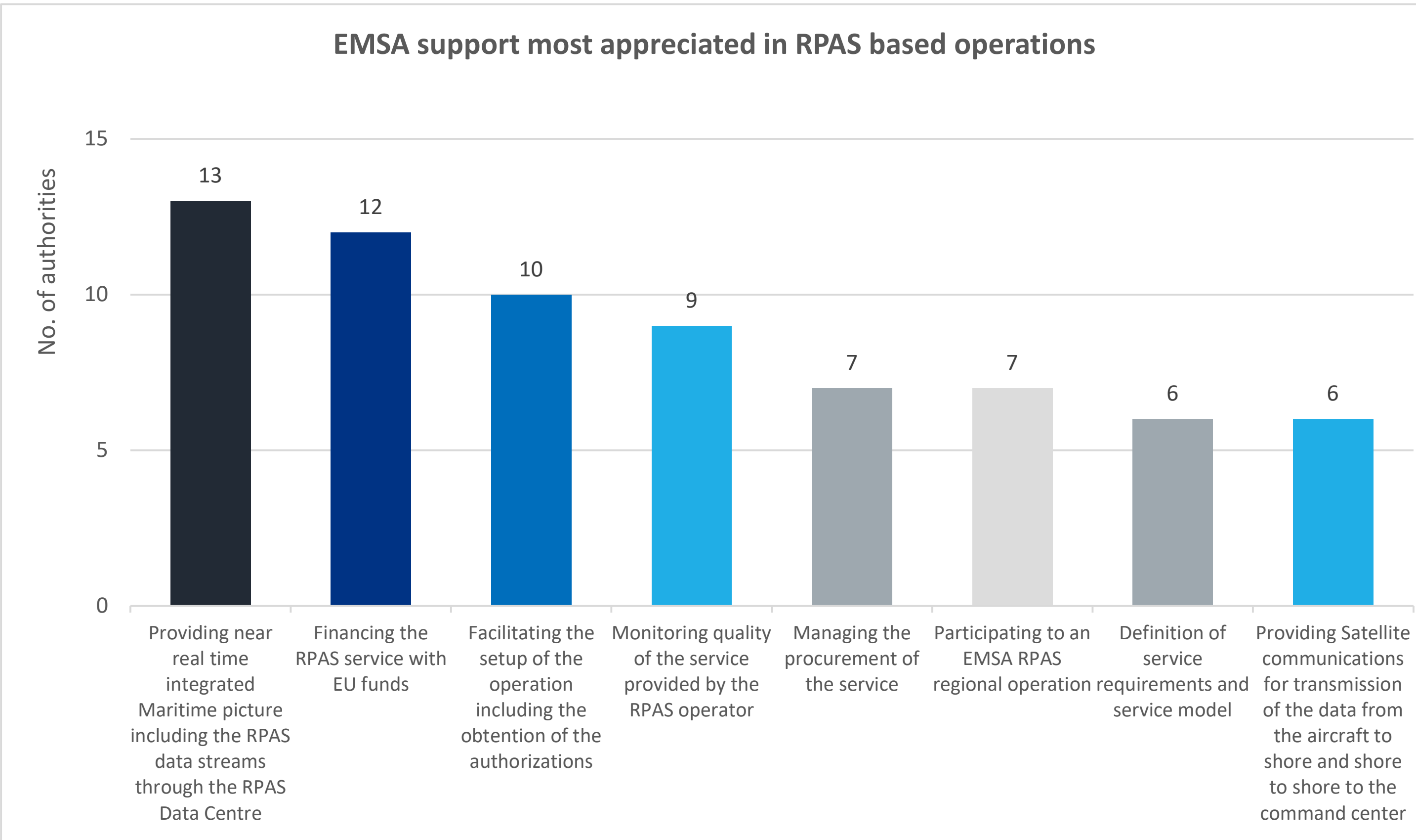

Figure 4.11- Most appreciated support in EMSA RPAS operations (question 4.5.1).

Additionally, for those who had utilized EMSA RPAS services, we assessed the quality of the service provided, in a scale from 1 (Not at all) to 5 (very much). The median of the evaluation of the quality of the services provided is at 4,2 out of 5. For users the EMSA RPAS service were mainly appreciated in terms of RPAS service provider ("professional, responsive, and prepared service"), the training of the user the staff provided and the overall role of EMSA within the operation.

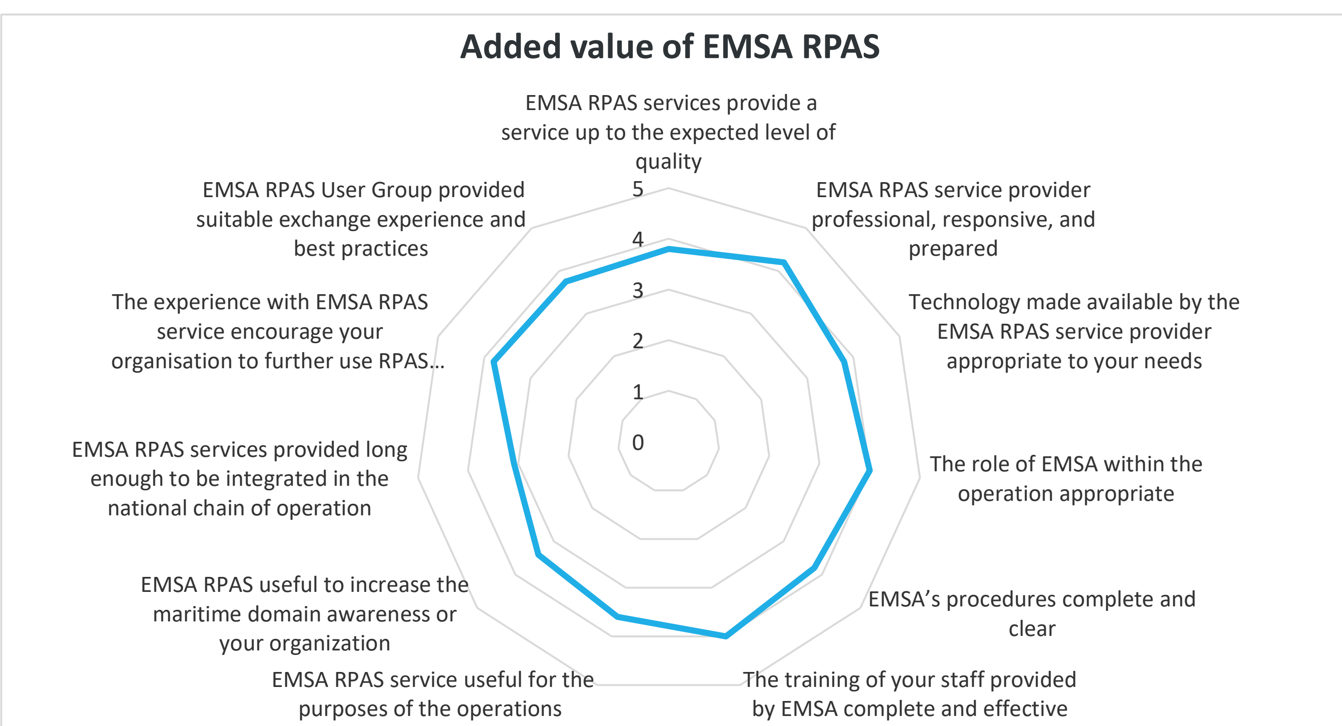

Figure 4.12 - Results regarding the average added value of EMSA RPAS services in each domain (question 4.5).

Regarding the EMSA RPAS Data Centre, overall satisfaction with the service is at 4 for all the topics (out of 5 points for the maximum “very much”),

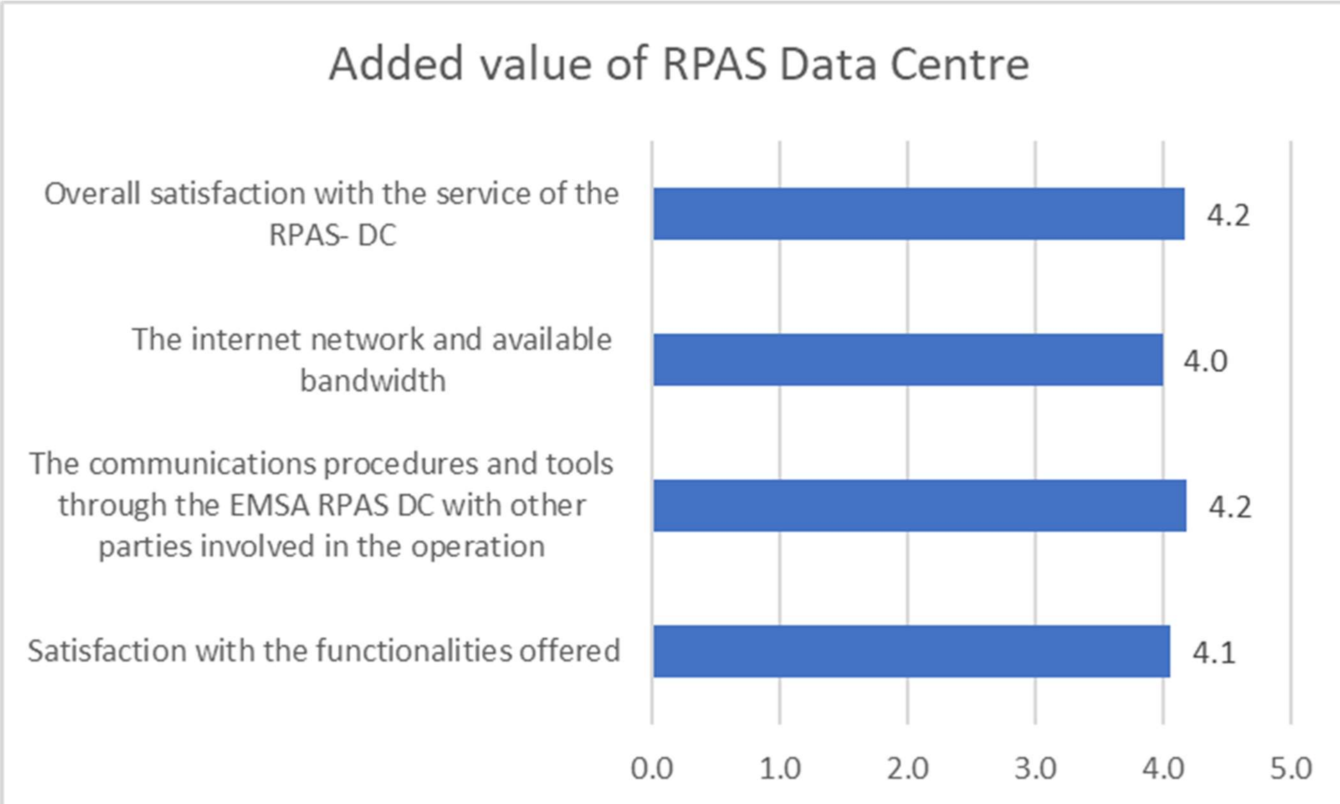

Figure 4.13 - Results regarding the average added value of EMSA RPAS Data Centre in each domain (question 4.6).

Future perspectives for use of RPAS for Maritime Surveillance

Out of 26 Countries and Agencies that participated in the survey, 25 answered that their organizations intend to use RPAS based services for maritime surveillance and pollution monitoring in the civil domain, and also would be interested in using the EMSA RPAS services in the coming years. 23 are interested in vessel based RPAS services and 22 would be interested in using EMSA RPAS services in the context of regional cooperation with organizations in other neighbouring countries.

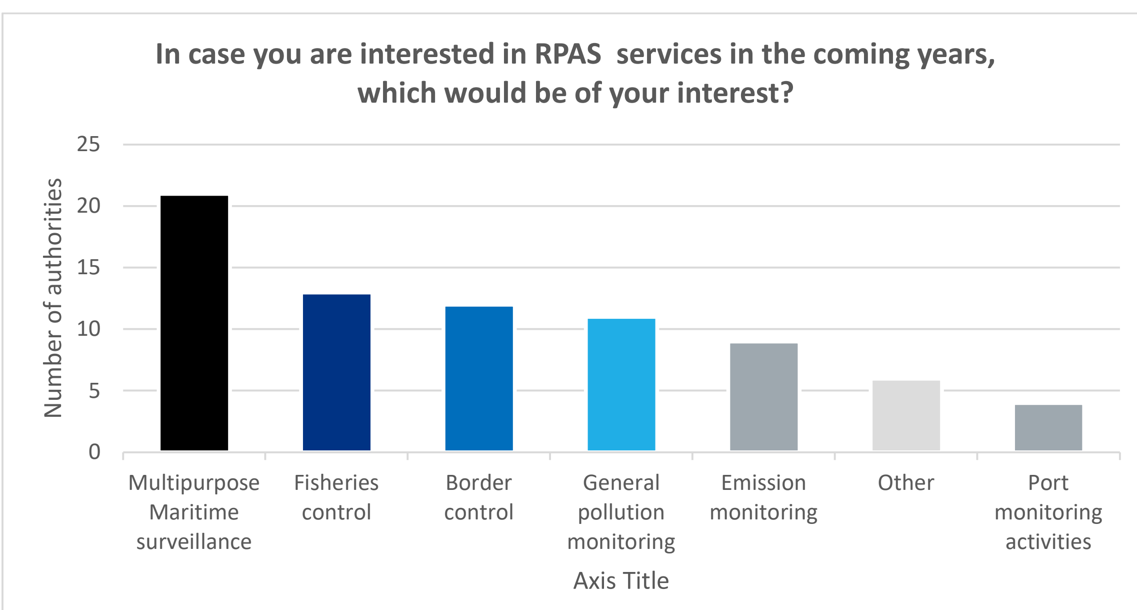

Figure 4.14 - Interest in RPAS services in the coming years (question 7.1).

When users where asked if they would be interested in using EMSA RPAS services in the context of regional cooperation with organizations in the neighbouring countries, the following potential cooperation were mentioned:

Table 1.15: List of countries and organizations that confirmed an interest in working with neighbouring countries (question 8).

Iceland	Iceland's closest neighbours are Greenland and Faroe Islands who unfortunately are not eligible to receive EMSA services. If in far future services would be provided on the high seas, a regional cooperation with Norway could be of interest.
Ireland	MCA, France, Spain.
Finland	Estonia, Latvia, Sweden.
Estonia	Neighbour countries law enforcement. Finland, Latvia.
Latvia	Finland - Finnish Border Guard (JRCC Turku), Estonia - Estonian Navy/Police and Border Guard Board (JRCC Tallinn), Lithuania - Lithuanian Navy (MRCC Klaipeda) and Sweden - Swedish Coast Guard (JRCC Gothenburg).
Lithuania	Latvia
Germany	Netherlands, Denmark (Emissions monitoring).
Denmark	All the Baltic Member States.
The Netherlands	Belgium: MIK and MRCC, Germany: MRCC Bremen, UK: HM Coastguard.
Belgium	France and Netherlands.
France	Italy, Spain. Bonn agreement and contracting parties.
Portugal	Spain, specifically Guardia Civil (general Law enforcement and Costal Control).
Italy	At the moment our organization is still evaluating the use of the RPAS service for the next few years.
Romania	Bulgaria, if the interest will be raised by any entities responsible for maritime domain.
EFCA	In all EU maritime areas pending fisheries interest and cooperation - pending resources available.
EU NAVFOR ATALANTA	UNOCD
Frontex	Third Countries which have a Status Agreement with Frontex.

TABLE OF FIGURES