D5.3 REPORT ON FIELD TRIALS AND LESSONS LEARNT

SUMMARY REPORT

WP 5: Studies for the integrated response to pollution accidents: the use of UAS (Unmanned Aircraft System) in emergency response

Task 5.3 and 5.4: Organisation and development of field trial(s)

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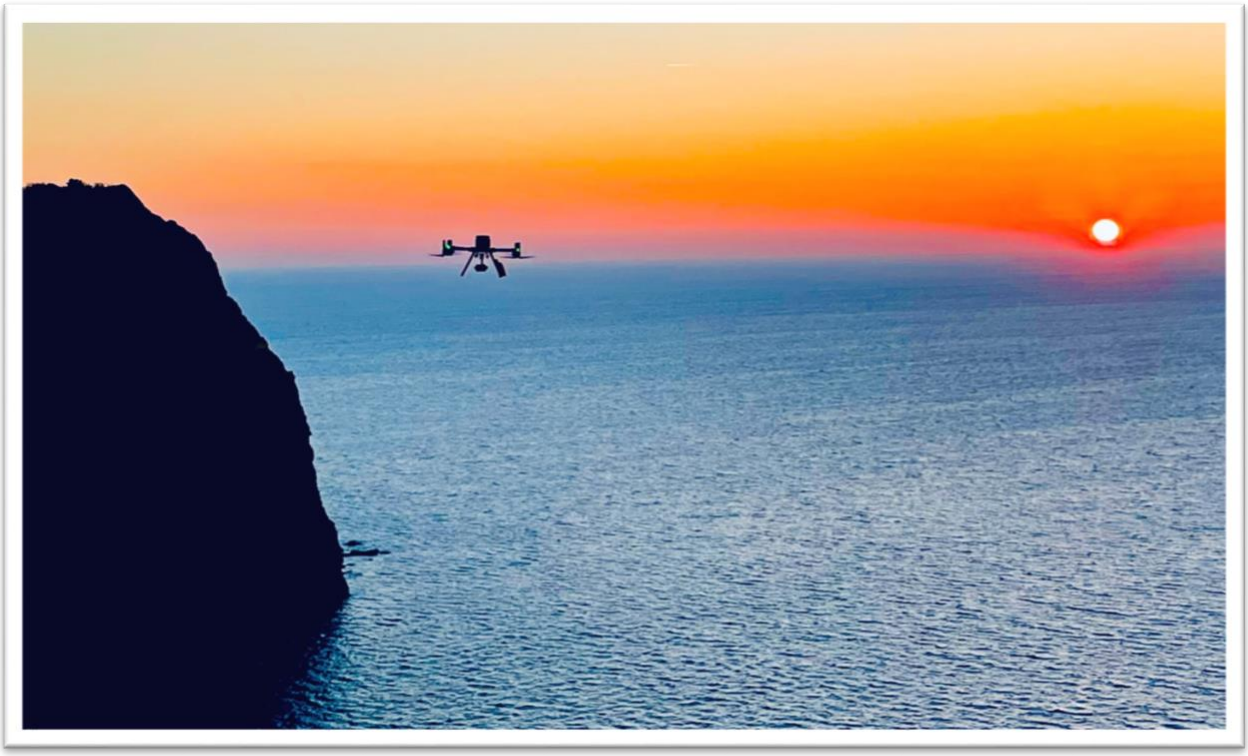

ROYAUME DU MAROC

Ministère de l'Energie, des

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IRA-MAR project – improving the Integrated Response to pollution Accident at sea and chemical risk in port

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D5.3 Report on field trials and lessons learnt

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INTRODUCTION

Note: this report is addressed to all terrestrial and maritime authorities that may be involved in an emergency at sea. In particular, it targets at institutions that have teams, within their organization, specialising in the use of drones in environmental emergencies, such as:

- European Civil Protection Services;
- Maritime Authorities;
- Port Authorities;
- Private entities as oil and gas companies and contractors operating offshore

While the frequency of emblematic maritime incidents in Europe has fallen sharply, maritime transport is undergoing many changes that are altering the associated risk profiles. New concerns are emerging in the face of increasing maritime traffic and larger ships, new cargoes, innovative propulsion systems with new proper�es, the development of offshore wind farms, and meteorological risks reflecting the consequences of global warming. These changing risk profiles require us to adapt our emergency preparedness, both in terms of capacity and methodology.

In addition, the most recent marine pollution preparedness and response exercises organised at national or regional level (RAMOGEPOL 23) have shown the importance of better coordinating the actions of the various response services, strengthening the land-sea interface in maritime emergency response and identifying new port risks.

The IRA-MAR project "Improving the Integrated Response to Pollution Accidents at Sea and Chemical Risks in Ports" addresses these concerns by seeking to improve the preparedness of Western Mediterranean countries for marine pollution incidents through an integrated approach to response at sea, on the coast and in ports.

Co-funded by the European Civil Protection Mechanism, it aims to:

- increase knowledge of the risks associated with the trafficking of chemical products in ports;
- improve marine pollution detection systems and methods; and
- propose a new holistic and integrated management of emergency response and strengthen the land-sea interface.

Designed to support the beneficiary countries (Spain, France, Italy, Malta, Morocco, Portugal and Tunisia), and benefiting from the international expertise of the project partners (CEDRE, ISPRA and Sea Alarm Foundation), this project presents results that are relevant and useful for all European countries and those of the Mediterranean basin.

It thus contributes to the initiatives and tools facilitating regional cooperation to improve maritime safety and prevent pollution (Bonn Agreement, Ramoge, OSPAR, WestMED initiative) and their respective Action Plans such as the Mediterranean Strategy for the prevention, preparedness and response to marine pollution from ships.

WP 5: the use of UAS (Unmanned Aircraft System) in emergency response

One objective of the project is to test the use of Unmanned Aircraft System (UAS) to improve monitoring, detection and response capabilities to various pollutants. New technologies such as drones have enormous potential to improve the response to maritime emergencies involving the spillage of oil or other chemicals. These new technologies make it possible to improve the effectiveness of the response by more rapidly acquiring the information needed to understand an event and its extent, to have better quality information, and to rapidly define the best response strategies. That's why it's important to understand how they perform in the varied uses and situations presented by maritime emergencies.

ISPRA is leading the activities of WP5, which focuses on the studies for the integrated response to pollution accidents, precisely: the use of UAS (Unmanned Aircraft System) in emergency response.

The different sub-tasks of WP5 are:

- Action 5.1: Research on Best Available Technologies (BAT) for shoreline use.
- Action 5.2: Identification of experiences, current good practices and needs of Civil Protection in the use of drones on the shoreline.
- Actions 5.3 and 5.4: Organisation and development of field trials.
- Action 5.5: Production of the technical guide “Best Available Technologies for the use of drones to carry out surveys in emergency response”

These tasks resulted in three deliverables:

⇒ The first one: Preliminary bibliographic research on the Best Available Technologies for the use of drones in maritime emergency response surveys;

⇒ The second one: Analysis and synthesis of the survey “Current equipment, practice, needs and experiences in terms of use of drones in coastal/marine pollution response”.

⇒ The third one: “Report on field trials and lessons learnt” refer about the two field trials, that have been conducted to test various types of drones and sensors. The first series of tests have taken place from the 26th to the 30th of June in the Cedre basins in France. The second trial held in Italy, on the Island of Ventotene from the 1st to the 6th of October

The deliverables are available on the IRA-MAR website (LINK)

The realisation of the two trials made it possible to verify the feasibility of using drones as innovative tools also aimed at improving the holistic and integrated approach to dealing with an environmental emergency at sea. The document discusses the best setups to apply, the advantages of using them and the challanges that need to be addressed.

The information achieved with the three deriverables will be used to produce other two deliverables:

- “Tutorial on the use of UAS to carry out surveys in emergency response” – deliverable 5.4
- technical guide on “Best Available Technologies for the use of drones to carry out surveys in emergency response” – deliverable 5.5

This Summary Report synthesises the findings of the Report on field trials and lessons learnt” and presents the tests conducted in Brest (Part 1) and their main findings, then the test conducted in Ventotene (Part 2). This Summary Report concludes by providing some recommendations on the use of drones (Part 3).

1. FIRST TRIAL CEDRE BASIN, JUNE 2023 - EXPERIMENTATION ON SENSORS AND OTHER PAYLOADS MOUNTED ON UAS

1.1. Objective and organisation of the 1st trial

The main objective was to test the use of Unmanned Aircraft System (UAS) and sensors to improve the monitoring, detection and response capabilities to various pollutants in marine pollution incidents.

To this end, field tests were carried out using multi-copter Unmanned Aircraft Systems (UAS) in the Cedre artificial basin with the release of real pollutants (oil, chemicals, and plastic pellets). A significant proportion of the experiments were carried out in the 3,500 m² of water in the artificial pool. Chemicals used in the tests were placed in floating wooden frames. Tanks used to release volatile Hazardous and Noxious Substances (HNS) to analyse pollutants in the atmosphere using a "sniffer" were positioned close to the outdoor test tank.

For one week, drone pilots from French and Italian fire brigades and a private company operated different types of commercial multi-copter UAS. These participants used different types of multi-copter UAS to assess their flight capabilities and payload sensors, such as an optical camera, to capture images at different times of the day. Various additional equipment was mounted and tested on the drones, such as remote sensors (RGB, thermal IR), in-situ sensors (explosives, gas sensor) or chemical-specific test strips. Thanks to different flight configurations, such as distance, altitude or observation angle, optimal conditions for relevant observations have been defined for each type of pollutant.

In addition, a portable sampling device, designed and mounted on a platform by the Brittany Fire Brigade prior to the start of the IRA-MAR project, was used. The whole system is light enough to be lifted by a UAS.

Drones have been tested to perform essential tasks in an environmental emergency at sea: sampling and detection, observation of floating pollutants, tracking of drifting pollutants, and surveying of flora and fauna.

A series of tests were successfully carried out to verify the ability of the UAS to fly with the sampling platform, land it on the surface water, take samples at different depths using a peristaltic pump and return the contaminated water for further analysis. Compatibility and resistance of materials were also tested in the field, particularly with aggressive contaminants.

Prior to take-off, during the field trials, the UAS pilots were briefed on the survey mission to be performed under operational conditions. In order to reflect the reality of an incident, incomplete information was provided, and the pilots had to conduct a full survey to obtain the required data. To complete the integrated approach, the observations made by the UAS were transmitted in real time and reported via the CRIMSON GIS[1] tool used by the French Civil Protection and displayed in the on-site crisis room.

[1] CRIMSON GIS is a geoportal where data trasmitted in real time are processed.

1.2. Main results and lessons learnt from the CEDRE tests

During the trial conducted in the CEDRE artificial basin, the following main tasks were carried out:

- observation of floating pollutants;
- tracking floating pollutants drifting;
- fauna and flora surveys.
- sampling and detection in water and in atmosphere;

Thanks to different flight configurations, such as distance, altitude or observation angle, optimal conditions for relevant observations have been defined for each type of pollutant. The trial give the opportunity, also, to determine the best viewing zenith angle and relative azimuth angles to observe and characterise the type of pollutant, with respect to the relative position of sun and the solar glare effect on the water surface.

Tests were carried out in the presence of both scientists, including experts in aerial observation of pollution, and high-level technicians who pilot drones. The interesting conclusion is that **both expertise is needed in case of accidental spillage**.

The performance of the various tests has demonstrated that unmanned aircraft systems (UAS) can be a **valuable tool to carry out certain operations effectively and quickly, like**:

a) **Drones are able of tracking the drift of a pollutant slick**; it is possible to calculate the speed and direction of movement of a pollution plume in the sea. The time needed to carry out these measurements is only a few minutes and the accuracy of the measurements is very high, thanks to the help of some software such as CRIMSON.
b) The possibility of **using drones to observe and monitor the state of marine organisms during an oil spill at sea** is an important added value compared to "classical" observation methods, in particular because 1) the monitored area can be very large; 2) the quality of the images obtained is very high.
c) Various devices equipped drones and offered the **possibility to carry out sampling of water**, at the surface or at different depths in the water column, as well as of air.

The testing and validation of these technical capabilities is essential to demonstrate the possibility of **obtaining essential information for both operational and scientific purposes**. Indeed, in the context of a real HNS spill, verifying the presence of HNS in the environment, identifying the nature of the pollutant in the case of an unknown chemical, or quantifying whether it is present in the water or in atmosphere, can provide **essential information for decision-makers**.

Furthermore, water and atmosphere monitoring and sampling using drones allows to **minimise risks for operators when activities are carried out in dangerous areas**.

The implementation of a monitoring network can be operational very quickly. For example, three zones can be defined:

- ⇒ Exclusion zone
- ⇒ Possible containment zone
- ⇒ Support zone

Once these zones have been set up, the drone can carry out control measurements.

2. SECOND TRIAL ON VENTOTENE ISLAND (ITALY) – 1-6 OCTOBER 2023

2.1. Objective of the 2nd trial and characteristics of Ventotene island

The second field test, foreseen by WP5.3 of the IRA-MAR project, took place in Ventotene from 1 to 6 October 2023, with the main objective of testing the flight of drones, provided by the Italian Fire Brigades, in different and hypothetical oil spill/HNS scenarios affecting marine and coastal areas, including wildlife (seabirds). In particular. The main objectives of this second experiment are

1. Test the use of drones in different possible scenarios that are more likely to occur during a marine environmental emergency. For example, detecting and tracking oil slicks; guiding recovery vessels to slicks; inspecting remote areas; the Shoreline Monitoring and Assessment Technique - SCAT[2]; monitoring wildlife populations.
2. Review national (Italian) procedures and policies for the authorisation and use of drones at sea.
3. Assess the benefits and challenges of using drones in the field to assist the authorities responsible for coordinating the response to an oil or HNS spill.

The project partners, the Italian and Breton fire brigades and the local institutions participated in a very effective collaboration.

Ventotene is a small island in the Pontine Archipelago. The Municipality of Ventotene island also includes the nearby island of Santo Stefano. Both islands are protected.

[2] Survey of polluted coasts following procedures internationally approuved.

The main island (Ventotene) has an area of about 1.7 km^2. The coastline is about 10 km long, including the coast of the nearby island of Santo Stefano. It is characterised by cliffs, promontories, and large tongues of black basalt in the sea. These features are the result of the retreat of the coastline due to the lack of erosion of the basalt that forms the island's base and, conversely, the excessive erosion of the tuff, the lack of watercourses and the low rainfall.

The choice of Ventotene as the site for our 2nd trial of WP5 was made for several reasons:

1. Geology of the costs: High variability of coastal types on Ventotene (cliff, sandy beach, rocky beach, etc.);
2. Rich biodiversity: Ventotene is a Marine Protected Area with which ISPRA usually collaborates; There is an important scientific centre for wild avifauna (*Museo della Migrazione e Osservatorio Ornitologico*), used also as base for trial;
3. Support and active involvement of local institutions.
4. Practicality of the site: This accommodation avoids spending time to reach the site of the trial because it would be just on the spot.

2.2. Main results and lessons learnt from Ventotene tests

As in the case of the trial conducted in the CEDRE artificial basin, the realisation of the various tests carried out in Ventotene give the opportunity to appreciate the **usefulness of employment of drones to enhance effectiveness of response to an environmental marine emergency**.

It was important to have simulated a real emergency by initiating all the administrative procedures to obtain flight authorisation from the National Aviation Authority. This is still an evolving subject that deserves to be tested with other national authorities.

Conducting the various tests in a marine environment made it possible to assess which **are the best set-ups to consider during a flight mission in terms of: type of drone to be used; flight plan; mission execution time; and time for post-processing.**

During the trial conducted in Ventotene the following main tasks have been carried out:

- Survey of polluted shoreline (SCAT)
- Slick detection and tracking floating pollutants drifting
- Detection of pollutants during the night
- Monitoring and survey of seabirds
- sampling of floating pollutants
- location and tracking a floating object (e.g. drums)

The performance of the various tests has demonstrated that unmanned aircraft systems (UAS) can be a **valuable tool to provide the following information:**

a) The survey of polluted shoreline using a drone allows to produce an **accurate digital mapping and georeferenced assessment of contaminant distribution**. Estimating compromised areas will provide data to assess contamination extent and facilitate cleanup strategy planning. The real added value seems to be the possibility of mapping the investigated area to be provided to decision makers in a short time, thus in accordance with the tight timeframe of an environmental emergency. Furthermore, **the survey can also be conducted in areas that are difficult to access, minimising risks for operators.**

b) A **three-dimensional (3D) survey** could offer a range of significant advantages not only in the context of **assessing and responding to coastal contamination events but also in case of a ship in distress or in port area to highlight access points or damaged zones** from which a pollutant is spilling into the sea or in atmosphere.

c) The test performed by **simulating pollution, spilling rice husks at sea**, showed how drones can be useful for:
   - searching, detection and classification of floating pollutant;
   - tracking pollutants drifting;
   - allowing the anti-pollution fleet to know the real-time distribution of the slicks in order to better "attack" them;

Real-time visualisation of UAV acquisitions allowed the experts on board the vessel to interact with the pilot during the flight. Close communication between pilots and experts is crucial for an effective and timely response.

If the area affected by the pollution is in open seas, the multi-rotor drone seems to be the best solution to operate for a number of reasons:

- it is possible to take off from a vessel;
- the flight is essentially manual, which in this type of scenario appears to be the best solution;
- the hovering position is often required to make observations;
- real time images are important to share with a command centre.

d) The **test "sensor in the dark" demonstrates that drones can be used also during nighttime to improve marine pollution response, mounting a thermal sensors measuring electromagnetic radiation in the mid-wave and long-wave infrared**. This is a very important result because it can be applied, for example, if a ship is in distress during the night and it is necessary to intervene to check if a spill at sea is taking place.

e) The results showed, moreover, that the use of UAVs is an important development in the **assessment and response to avifauna affected by an oil or HNS spill and in ornithological monitoring studies**. Their use allows during an emergency to: monitor and count marine fauna; carry out observations also during nighttime; verify state of contamination of each specimen. Using drones to observe and monitor the state of marine organisms is an important added value compared to "classical" observation methods, in particular because 1) the monitored area can be very large; 2) the quality of the images obtained is very high.

f) In continuation with the tests carried out at CEDRE, the testing and validation of drone's capability to **carry out samples is essential to demonstrate the possibility of obtaining essential information for both operational and scientific purposes**. Indeed, in the context of a real HNS spill, verifying the presence of HNS in the environment, identifying the nature of the pollutant in the case of an unknown chemical, or quantifying whether it is present in the water, can provide essential information for decision-makers. Moreover, sampling activities could be conducted also in a dangerous environment minimizing risks for operators.

g) **Drones can recognise a floating object (e.g. a drum or container) that is 'hooked' by the drone, which will follow the object in autonomous flight**. Clearly, this capability is very important in case objects, such as drums and containers, are lost from a ship and may pose a hazard to navigation and potential marine pollution.

Finally, the comparison of results obtained using fixed-wing and multirotor presents several key considerations.

Multirotor Drone:

Advantages:

1. **Maneuverability and Agility:** Multirotor drones are known for their excellent maneuverability and agility, allowing for precise and flexible flight suitable for exploring specific details of the island.
2. **Real-Time Data Collection:** The ability to transmit real-time data allows for immediate assessment of the terrain, facilitating quick responses to emergencies or changes in environmental conditions.
3. **Adaptability to Different Altitudes:** Multirotor drones can easily vary the flight altitude, enabling detailed data collection at different heights and providing a more comprehensive view of the island.

Challenges:

1. **Limited Autonomy:** Compared to fixed-wing drones, multirotors often have limited autonomy, which may require frequent battery changes during an extended survey.
2. **Limited Coverage:** Due to reduced autonomy, covering a large island may require more flights and, consequently, more time compared to a fixed-wing drone.

Fixed-Wing Drone:

Advantages:

1. **Extended Autonomy:** Fixed-wing drones are known for their longer autonomy, allowing for extended flights and broader coverage of the island without the frequent need for landings to change the battery.
2. **Efficiency in Large Areas:** Ideal for surveying large islands, fixed-wing drones can cover longer distances in a single flight, reducing the overall time required for data collection.

Challenges:

1. **Maneuvering Complexity:** Unlike multirotors, fixed-wing drones require larger landing spaces and greater expertise in managing takeoff and landing phases.
2. **Challenges in Real-Time Data Collection:** Transmitting real-time data can be more complex than with multirotors, possibly requiring data storage for subsequent processing.

The choice between a multirotor drone and a fixed-wing drone will depend on the specific needs of the project, the extent of the territory for which to create a 3D map, and the precision required in data collection..

3. CONSIDERATIONS AND LESSONS LEARNT FROM TRIALS ON THE USE OF UAS IN SUPPORT OF MARINE EMERGENCY RESPONSE

The realisation of the various tests carried out during the two trials, made it possible to verify that Unmanned Aircraft System (UAS) can be a valuable tool to perform certain operations effectively and quickly.

During the trials carried out in CEDRE artificial basin and Ventotene island the following main tasks have been developed:

- Survey of polluted shoreline (SCAT)
- Slick detection and tracking floating pollutants drifting
- Detection of pollutants during the night
- Location and tracking a floating object (e.g. drums)
- Sampling and detection of pollutants in water and in atmosphere;
- Surveying of marine fauna;

These may correspond to different scenarios that may be encountered when an environmental emergency occurs at sea. After the completion of the two trials, the advantages and challenges of using drones are clearer for each scenario in terms of: logistical organisation; best asset; flight plan; post-processing procedure.

In all cases, it was possible to appreciate the advantages of using drones to perform the assigned tasks, compared to the application of “classical” methods that involve the direct intervention of personnel on board boats or piloted aircraft (planes or helicopters).

Basically, the advantages that emerge are:

- rapidity of intervention and collection of information to be transmitted to decision-makers
- high quality images and videos describing the observed situation
- intervention in areas that are dangerous or difficult for operators to access, minimizing risks

On the other hand, the limitations in the use of drones that need to be taken into consideration were evident, namely:

- regulatory constraints;
- bad weather limitations;
- limited sensor payload;
- short battery life;

- large data management.

The two trials highlighted, in particular, **the importance of the use of a web server for data collection and user's management**. The use of a "geoportal" allows the management of all data collected, enabling decision makers located in a coordination centre to be aware of the evolving scenario and the complexity of activities carried out and information acquired and available.

Another important output that emerged from the trials is the **relevance of co-operation between a team of experienced drone pilots with a team of specialists in the environmental consequences of a maritime accident** such as: marine ecologists; experts on the behaviour at sea of pollutants; chemists, etc. This cooperation can create the right synergy that provides the added value in choosing to use drones during environmental emergencies at sea.

Main outputs and lessons learned from observations during these experimentations, reflecting real conditions found during accidental incident, could be translated into procedures and good practices to make observations with drones.

This is the purpose of deliverable 5.5 "*Best practices for the use of drones during environmental maritime emergencies*", where the use of drones in different scenarios will be described, taking into consideration advantages and challenges. This technical guide could be used by terrestrial and maritime authorities that may be involved in an emergency at sea. In particular, it targets at institutions that have teams, within their organization, specialising in the use of drones in environmental emergencies, such as:

- European Civil Protection Services;
- Maritime Authorities;
- Port Authorities;
- Private entities as oil and gas companies and contractors operating offshore.