Use cases definition
PASSport - D2.2

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DOCUMENT STATUS SHEET

EDIT.	DATE	§ - CHANGES	AUTHOR
1.0	04/11/2021	Issue 1.0	PASSport team
1.1	03/12/2021	Update based on DRS. Main corerctions: • Added missing acronyms • Added section definition including e-naviagtion, safety and security meanings • Complemented chapter 2 with additional info on camapigns synoptics • Added a section on chapter 2 including for each proposed configuration (in each campaign) the relevant impacted requirements and to include a summary for the final justification of the selected architecture • Added for each campaign (ch 3.3, 4.3, 5.3, 5.3, 7.3) the relevant user requirements and its tarcebility to system requirements. • Revised all configurations (ch x.3) and checked alignment with operational processes' decription (ch x.4) • Added description for use cases concept (sequence diagrams)	PASSport team

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

1.1 SCOPE

This document aims at presenting the identified use cases calling for dedicated campaigns arrangement.

For each campaign (use case) the following information is pointed out:

- ✓ Scope, identifying the need and the rationale for session implementation
- ✓ Identified areas, underlining peculiar needs for each port
- ✓ PASSport configuration: whereas the full architecture is reported in [RD 2], in this document the peculiar configuration is reported
- ✓ Logistics: several areas have been preliminary identified to allow installation of PASSport platform and to initiate the authorization request in order to operate the proposed fleet of drones. This subject is currently in discussion with hosting port, as the intention of PASSport consortium is to stay as much as possible close to the actual need of port actors.

1.2 APPLICABLE DOCUMENTS

ID	Description
[AD 1]	GRANT AGREEMENT NUMBER - 101004234

Table 1-1 - Applicable Documents

1.3 REFERENCE DOCUMENTS

ID	Description
[RD 1]	PASSport D2.3 - Regulation for RPAS usage in port areas (issue 1)
[RD 2]	PASSport D2.4 – PASSport specifications and design

Table 1-2 Reference Documents

1.4 ACRONYMS

Acronym	Description
AD	Aerial Drone
AI	Artificial Intelligence
AIS	Automatic identification system
ALC	Alcina (PASSPORT partner)
APRA	Ravenna Port Authority (PASSPORT partner)

Acronym	Description
AR	Augmented Reality
AUV	Automated Underwater Vehicle
ATZ	Air Traffic Zone
BM	Bergman Marine (PASSPORT partner)
BVLOS	Beyond Visual Line of Sight
CAA	Civil Aviation Authority
CRM	CEREMA (PASSPORT partner)
CTR	Control Zone
DBL	Deep Blue (PASSPORT partner)
DG1	Digi-one (PASSPORT partner)
DLR	German Aerospace Agency (PASSPORT partner)
DPO	Data Protection Officer
EASA	European Union Aviation Safety Agency
ECAT	EURECAT (PASSPORT partner)
ENV	Environment
FVP	Valencia Port Foundation (PASSPORT partner)
FW	Fixed Wings
G7I	G7 International (PASSPORT partner)
GDPR	General Data Protection Regulation
GIS	Geographical Information System
GMV	GMV (PASSPORT partner)
GNSS	Global Navigation Satellite System
M3S	M3 Systems (PASSPORT partner)
MI	Monitoring and Inspection
MR	Mixed Reality
MTD	Master Tethered Drone
MUS	Maritime University of Szczecin (PASSPORT partner)
OL	Operation and Logistics
P	Prohibited Area
PAS	PASSport Aerial Segment
PASSPORT	Operational Platform managing a fleet of semi-autonomous drones exploiting GNSS high Accuracy and Authentication to improve Security & Safety in port areas

Acronym	Description
PCE	PASSport Control Element (part of PGS)
PGS	PASSport Ground Segment
PME	PASSport Mission Element (part of PGS)
R	Restricted Area
RPAS	Remotely Piloted Aircraft Systems
RW	Rotary Wings
SIST	Sistematica S.p.A. (PASSPORT partner)
SMP	Security Management Platform
TOP	Topview (PASSPORT partner)
UAV	Unmanned Aerial Vehicle; Drone
UD	Underwater Drone
UNI-FI	University of Florence (PASSPORT partner)
U-space	European Air Traffic Management for drones (UAV)
VLOS	Visual Line of Sight
VTS	Vessel Traffic Service

Table 1-3 Acronyms

1.5 DEFINITIONS

Safety

The term safety is used to refer to the condition of being protected from the aspects that are likely to cause harm. In addition, the term safety is intended to be used to refer to the state at which one has the control of the risk causing aspects hence protecting himself or herself against risk that is fully unintended.

Definition: The state of being away from hazards caused by natural forces or human errors randomly. The source of hazard is formed by natural forces and/or human errors.

Security

The term security is broadly used to refer to the protection of individuals, organizations, and assets against external threats and criminal activities that can be directed to such entities hence rendering them inactive. It is important to note that security is highly focused on the deliberate actions that are geared towards inflicting harm to an individual, organization, or even assets.

Definition: The state of being away from hazards caused by deliberate intention of human to cause harm. The source of hazard is posed deliberately by human.

e-Navigation

e-Navigation is a strategy developed by the International Maritime Organization (IMO), a UN specialized agency, to I shipping through better organization of data on ships and on shore, and better data exchange and communication between ships and the ship and shore. The concept was launched when maritime authorities from seven nations requested the IMO’s Maritime Safety Committee to add the development of an e-navigation strategy to the work programs of the IMO's NAV and COMSAR sub-committees.

e-navigation is the harmonized collection, integration, exchange, presentation and analysis of marine information on board and ashore by electronic means to enhance berth to berth navigation and related services for safety and security at sea and protection of the marine environment.

2 PASSPORT SAFETY AND SECURITY NEEDS

This section summarises the envisaged campaigns and use cases, the relevant scope and short description, the identification (and role) of each partner as well as a tentative planned date

	Site	Scope	Short Description	Involved partners	Date (TBC)
C1	Kolozberg	Pollution monitoring (safety)	Air/water quality monitoring ✓ Quality parameters (i.e. PM, O3, So2, No2) will be measured and located for a representation on a map. Data collected form the drone will be compared with data acquired and processed by using Copernicus services and .ingested on a GIS ✓ AR for real time mission control ✓ Video for context awareness	Kolozberg port (MUS) (Validator) MUS (TOIP support) (Rotary wings drone) SIS/ DG1 (Ground Platform) DBL/DLR (support for authorisation) MUS (Augmented Reality) UNI-FI (EO)	2022/09
C2	Ravenna	Underwater threats monitoring (safety)	Air and underwater monitoring In particular, the following features will be implemented: ✓ Bathymetry integrated with underwater inspection (ship/vessel and pier yard): comparison between surface vehicle and underwater also for 3D of submerged infrastructure the monitor status ✓ Video for context awareness (fully or semi-autonomous flight). Drone integrated with already existing CCTV ✓ Drone segment: self-charged drone + tethered (surveillance + communication relay)	APRA (Validator) SIS/ TOP (Rotary wings drone) UNI-FI (underwater drone) SIS/ DG1 (Ground Platform) G7 (Security Management Platform) DBL (Pilots)	2023/04-05

	Site	Scope	Short Description	Involved partners	Date (TBC)
C3	Le Havre	Protection against non-cooperative small craft approaching the port areas (security)	Sea side (vessel traffic monitoring) and ground side surveillance ✓ Non cooperative ships detection and location based on AI algos ✓ Ground side asset/ people detection and location based on AI algos ✓ GNSS interference detection ✓ Video for context awareness Note: AI-based algorithms shall allow to detect an object (e.g. a ship), while geolocalization methods shall locate it based on drone (observing a scene) location. AI-based algorithms are chosen for the object detection task due to their high performance in terms of detection accuracy and good generalization to different object types. Compared to traditional computer vison algorithms, the computational requirements are lower making them an ideal option for embedded computers on-board robotic platforms such as UAVs.	Le Havre port (CRM) (validator) SIS/ TOP (Rotary wings drone) M3S (Fixed wings drone) GMV (GNSS Rx MagicUT, SRX-10i/DINTEL) SIS/ DG1 (Ground Platform) ECAT (Artificial Intelligence) G7 (Security Management Platform) DBL (Pilots)	2023/06
C4	Hamburg	Critical buildings/ Infrastructures protection (security)	The campaign performed in Hamburg will be devoted to operate a fleet of drones for surveillance purposes being integrated as interface to SRX-10i/DINTEL GNSS interference detector in the port to detect interference events that could compromise the security and the safety of port operations. The scope of the demonstration campaign will be to test the following benefits: ✓ Sea side (vessel traffic monitoring) and ground side surveillance ✓ Non cooperative ships detection and location based on AI algos ✓ Ground side asset/ people detection and location based on AI algos ✓ GNSS interference detection Video for context awareness	Hamburg port (BM) (validator) SIS/ TOP (Tethered Rotary wings drone) SIS/ DG1 (Ground Platform) GMV (GNSS Rx MagicUT, shiplocus, SRX-10i/DINTEL) ECAT (Artificial Intelligence) G7 (Security Management Platform) DLR (rotary wing drone) UNI-FI (EO)	2023/07

	Site	Scope	Short Description	Involved partners	Date (TBC)
C5	Valencia	Support to e-navigation (safety)	Support to vessel traffic monitoring (e-navigation) ✓ Non cooperative ships detection and location based on AI algos ✓ Integration with shiplocus (vessel traffic management tool based on AIS data) ✓ GNSS interference detection ✓ Video for context awareness e-navigation is supporting traffic monitoring in port area having increasing of safety as one main objective. This is specifically mentioned in the IMO "Maritime Services" (MS) definition of MS 1 – VTS information services, MS 3 – Traffic organization service and MS 4 – Port support service. Traffic monitoring will be based on ships (cooperative and non-cooperative) detection and location and localisation brought by PASSport solution. Moreover, integration with existing systems (e.g. AIS) devoted to cooperative vessels (more accurate) is considered important to have a complete system also based on different techniques and technologies	VPF (validator) SIS/ TOP (Rotary wings tethered drone) SIS/ DG1 (Ground Platform) G7 (Security Management Platform) GMV (GNSS Rx MagicUT, shiplocus+SRX-10i/DINTEL) ECAT (Rotary wing drone + Artificial Intelligence) DBL (Pilots) UNI-FI (EO)	2023/09

Table 2-1 Envisaged PASSport campaigns

In the following sections, for each proposed configuration (in each campaign) the relevant impacted requirements is reported to include a summary for the final justification of the selected architecture (see chapters x.3 and x.4)

3 POLLUTION MONITORING

3.1 SCOPE AND PLANNING

All ports and harbours face the challenge of maintaining air and water quality. Mitigating against problems means taking care of the whole marine ecosystem and surrounding land.
Ports and harbours are very highly concentrated industrial areas next to the water. Many activities such as boat repair, transportation, terminal operations, cargo handling and storage all have potential impacts on air/water quality above all if an incident were to occur.
In addition to PASSport partners, also several other authorities will be invited to attend (e. g. Polish SAR).

High level planning (TBC)

- Campaign preparation: starting from 2022 Q1
- Campaign dissemination: all 2022
- Campaign execution: 2022 Q3 (Sept 2022)
- Campaign event organisation 2022-Q3
- Campaign report: 2022 Q4

3.2 SELECTED AREA: PORT OF KOLOBRZEG

The Kołobrzeg Port is located on the Baltic Sea (130km from Szczecin, and 270km from Berlin by road), at the mouth of the Parsęta River. It performs a merchant ship loading/discharging, fishing and passenger function, it also has a 2 yacht marina. The port has a several loading quay, two shipyards, fishing harbour and two marinas.

Figure 3-1. Location of Kołobrzeg

In the area where the commercial function is performed, ships with a length of up to 100 meters, width of up to 15 meters and a draft of up to 5.0 meters are operated. Yearly traffic of commentarial ships is around 100 per year. There is passenger ship traffic in the summer (several moves daily) and fishing (several moves daily). There are Cost Guard and SAR located in Kołobrzeg. The total area of the storage areas in this area is approx. 50,000 m2, storage area approx. 6,000 m2, office space about 2,000 m2 and the capacity of two grain elevators about 6,000 tons. The commercial port has a complete infrastructure, i. e. high-voltage power networks, water intake points, lighting and railway sidings, and on its premises Customs Office, State Border Sanitary Inspector and Border Guard have their headquarters.

Figure 3-2. - Port of Kołobrzeg. Layout. (1) – cargo handling and administration area, (2) – fishing port and shipyard area, (3) – yacht marina

The port does not have any restriction in obtaining authorisation for drone usage – oral agreement is needed from Port Authority before using the port air space and typical registration of flight in Polish application *Droneradar*. Typical restriction in standard operation max. 120m height and VLOS. Port Authority is very positive about the drones they made some small-scale experiments already.

Port of Kołobrzeg is one of invited interested parties and, as per questionnaire used for defining user requirements, is planning to use drones for specific mission.

After collecting data via the questionnaire, the port board has been invited for discussion and pointed out that the city of Kołobrzeg, being a health resort, is very aggressive towards any possible source of pollution. The port would like to position itself as one of leading examples of air and water pollution monitoring.

Hence the port of Kołobrzeg identified problem of pollution monitoring and is convinced that it could be solved using drones and is interested in Passport as a possible solution.

3.3 IMPACTED USER AND SYSTEM REQUIREMENTS

Pollution monitoring scenario will be used to test innovative interface for mission coordinator.Such system will improve overall situational awareness of the drone operator or mission coordinator providing much larger field of view, beyond operator's line of vision. It should also improve decision making time by providing the operator with a real overview of the situation as soon as the drone arrives at the designated location. The following dedicated User Requirement is identified:

UR-050. POLLUTION MONITORING (OPERATIONAL)

PASSport system shall support detecting the environmental pollutions from ships, tracking the pollution for combat action needs, and help in polluters identifying.

UR_ID	Title	SR ID	ReqTitle
UR-050	Pollution monitoring	SR-020	PASSport aerial drone - rotary wings
		SR-060	PASSport ground - control
		SR-070	PASSport ground - mission
		SR-120	PASSport aerial drone - rotary wings - GNSS Rx payload - authentication
		SR-130	PASSport aerial drone - rotary wings - GNSS Rx payload - accuracy
		SR-140	PASSport aerial drone - rotary wings - communications availability
		SR-150	PASSport aerial drone - rotary wings - operations continuity
		SR-160	PASSport aerial drone - rotary wings - environmental conditions
		SR-170	PASSport aerial drone - rotary wings - autonomy of mission degree
		SR-400	PASSport algorithms - pollution monitoring
		SR-410	PASSport algorithms - mixed reality support
		SR-420	PASSport algorithms - Sentinel 5P - air pollution
		SR-440	PASSport algorithms - Sentinel-1 - wind speed map
		SR-470	PASSport ground - data and process management
		SR-480	PASSport ground - data archiving and retrieving
		SR-490	PASSport ground - data export and final report

Table 3-1 – Pollution Monitoring user and system requirements

Based on Table 3-1 the relevant architecture configuration is reported in next chapter.

3.4 PASSPORT ARCHITECTURE CONFIGURATION

A single rotary wings drone will be used for the campaign as a part of the Passport Aerial Segment. Passport Mission Element will be in place for mission planning, Passport Control Element will be in place for mission control.

PASSport Ground segment is. composed by the mission platform able to process air/water pollution data collected by both drone and Copernicus

Full description of architecture elements is reported in [RD 2].

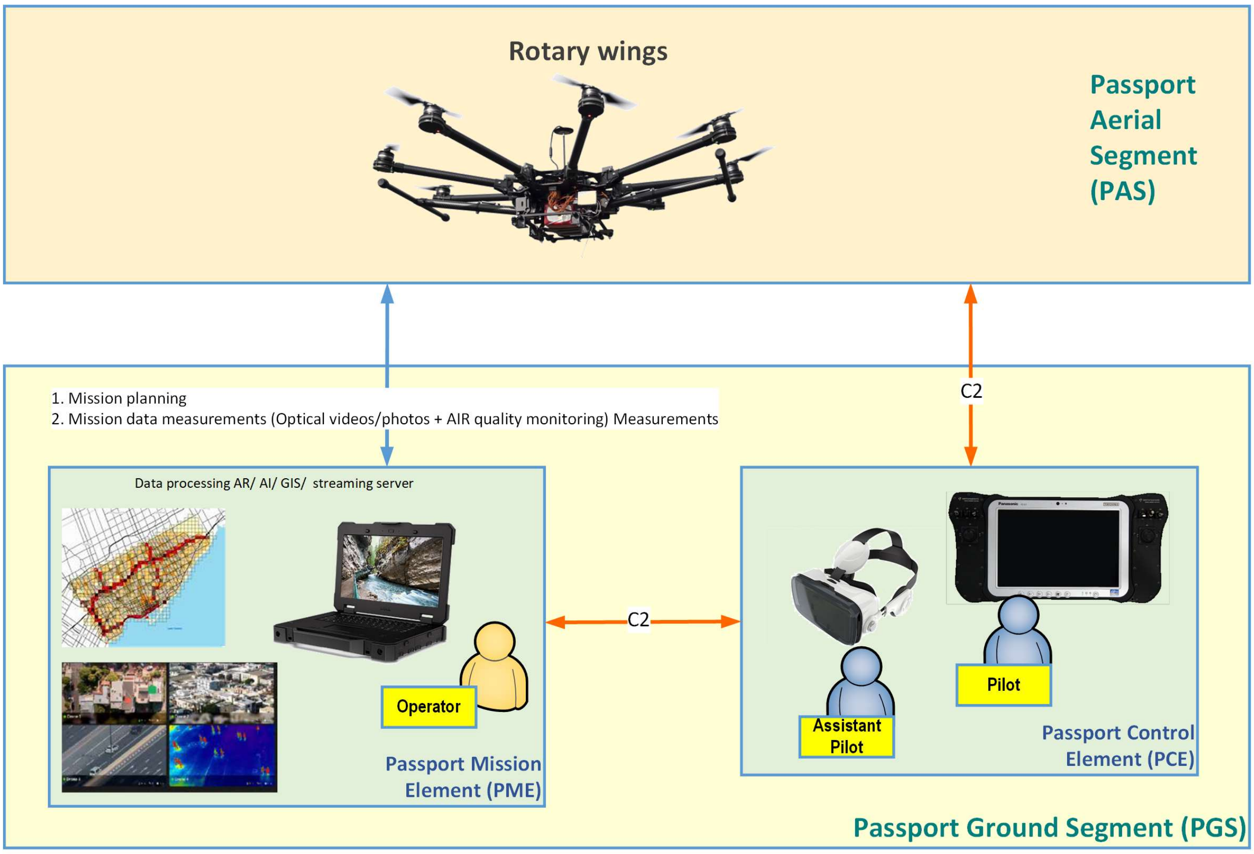


Figure 3-3. PASSport configuration for Kolobrzeg campaign

PASSport configuration for this campaign is composed by:

- One (1) rotary wing drone equipped by pollution sensors and optical camera for distant video monitoring
- One (1) pilot ground segment composed by a remote command and mixed reality goggles
- One (1) mission center (PME) where both real time (video for situational awareness) and data for post-processing are collected, processed together with Copernicus, validated and published. PME also manages all mission phases, i. e. planning, acquisition, processing, validation, reporting.

Accordingly, *Figure 3-4* reports the relevant use case concept.

The PME operator plans a mission notifying the pilot in charge of operations for the rotary wings drone. The pilot is supported by an assistant pilot equipped by MR equipment to improve trajectories execution, context awareness via video return link and data collection. Finally, the collected data are uploaded on the platform for final report generation

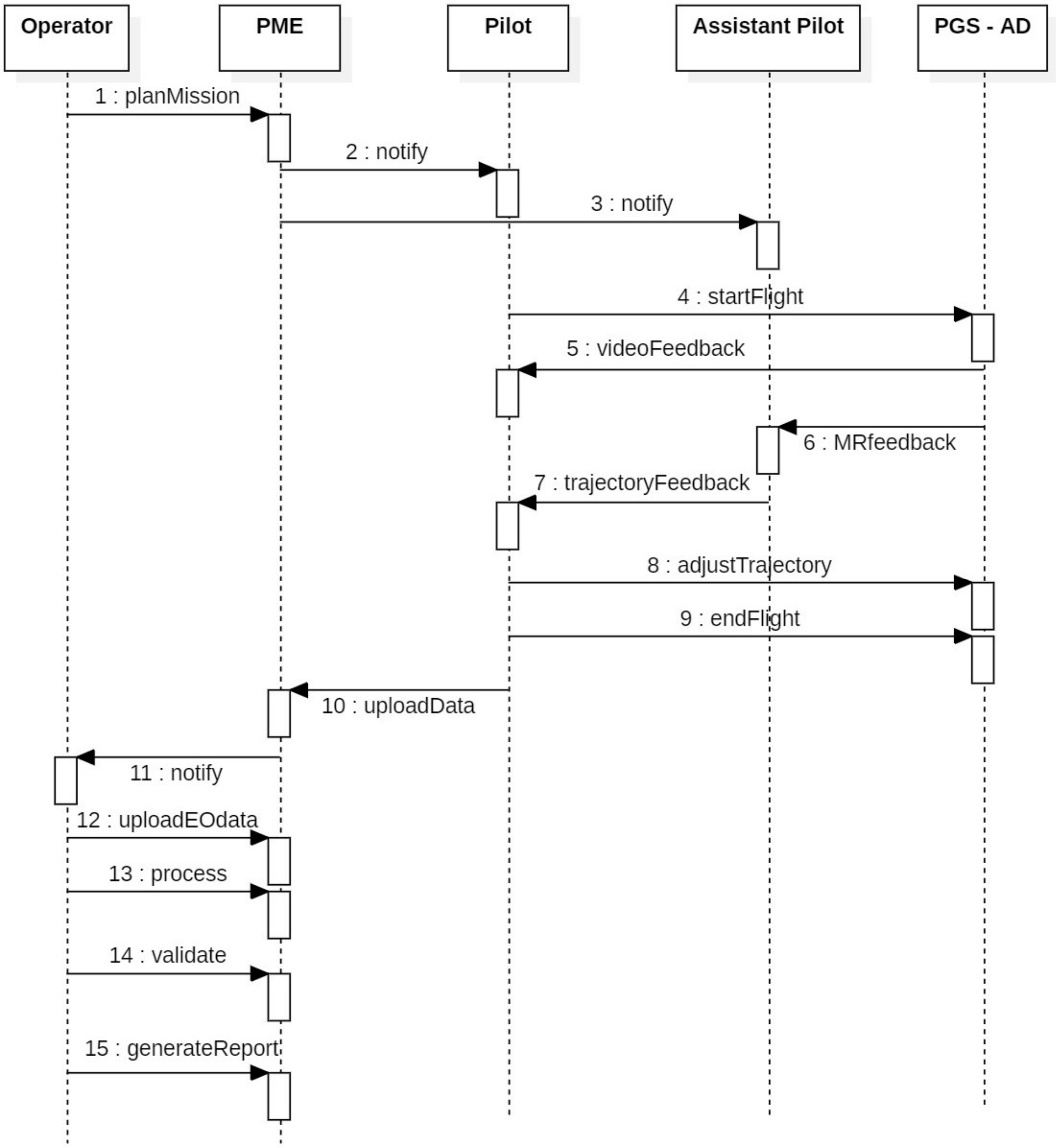


Figure 3-4. – Use case concept for Kolobrzeg campaign

Drone platform

As a drone platform DJI Matrice 300RTK is selected due to its performance as world leading platform for monitoring in industrial applications. Platform is compatible with Passport User Requirements and give possibility to max payload of almost 3 kg with flight time up to 3 sensors onboard. Most important technical parameters are presented in Table 4, the full technical specification is available on the producer's website. Quality parameters (i.e. PM, O3, So2, No2) will be measured and located for a representation on a map. Data collected form the drone will be compared with data acquired and processed by using Copernicus services. The table reports a sample of DJI Matrix 300 RTk data sheet. This drone will be likely selected for the campaign as it can embark the identified sensors to collect air/water quality parameters.

1	Max Takeoff Weight	9 kg
2	Operating Frequency	2.4000-2.4835 GHz 5.725-5.850 GHz
3	Hovering Accuracy (P-mode with GPS)	Vertical: ±0.1 m (Vision System enabled) ±0.5 m (GPS enabled) ±0.1 m (RTK enabled) Horizontal: ±0.3 m (Vision System enabled) ±1.5 m (GPS enabled) ±0.1 m (RTK enabled)
4	RTK Positioning Accuracy	When RTK enabled and fixed: 1 cm+1 ppm (Horizontal) 1.5 cm + 1 ppm (Vertical)
5	Max Wind Resistance	15 m/s
6	GNSS	GPS+GLONASS+BeiDou+Galileo
7	Max Transmitting Distance (unobstructed, free of interference)	NCC/FCC: 15 km CE/MIC: 8 km SRRC: 8 km
8	Max flight time	55 min
9	Operating Temperature	-20°C to 50°C (-4°F to 122° F)

Table 3-2 Selected technical parameters for DJI Matrice 300 RTK

Passport solution on Matrice 300RTK platform will be able to monitor air quality, including in particular the following sensors:

1. Air quality integrated sensor (Sniffer 4D) including following components:
    1.1. PM sensor (0,3 – 10 um)
    1.2. O3 sensor (0-10 ppm)
    1.3. SO2 sensor (0- 10 ppm)
    1.4. NO2 sensor (0-10 ppm)

Passport solution shall be able to remotely monitor water quality, including in particular the following sensors:

1. Multi sensor camera Zenmuse H20t, that include integrated:
    1.1. Visible spectrum camera (1/1.7" CMOS, 20 MP, 20x zoom)
    1.2. IR (thermal) camera (640×512 @ 30 Hz)
    1.3. Laser range finder (1200m +/-0,2m)
2. UV camera (PCO-UV 14 bit CCD camera - 1392x1040, 190nm – 1100nm)
3. Multi spectrum visible light camera (Mica sense RedEdge MX including 10 bands with following spectrum: coastal blue 444nm, blue 475nm, green 531nm, green 560nm, red 650nm, red 668nm, red edge 705nm, red edge 717nm, red edge 740nm, NIR 842nm, 1280 x 960 – 1.2 MP per band))

Copernicus usage

Due to the massive traffic involving the coastal area of Kołobrzeg, the monitoring of the air pollution is a paramount task in order to contribute to the risk management of environmental health problems

The Sentinel-5P satellite mission enables air quality monitoring on a global scale. Sentinel-5 Precursor, or Sentinel-5P is the first mission dedicated to monitoring our atmosphere. Operating in a sun-synchronous orbit, the satellite maps a multitude of air pollutants around the globe. After launching in 2017 and subsequent calibration periods, Sentinel-5P reached its routine operations phase in early 2019.

Since then, the European Space Agency (ESA) has made the final array of Level-2 data products of atmospheric gases available, offering daily coverage of the entire globe at 7x7 km resolution. The acquisition of such parameters is based on a 8-band spectrometer instrument, called TROPOMI (TROPOspheric Monitoring Instrument), which takes measurements in the ultraviolet, visible, near and short-wavelength infrared light spectrum. In combination with auxiliary input data (e.g. air pressure, snow/ice masks), the concentration of each atmospheric gas is then modeled based on their absorption characteristics at specific wavelengths of the light. While orbiting the globe at an altitude of ~800 km, Sentinel-5P continuously takes measurements of a 2600 km wide area. The orbital cycle is 16 days (14 orbits per day, 227 orbits per cycle). TROPOMI sensor is capable to monitor wide range of pollutants such as carbon monoxide (CO), formaldehyde (CH2O/H2CO), methane (CH4), nitrogen dioxide (NO2), ozone (O3), and sulphur dioxide (SO2). In the specific, the Ultraviolet-visible signal (270–500 nm) is capable to measure O3, CH2O/H2CO, NO2 and SO2, the near-infrared (675–775 nm) the CH4 while in the shortwave-infrared field (2305–2385 nm), CO and CH4 concentrations can be measured. Level-2 data will be used to monitor the air quality: they consist of geolocated total columns of ozone, sulfur dioxide, nitrogen dioxide, carbon monoxide, formaldehyde and methane; geolocated tropospheric columns of ozone; geolocated vertical profiles of ozone; geolocated cloud and aerosol information (e.g. absorbing aerosol index and aerosol layer height). The spatiotemporal evolution of the main pollutant will be evaluated on the Kołobrzeg area to estimate the seasonal effect and the role of the anthropic activities in the harbour area. Based on the application of dedicated software (e.g., Google Earth Engine, SNAP, etc.) images in a period of at least one year will be processed and the minimum, maximum, mean, and sum of the pollutant concentration will be analyzed in order to find possible correlations with the main abovementioned factors.

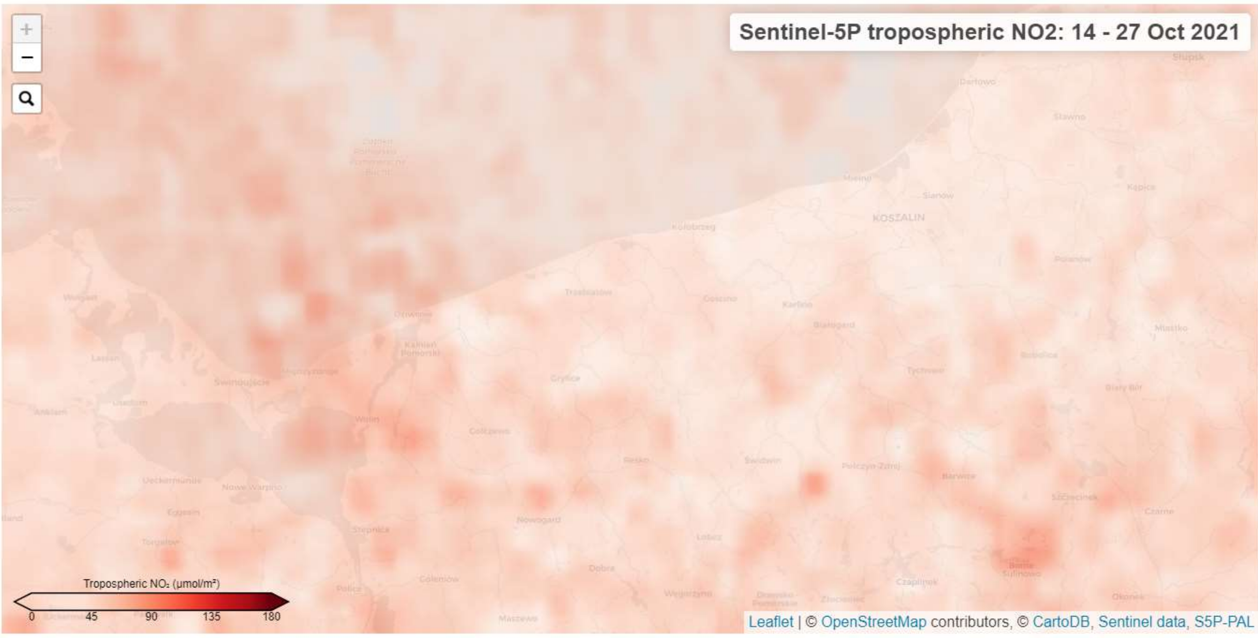


Figure 3-5. PASSport Map of tropospheric NO_2 concentrations averaged over 14 days

<u>MR interface</u>

For the campaign a custom Mixed reality (MR) system will developed as a PASSport system user interface. It will be based on the following assumptions:

1. The interface will provide full 3D, accurate overview of the port area.
2. A real-time position of all active drones will be presented on the 3D overview of the port area.
3. The user will be able to use dedicated controllers or his/her own hands to perform basic interactions with the interface.
4. The interface will allow to select a drone and access information about its mission's status.
5. Where possible, the interface will allow for data stream from the selected drone.

Two devices are being considered for the test:

- Microsoft Hololens, 1st generation – one of the most advanced AR system available, that allows for a full 3d, spectroscopic holographic projection to the user without blocking the view of the surrounding.
- Oculus Quest 2 – most advanced mobile VR headset with AR capabilities. Mobility of this system does not require additional computer or power supply. It will allow for a full 3d, detailed visualization of the port area with different data layers, supporting highest readability.

Figure 3-6. Sample about MR equipment (Microsoft Hololens, 1st generation, Oculus Quest 2)

Operators will be surveyed, and the following will be evaluated:

- comfort,
- usability,
- situational awareness,
- readability,
- simulator sickness (VR only).

The detailed achievable performances will be evaluated during field tests, where positioning and display capabilities will be measured.

3.5 LOGISTICS

Pilot and passport crew will be located at the quey, next to the main administration building. Such location gives a good overview of the port, including shipyard and fishing port area, provides easy access the electrical and network infrastructure, if needed, and is close to the actual location of the system operator, if Passport would be installed in the port in the future.

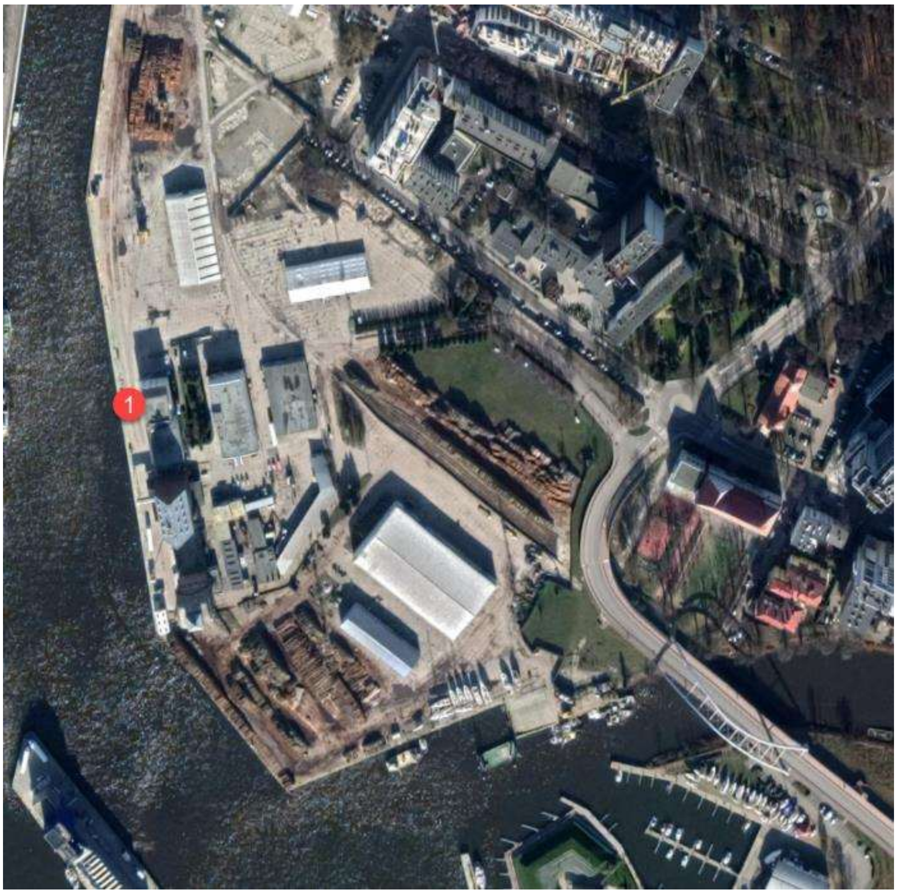


Figure 3-7. - Location of the pilot during validation campaign

At minimum two separate mission will be conducted:

- Air quality surveillance mission
- Water pollution surveillance mission

During air quality surveillance mission, a 3d point map will be generated with each data point describing air quality as measured with all installed sensors. Colour coding and simple alert system should be implemented. The mission assumes the surveillance flight around the cargo and administration area with few height levels. Details of the flight will be established with the pilot. Flight will be realised in square patterns with increasing heights of 20m (above the port buildings), 40m and 60m.

During water pollution surveillance mission drone will be equipped with a camera, thermal camera and UV camera system and will perform flight around the shipyard and fishing port area analysing visible, UV and IR spectra. With cooperation with local SAR service, it may be possible to perform such mission during SAR oil spill training. T

he oil spill will be simulated by natural materials (popcorn) floating down the river Parsęta. Cooeration wit the SAR service and port cleaning vessel is planned to perform oil – combat action. The drone will move down river in patterns presented on Figure 3-9

Figure 3-8. Preliminary mission plan for air quality monitoring

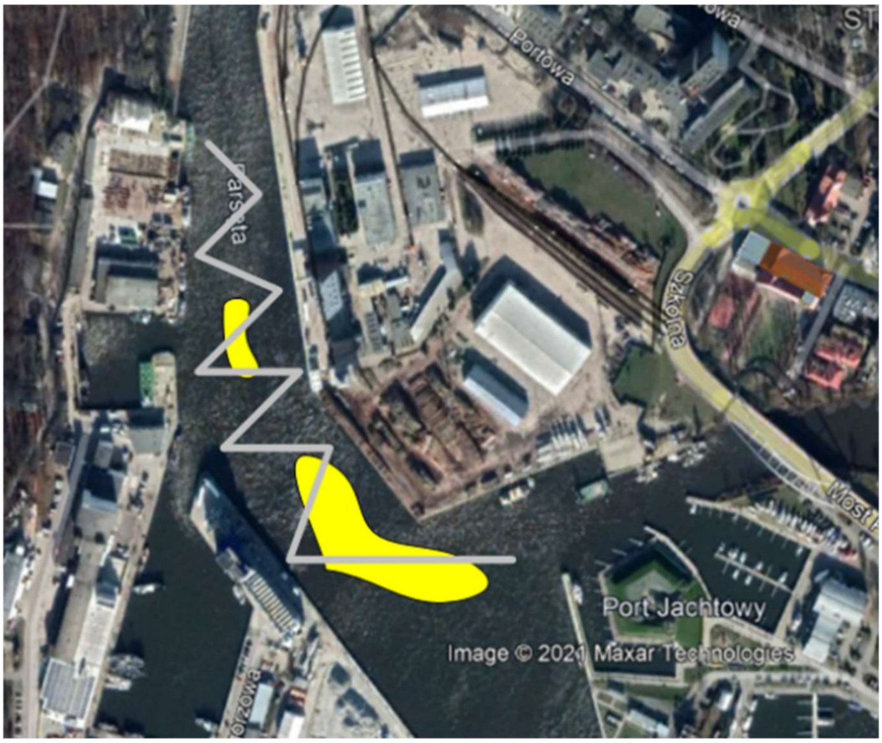


Figure 3-9. Simulated oil pollution and drone patterns for monitoring and detection

4 AIR AND UNDERWATER MONITORING USING DATA RELAY

4.1 SCOPE AND PLANNING

This campaign is related to air/ underwater surveillance including sea and ground side.
In particular, the following features will be implemented:

- ✓ Bathymetry integrated with underwater inspection (ship/vessel and pier yard): comparison between surface vehicle and underwater also for 3D of submerged infrastructure the monitor status
- ✓ Video for context awareness (fully or semi-autonomous flight). Drone integrated with already existing CCTV
- ✓ Drone segment: self-charged drone + tethered (surveillance + communication relay)

In addition to PASSport partners, also several other authorities will be invited to attend:

- ✓ Maritime .Authority (Italian Coast Guard)
- ✓ Customs Police (Guardia di Finanza)
- ✓ Terminal Operators
- ✓ Port Security Officer
- ✓ Ship Agents
- ✓ Port Digital Twin manager
- ✓ IT infrastructure maintainer

High level planning (TBC)

- Campaign preparation: starting from 2022 Q3
- Campaign dissemination: starting from 2022- Q4
- Campaign execution: 2023 Q2 (April/May 2023)
- Campaign event organisation 2023-Q2
- Campaign report: 2023 Q3

Some results will be also presented referred to La Spezia port, being the consortium (UNI-FI) performing with "Marina Militare Italiana" an on-going activity related to Threats monitoring. Potentially a dedicated campaign (TBC) will be added planned in 2023.

4.2 SELECTED AREA: PORT OF RAVENNA

The Port of Ravenna is a canal port with 27 private terminal operators; the overall length of quays is almost 24 km, 14,5 km of which are in operation. Current capacity comprises 603.000 square meters of warehousing, 1.350.000 square meters of yards and 1.256.000 cubic meters of tank storage. The Port manages mainly dry bulk cargo, general cargo, agricultural products, liquid bulk cargo (oil and others) and, to a lesser extent, containers and Ro-Ro traffic..

The port of Ravenna is an "A" Category port as indicated in Decision N. 661/2010/EU of the European Parliament and of the Council of 7 July 2010 on "Union guidelines for the development of the trans-European transport network". With the approval of the new TEN-T guidelines (Annex II of Regulation (CE) 1315/2013 of the European Parliament and of the Council of 11 December 2013 on Union guidelines for the development of the trans-European transport network), the Port of Ravenna is included within the TEN-T list of core ports and core inland ports.

Figure 4-1. Port of Ravenna

As far as the Trans European transport networks are concerned, it is to be highlighted that the Port of Ravenna which, on the basis of the Regulation (EU) No 913/2010 of the European Parliament and of The Council of 22 September 2010, concerning a European rail network for competitive freight, is included in the rail freight corridor which runs from Gdynia to Trieste, was recently included by Regulation (EU) No. 1316/2013 of the European Parliament and of the Council establishing the Connecting Europe Facility, in the list of nodes of the core network corridors Baltic–Adriatic (which runs from Helsinki to Ravenna) and Mediterranean according to the Regulation (EU) No. 1315/2013 of the European Parliament and of the Council of 11 December 2013 on Union guidelines for the development of the trans-European transport network and repealing Decision No 661/2010/EU.

As far as handled cargo volumes are concerned, the Port of Ravenna is a major European seaport. Over the past 10 years it has been regularly included in the top 45 seaports around Europe (source: Eurostat). Ravenna is firmly in the top 20 European seaports for "dry bulk goods" and "other general cargoes" (that is goods not in containers or on trailers carried by Ro-Ro vessels).

4.3 IMPACTED USER AND SYSTEM REQUIREMENTS

Air and underwater monitoring is another core use case which requests the usage of both aerial and underwater drones. In particular the identification of underwater threat can be performed by using Autonomous Underwater Vehicles (AUVs) and aerial rotary wings drones acting as bridge for communication relay to the control centre. Moreover, the aerial drones can be used as a support for surveillance inspections. The following dedicated User Requirement is identified:

UR-090. PROTECTION AGAINST UNDERWATER THREATS (OPERATIONAL)

PASSport system shall support infrastructure monitoring and protection in port area by providing the following features:

- ✓ *dedicated underwater surveillance monitoring including detection and localisation of fixed or moving (by acoustic devices) objects*
- ✓ *bathymetric analysis to support for seabed monitoring and vessels mooring in port area*

UR_ID	Title	SR ID	ReqTitle
UR-090	Air and Underwater Monitoring	SR-020	PASSport aerial drone - rotary wings
		SR-050	PASSport underwater drone
		SR-060	PASSport ground - control
		SR-070	PASSport ground - mission
		SR-080	PASSport ground - Security Monitoring Procedures
		SR-120	PASSport aerial drone - rotary wings - GNSS Rx payload - authentication
		SR-130	PASSport aerial drone - rotary wings - GNSS Rx payload - accuracy
		SR-140	PASSport aerial drone - rotary wings - communications availability
		SR-150	PASSport aerial drone - rotary wings - operations continuity
		SR-160	PASSport aerial drone - rotary wings - environmental conditions
		SR-170	PASSport aerial drone - rotary wings - autonomy of mission degree
		SR-310	PASSport underwater drone - GNSS Rx payload (buoy) - accuracy
		SR-320	PASSport underwater drone - communication availability
		SR-330	PASSport underwater drone - operations continuity
		SR-340	PASSport underwater drone - environmental conditions
		SR-350	PASSport underwater drone - autonomy of mission degree
		SR-380	PASSport algorithms - ground object recognition

UR_ID	Title	SR ID	ReqTitle
		SR-390	PASSport algorithms - ground object location
		SR-470	PASSport ground - data and process management
		SR-480	PASSport ground - data archiving and retrieving
		SR-490	PASSport ground - data export and final report
		SR-306	PASSport underwater drone - operations

Table 4-1 – Air and Underwater Monitoring user and system requirements

Based on Table 4-1 the relevant architecture configuration is reported in next chapter.

4.4 PASSPORT ARCHITECTURE CONFIGURATION

A Tethered rotary wings drone and a self-charged station will be used for the campaign as a part of the Passport Aerial Segment. The underwater drone will be able to provide bathymetric analysis and send in near real time to PME via tethered drone relay.

Passport Mission Element will be in place for mission planning, Passport Control Element will be in place for mission control.

Full description of architecture elements is reported in [RD 2].

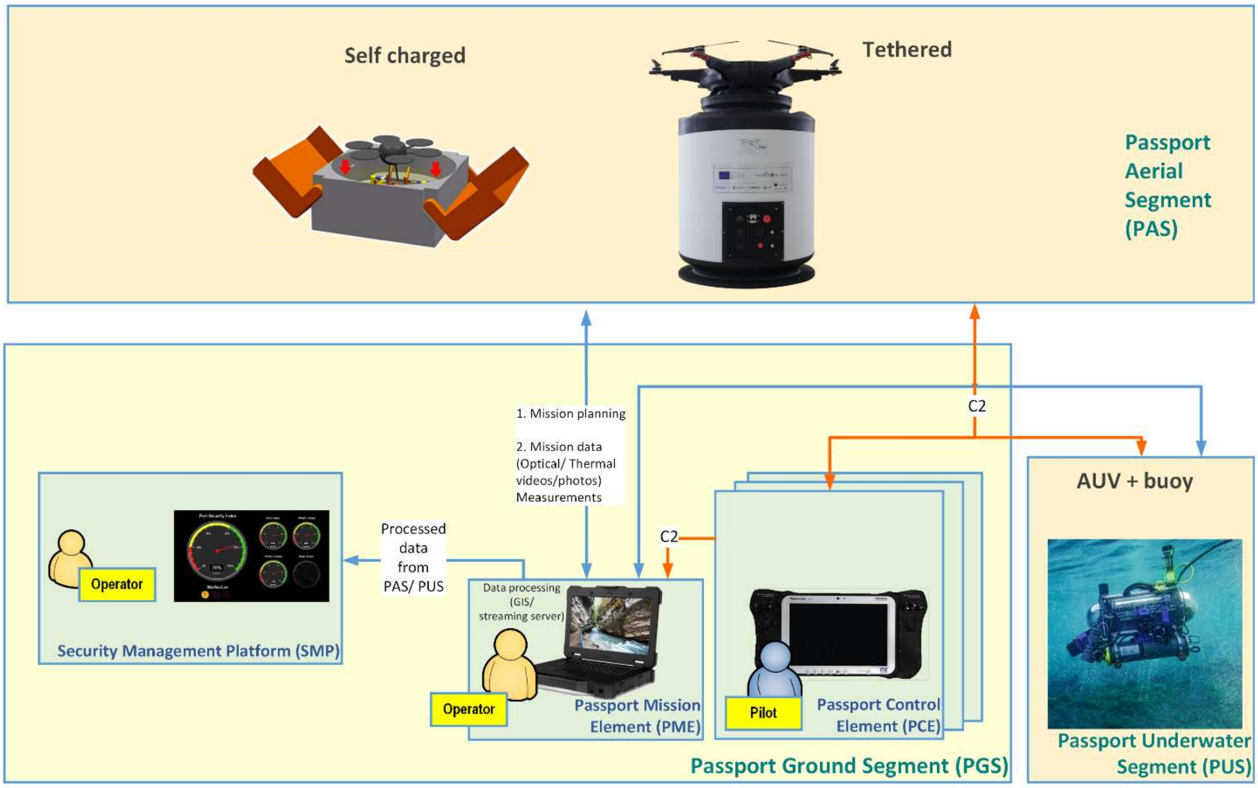


Figure 4-2. PASSport configuration for Ravenna campaign

PASSport configuration for this campaign is composed by:

- One (1) self-charged semi-autonomous drone commanded by the PME for missions in dedicated areas in a limited time
- One (1) rotary wing tethered drone equipped by optical camera for distant video monitoring and acting as bridge between the underwater drone and the PME.
- One (1) underwater drone for bathymetry and distant video monitoring also equipped with a buoy (with GNSS Rx)
- One (1) control segment (PCE) composed managing the fleet of drones
- One (1) mission center (PME) where both real time (video for situational awareness) and data for post-processing are collected, processed together with Copernicus, validated and published. PME also manages all mission phases, i. e. planning, acquisition, processing, validation, reporting.
- One (1) Security Management Platform (SMP) used to trigger threats and activate relevant intervention procedures

Accordingly, *Figure 4-3* reports the relevant use case concept.

The PME operator plans a mission notifying the pilot(s) in charge of operations for the fleet of drones. The pilot(s) is in charge to manage context awareness via video return link and data collection. Finally, the collected data are uploaded on the platform for final report generation.

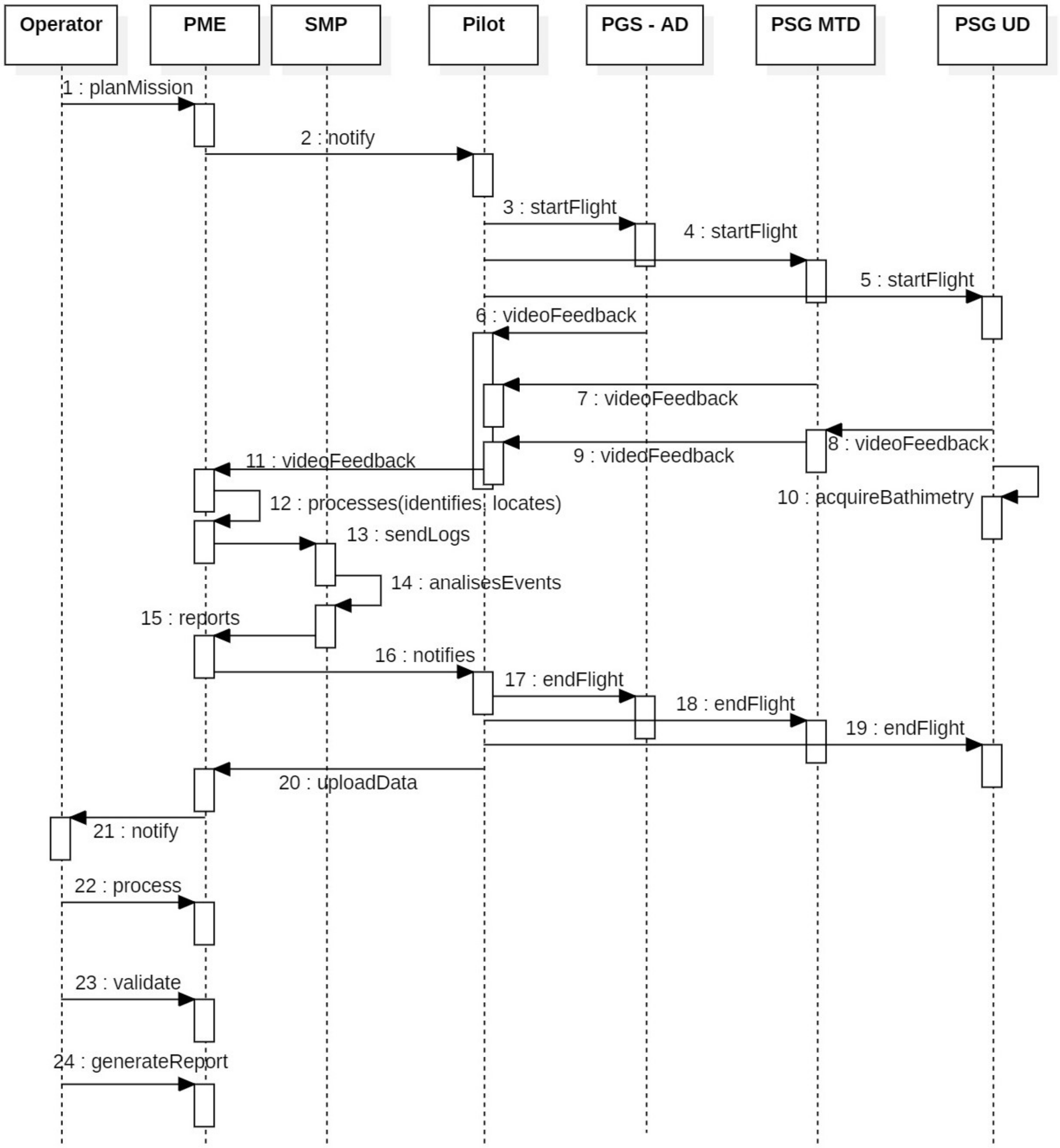


Figure 4-3. Use case concept for Ravenna campaign

4.5 LOGISTICS

An area has been preliminary identified: Piombone Canal and quay

The Piombone quay is a "public quay" (i.e. a quay not in concession to a specific terminal operator) and different vessels can be moored here to carry out port operations or for other reasons like maintenance works or if are under seizure. The quay is about 1 km. long and can host up to 6 vessels. After the end of the concrete quay, are moored some abandoned ships waiting to be dismantled. The quay is on the Piombone canal that is part of a protected wet area and nesting site for different bird species.The potential presence of many ships for different reasons, the absence of a concessioner responsible for the security of the facility, the presence of abandoned ships and the nearness with a protected area make this quay a perfect site for the campaign related with the inspection and security aspects.

Figure 4-4. Piombone Canal and quay (air views)

Figure 4-5. Piombone Canal and quay (ground views)

The Piombone Canal is the canal that join the Piallassa del Piombone (the southeastern wetland) and the Candiano Canal (the main canal of the port). The canal is 2,5 km. long, 100 metres width, with a draft between 6 and 7 metres and represent good location where carry-out the campaign for bathymetry and underwater inspections because there is no much traffic (so we can plan sufficient time for the measurement without interfere critically with the navigation plans) and for the presence of abandoned ships that are a good target for the inspections.

The area is equipped with 7 cameras covering more or less the entire quay, is reached by our optical fiber and wifi network and we have several connections with the electrical power network.

The proximity with a natural area and with a not urbanizated area causes the presence of a lot of birds (mainly seagulls) that can represent a problem mainly during the nesting season (aprox. from March to June).

5 PROTECTION AGAINST NON-COOPERATIVE SMALL CRAFT

5.1 SCOPE AND PLANNING

The aim of port security is to detect threats of unlawful actions against ports and port facilities (terminals) in their role as an interface with ships engaged in international transport, and to take appropriate measures to prevent these threats and limit their impacts.

The scope of this campaign is to assess operational contribution of RPAs in support to protection against non-cooperatives small crafts approaching the port areas. Migrant or activist semi-rigid inflatable boats, leisure boats with deliberate or undeliberate illicit behaviour, should be consider as non-cooperative crafts.

Haropa Port – Le Havre is aware of the security of its waterways in order to welcome ships in the best conditions. Threats, whether they are diffuse or very specific, concern the port and this is why we have proposed a series of scenarios that have a direct link with the protection against non-cooperative small craft approaching the port areas.

In addition to PASSport partners, also several other authorities will be invited to attend on invitation of CEREMA: all the ports Haropa ports (Rouen and Paris in particular), "l'union des ports français", and the "grands ports maritimes" could be invited to this demonstration. The port and river security office of the General Directorate for Infrastructure, Transport and the Sea could also attend to the campaign.

High level planning (TBC)

- Campaign preparation: starting from 2022 Q3
- Campaign dissemination: starting from 2022- Q4
- Campaign execution: 2023 Q2 (June 2023)
- Campaign event organisation 2023-Q2
- Campaign report: 2023 Q3

5.2 SELECTED AREA. THE PORT OF LE HAVRE (HAROPA)

The port of Le Havre is part of Haropa Port and its activity is mainly specialized in the transport of containers, motor vehicles, chemical materials, passengers, building materials, energy and agro-food materials and bulk.

Figure 5-1. Port of Le Havre

With nearly 4,400 ships to be received in 2020, including 1,835 container ships, the port's traffic amounts to 55 MT. The port area covers 77,700 hectares and 35 km of quays dedicated to specific uses. The port has an oil terminal in Antifer, about 20 km from the port.

Since June 1st 2021, the ports of Le Havre, Rouen and Paris, have now merged to form a single port: HAROPA PORT, the Seine axis Major River & Sea Port. => 1st port in France.

The leading port complex in France, HAROPA PORT is the 5th largest in northern Europe with more than 120 million tonnes of maritime and river traffic.

- maritime and river activity around 130m tons
- financial underpinning of €1.45 billion
- a first-rate international shipping offer linking around 650 ports worldwide
- No. 1 logistics hub in France, over 2.5m sq. m. of operational warehousing
- 160,000 associated jobs

5.3 IMPACTED USER AND SYSTEM REQUIREMENTS

The aim of port security is to detect threats of unlawful actions against ports and port facilities (terminals) in their role as an interface with ships engaged in international transport, and to take appropriate measures to prevent these threats and limit their impacts. Accordingly, PASSport shall have the scopes to assess the need of operational contribution of drones in support to protection against non-cooperatives small crafts approaching the port areas. On this scope, migrant or activist semi-rigid inflatable boats, leisure boats with deliberate or undeliberate illicit behaviour, should be consider as non-cooperative crafts. In particular, it is considered of interest:

- ✓ the complementary usage of rotary wings drones for performing automatic surveys (preventive phase) on predefined patterns in the close vicinity of the port, and fixed-wings ensuring the surveillance at a larger scale (such as mooring areas, approach channels, pilot waters) for the detection and localisation of non-cooperative crafts.
- ✓ the need for the port authority to check an abnormal situation, in complement to existing port sensors (Vessel Traffic Services system including radars, AIS, optical) and help for decision-making process
- ✓ a reliable and accurate tracking of drones that allows ensuring and increasing trust of information and videos captured. This will globally demonstrate the possibility to use drones' data to establish some legal records (staying in forbidden areas, dangerous comportments, illegal fishering, etc). The following dedicated User Requirement is identified:

UR-080. Protection Against Non-Cooperative Small Crafts Approaching the Port Areas (Operational)

PASSport system shall support the protection against non-cooperatives small crafts approaching the port areas. Migrant or activist semi-rigid inflatable boats, leisure boats with deliberate or undeliberate illicit behaviour, should be consider as non-cooperative crafts. In particular, PASSport system shall allow to recognize and identify non-cooperative ships (VHF non-response and / or AIS off) detected by the radar or not (out of radar range).

UR_ID	Title	SR ID	ReqTitle
UR-080	Protection against non-cooperative small crafts approaching the port areas	SR-020	PASSport aerial drone - rotary wings
		SR-030	PASSport aerial drone - rotary wings tethered
		SR-040	PASSport aerial drone - fixed wings
		SR-060	PASSport ground - control
		SR-070	PASSport ground - mission
		SR-080	PASSport ground - Security Monitoring Procedures
		SR-100	PASSport ground - GNSS Interference Detection
		SR-120	PASSport aerial drone - rotary wings - GNSS Rx payload - authentication
		SR-130	PASSport aerial drone - rotary wings - GNSS Rx payload - accuracy

UR_ID	Title	SR ID	ReqTitle
		SR-140	PASSport aerial drone - rotary wings - communications availability
		SR-150	PASSport aerial drone - rotary wings - operations continuity
		SR-160	PASSport aerial drone - rotary wings - environmental conditions
		SR-170	PASSport aerial drone - rotary wings - autonomy of mission degree
		SR-250	PASSport aerial drone - fixed wings - GNSS Rx payload - authentication
		SR-260	PASSport aerial drone - fixed wings - GNSS Rx payload - accuracy
		SR-270	PASSport aerial drone - fixed wings - communications availability
		SR-280	PASSport aerial drone - fixed wings - operations continuity
		SR-290	PASSport aerial drone - fixed wings - environmental conditions
		SR-300	PASSport aerial drone - fixed wings - autonomy of missions degree
		SR-360	PASSport algorithms - vessels recognition
		SR-370	PASSport algorithms - vessels location
		SR-430	PASSport algorithms - Sentinel 1 - small ship detection
		SR-450	PASSport algorithms - EGMS
		SR-470	PASSport ground - data and process management
		SR-480	PASSport ground - data archiving and retrieving
		SR-490	PASSport ground - data export and final report

Table 5-1 – Protection against non-cooperative small crafts approaching the port areas user and system requirements

Based on Table 5-1 the relevant architecture configuration is reported in next chapter.

5.4 PASSPORT CONFIGURATION

A Tethered rotary wings drone and a fixed wings will be used for the campaign as a part of the Passport Aerial Segment. A COTS rotary wings is also used for ground-side monitoring.

Passport Mission Element will be in place for mission planning, Passport Control Element will be in place for mission control.

Full description of architecture elements is reported in [RD 2].

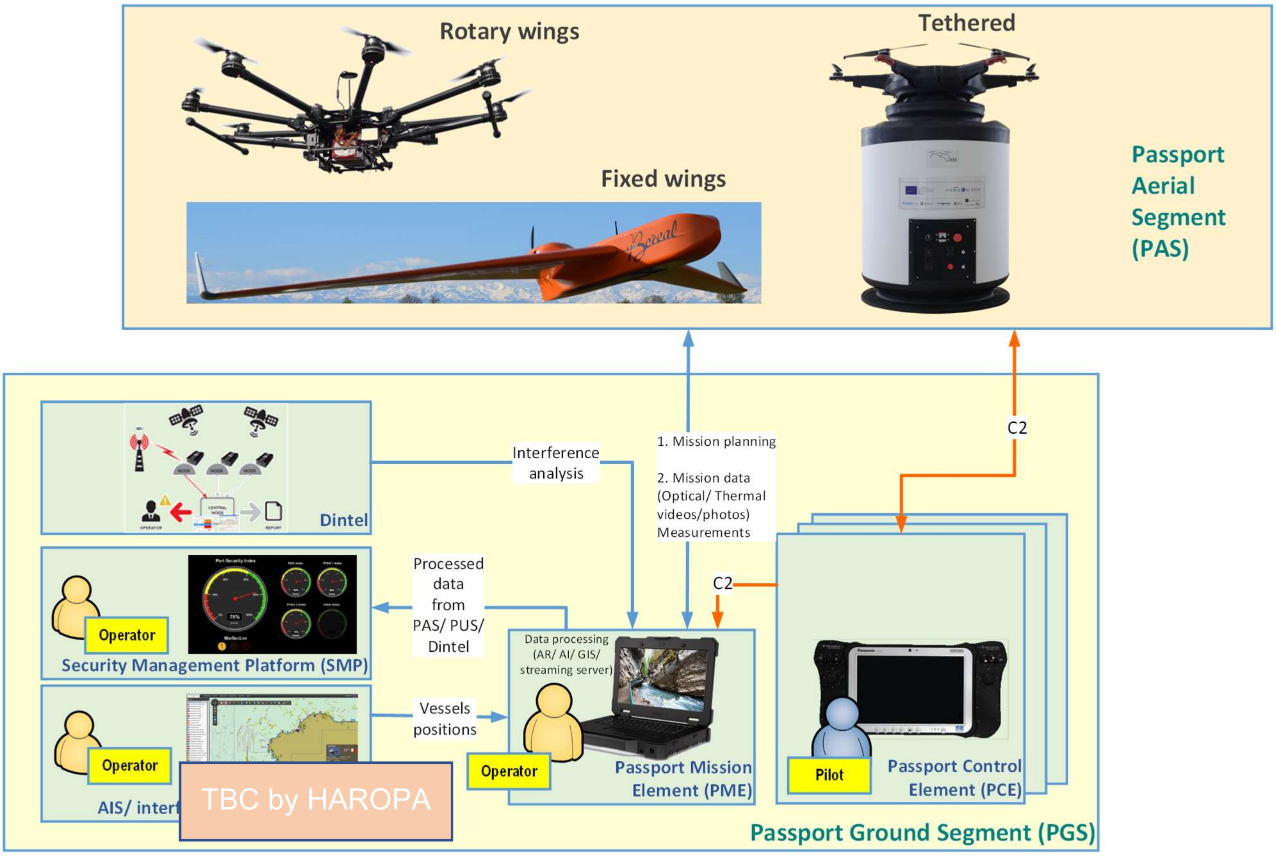


Figure 5-2. PASSport configuration for Le Havre campaign

PASSport configuration for this campaign is composed by:

- One (1) fixed wing drone for long endurance missions for distant video monitoring
- One (1) rotary wing tethered drone equipped by optical camera for distant video monitoring
- One (1) rotary wing drone optical camera for distant video monitoring
- One (1) control segment (PCE) composed managing the fleet of drones
- One (1) mission center (PME) where both real time (video for situational awareness) and data for post-processing are collected, processed together with Copernicus, validated and published. PME also manages all mission phases, i. e. planning, acquisition, processing, validation, reporting.
- One (1) Security Management Platform (SMP) used to trigger threats and activate relevant intervention procedures
- One (1) GNSS interference detection to check quality of GNSS signal
- Interface to already existing AIS systems

Accordingly, *Figure 4-3* reports the relevant use case concept.

The PME operator plans a mission notifying the pilot(s) in charge of operations for the fleet of drones. The pilot(s) is in charge to manage context awareness via video return link and data collection. Finally, the collected data are uploaded on the platform for final report generation.

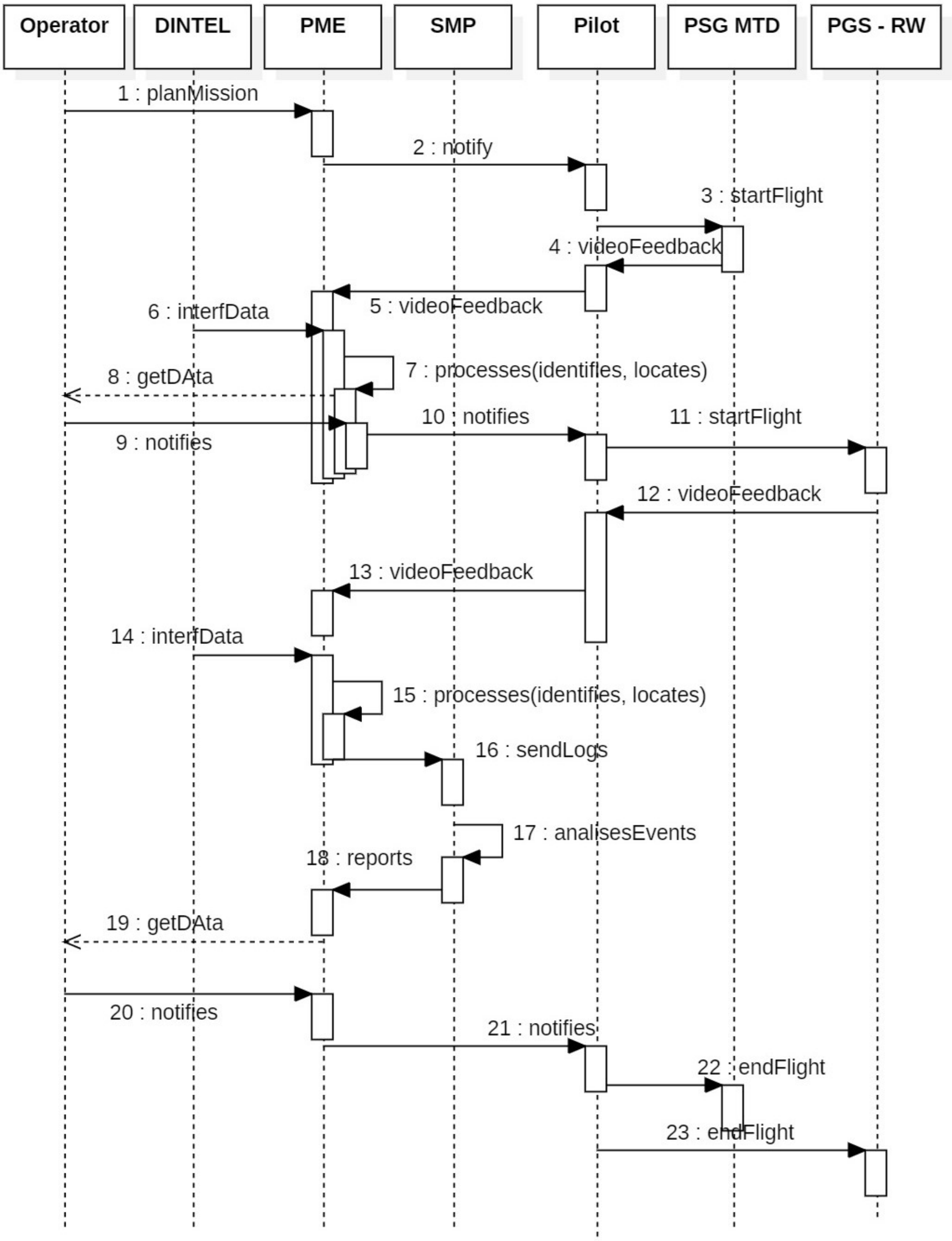
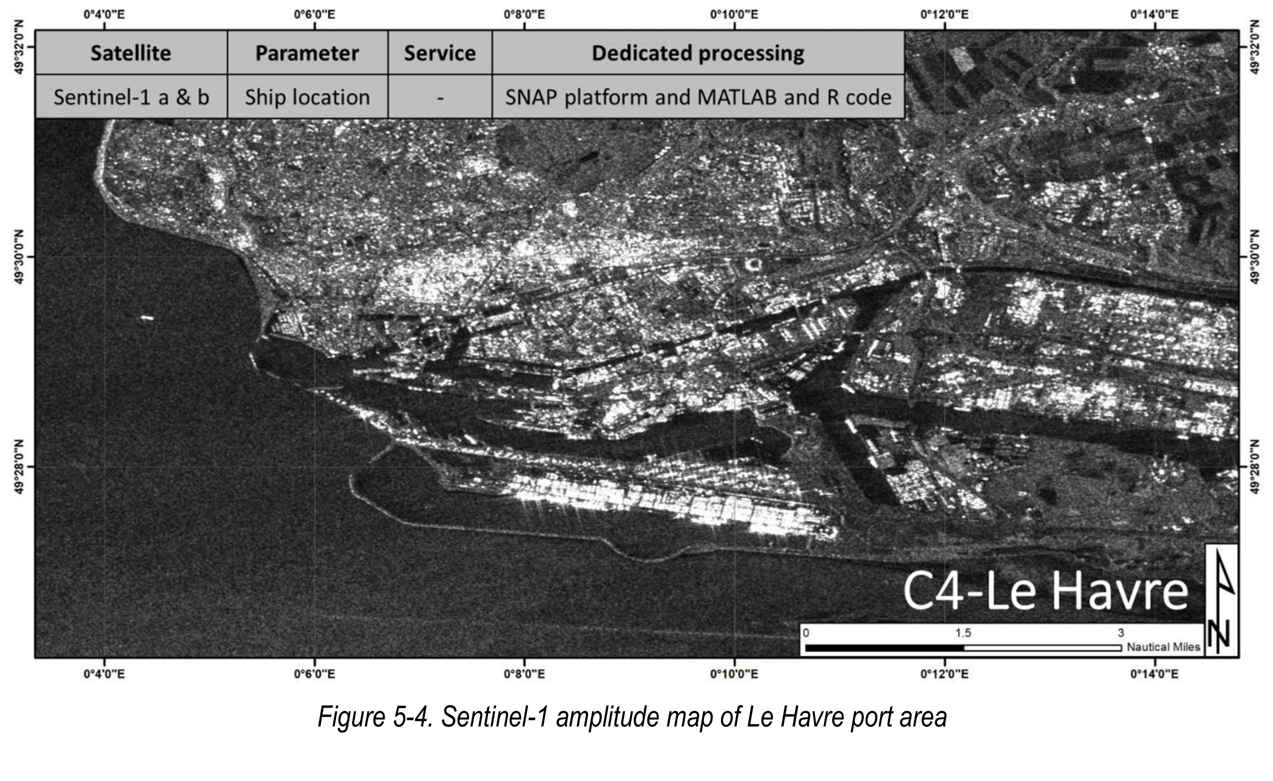


Figure 5-3. Use case concept for Le Havre campaign

Copernicus Usage

Sentinel-1 uses wide area coverage with improved revisit times and is able to potentially detect small ships. The mission's ability to observe in all weather and in day or night time, makes it ideal for precise cueing and location of ship activities at sea, allowing for more efficient and cost-effective use of other security assets, such as patrol aircraft and ships. SAR sensors use radar frequencies to construct an image of the surface of the Earth, which means that images can be acquired regardless of weather conditions and cloud cover, and at any time of day or night. By measuring the roughness of the sea surface, resulting images display features which stand out against the background; for example, vessels appear as bright spots, while oil spills appear as dark shapes. SAR is used primarily for vessel detection and pollution monitoring but can also be used for other purposes such as extracting wind, wave, and ice formation. Ship detection from remote sensing imagery is a crucial application for maritime security, which includes among others traffic surveillance and control, protection against illegal fisheries, oil discharge control and sea pollution monitoring. Sentinel-1 is a constellation of two polar-orbiting twin satellites, operating day and night performing C-band SAR imaging, enabling them to acquire imagery regardless of the weather. Sentinel-1 will work in a pre-programmed operation mode to avoid conflicts and to produce a consistent long-term data archive built for applications based on long time series. Devoted to radar imaging mission for land and ocean services. The first Sentinel-1A satellite was successfully launched on 3 April 2014, by an Arianespace Soyuz, from the Guyana Space Center. The second Sentinel-1B satellite was launched on 25 April 2016 from same spaceport. The combination of data acquired from S1A and S1B satellites provides almost global coverage of the Earth's surface and revisit times between 6 and 12 days. Ground Sampling Distances (GSD) are in the order of 2.3 m in range and 13.6 m in azimuth directions, respectively. Ship detection, identifying and extracting the coordinates in the maritime area, will be formulated through semi-automatic procedure based on the pre-processing of the SAR images, a thresholding of intensity value to extract the coordinates of high reflecting elements. The extraction of reflecting elements is possible thanks to their amplitude signature that results significantly higher with respect to the seawater. This diversity is due to the different reflectance of the material of the boats (high reflectance which corresponds to white/bright colour in the image) and the water (low reflectance which corresponds to dark colours). The SAR change detections and the texture analyses, useful to detect the ships, will be performed on the GRDH Sentinel-1 satellite images (Ground Range Detected High Resolution), consisting of focused SAR data that has been detected, multi-looked and projected to ground range using an Earth ellipsoid model.



Satellite	Parameter	Service	Dedicated processing
Sentinel-1 a & b	Ship location	-	SNAP platform and MATLAB and R code

Figure 5-4. Sentinel-1 amplitude map of Le Havre port area

5.5 LOGISTICS

the objective is to demonstrate in the case of ports such as Le Havre, how rotary wing fleet and fixed-wing RPAS can collaborate to ensure the surveillance of a port, its mooring area, and globally its vicinity (up to about 50km) for the detection and localisation of non-cooperative crafts.

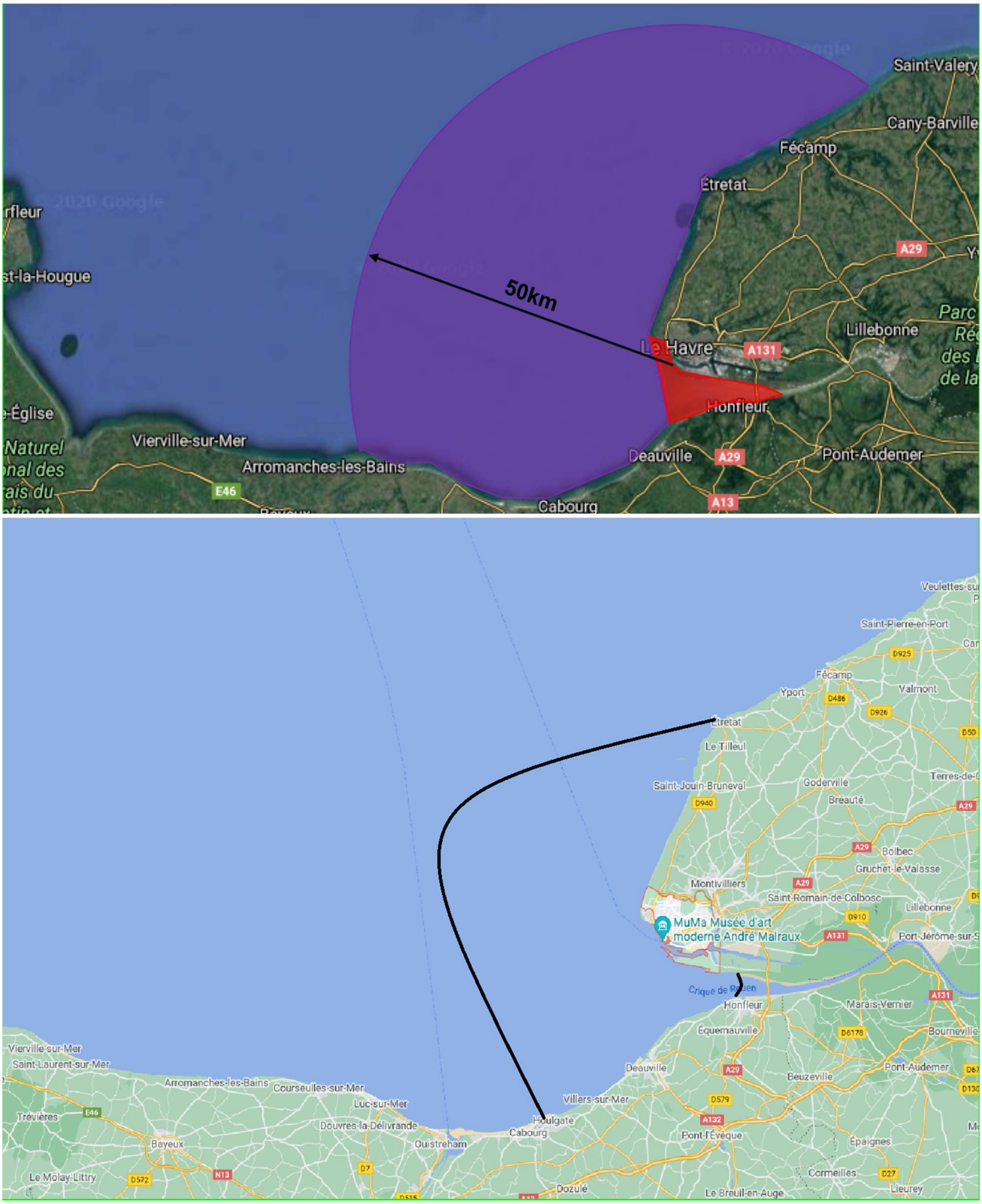


Figure 5-5. Interested areas in Le Havre

The demonstration scenario will be based on the complementary use of rotary wing UAVs for performing automatic survey on predefined patterns 24/7 in the close vicinity of the port, and fixed-wings will ensure the surveillance at a larger scale (such as mooring areas, approach channels, pilot waters).

In addition, scenarios of deployment on order from the port authority in order to check an abnormal situation, in complement to existing port sensors (Vessel Traffic Services system including radars, AIS, optical) and help for decision-making will also be addressed.

Several scenarios have identified in collaboration with HAROPA (on-going-activity):

DIFFUSE THREAT

Context: In the event of a major risk or knowledge of a proven but undetermined threat (risk of attack, for example), the port could mobilize all its surveillance resources to counter the threat.

Proposal to use drones to carry out surveillance and active watch patrols. Mobilized means could be fixed-wing drone for patrols in ZRT, rotating wing drone for patrols near the port, tethered drone to activate a lookout point to extend the port's detection capabilities. They could be mobilized simultaneously but on different geographical areas. Payload capabalities could be visible and IR wavelength.

SPECIFIC THREAT

Context : In case of reception or movement of a ship carrying a particularly dangerous cargo for example, the port could mobilize all its surveillance means to counter the risk.

Proposal to deploy drones to secure the approach of the vessel. It means to use fixed-wing drone for patrolling the ship's trajectory offshore, rotating wing drone for patrol accompanying the trajectory of the ship to take over from the fixed wing and tethered drone positioned near the ship at dockside to secure the environment. The use of a cooperative vessel will be needed. Payload capabalities could be visible and IR wavelength.

POTENTIAL THREAT AND TARGET SEARCH

Context : In case of presence of an unknown radar echo or abnormal behavior.

Proposal is to use drones over the zone and have a visual for decision making. Mobilized means can be fixed wing drone to have a wide view and to locate the vessel, rotating wing drone to identify the ship, to show that it is the object of particular attention. Tethered drone can also be deployed on the land side of the port in case of intrusion. The use of a small vessel simulating a non-cooperative vessel is needed (pilot boat, semi-rigid). Means will be deployed simultaneously on the same geographical area. Payload capabilities could be visible and IR wavelength.

VISUALIZATION OF SENSITIVE SITUATION

Context: In case of a situation for which the port does not have a visual (SAR, collision, accident, damage, fire).

Proposal : The drones will take off and fly to the area and have a visual for decision making. Mobilized means are fixed-wing drone to have a wide view, and rotating wing drone to get closer to the situation. Cooperative ship can be simulated by a pilot for example and a non-cooperative boat will be needed to. There is a need for long duration flights to monitor the situation (relay on rotary wing drone area could be necessary). Payload capabilities could be visible and IR wavelength.

SUPPLETIVE TO TRADITIONAL MEANS

Context : In case of damage or maintenance of land cameras visible from the port for example.

Proposal : Use of drones to fly to the area and have a visual for decision making. Means mobilized will be fixed-wing drone to have a wide view and rotating wing drone to have a closer view of the port.

6 CRITICAL BUILDINGS/ INFRASTRUCTURES PROTECTION

6.1 SCOPE AND PLANNING

Port areas are characterized by a large number of infrastructures which makes those unintentional interferences can occur more than desired. Nevertheless, maritime community is increasingly be concerned about intentional attacks such as jamming and spoofing. The former may not critically affect to maritime safety since GNSS signal disruption would lead to service not being available. However, spoofing could potentially provoke accidents, vessel misrouting or theft.

For this reason, the campaign performed in Hamburg will be devoted to operate a **fleet of drones for surveillance purposes being integrated as interface to SRX-10i/DINTEL GNSS interference detector** in the port to detect interference events that could compromise the security and the safety of port operations.

The scope of the demonstration campaign will be to test the following benefits:

- ✓ Sea side (vessel traffic monitoring) and ground side surveillance
- ✓ Non cooperative ships detection and location based on AI algos
- ✓ Ground side asset/ people detection and location based on AI algos
- ✓ GNSS interference detection
- ✓ Video for context awareness

In addition to PASSport partners, also several other authorities will be invited to attend on invitation of BM:

- ✓ HPA (Hamburg Port Authority) HPA (hamburg-port-authority.de)
- ✓ HVCC (Hamburg Vessel Coordination Center) Hamburg Vessel Coordination Center (hvcc-hamburg.de)
- ✓ HHLA (Hamburger Hafen und Logistik AG) Home - HHLA
- ✓ BWI Hamburg (Hamburg Authority for Economy and Innovation – Port Air Traffic Control) Behörde für Wirtschaft und Innovation - hamburg.de
- ✓ EUROKAI GMBH & CO. KGAA Eurokai The Company owned by J.F. Müller & Sohn AG *https://jfms.ag*

High level planning (TBC)

- Campaign preparation: starting from 2023 Q1
- Campaign dissemination: all 2023
- Campaign execution: 2023 Q3 (Sept 2023)
- Campaign event organisation 2023-Q3
- Campaign report: 2023 Q4

6.2 SELECTED AREA. THE PORT OF HAMBURG

The Port of Hamburg (German: Hamburger Hafen) is a seaport on the river Elbe in Hamburg, Germany, 110 kilometres (68 mi) from its mouth on the North Sea.

Known as Germany's "Gateway to the World" (Tor zur Welt), it is the country's largest seaport by volume. In terms of TEU throughput, Hamburg is the third-busiest port in Europe (after Rotterdam and Antwerp) and 15th-largest worldwide. In 2014, 9.73 million TEUs (20-foot standard container equivalents) were handled in Hamburg.

The port covers an area of 73.99 square kilometres (28.57 sq mi) (64.80 km² usable), of which 43.31 km² (34.12 km²) are land areas. The branching Elbe creates an ideal place for a port complex with warehousing and transhipment facilities. The extensive free port was established when Hamburg joined the German Customs Union. It enabled duty-free storing of imported goods and also importing of materials which were processed, re-packaged, used in manufacturing and then re-exported without incurring customs duties.

Figure 6-1. Port of Hamburg

Deepening of the river Elbe for large vessels is controversial for ecological reasons. In part due to cooperation with Lower Saxony and Bremen to build a new container port (JadeWeserPort) in the deep waters of Jadebusen in Wilhelmshaven, Hamburg withdrew from this plan after a change of government in 2001.

Hamburg is a major cruise destination and one of Europe's largest ports of call for cruise passengers traveling the Atlantic, or the Norwegian and Baltic Seas. The port is also a major location for shipbuilder and shipyards, designing, building and reconditioning yachts and cruise liners. Hamburg has three passenger terminals for cruise ships: Hamburg Cruise Center HafenCity, the Hamburg Cruise Center Altona and the Hamburg Cruise Center Steinwerder, all three capable of processing the world's largest cruise ships.

6.3 IMPACTED USER AND SYSTEM REQUIREMENTS

Port areas are characterized by a large number of infrastructures which makes those unintentional interferences can occur more than desired. Nevertheless, maritime community is increasingly be concerned about intentional attacks such as jamming and spoofing which could potentially provoke accidents, vessel misrouting or theft. or compromise the security and the safety of port operations. The following dedicated User Requirement is identified:

UR-070. INFRASTRUCTURES PROTECTION (OPERATIONAL)

PASSport system shall support infrastructure protection in port area by providing the following features:

- ✓ *Continuous aerial surveillance monitoring*
- ✓ *Continuous monitoring of interferences in GNSS bands.*
- ✓ *Identification and characterization of interference sources*

UR_ID	Title	SR ID	ReqTitle
UR-070	Infrastructure's protection	SR-020	PASSport aerial drone - rotary wings
		SR-030	PASSport aerial drone - rotary wings tethered
		SR-060	PASSport ground - control
		SR-070	PASSport ground - mission
		SR-080	PASSport ground - Security Monitoring Procedures
		SR-090	PASSport ground - Vessels traffic monitoring – drones and vessels positions
		SR-095	PASSport ground - Vessels traffic monitoring - AIS-based vessels positions
		SR-100	PASSport ground - GNSS Interference Detection
		SR-120	PASSport aerial drone - rotary wings - GNSS Rx payload - authentication
		SR-130	PASSport aerial drone - rotary wings - GNSS Rx payload - accuracy
		SR-140	PASSport aerial drone - rotary wings - communications availability
		SR-150	PASSport aerial drone - rotary wings - operations continuity
		SR-160	PASSport aerial drone - rotary wings - environmental conditions
		SR-170	PASSport aerial drone - rotary wings - autonomy of mission degree
		SR-380	PASSport algorithms - ground object recognition
		SR-390	PASSport algorithms - ground object location

UR_ID	Title	SR ID	ReqTitle
		SR-430	PASSport algorithms - Sentinel 1 - small ship detection
		SR-450	PASSport algorithms - EGMS
		SR-470	PASSport ground - data and process management
		SR-480	PASSport ground - data archiving and retrieving
		SR-490	PASSport ground - data export and final report

Table 6-1 – Infrastructure's protection user and system requirements

Based on Table 6-1 the relevant architecture configuration is reported in next chapter.

6.4 PASSPORT CONFIGURATION

A Tethered rotary wings drone and a free to flight rotary wing will be used for the campaign as a part of the Passport Aerial Segment. The PASSport automated RPAS will be used as additional sensors to provide data for more situational awareness to be operationally integrated with AIS product (TBC by HPA) including advanced EGNSS solution onboard rotatory axis RPAS and external interface SRX-10i/DINTEL GNSS interference detector in the port to detect GNSS interference events that could compromise the security and safety of port operations.

Passport Mission Element will be in place for mission planning, Passport Control Element will be in place for mission control.

Full description of architecture elements is reported in [RD 2].

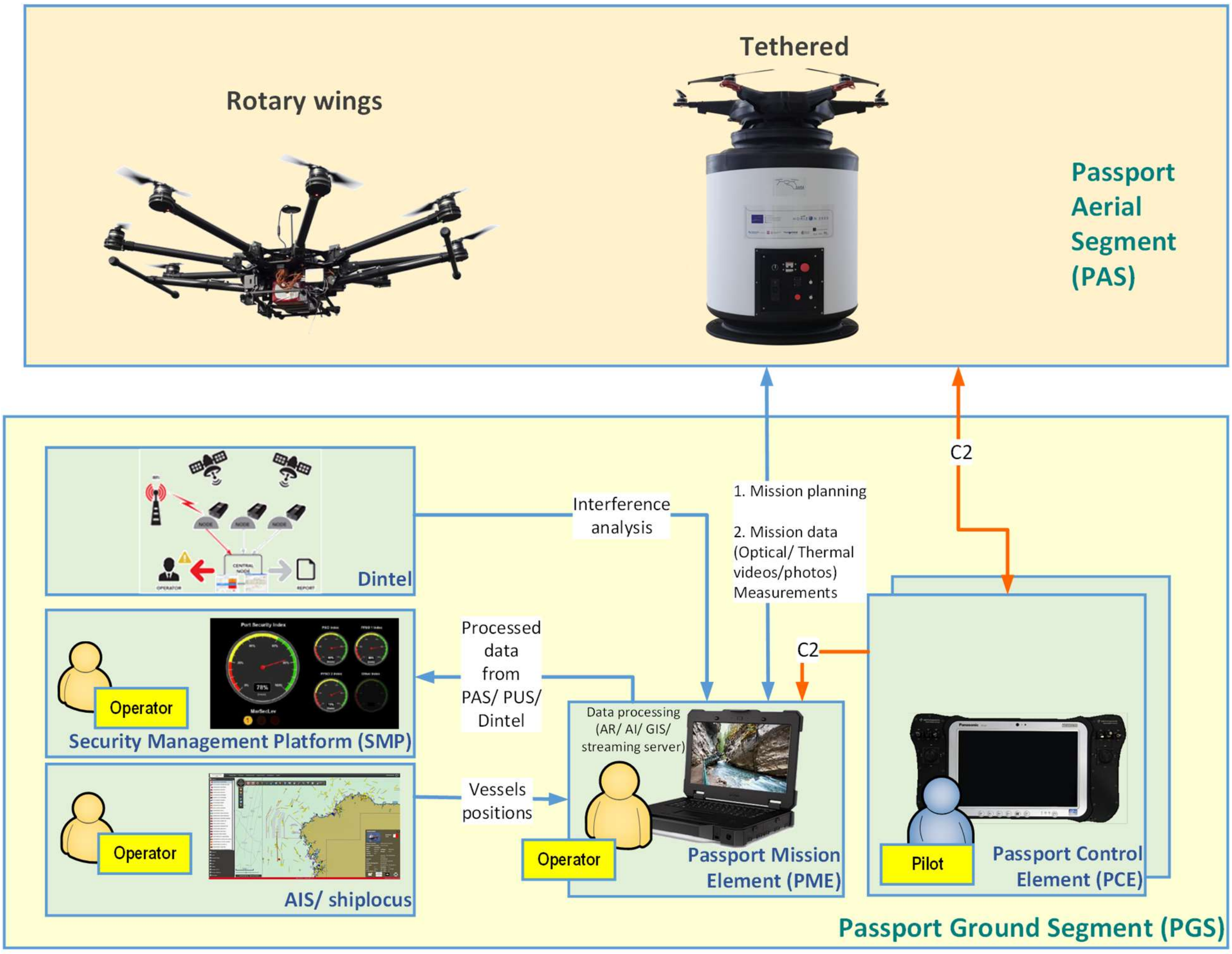


Figure 6-2. PASSport configuration for Hamburg campaign

PASSport configuration for this campaign is composed by:

- One (1) rotary wing tethered drone equipped by optical camera for distant video monitoring
- One (1) rotary wing drone optical camera for distant video monitoring
- One (1) control segment (PCE) composed managing the fleet of drones
- One (1) mission center (PME) where both real time (video for situational awareness) and data for post-processing are collected, processed together with Copernicus, validated and published. PME also manages all mission phases, i. e. planning, acquisition, processing, validation, reporting.

- One (1) Security Management Platform (SMP) used to trigger threats and activate relevant intervention procedures
- One (1) GNSS interference detection to check quality of GNSS signal
- Interface to already existing AIS systems, namely shiplocus, already managed by PASSPort consortium

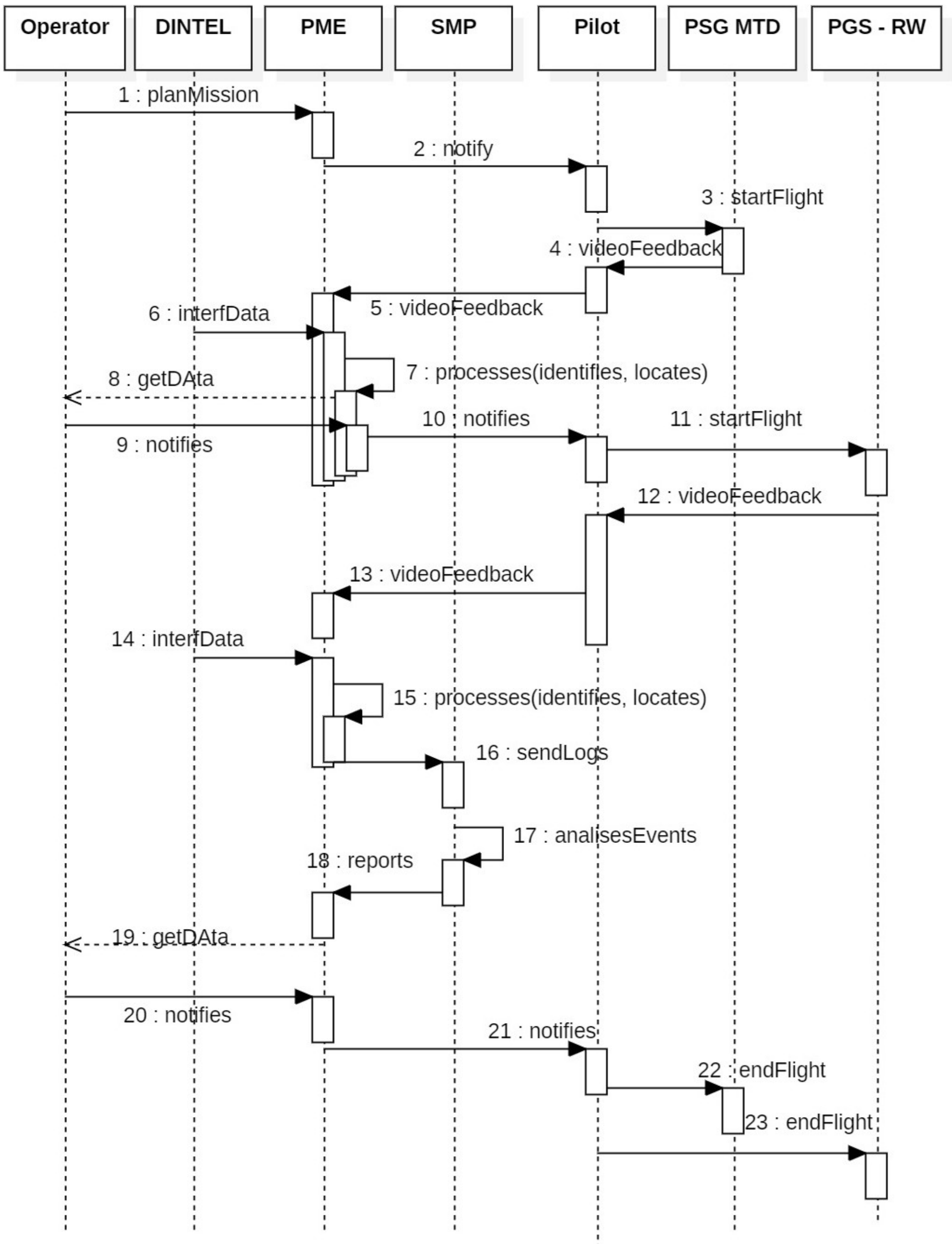


Figure 6-3. Use case concept for Hamburg campaign

Accordingly, *Figure 6-3Figure 4-3* reports the relevant use case concept.
The PME operator plans a mission notifying the pilot(s) in charge of operations for the fleet of drones. The pilot(s) is in charge to manage context awareness via video return link and data collection. Finally, the collected data are uploaded on the platform for final report generation.

Copernicus Usage

The monitoring of the stability of Hamburg port facilities will benefit from InSAR data belonging to the EGMS (European Ground Motion Service). InSAR techniques, are based on large stacks of SAR images and appropriate tools to process them, enabling the measurement from space of small displacements, at millimeter-scale. It covers wide areas with a relatively high spatial measurement density. It provides a systematic temporal deformation monitoring. It can measure past deformation phenomena, exploiting the SAR image historical archives. The EGMS aims to provide consistent, updated, standardized, harmonized across national borders and reliable information regarding natural and anthropogenic ground motion phenomena over Europe. It will be based on full resolution processing by means of DInSAR techniques of Sentinel-1A and 1B SAR data. A total of ~750 single look complex (SLC) scenes cover Europe in ascending and descending orbit (~200000 bursts). On average 260 scenes are available for each stack for the baseline product. During the last two decades, a large variety of InSAR time series analysis methods have been published. These fall into three main categories, with different characteristics: Methods for analysis of pointlike scatterers (PS); Methods for analysis of distributed scatterers (DS); Methods that exploit both PS and DS. Pointlike Scatterers (PS) typically belong to the family of persistent targets and correspond to single dominant scatterers within their resolution cells, exhibiting a very stable value of reflectivity as a function of time and possible variations in acquisition geometry. Many PS are usually available in urban areas and most of them correspond to man-made structures (poles, antenna, metallic objects, buildings, etc.).

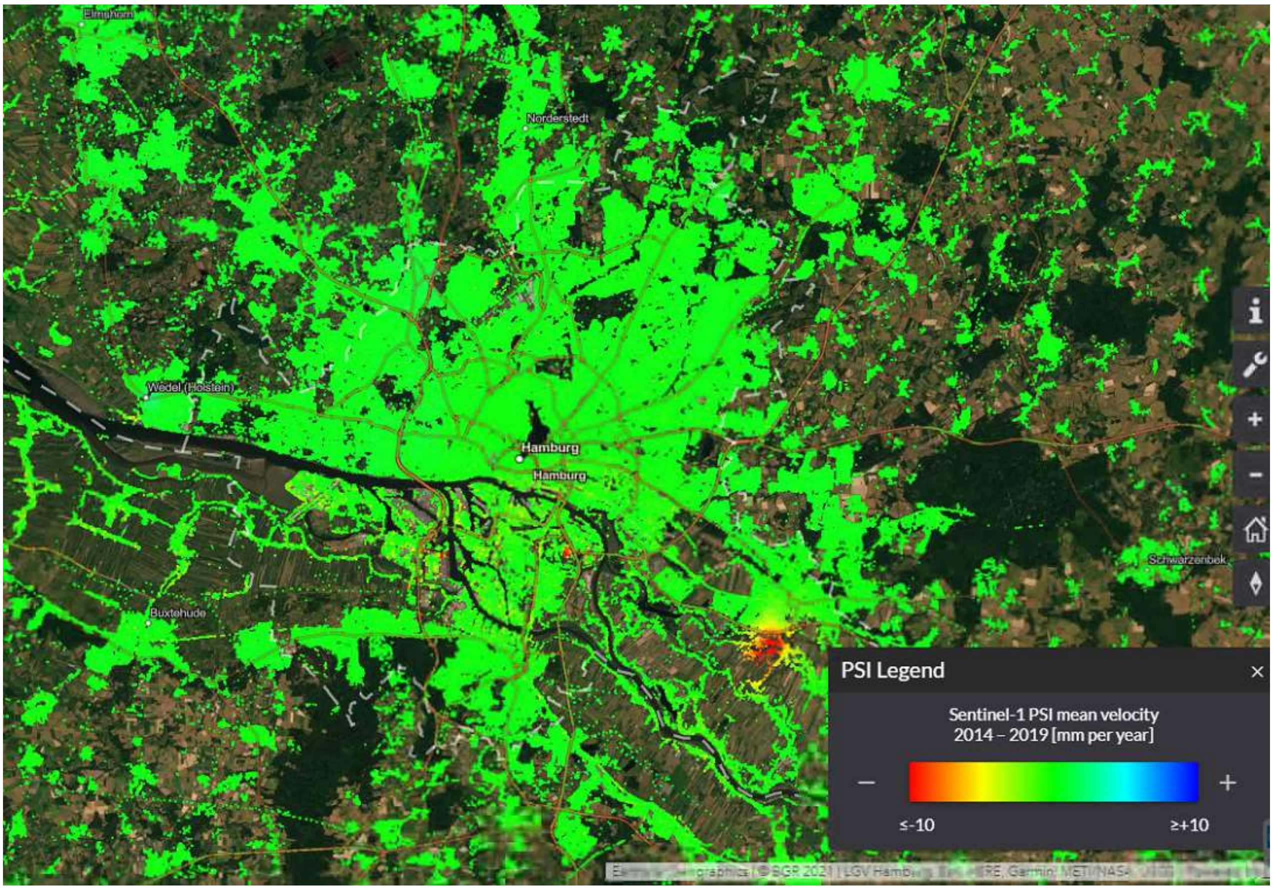


Figure 6-4. Sentinel-1 PS map of the Hamburg area

Distributed scatterers (DS), exhibiting fairly good coherence in some interferograms but not all, are identified from homogeneous ground, scattered outcrops, debris flows, non-cultivated lands and desert areas. They typically correspond to natural targets and originate by a multitude of individual scattering centres distributed over a volume or a surface and can be described only in statistical terms. DS are characterised by lower reflectivity values compared to PS, but their information content can be improved by spatially averaging neighboring samples with similar statistical properties. The most recent multi-interferogram techniques can identify both families of measurement points, PS and DS.

The EGMS will include three main products: The first product is Level 2a, which includes deformation maps and deformation time series with measurements along the radar LOS. This is the basic EGMS product, which will be delivered for individual and consistent frames of the original SAR image stacks. The MPs will be referred to reference points, one for each frame. Level 2a products will be generated at full Sentinel-1 resolution; The second product is Level 2b. This is an advanced product, where the frames of Level 2a will all be mosaicked. It will consist in an InSAR deformation map combined with a reference GNSS network. The deformation will refer to the radar LOS. The generation of this product will have to overcome the uneven availability of GNSS data across Europe. Level 2b will be generated at full Sentinel-1 resolution; The third product is Level 3. This represents a more advanced product, especially with respect to Level 2a. It will include two main deformation components: the horizontal east–west and up–down vertical deformation. The input deformation map is Level 2b. Level 3 will be obtained by combining, at a coarser resolution (100 × 100 m) with respect to the resolution of the Level 2b, the ascending and descending InSAR results.

6.5 LOGISTICS

The Hamburg Port spans a very large area. In addition, the approach through the Elbe River creates special conditions.

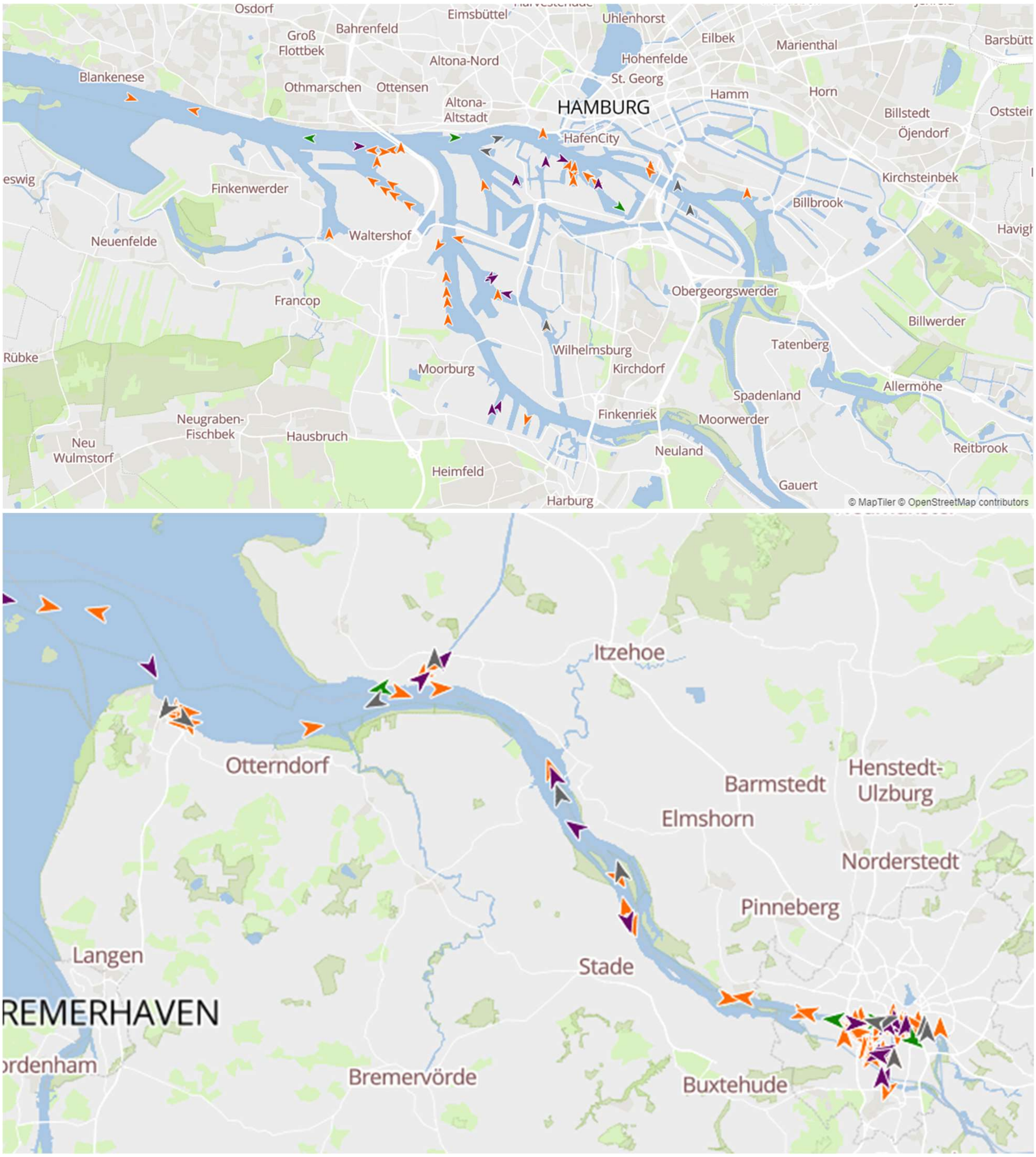


Figure 6-5. Hamburg port areas

With the tides observed in Hamburg, the water levels at the Elbe River are changing massively. Deep draft vessels may only be able to enter the harbour by using high tide water levels and may need to sail with the tide into the harbour.

Within the harbour limits various critical infrastructure components are potential candidates for the PASSport campaign in Hamburg.

<u>5 potential special focus areas for the Hamburg campaign are identified</u>

Focus area 1 is the harbour section Steinwerder. Here both cargo operations (e.g. Container and bulk) as well as ship building and repair is located. Larger military ships are constructed or refit here and there is a larger cruise terminal in this part of the harbour

In focus area 2, the "Hafencity" mots prominent tourist attractions, like the Hamburg opera, the historic "Speicherstadt" or the living quarter "Hafencity" are building an ensemble of well know landmarks with specific need for protection. Key offices of the Hamburg Port Authority are located here as well.

Focus area 3 focuses on car carrier as well as reefer cargo are in this area.

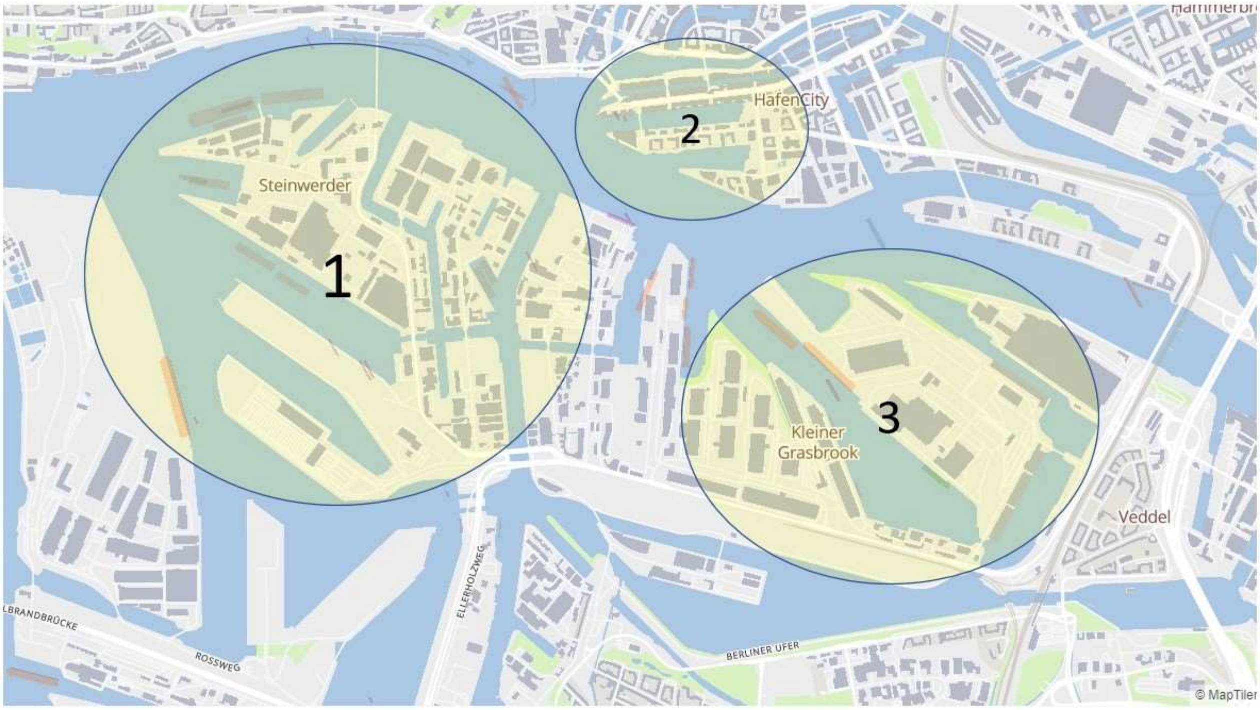


Figure 6-6. Hamburg port preliminary identified areas 1) 2) 3)

Another special focus area (4) in Finkenwerder. For one it holds larger container and wet bulk terminals but it also is home of the Airbus factory with an airport for test flights.

Finally focus area 5 "Altenwerder" is a large container terminal area. Of specific interest is the "Köhlbrandbrücke", a bridge build so allow also larger container ships to allow passing towards the terminals, but very large container vessels may need to observe the available air draft.

Figure 6-7. Hamburg port preliminary identified areas 4) 5)

7 SUPPORT TO E-NAVIGATION

7.1 SCOPE AND PLANNING

The campaign performed in Valencia will be devoted to capture operational benefits brought by PASSport in support to **e-Navigation** providing a concrete contribution to initiatives started by the International Maritime Organization (IMO) more than 10 years ago and well in the implementation phase.

About **e-navigation** topic, the Port of Valencia participated in two main projects named MONALISA2.0 (https://www.seatrafficmanagement.info/projects/monalisa-2/) and STM (www.stmproject.eu). Both projects addressed the **e-navigation** integration of ship-ship, ship-port and ship-shore information systems such as: **AIS, VTS, port community system (PCS), tugboats, pilotage and mooring information systems.** In this sense, the campaign will be conducted in order to have feedback on how automated RPAs could support current systems with valuable ship information, for instance, confirmation from port users about ship berthing operations. So, together with other e-Navigation aspects, like automated ship reporting, e.g. through National Maritime Single Window or e-Certificate exchange with Port State Control, **PASSport can provide the effected port authorities with preliminary information to facilitate better coordination of safety and security related to port operations.**

The PASSport system shall complement existing e-Navigation systems by providing real time data and visualization of ship movements, monitoring of dangerous and difficult to access areas and providing such data to VTS/ships. In particular, the following functionalities will be implemented:

- ✓ Contribute to continuous real-time monitoring for ship arrival/departure to/from port.
- ✓ Detection of vessels with AIS disabled.
- ✓ Provide real-time information/data to support "Pilots" VTS.
- ✓ Ships monitoring in anchorage areas

In addition to PASSport partners, also several other authorities will be invited to attend on invitation of FVP:

- ✓ Port Pilots from the ports of Valencia, Sagunto and Gandía and form other ports of interest with VTS systems
- ✓ Valencia port control
- ✓ Other port authorities of interest
- ✓ Puertos del estado (State ports)
- ✓ SASEMAR (Maritime Safety Agency at sea)
- ✓ Technical nautical services (mooring and tug services)
- ✓ Port terminal operators

<u>**High level planning (TBC)**</u>

- Campaign preparation: starting from 2023-Q1
- Campaign dissemination: starting from 2023-Q1
- Campaign execution: 2023 Q2 (<u>September 2023)</u>
- Campaign event organisation 2023-Q3
- Campaign report: 2023 Q4

7.2 SELECTED AREA. THE PORT OF VALENCIA

The Port of Valencia has been selected as it is the fifth busiest seaport in Europe. As of 2019, it moves an annual cargo traffic of around 81 million tonnes and 5.4 TEU, ranking first in Spain and second in the Mediterranean basin in container shipping (after the Port of Piraeus), and second in Spain in annual cargo traffic, after the Port of Algeciras.

Figure 7-1 Valencia Port (South)

Figure 7-2 Valencia Port (West)

7.3 IMPACTED USER AND SYSTEM REQUIREMENTS

The campaign will be devoted to capture operational benefits brought by PASSport in support to e-Navigation providing a concrete contribution to initiatives started by the International Maritime Organization (IMO) more than 10 years ago and well in the implementation phase.

The campaign will be conducted in order to have feedback on how automated drones could be a supported tool in order to be integrated among the different systems as well as send confirmation from port users about the ship berthing operations. The following dedicated User Requirement is identified:

UR-60 E-NAVIGATION SUPPORT (OPERATIONAL)

PASSport system shall complement existing e-navigation systems by providing real time data and visualization of ship movements, monitoring of dangerous and difficult to access areas and providing such data to VTS/ships. In particular, the following functionalities have to be implemented:

- ✓ *Contribute to continuous real-time monitoring for ship arrival/departure to/from port.*
- ✓ *Detection of vessels with AIS disabled.*
- ✓ *Provide real-time information/data to support "Pilots" VTS.*
- ✓ *Ships monitoring in anchorage areas*

UR_ID	Title	SR ID	ReqTitle
UR-060	E-navigation support	SR-020	PASSport aerial drone - rotary wings
		SR-030	PASSport aerial drone - rotary wings tethered
		SR-060	PASSport ground - control
		SR-070	PASSport ground - mission
		SR-080	PASSport ground - Security Monitoring Procedures
		SR-090	PASSport ground - Vessels traffic monitoring - drones and vessels positions
		SR-095	PASSport ground - Vessels traffic monitoring – AIS-based vessels positions
		SR-100	PASSport ground - GNSS Interference Detection
		SR-120	PASSport aerial drone - rotary wings - GNSS Rx payload - authentication
		SR-130	PASSport aerial drone - rotary wings - GNSS Rx payload - accuracy
		SR-140	PASSport aerial drone - rotary wings - communications availability
		SR-150	PASSport aerial drone - rotary wings - operations continuity

UR_ID	Title	SR ID	ReqTitle
		SR-160	PASSport aerial drone - rotary wings - environmental conditions
		SR-170	PASSport aerial drone - rotary wings - autonomy of mission degree
		SR-190	PASSport aerial drone - rotary wings tethered - GNSS Rx payload - accuracy
		SR-200	PASSport aerial drone - rotary wings tethered - communications availability
		SR-210	PASSport aerial drone - rotary wings tethered - operations continuity
		SR-220	PASSport aerial drone - rotary wings tethered - environmental conditions
		SR-230	PASSport aerial drone - rotary wings tethered - autonomy of mission degree
		SR-233	Passport aerial- drone – rotary wings – robustness and safety of autonomous mission
		SR-360	PASSport algorithms - vessels recognition
		SR-370	PASSport algorithms - vessels location
		SR-430	PASSport algorithms - Sentinel 1 - small ship detection
		SR-450	PASSport algorithms - EGMS
		SR-470	PASSport ground - data and process management
		SR-480	PASSport ground - data archiving and retrieving
		SR-490	PASSport ground - data export and final report

Table 7-1 – Infrastructure's protection user and system requirements

Based on Table 7-1the relevant architecture configuration is reported in next chapter.

7.4 PASSPORT CONFIGURATION

A Tethered rotary wings drone and a free to flight rotary wing will be used for the campaign as a part of the Passport Aerial Segment. The PASSport automated RPAS will be used as additional sensors to provide data for more situational awareness to be operationally integrated with shiplocus product including advanced EGNSS solution onboard rotatory axis RPAS and external interface SRX-10i/DINTEL GNSS interference detector in the port to detect interference events that could compromise the security and safety of port operations.

Passport Mission Element will be in place for mission planning, Passport Control Element will be in place for mission control.

Full description of architecture elements is reported in [RD 2].

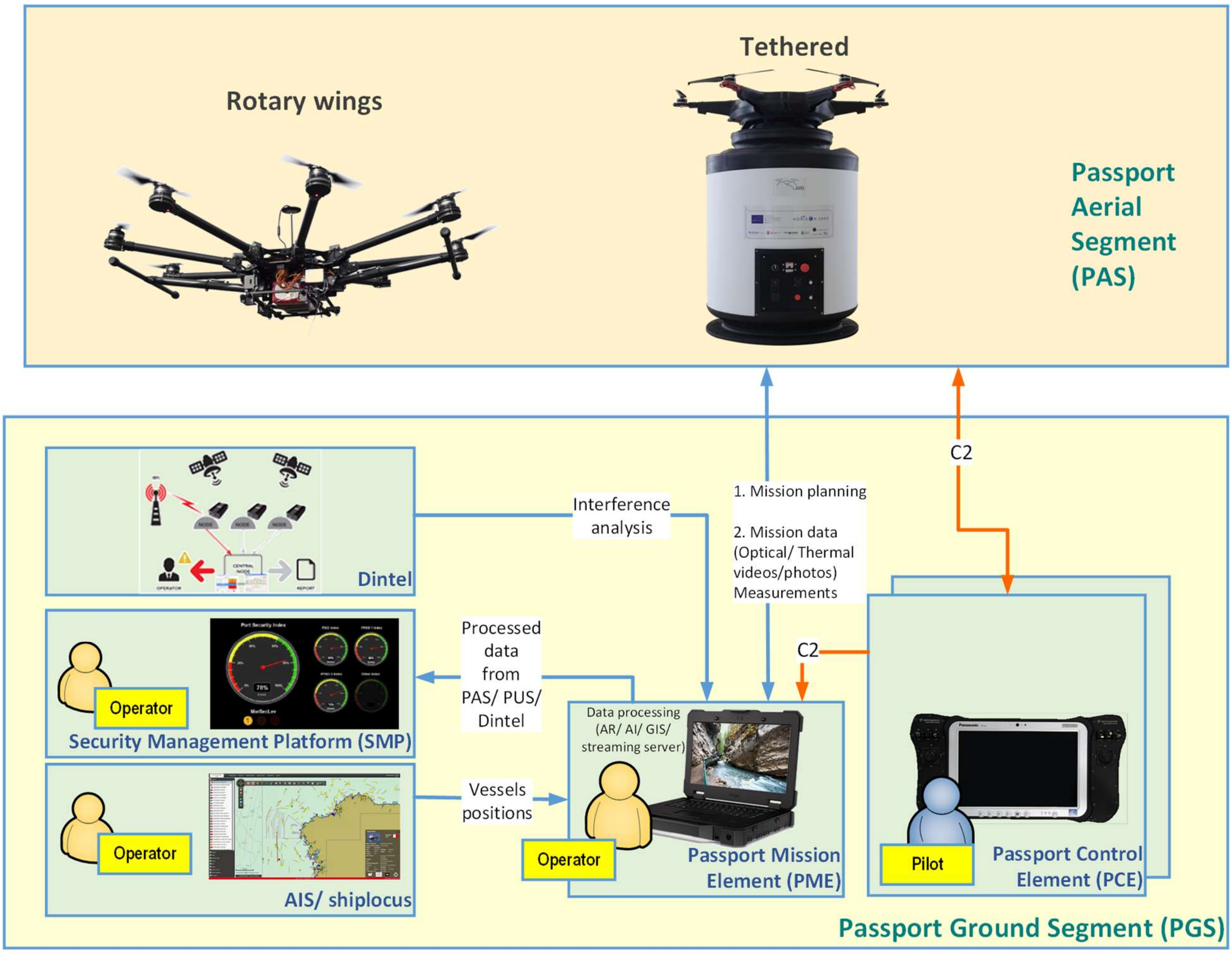


Figure 7-3. PASSport configuration for Valencia campaign

PASSport configuration for this campaign is composed by:

- One (1) rotary wing tethered drone equipped by optical camera for distant video monitoring
- One (1) rotary wing drone optical camera for distant video monitoring
- One (1) control segment (PCE) composed managing the fleet of drones
- One (1) mission center (PME) where both real time (video for situational awareness) and data for post-processing are collected, processed together with Copernicus, validated and published. PME also manages all mission phases, i. e. planning, acquisition, processing, validation, reporting.

- One (1) Security Management Platform (SMP) used to trigger threats and activate relevant intervention procedures
- One (1) GNSS interference detection to check quality of GNSS signal
- Interface to already existing AIS systems, namely shiplocus, already managed by PASSport consortium

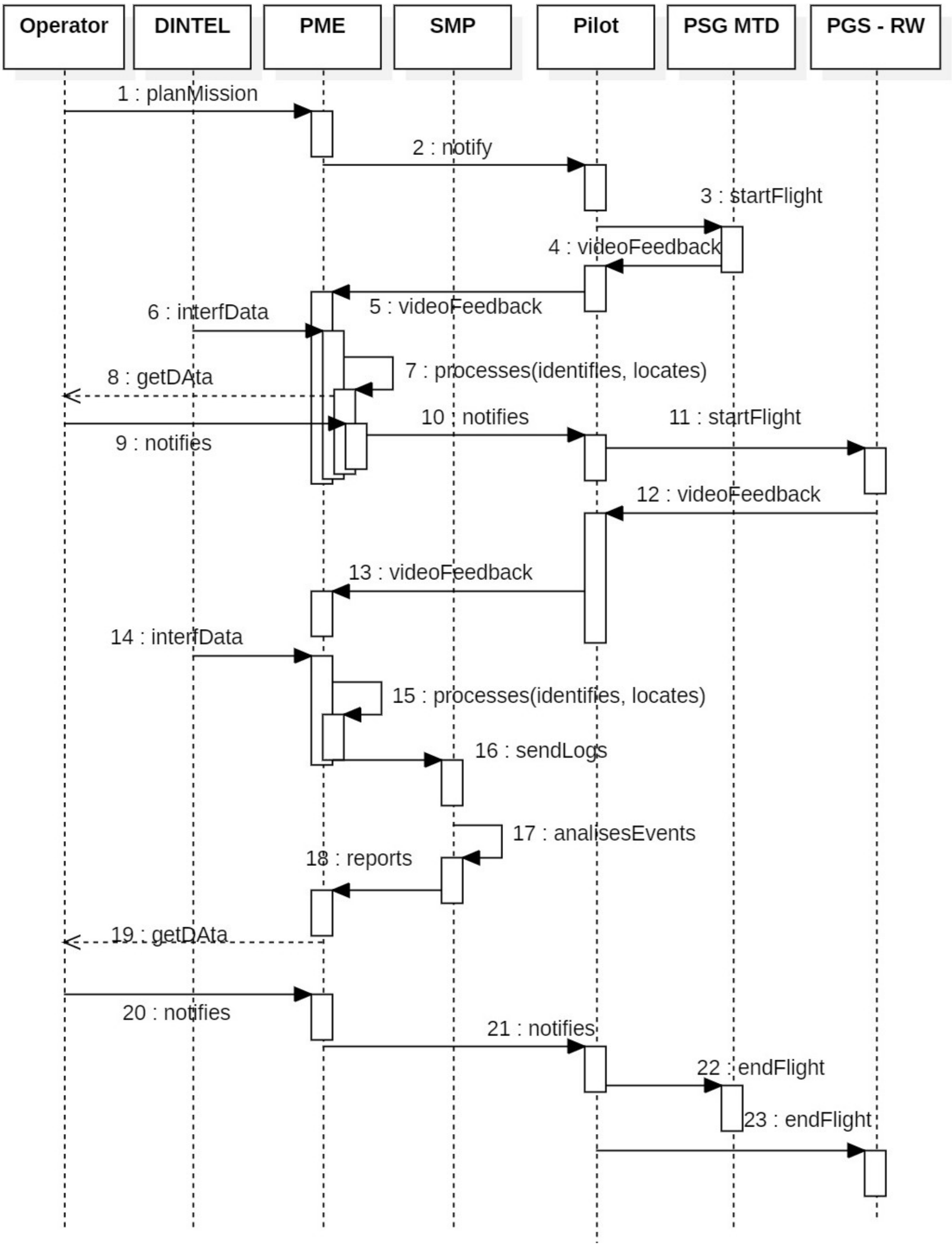


Figure 7-4. Use case concept for Valencia campaign

Copernicus Usage

Sentinel-1 uses wide area coverage with improved revisit times and is able to potentially detect small ships. The mission's ability to observe in all weather and in day or night time, makes it ideal for precise cueing and location of ship activities at sea, allowing for more efficient and cost-effective use of other security assets, such as patrol aircraft and ships. SAR sensors use radar frequencies to construct an image of the surface of the Earth, which means that images can be acquired regardless of weather conditions and cloud cover, and at any time of day or night. By measuring the roughness of the sea surface, resulting images display features which stand out against the background; for example, vessels appear as bright spots, while oil spills appear as dark shapes. SAR is used primarily for vessel detection and pollution monitoring but can also be used for other purposes such as extracting wind, wave, and ice formation. Ship detection from remote sensing imagery is a crucial application for maritime security, which includes among others traffic surveillance and control, protection against illegal fisheries, oil discharge control and sea pollution monitoring. Sentinel-1 is a constellation of two polar-orbiting twin satellites, operating day and night performing C-band SAR imaging, enabling them to acquire imagery regardless of the weather. Sentinel-1 will work in a pre-programmed operation mode to avoid conflicts and to produce a consistent long-term data archive built for applications based on long time series. Devoted to radar imaging mission for land and ocean services. The first Sentinel-1A satellite was successfully launched on 3 April 2014, by an Arianespace Soyuz, from the Guyana Space Center. The second Sentinel-1B satellite was launched on 25 April 2016 from same spaceport. The combination of data acquired from S1A and S1B satellites provides almost global coverage of the Earth's surface and revisit times between 6 and 12 days. Ground Sampling Distances (GSD) are in the order of 2.3 m in range and 13.6 m in azimuth directions, respectively. Ship detection, identifying and extracting the coordinates in the maritime area, will be formulated through semi-automatic procedure based on the pre-processing of the SAR images, a thresholding of intensity value to extract the coordinates of high reflecting elements. The extraction of reflecting elements is possible thanks to their amplitude signature that results significantly higher with respect to the seawater. This diversity is due to the different reflectance of the material of the boats (high reflectance which corresponds to white/bright colour in the image) and the water (low reflectance which corresponds to dark colours). The SAR change detections and the texture analyses, useful to detect the ships, will be performed on the GRDH Sentinel-1 satellite images (Ground Range Detected High Resolution), consisting of focused SAR data that has been detected, multi-looked and projected to ground range using an Earth ellipsoid model.

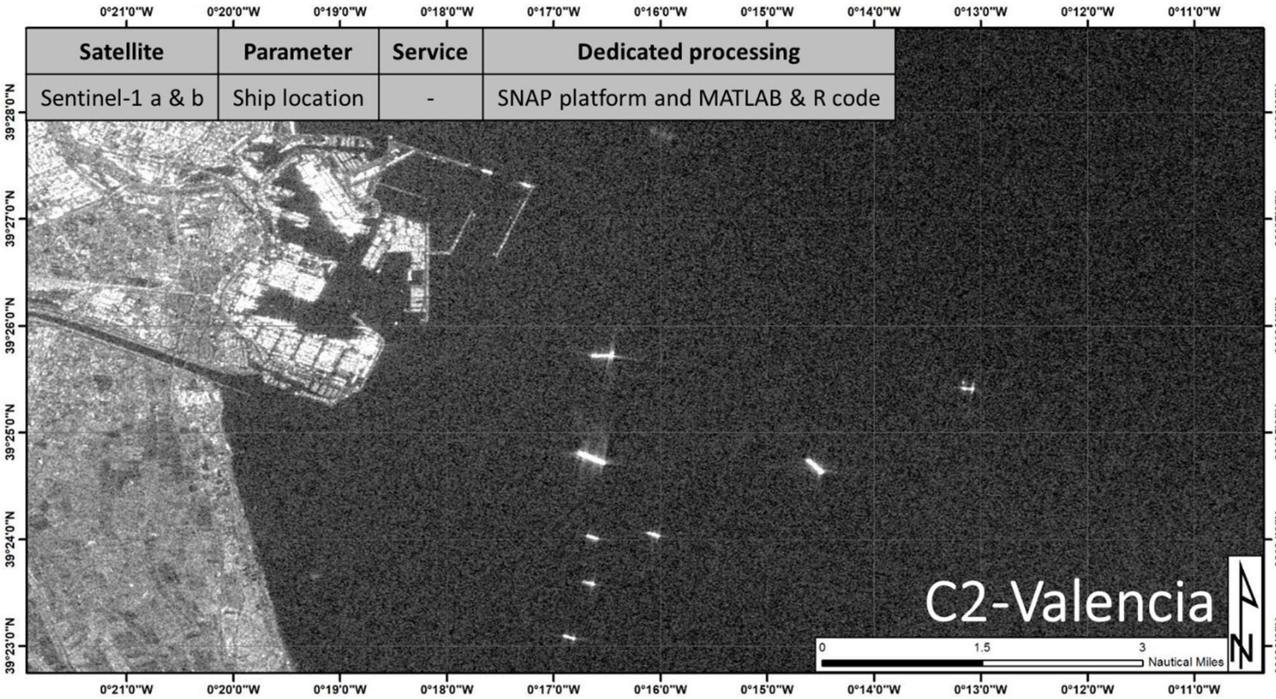


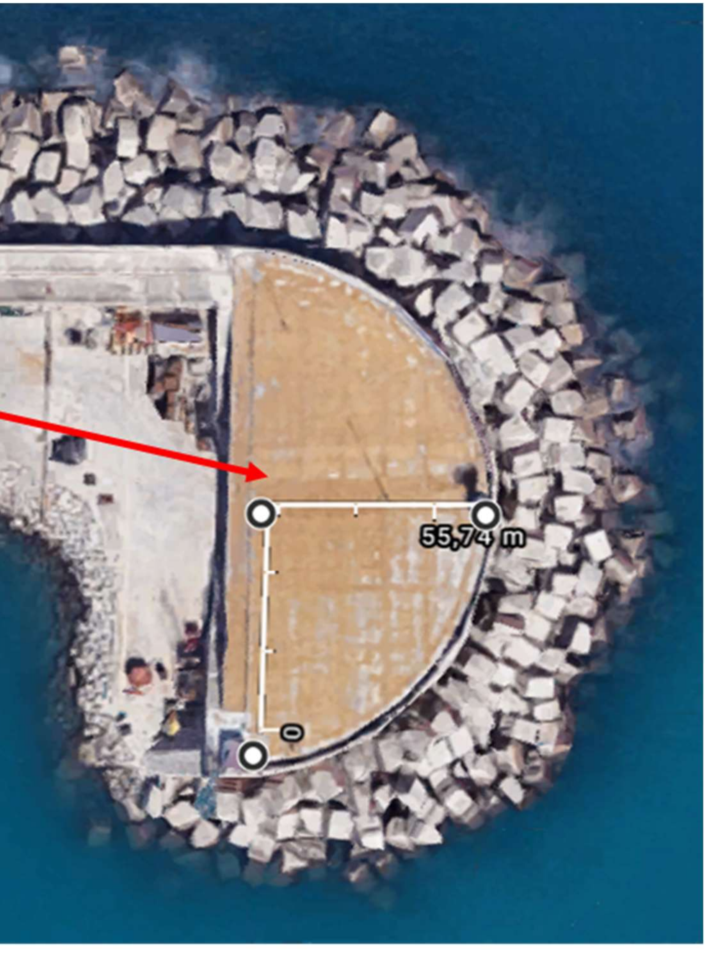
Figure 7-5. *Sentinel-1 amplitude map of Valencia port area*

7.5 LOGISTICS AND PLANNING (FVP)

The validation campaign in Valencia is planned to be carried out in September 2023. Five potential locations within the Port of Valencia have been identified to deploy the validation campaign. Each one of these will require a specific authorisation from the port authority prior to it starting. These areas are:

Figure 7-6. Identified areas for operations in Valencia port

Location 1: East dike



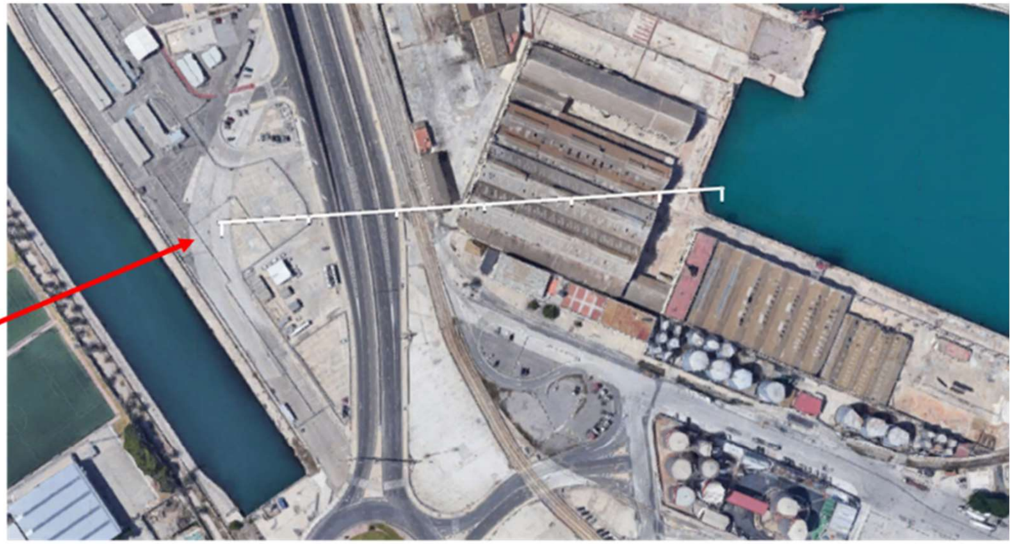
Esplanade on the ports East dike.

- Disposes of sufficient ground space (>10m diameter) for pilot deployment
- With power source for electronic equipment

Location 2: Boluda tug boat's dock

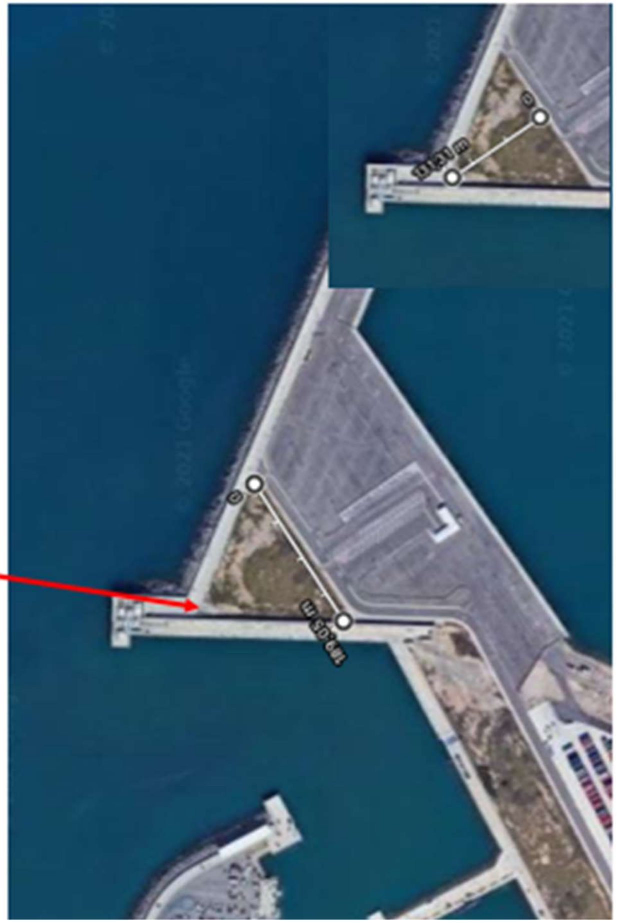
- Centralized area with sufficient ground space (>10m diameter).
- Without power source for electronic equipment.

Location 3: Port Authority parking



- Area located at in the close proximity of the Port Authority.
- Approximately 290m from the water, with sufficient ground space (>10m diameter) for drone flight testing without obstacles.

Location 4: Port's northern enlargement 1



- Area located at the port's northern expansion.
- Currently not in use, with irregular ground surface.
- Sufficient ground space (>10m diameter)

Location 5: Valeniciaport's northern enlargement 2

- Area located at the port's northern expansion.
- Currently not in use, with irregular ground surface.
- Sufficient ground space (>10m diameter)

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