PASSport project. A case study about aerial surveillance of maritime areas and infrastructures

Valencia, October 19th 2023

Agenda

- 10.00 - 10.15 Welcome
(R. C. Peris, FVP)
- 10.15 - 10.30 The OSNMA service
(P. Haro, EUSPA)
- 10.30 - 10.45 PASSport solution
(M. Nisi, SIST)
- 10.45 - 11.00 OSNMA activities in PASSport
(I. Armengol, GMV)
- 11.00 - 11.15 Aerial solution detection and localisation
(J. Cayero, Ecat)

11.15 - 11.30 Copernicus service and activities in PASSport
(P. Confuorto, UNIFI)

- 11.30 - 11.45 Introduction and Training to PASSport
(D. Taurino, DBL)
- 11.45 - 12.35 DEMO presentation and execution
(M.Nisi, SIST, R. C. Peris, FVP, D.M. Delgado GMV, M. G. Arias GMV)

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1. Valencia Port

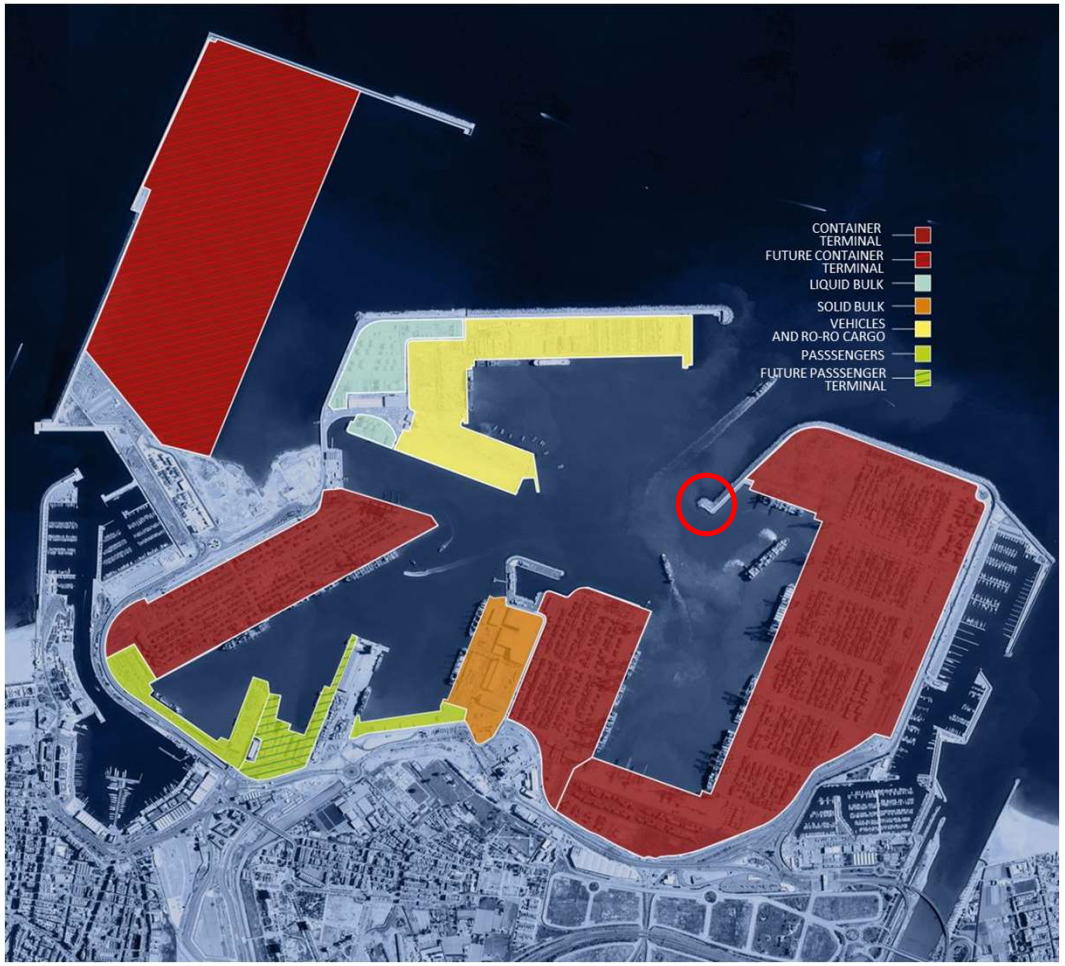
The Port Authority of Valencia, known as 'Autoridad Portuaria de Valencia', oversees the management and operations of three different ports in the Valencia region of Spain.

2. Area for campaign deployment

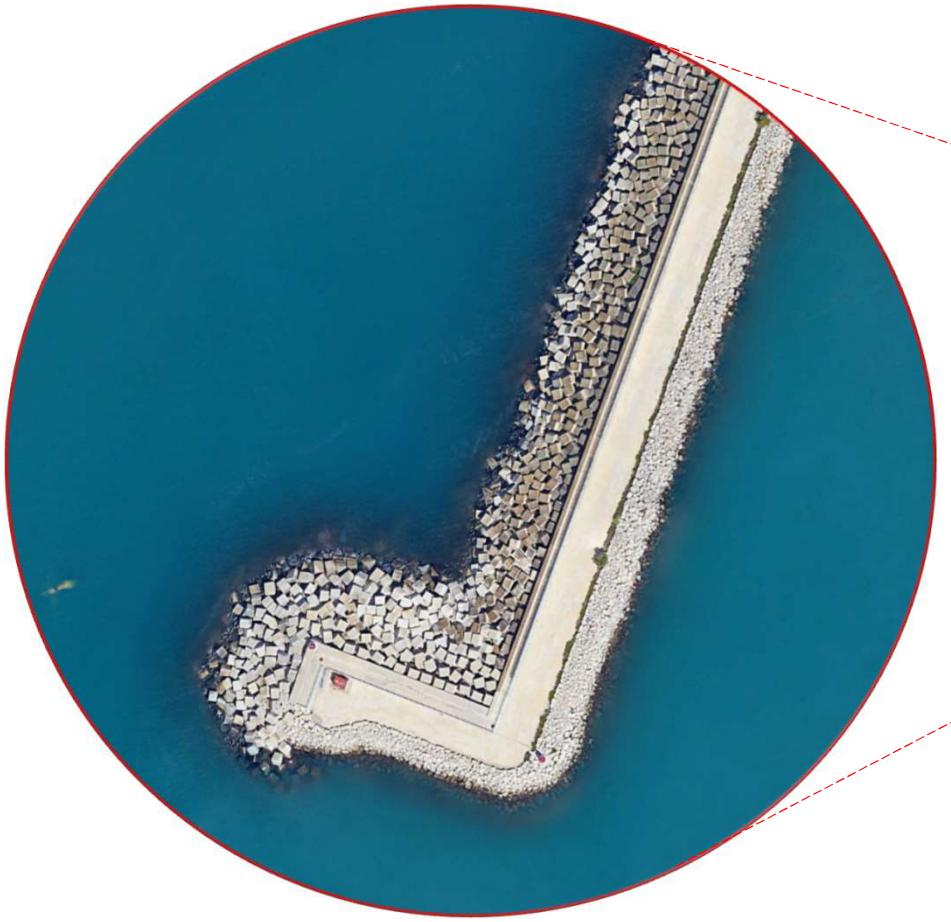
Although the Port of Valencia is primarily recognized for container traffic, it also hosts:

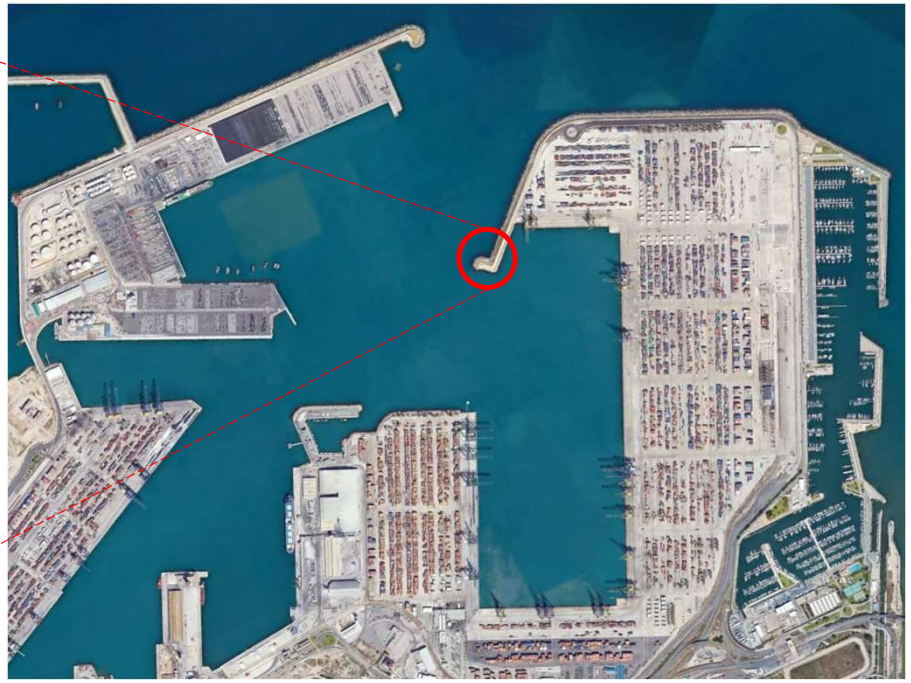
- 3 container terminals,
- 2 ro-ro terminals,
- 2 bulk terminals
- 1 passenger terminal

A strategic area has been chosen, where all the ships entering the main entrance to the port of Valencia can be seen.



2. Area for campaign deployment





2. Area for campaign deployment

3. Typology of vessels

During the pilot, a series of vessels that participate in port operations will be visualized, including both commercial ships and port service vessels.

TUGGERS

PILOTS

MARITIME RESCUE

PASSPORT

3. Typology of vessels

During the pilot, a series of vessels that participate in port operations will be visualized, including both commercial ships and port service vessels.

MOORERS

BULK CARRIER

CONTAINER SHIP

PASSPORT

3. Typology of vessels

During the pilot, a series of vessels that participate in port operations will be visualized, including both commercial ships and port service vessels.

CRUISE

RORO

FERRY

FUNDACIÓN
VALENCIAPORT

Innovation & Training in
Ports, Transport & Logistics

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Agenda

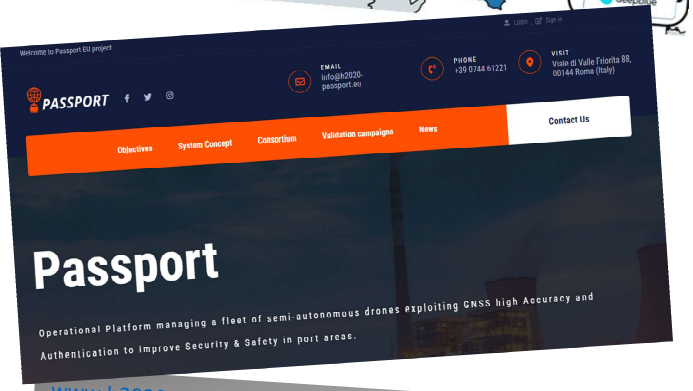
- The need for PASSport initiative
- The consortium
- The architecture
- AI, EGNSS, EO and MR as enabling technologies
  - => OSNMA service usage
- DEMO

PASSport

Operational *P*latform managing a fleet of semi-autonomous drones exploiting GNSS high *A*ccuracy and Authentication to improve *S*ecurity & *S*afety in ***port*** areas

- The need stems from the directive 2005/65/CE asking to complement surveillance systems for the whole port area, in order to significantly improve security and safety for daily operations implanted in port area. Around one thousand European ports fall within the scope of the directive.
- The proposed solution is intended to **complement already operational platforms** by extending the surveillance perimeter using a fleet of drones to provide innovation and operational support to the recognition, management and analysis of safety and security aspects of daily operations
  - ✓ Pollution monitoring (safety)
  - ✓ Support to e-navigation (safety)
  - ✓ Critical buildings/ Infrastructures protection (security)
  - ✓ Protection against non-cooperative small craft approaching the port areas (security)
  - ✓ Underwater threats monitoring (security)
- The project novelty is represented by **the usage of a fleet of semi-automated drones integrating Galileo services** (and other sensors) for a safe and efficient guidance, navigation and control (GNC) even in a challenging environment in presence of obstacles - including buildings and other ground assets - and potentially unfavorable weather conditions.

Team and identity

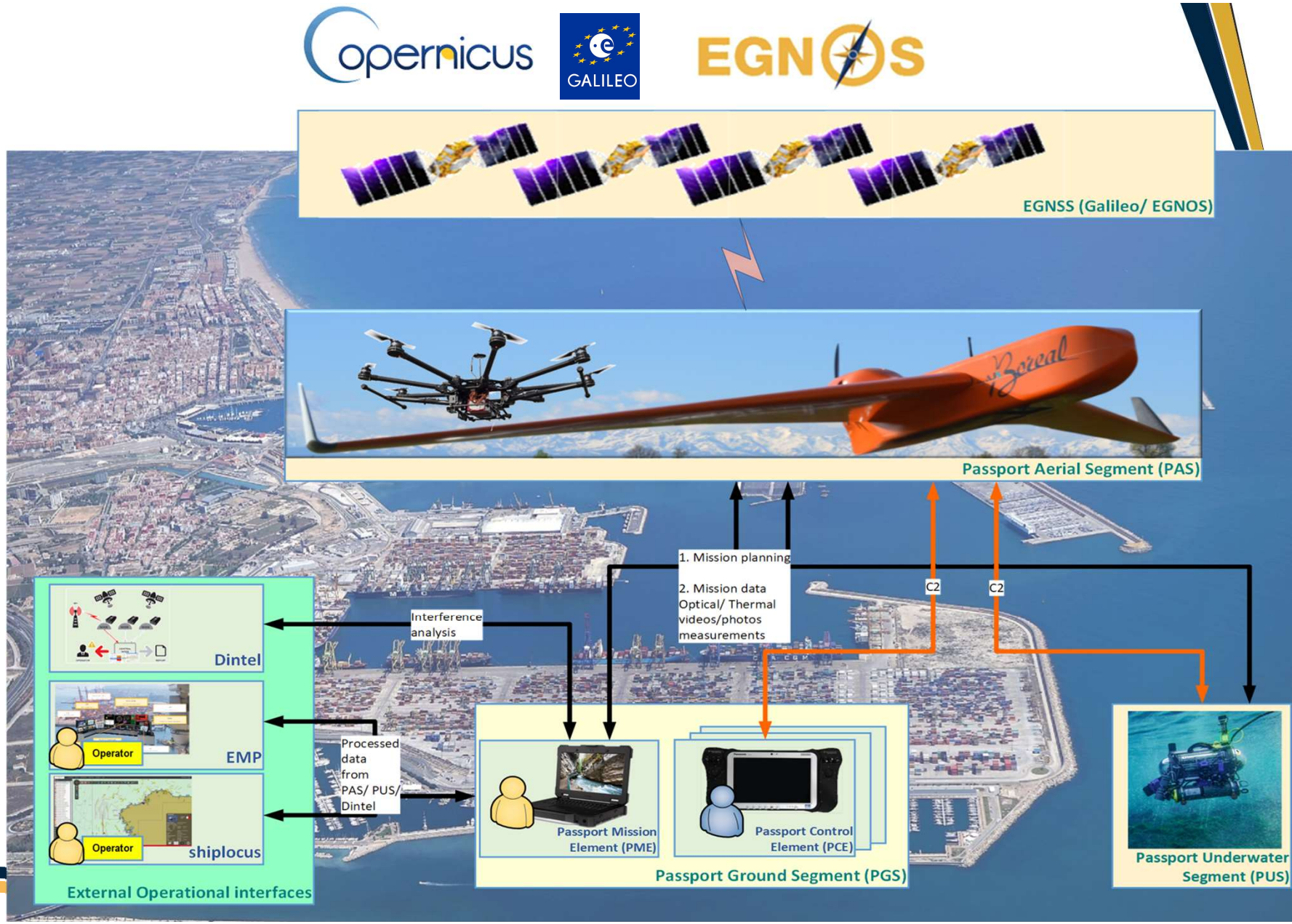


www.h2020-passport.eu
https://www.linkedin.com/company/h2020-passport
https://twitter.com/PassportH2020
https://www.facebook.com/H2020-PASSport-100313468652600
https://www.instagram.com/h2020_passport/

EUSPA
European Union Agency for the Space Programme

ALCINA
Bergmann Marine Consultants & Advisors
gmv Innovating Solutions
Sistematica ICT innovators
DiGi ONE
TOPVIEW Looking Over
deepblue
DLR
eurecat Centre Tecnològic de Catalunya
m3 systems Groupe Mistral
Università degli Studi Firenze
Maritime University of Szczecin
Fundación valenciaport
Cerema
Autorità di Sistema Portale del Mare Adriatico centro settentrionale

Port de Barcelona
Port Authority Gioia Tauro
North Adriatic Sea Port Authority
Ports of Venice and Chioggia
Federal Ministry of Transport and Digital Infrastructure
EUROCONTROL
Port Morski Police
Port Szczecin-Świnoujście
Maritime Office in Szczecin
République Française Service-Public.fr
CiRCOÉ Conseil & Innovation en Logistique
Sous-direction des ports et du transport fluvial


Copernicus
GALILEO
EGNOS
EGNSS (Galileo/ EGNOS)
Passport Aerial Segment (PAS)
1. Mission planning
2. Mission data
Optical/ Thermal
videos/photos
measurements
C2
C2
Interference analysis
Dintel
Operator
EMP
Operator
shiplocus
External Operational interfaces
Processed data from PAS/ PUS/ Dintel
Passport Mission Element (PME)
Passport Control Element (PCE)
Passport Ground Segment (PGS)
Passport Underwater Segment (PUS)

Innovation potential

Innovation brought by PASSport providing Extended surveillance service with a semi-automated drones	
Coverage	RPAS allows to cover large area in reduced time
Cost saving	No need for static infrastructure to be deployed
Operational Time efficiency	The implementation of AI & DL algorithm allows to have additional information (image and video metadata) for an improved situational awareness in real time
Service reliability	GNSS (high accuracy, integrity, authentication) and other sensors allow the solution to be more reliable and resilient
Usability	Operator does not require specific expertise as operations (take off, mission management, area scanning and landing) are driven by an automated process once waypoints are configured (although a qualified remote pilot will still be present when required by the regulation)
Interoperability	interface with some already deployed and daily used operational platforms (developed by partners of the consortium)

- **GOAL:**

To use dedicated algorithm based on Copernicus data: wind detection and measurement, ship detection, air pollution estimation, port facility stability assessment

Earth Observation (EO) usage to support port operation monitoring

- **Maritime applications**

Sentinel-1 data for the detection of ships within Le Havre and Valencia port areas.

- **Maritime applications:**

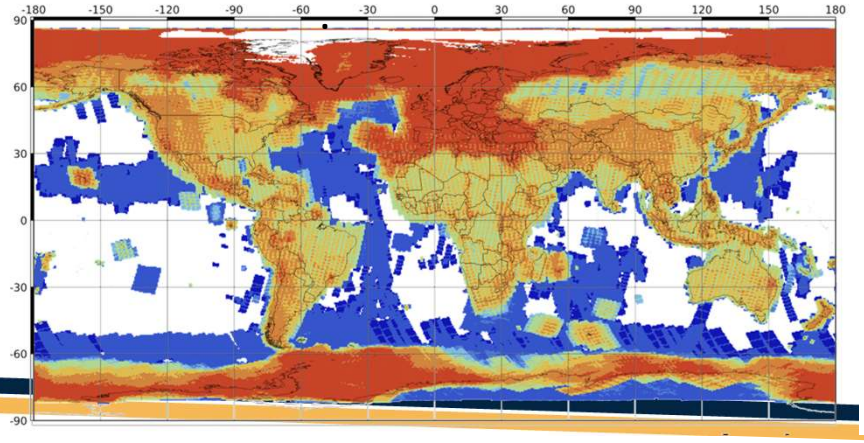
Sentinel-1 data for the assessment of the major winds within Ravenna and Le Havre port areas.

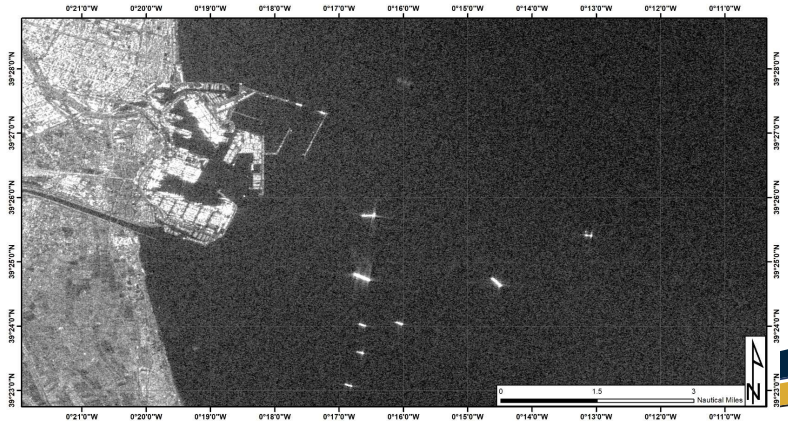
- **Terrestrial applications**

analysis of EGMS interferometric data for the assessment of the stability of Hamburg port facilities and infrastructures.

- **Atmosphere applications**

Sentinel-5p data for the Kołobrzeg air quality assessment





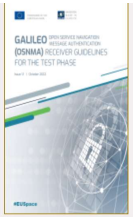
- **GOAL:**

To use E-GNSS capabilities to contribute to **safety** (automated drones flying in a challenging environment) and **security** (image geo-referencing for surveillance analysis or the need of a robust and protected GNSS signal as input for GNC of the drones) for operations in ports.

GNSS usage as enabling technology

E-GNSS can provide:

- **High accuracy:** E-GNSS can provide drones position very accurately, even in the level of centimeter depending on the technology used.
- **Integrity and reliability** of the solution is required not only for the safety of the operations but also as means of measuring the confidence in the correctness of the positioning information provided by the navigation system. The reliability on the RPAS position provided by the GNSS user terminal will be also very useful to increase the reliability of the images taken from the RPA.
- **Robustness against interferences or spoofing attacks.** The concern on GNSS interferences, mainly the intentional ones, recommends the use of GNSS solutions that are robust against interferences.



Galileo OSNMA Receiver Guidelines for Test Phase (v1.1)

Annex 2 - OSNMA Test Vectors

https://www.gsc-europa.eu/electronic-library/programme-reference-documents

User requirement	GNSS contribution
Safe trajectory for automated RPAS	High accuracy (e.g. Galileo HAS, PPP) Integrity (e.g. SBAS, HA with integrity)
Geo-localisation of detected target	
System resilience	Signal authentication (e.g. Galileo OS-NMA) Interference detection (e.g. DINTEL)

HOW?

GNSS user terminal (e.g. magicUT)

Interference monitoring system (DINTEL)

- **GOAL:**

to increase **situational awareness and improve decision making** time by providing the user with real-time data from drones that are part of the system.

Mixed Reality device for drones performed mission

Use-cases:

- Pollution detection where drone monitors discharged ballast waters or ships' emissions and measures level of SO2. An immediate alert will be visible through the glasses with the identification of a polluter if a pollution is detected.
- Safety and security monitoring where immediate alert and video feed will be shown to the operator when a predefined criterium is met, e. g. movement detection (unauthorized entry to port facilities) or elevated building temperature (fire indication).

Promotion and Stakeholders perspectives gathering

H2020-PASSport
158 followers
5mo •

https://lnkd.in/enKZr5pr

Présentation du projet PASSport à la 11e édition des assises port du futur 2021. Notamment, en présence des principaux ports français et du Ministre de la Mer, a été présentée la campagne C4 qui se déroulera au port du Havre en mai 2023.

Presentation of the PASSport project at the 11th edition of the assise du port du futur 2021. In particular, in the presence of the main French ports and the Minister of the Sea, the C4 campaign was introduced which will be carried out at the port of Le Havre in May 2023

EUSPA - EU Agency for the Space Programme
#Galileo #Copernicus #drones #EGNSS

See translation

PASSPORT. 11me Assises port du futur. Novembre 2021
youtube.com

https://lnkd.in/eATqKh-E

#technology #marine #sustainability #iaph

H2020-PASSport
158 followers
6h •

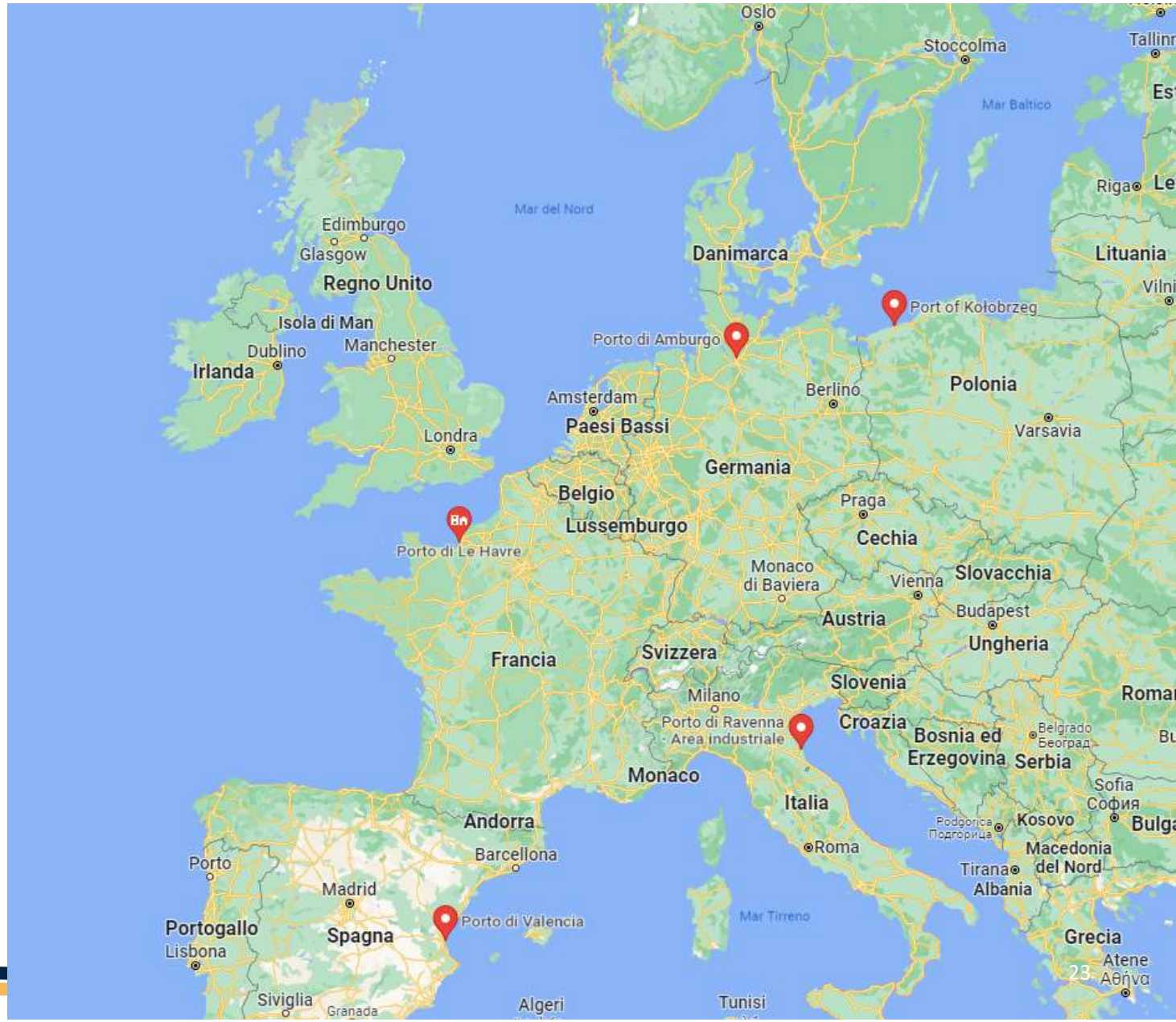
Vancouver, May 17th 2022
Inernation Association of Ports and Harbours (IAPH) conference sor sustainability awards. ...see more

BM Bergmann-Marine
228 followers
7h •

The H2020-PASSport Project nas been presented the International Association of Ports and Harbors (IAPH) Sustainability Award in the category Digitalization. BM Bergmann-Marine is one of the partner in the project and as associated member of IAPH we could comvince our partners for BM to submit it to the award. Now, as we are successfull, we congratulate our partners ALCINA, GMV, Sistematica S.p.A., G7 International Srl, DiGi ONE Srl, TopView srl, DEEP BLUE SRL, German Aerospace Center (DLR), Eurecat - Technology Centre of Catalonia, M3 Systems, Università degli Studi di Firenze, Akademia Morska w Szczecinie, Fundación Valenciaport, Cerema, AUTORITA ... PORTO DI RAVENNA, as well as our associated partners, especially the ports supporting our validation campaigns Hamburg, Ravenna, Kolobrzeg, Valencia and Le Havre. As our owner Michael Bergmann MBA FRIN AFNI wasn't able to join, we are very thankful to Dr. Phanthian Zuesongdham from Hamburg Port Authority (HPA) Anstalt öffentlichen Rechts to speak on behalf of the project consortium and together with the partners at the event to accept the award.

Thank you International Association of Ports and Harbors (IAPH), thank you expert joury and thank you public voters selecting our project. It is a great honor!

PASSport use cases and validation campaigns



DEMO

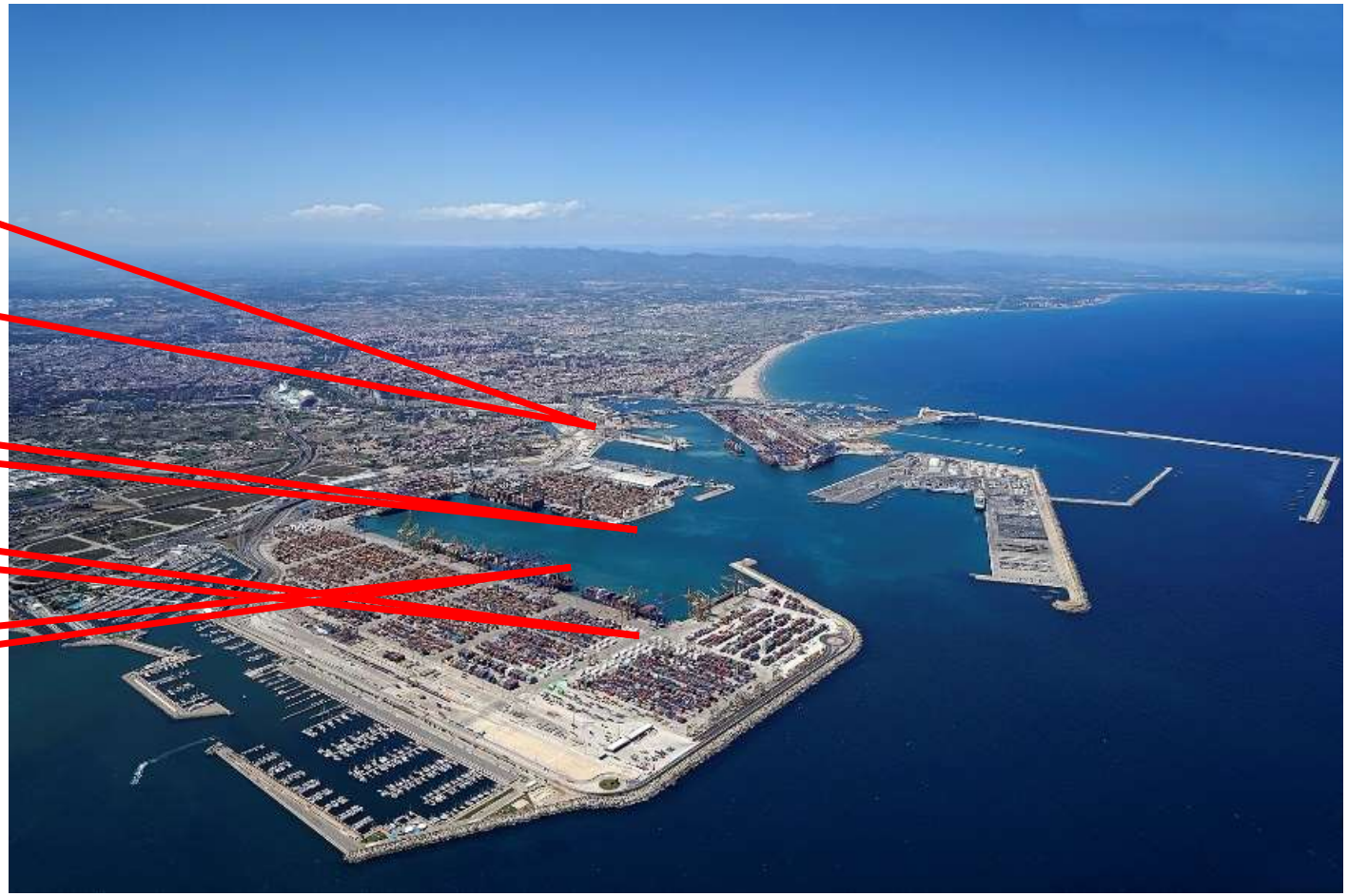
- Introduction to PASSport platform Desk + mobile
- Activity 1 DAPR: Copernicus EGMS
- Activity 2 RTVS: video collection and images analysis

Shiplocus AIS

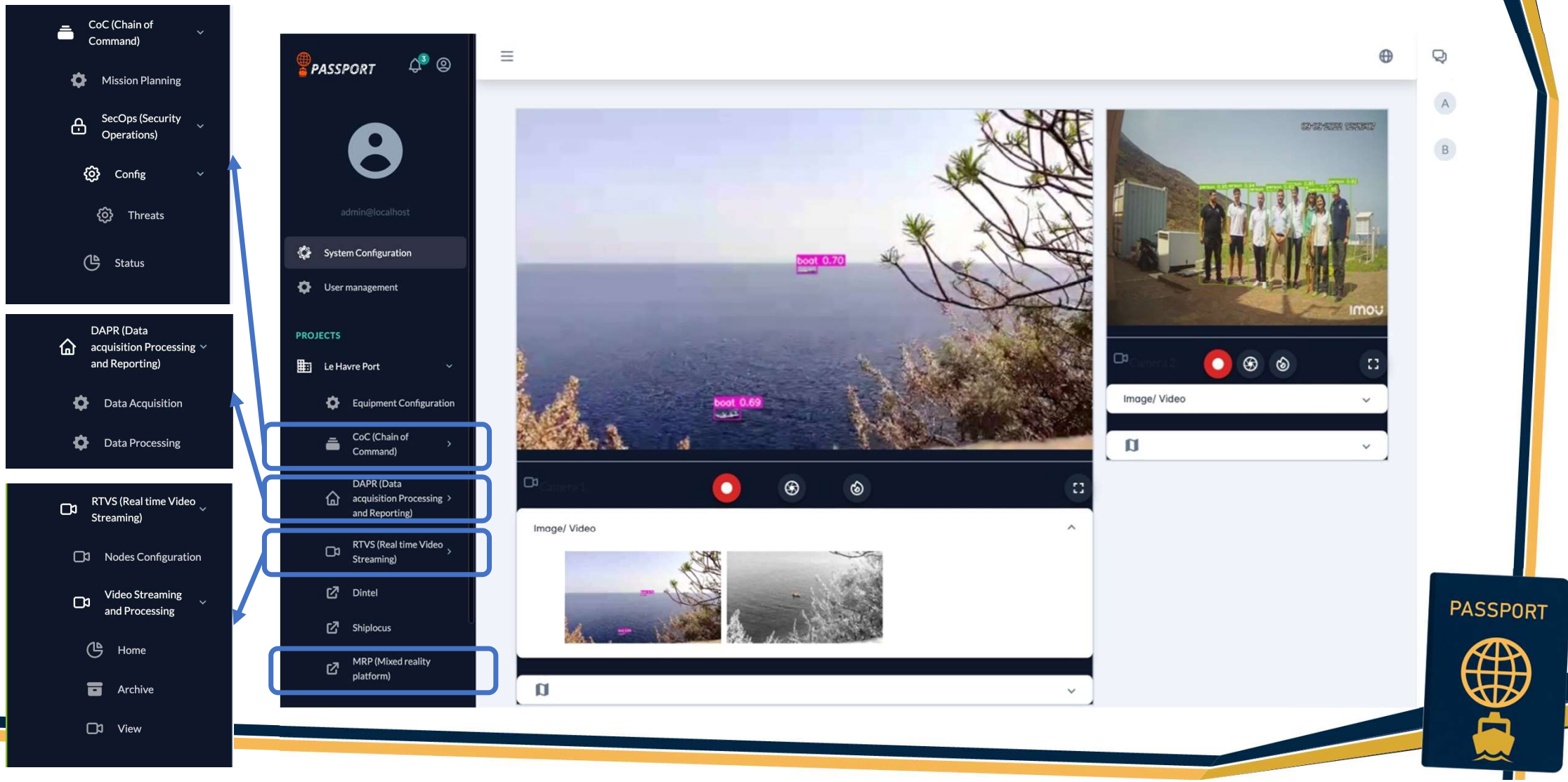
Dintel: interference analysis

CCTV

- ECAT+TOP drones+ MAGICUT tracker



The PASSport platform: Platform Admin Operator (PAO)



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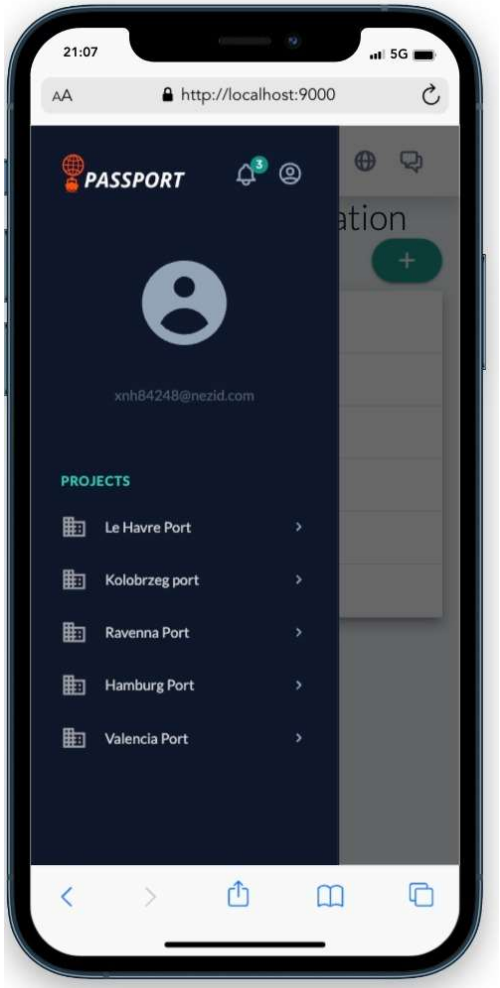
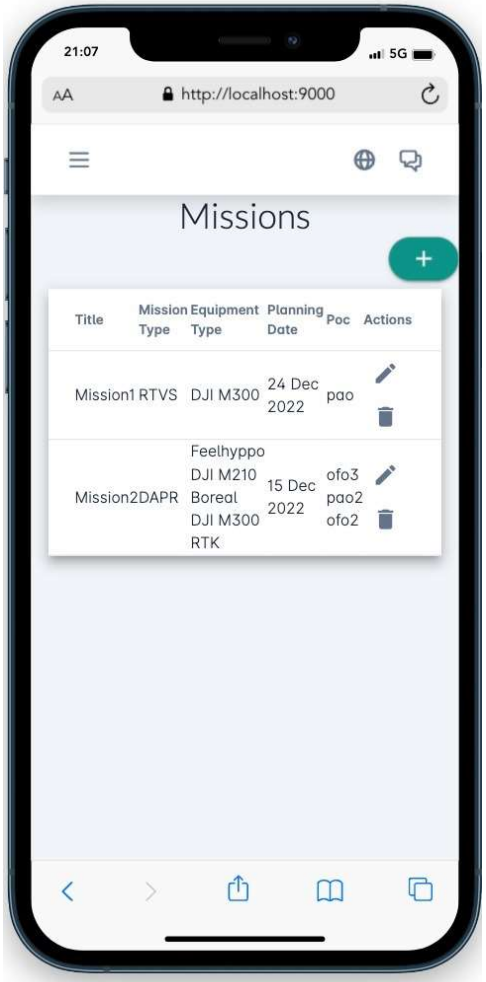

21:07
5G
AA
http://localhost:9000
PASSPORT
xnh84248@nezid.com
PROJECTS
Le Havre Port
Kolobrzeg port
Ravenna Port
Hamburg Port
Valencia Port


21:07
5G
AA
http://localhost:9000
Missions
Title
Mission Type
Equipment Type
Planning Date
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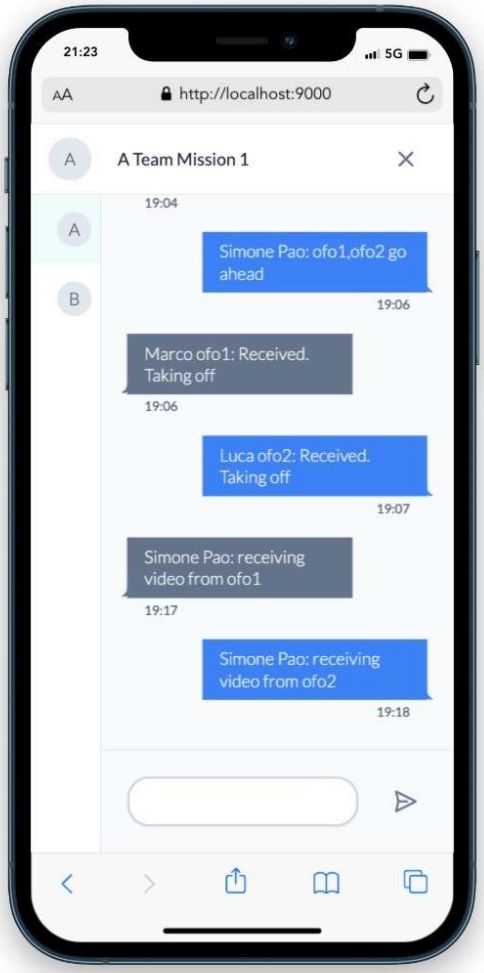
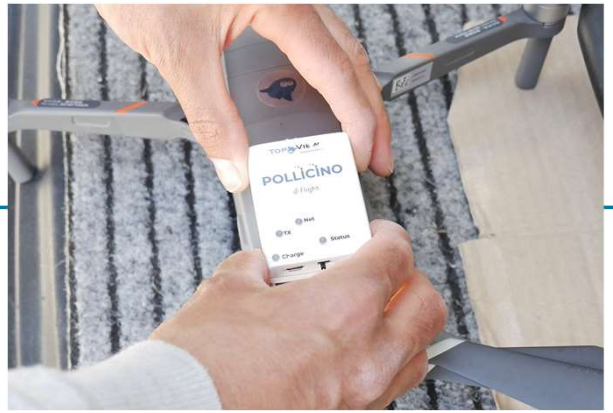
Actions
Mission1 RTVS
DJI M300
24 Dec 2022
pao
Mission2DAPR
Feelhyppo DJI M210 Boreal DJI M300 RTK
15 Dec 2022
ofo3 pao2 ofo2

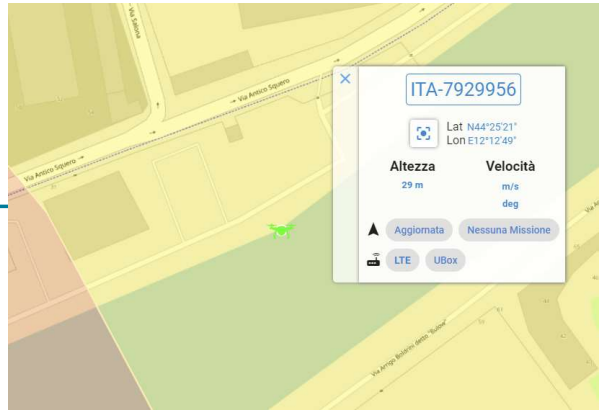

21:23
5G
AA
http://localhost:9000
A Team Mission 1
19:04
Simone Pao: ofo1,ofo2 go ahead
19:06
Marco ofo1: Received. Taking off
19:06
Luca ofo2: Received. Taking off
19:07
Simone Pao: receiving video from ofo1
19:17
Simone Pao: receiving video from ofo2
19:18


PASSPORT

Pollicino Box

Pollicino ™ Box allows one to identify and track any drone during the flight, transmitting the GNSS data-position via LPWAN technology.
The tracker comes from a specific request of d-flight, the candidate U-space service provider for Italy, and it's ready for EU Regulation 2021/664, which will enter into force on the next 23rd of January.





Compact and easy to install

Can be installed even on small drones and does not require configuration to be used.

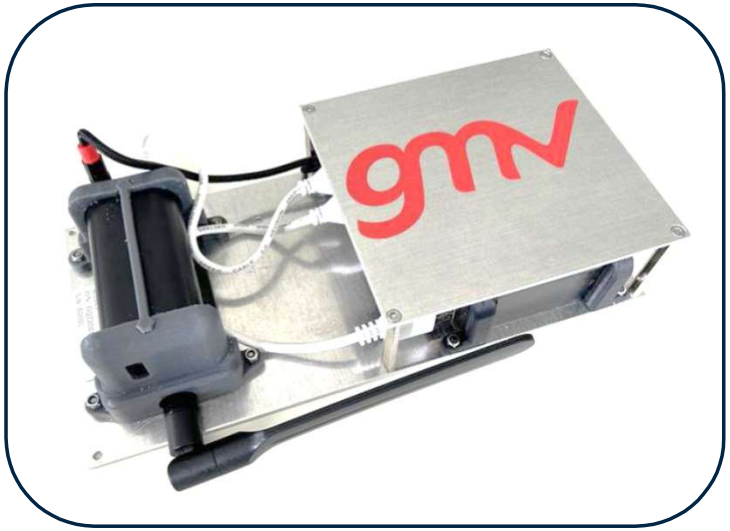
Tracking on d-flight

Location, speed, and height in real-time are all available to nearby operators.

magicUT OSNMA GNSS receiver

Authentication with OSNMA

Protection Levels with IBPL



Multifrequency: L1/E1 + L5/E5a

Multiconstellation: GPS + GAL

Validation roadmap:

Laboratory & Static Tests

Until 06/2023

Dynamic tests: Embarked in vessel

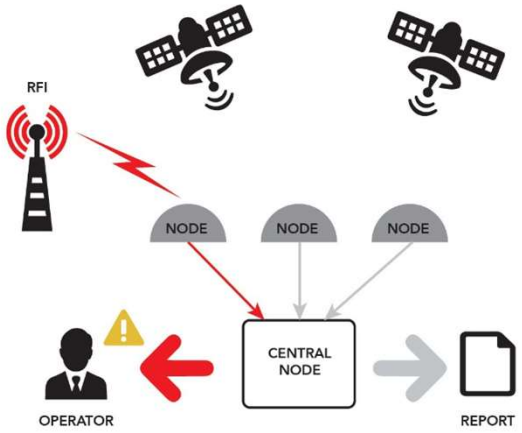
Homecoming Homeport Hamburg 06/2023

Dynamic tests: On-board UAS

Valencia - 10/2023

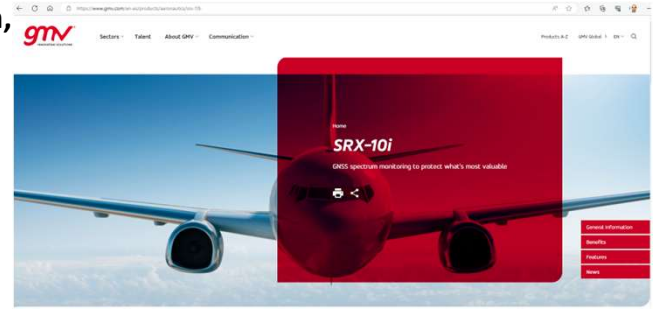
DINTEL/srx-10i: real-time dual-band GNSS interference detection system

- RF front-end with **dual-band** (e.g., GPS L1 + GPS L5) monitoring capabilities
- **Real-time** interference **detection, alert triggering** and **reporting**
- Different deployment **options:**
  - **Standalone remote node** with API for custom client needs
  - Complete **Central Acquisition Facility** (web panel) + **remote node(s)**
    - PASSport visitors' credentials:
      - https://passport-aes-vm.gmv.com
      - Username: visitorHPA
      - Password: demoPASSport23



- Proven record of success for **aviation** and **maritime** users
  - Deployed and operating in the **airports** of a **major European ANSP**
  - Tested in **lower Danube** (Romania)

For more information, visit GMV's website



marco.nisi@grupposistematica.it

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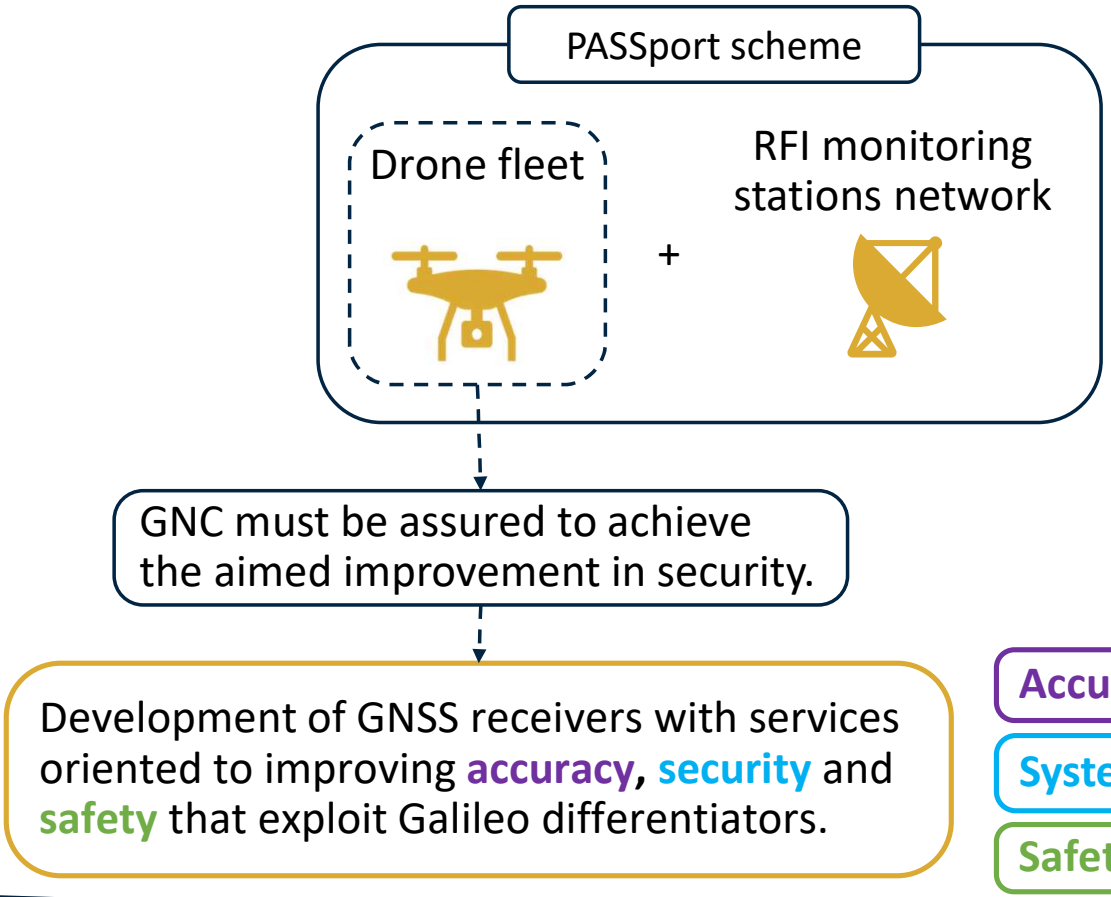
PASSport: towards an accurate, secure and safe navigation



Accuracy: Precise Point Positioning (PPP) algorithm

- Use of dual-frequency code and carrier phase measurements for centimetric accuracy applications.
- Detailed models with very precise orbit and clock information to account for all known effects.
- No need for base stations.

Safety: Isotropy-Based Protection Level (IBPL)

- Integrity approach to provide **Protection Levels (PLs)** that bound the position provided to a certain area with a given probability $(1 - \alpha)$.
- RAIM method that calculates the PL based on the least squares solution of all the pseudoranges in view.
- The probability that the position error exceeds the PL is the integrity risk, α.
- Implemented in PASSport for the multiconstellation configuration.

Security: Open Service Navigation Message Authentication (OSNMA)

- GNSS satellites continuously transmit a Navigation Data to compute the PVT solution.
- Inside the Galileo services, the **Galileo Open Service (OS)** is providing a **Navigation Message Authentication (NMA) capability**.
  - It confirms that received Galileo Open Navigation Data was originated from the Galileo system and has not been modified by any other source.
  - Galileo is the first GNSS system to provide this service, which is currently in the public test phase, free of charge for users worldwide.
  - OSNMA is an authentication protocol based on the TESLA protocol specifically tailored for Galileo Open Service currently transmitted in SiS.
  - It provides the possibility to authenticate satellites which do not transmit OSNMA data with the data retrieved from satellites transmitting OSNMA (**cross-authentication**).

magicUT GNSS receivers

Modular design:
- u-blox zed f9t-10b
- Raspberry Pi 4 Model B
- Optional: Dongle 4G & Battery

Multifrequency:
L1/E1 + L5/E5a

Multiconstellation:
GPS + GAL

Authentication with **OSNMA**, compatible with ICD V1.0 and SiS

Integrity with **IBPL**

Smartphone approach:
- Novatel receiver
- Touch screen
- 3G and Wifi, internal battery

Multifrequency &
Multiconstellation:

GPS (L1, L2, L5Q)
GAL (E1, E5a, E5b, E6)
GLO (G1, G2 C/A, P G3)

Compatible with **SBAS** and **PPP**

Validation roadmap and results

Laboratory &
Static Tests

Until 06/2023

Dynamic tests:
Embarked in vessel

Homecoming Homeport
Hamburg 06/2023

Dynamic tests:
UAS integration

Valencia 06/2023
Napoli 07/2023

Dynamic tests:
On-board UAS

Valencia - 10/2023

Main results: Hamburg

- First GNSS testing campaign of the Project.
- Goal: off-board receiver functionality verification.
  - Evaluation of PPP as a reference source.
  - Assessment of the effect of GNSS environment (open sky vs. degraded) on the performance of OSNMA.

PPP Assessment

- 2σ latitude and longitude error deviations are generally higher for degraded environments.
- Open sky 2σ latitude and longitude error deviations bounded by 0.4m and 0.15m.
- PPP considered suitable as a reference for open sky applications.

Recording ID	Test type	Location	GNSS Environment	Recording duration [min]	Latitude	Longitude	Latitude Error 2σ [m]	Longitude Error 2σ [m]
HAM-P1	Static	Building rooftop 1	Open sky	47	57° 32' 27.93"	9° 57' 55.87"	0.09	0.12
HAM-P2	Static	Building rooftop 2	Open sky	59	53° 32' 27.91"	9° 57' 56.69"	0.07	0.08
HAM-P3	Static	Between 2 port containers	Degraded	95.5	53° 32' 27.45"	9° 57' 55.43"	0.06	0.20
HAM-P4	Static	Between 3 port containers	Degraded	43.30	53° 32' 28.09"	9° 57' 56.88"	0.43	0.67
HAM-V	Dynamic	Elbe river trajectory	Open sky	278.77	-	-	0.38	0.10

Main results: Hamburg

OSNMA Assessment

KPIs:

- Time To First Authentication (TTFA)
- Mean Time Between Authentications (MTBA)
- Authentication Service Availability (ASA)
- Authentication Error Rate (AER)

Recording ID	Test type	Location	GNSS Environment	Recording duration [min]	TTFA [s]	MTBA [s]	Number of authentications	ASA [%]	AER
HAM-P1	Static	Building rooftop 1	Open sky	45.90	168	64.68	1326	100	0
HAM-P2	Static	Building rooftop 2	Open sky	45.03	104	51.49	836	100	0
HAM-P3	Static	Between 2 port containers	Degraded	42.14	156	59.39	1206	100	0
HAM-P4	Static	Between 3 port containers	Degraded	39.6	172	61.40	1330	100	0
HAM-V1	Dynamic	Elbe river trajectory	Open sky	40	172	56.01	1328	100	0
HAM-V2	Dynamic	Elbe river trajectory	Open sky	27.28	108	64.01	1172	100	0
HAM-V3	Dynamic	Elbe river trajectory	Open sky	132.52	98	60.36	5737	100	0

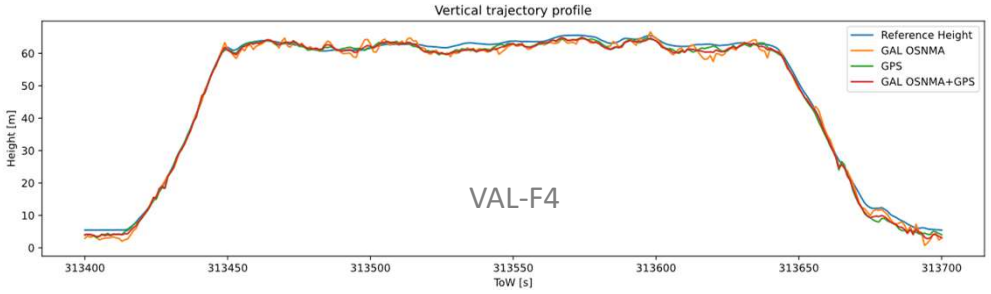
Average TTFA ~ 2.5 min
Average MTBA ~ 1 min

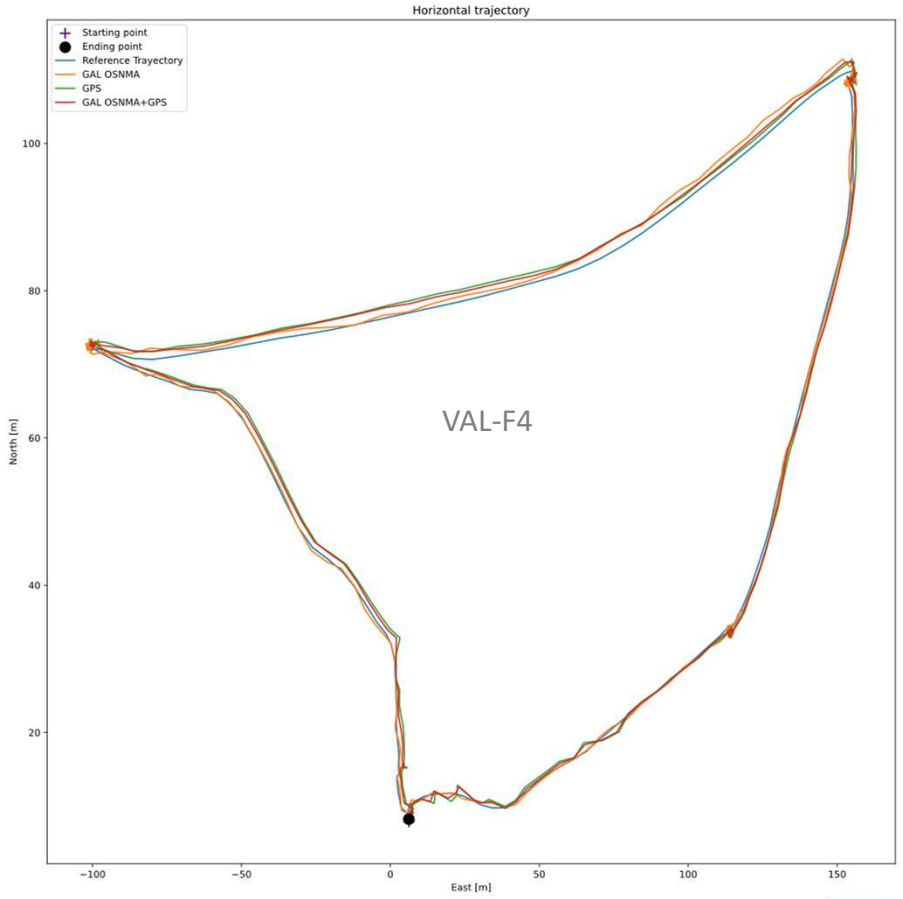
Initialisation period needed

Authentications 100% successful

Main results: Valencia

- First drone on-board testing in harbour conditions.
- Goal: performance assessment replicating real life operations
  - 13 manual flights on-board a Skyjib X4 Ti-QR.
  - Open-sky environment.





Main results: Valencia

Performance assessment: General overview of flights

- Mean number of satellites for GAL OSNMA higher than GPS.
- HE ~ 1m
- VE ~ 1m

  } No clear preferred configuration.
- Maximum availability and continuity.
- Integrity performance dependant on the number of satellites used.

GAL OSNMA

Flight ID	Flight duration [min]	Number of Satellites		HE [m]		VE [m]		Availability [%]	Continuity [%]
		Mean	STD	Mean	STD	Mean	STD		
VAL-F1	2.5	6.99	0.11	1.48	0.46	1.7	0.76	100	100
VAL-F2	10.85	7.99	0.11	0.58	0.44	1.51	0.89	100	100
VAL-F3	4.18	8.00	0.06	0.99	0.47	0.72	0.56	100	100
VAL-F4	5.02	6.00	0.06	0.77	0.45	1.37	0.98	100	100
VAL-F5	7.35	6.93	0.26	0.99	0.90	1.41	1.13	100	100

GAL OSNMA + GPS

Flight ID	Flight duration	Number of Satellites		HE [m]		VE [m]		Availability [%]	Continuity [%]	HPL 95%	VPL 95%
		Mean	STD	Mean	STD	Mean	STD				
VAL-F1	2.5	12.99	0.11	1.14	0.28	1.62	0.60	100	100	13.63	24.45
VAL-F2	10.85	13.99	0.12	0.69	0.40	0.81	0.53	100	100	16.23	23.56
VAL-F3	4.18	14.00	0.06	0.76	0.33	0.51	0.38	100	100	15.22	23.71
VAL-F4	5.02	12.00	0.06	1.07	0.37	1.17	0.74	100	100	16.17	21.32
VAL-F5	7.35	12.20	0.49	1.11	0.72	1.14	0.78	100	100	36.34	44.34

GPS

Flight ID	Flight duration	Number of Satellites		HE [m]		VE [m]		Availability [%]	Continuity [%]
		Mean	STD	Mean	STD	Mean	STD		
VAL-F1	2.5	6	0	0.92	0.32	1.86	1.05	100	100
VAL-F2	10.85	6.00	0.06	1.42	0.70	0.77	0.55	100	100
VAL-F3	4.18	6	0	0.81	0.52	0.70	0.44	100	100
VAL-F4	5.02	6	0	1.41	0.51	1.09	0.78	100	100
VAL-F5	7.35	5.27	0.44	1.69	0.86	1.19	0.71	100	100

Main results: Valencia

OSNMA Assessment

Recording ID	Recording duration [min]	TTFA [s]	MTBA [s]	Number of authentications	ASA [%]	AER
VAL-R1	15.70	120	62.03	714	100	0
VAL-R2	48.54	100	56.08	2348	100	0
VAL-R3	34.17	122	76.80	1520	100	0
VAL-R4	4.20	142	61.91	110	100	0
VAL-R5	2.91	104	57.99	78	100	0
VAL-R6	12.52	126	58.29	290	100	0
VAL-R7	13.04	120	58.18	428	100	0
VAL-R8	8.91	88	65.47	422	100	0
VAL-R9	7.70	106	50.97	234	100	0
VAL-R10	12.00	104	67.02	376	100	0

Average TTFA ~ 2 min

Average MTBA ~ 1 min

Authentications 100% successful

Conclusions

- **PPP** successfully validated as a reference source for open-sky scenarios.
- **OSNMA** library implementation successfully validated

  As part of the service, few minutes of **initialisation** are needed to ensure Galileo availability.

  There are different logic or strategies when implementing the OSNMA functionality.

  OSNMA does not allow authenticating that the pseudoranges used to calculate the position. It is interesting to combine OSNMA with other measures such as integrity mechanisms, such as **IBPL**.
- **Potential future developments**
  - Upon the development of an authentication service that includes GPS (direct/cross authentication): to work on a multiconstellation double frequency solution with all navigation data authenticated and protection levels.
  - Hybridisation with other sensors such as IMUs.
  - Integration of PASSport GNSS receivers in the drones' autopilots for GNC.

Agenda

- 10.00 - 10.15 Welcome
(R. C. Peris, FVP)
- 10.15 - 10.30 The OSNMA service
(P. Haro, EUSPA)
- 10.30 - 10.45 PASSport solution
(M. Nisi, SIST)
- **10.45 - 11.00 OSNMA activities in PASSport**
(I. Armengol, GMV)
- 11.00 - 11.15 Aerial solution detection and localisation
(J. Cayero, Ecat)

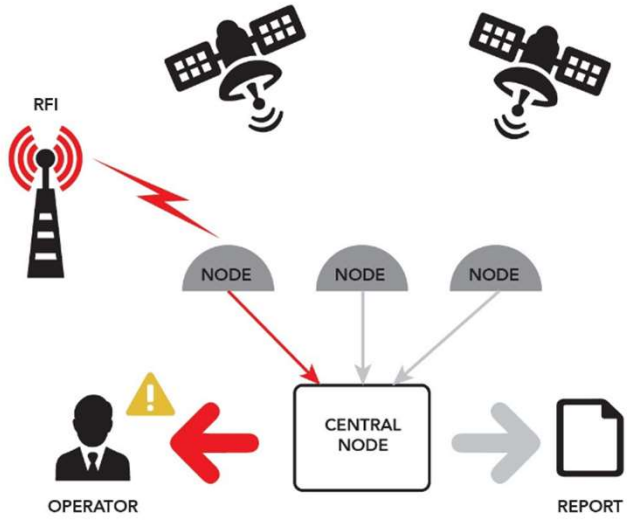
11.15 - 11.30 Copernicus service and activities in PASSport
(P. Confuorto, UNIFI)

- 11.30 - 11.45 Introduction and Training to PASSport
(D. Taurino, DBL)
- 11.45 - 12.35 DEMO presentation and execution
(M.Nisi, SIST, R. C. Peris, FVP, D.M. Delgado GMV, M. G. Arias GMV)

PASSport Architecture

DINTEL/srx-10i: real-time dual-band GNSS interference detection system

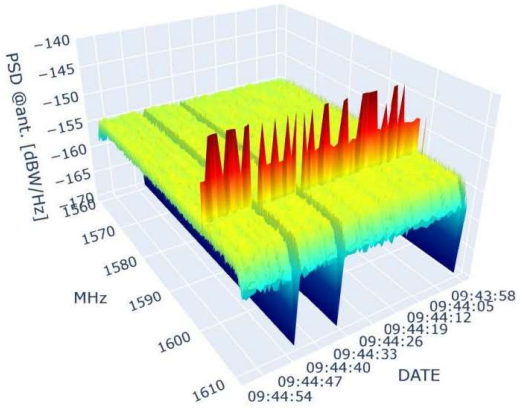
- RF front-end with **dual-band** (e.g., GPS L1 + GPS L5) monitoring capabilities
- **Real-time** interference **detection, alert triggering** and **reporting**



PASSport Architecture

DINTEL/srx-10i: real-time dual-band GNSS interference detection system

- Different deployment **options:**
  - **Standalone remote node** with API for custom client needs
  - Complete **Central Acquisition Facility** (web panel) + **remote node(s)**
    - PASSport visitors' credentials:
      - https://passport-aes-vm.gmv.com
      - Username: visitorValenciaport
      - Password: demoPASSport23



PASSport Architecture

DINTEL/srx-10i: real-time dual-band GNSS interference detection system

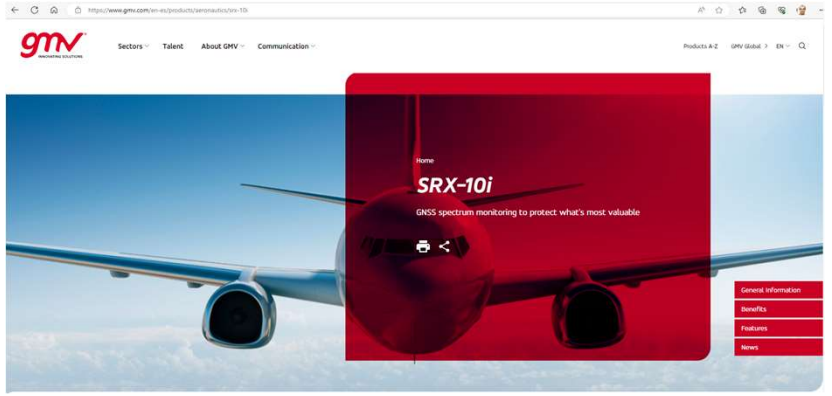
- Proven record of success for **aviation** and **maritime** users
  - Deployed and operating in the **airports** of a **major European ANSP**
  - Tested in **lower Danube** (Romania)

Aviation user

Maritime user

For more information, visit GMV's website:

https://www.gmv.com/en/products/aeronautics/srx-10i



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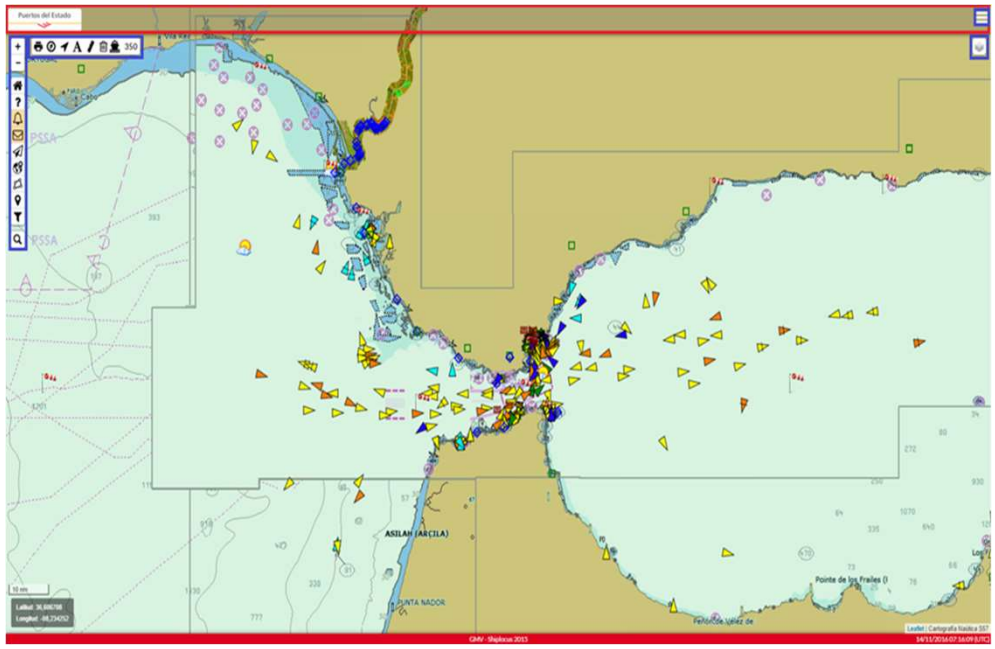
Shiplocus

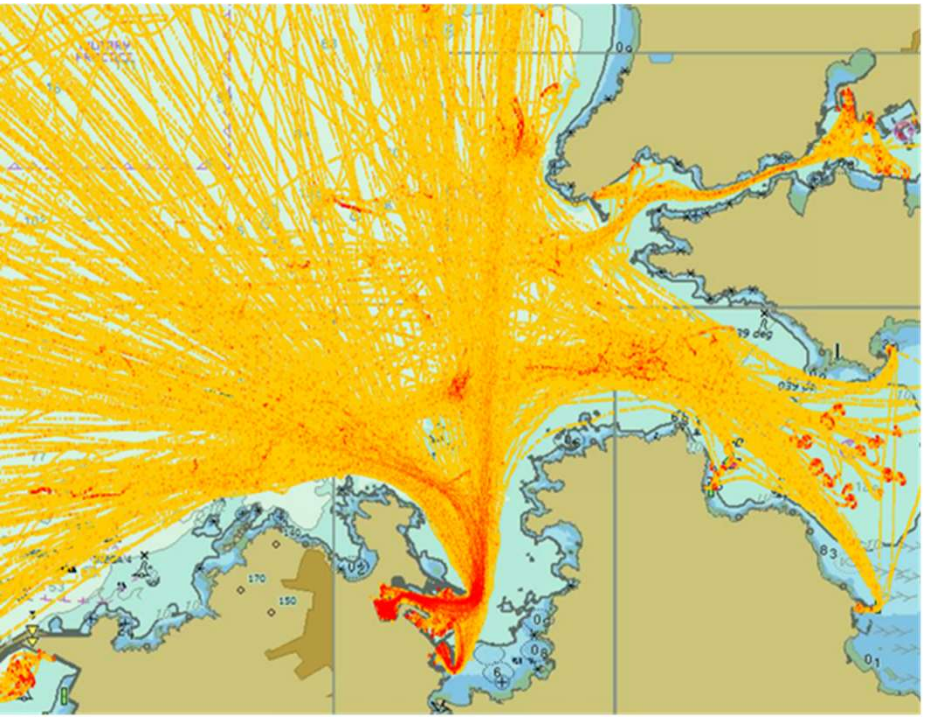
It is a multi-application platform for port management and maritime traffic operation.

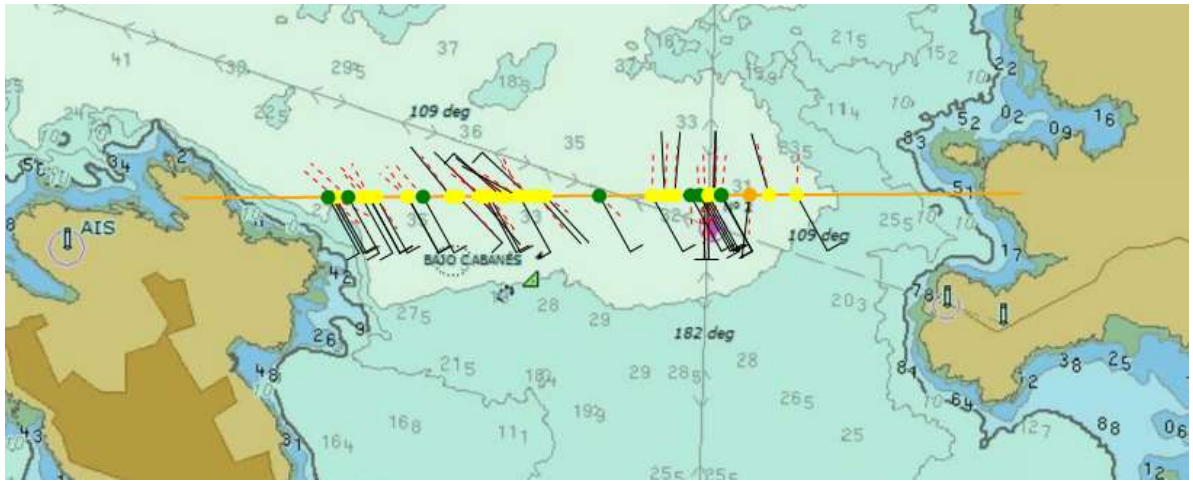
Users: harbor authorities and port operators in different areas and services.

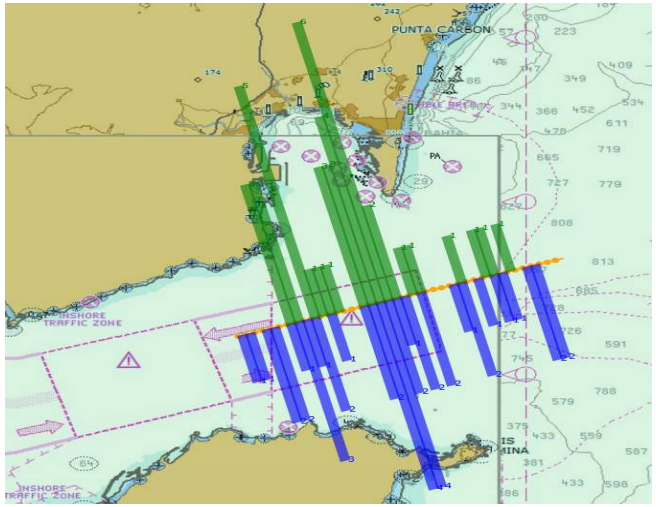
Enables ships to be managed in real time and improving port planning effectiveness, and the monitoring and control of navigation aids.



Shiplocus - Reporting







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eurecat

Robotics

PASSport: Surveillance of ports by means of aerial robots and artificial intelligence techniques

Julián Cayero
Julian.cayero@eurecat.org

"innovating with businesses"

Valencia Final Campaign

WHO WE ARE

eurecat Robotics

>30

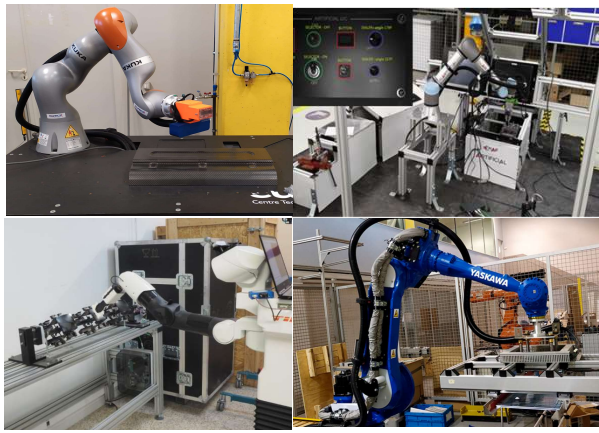
members

Applied R&D in
industrial and service robotics
for multiple sectors:

- Agriculture
- Logistics
- Last mile delivery
- Construction
- Safety & Security
- Manufacturing
- Infrastructure inspection
- Healthcare
- Environmental mapping

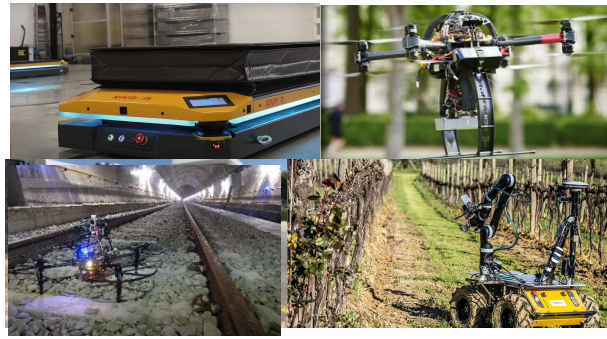
MANIPULATION and HRC

- Industrial & Collaborative Robotics
- Dexterous Manipulation & Grasping
- Planning & control
- Reinforcement Learning



MOBILE NAVIGATION

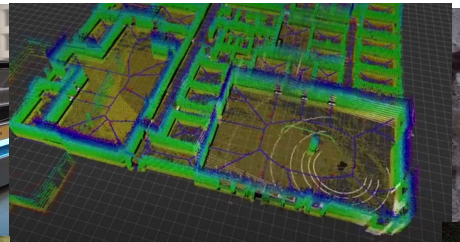
- AMR, ground and aerial vehicles
- 3D and Semantic SLAM
- Indoor and outdoor full autonomy
- Human-aware navigation



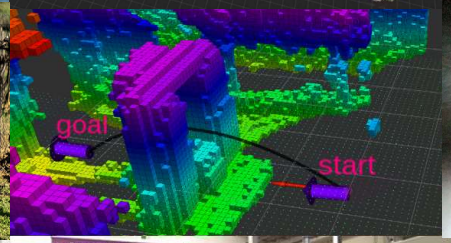
COGNITION and HRI

- Socially Assistive Robotics
- AI empowered robotics
- Affective HRI / Mutual understanding
- Robot Learning,
- Reasoning,Planning & BehaviorTree

SOME PROJECTS DONE BY EURECAT

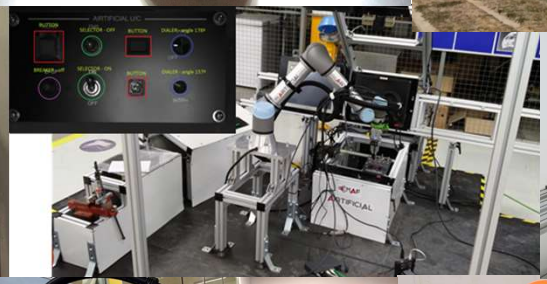



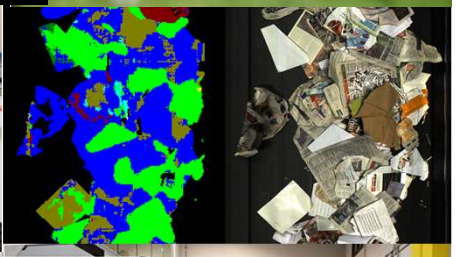


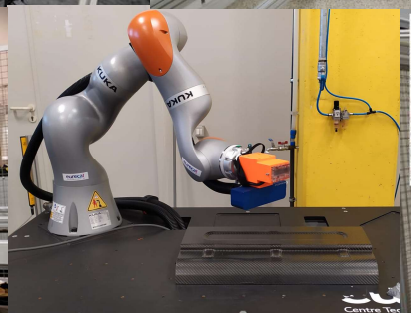










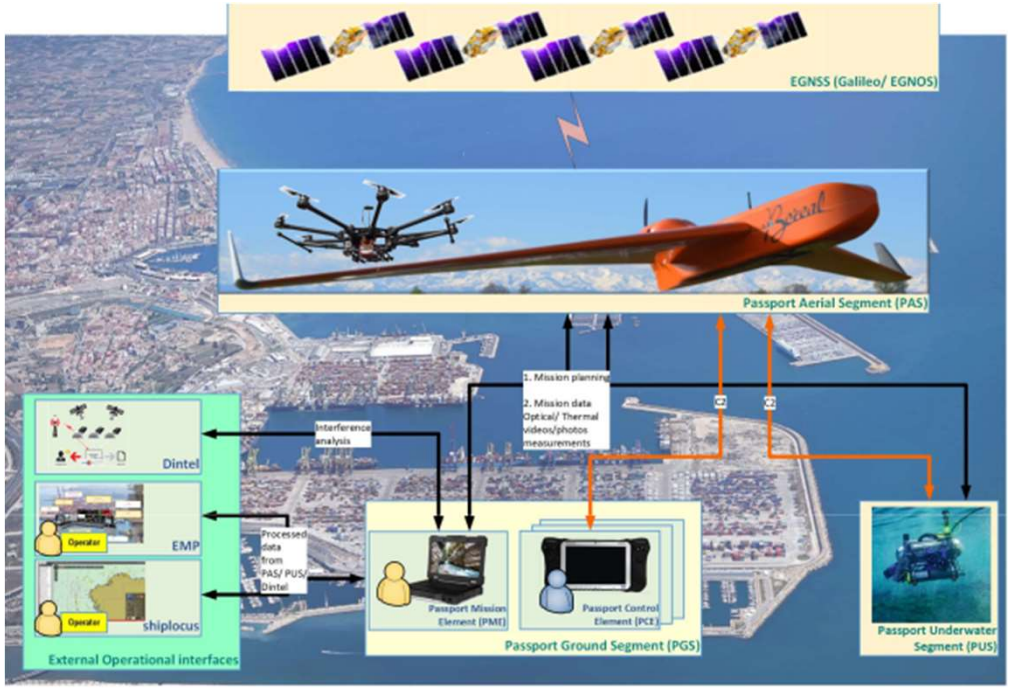




Outline

- Our contribution to PASSport project
- Modules of the Robotic Platform
  - Aircraft
  - UAV Localization system
  - DL-based Target Detection and Tracking
  - Target Georeferentiation system
  - AI-based Mission Planner
- Integration of GMV GNSS systems
- Results
- Integration with PASSport platform

PASSport (2020-2023)

- EURECAT contribution to PASSport



Intelligent surveillance of ports using aerial and marine autonomous robots

- 25 partners focused on safety & security
- 5 validation campaigns across Europe

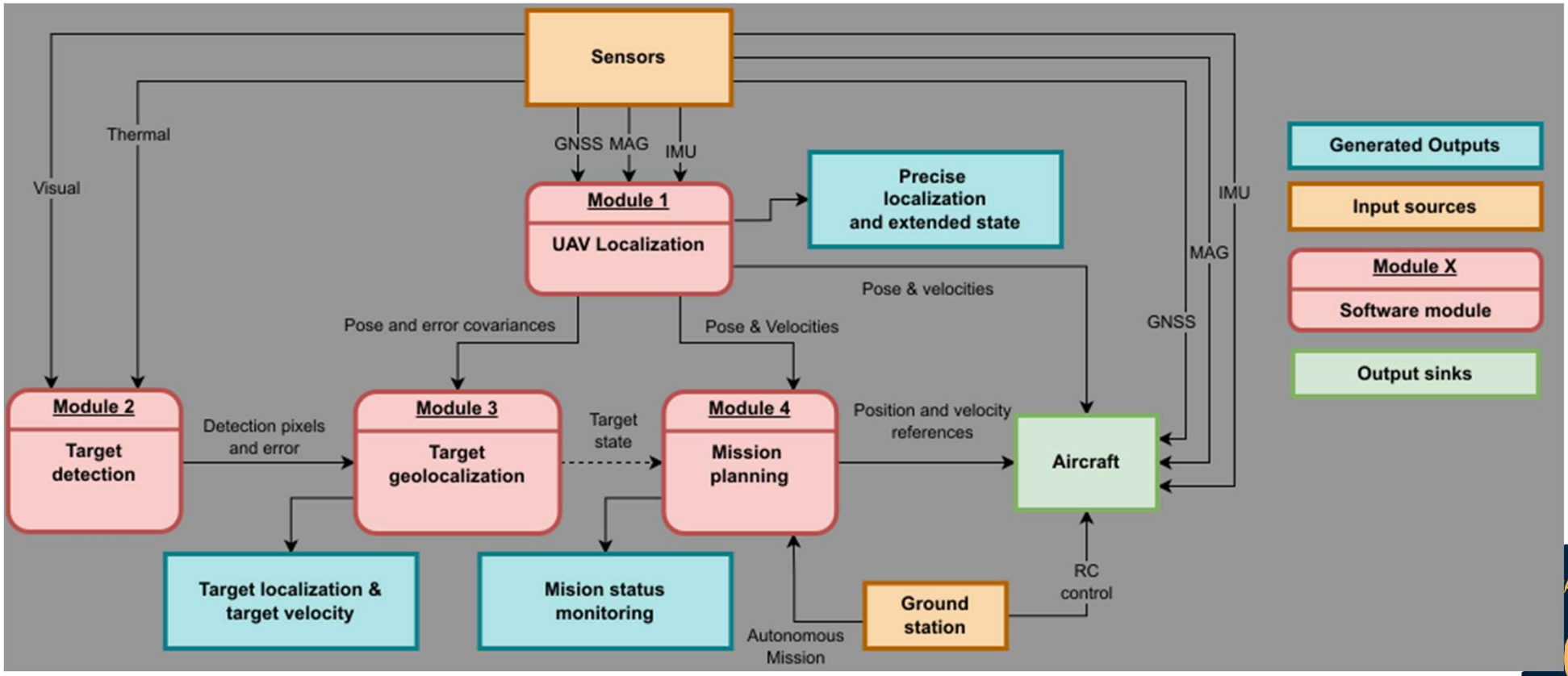
Eurecat's contributions:

- Sensor Hybridization: GNSS + internal systems for continuous and reliable localization & state estimation
- AI assisted GNC: HL control + mission execution, tracking & Patrolling
- DL based: Threat recognition, target tracking, georeferencing

European Global Navigation Satellite Systems Agency

PASSport (2020-2023)

- Modules of the EURECAT robotic platform

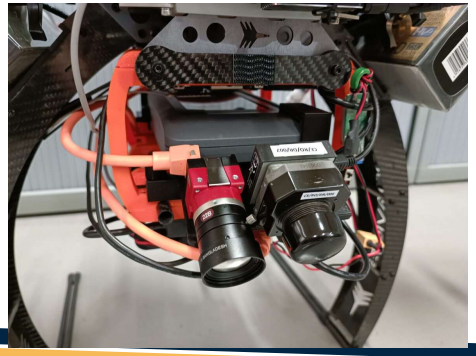


PASSport (2020-2023)

- Aircraft

- Aeronavix frame
- PixHawk as LLC
- NVIDIA Jetson Orin AGX as the mission HLC
  - DL Object Detection inference (ISAAC ROS DNN)
  - ROS: GNC, Georeferentiation and Localization
- Custom payload
  - Visual and Thermal cameras
  - IMU
  - Multi-band GNSS + differential corrections
  - Jetson PC
  - GMV GNSS systems
    - Magic-UT PPP
    - Magic-UT OSNMA

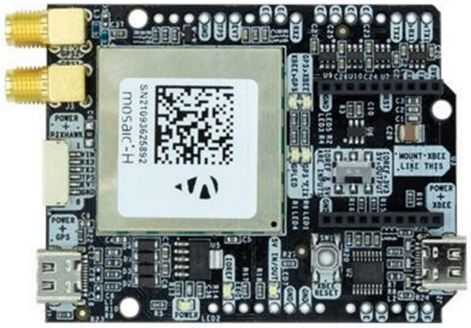
Mechanical specifications	
Dimensions	912 x 912 x 640 mm
MTOM	14 kg
Maximun Payload	3,5 kg
Max velocity	80 km/h (22m/s)
Wind resistance	40 km/h
Flight autonomy	20-45 min
GNSS	M8N: GPS, Galileo, GLONASS, BeiDou
Motor to motor distance	843 mm



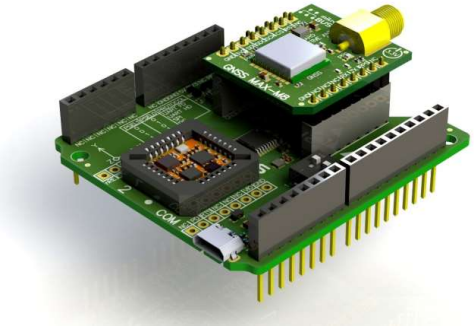
PASSport (2020-2023)

- UAV Localization

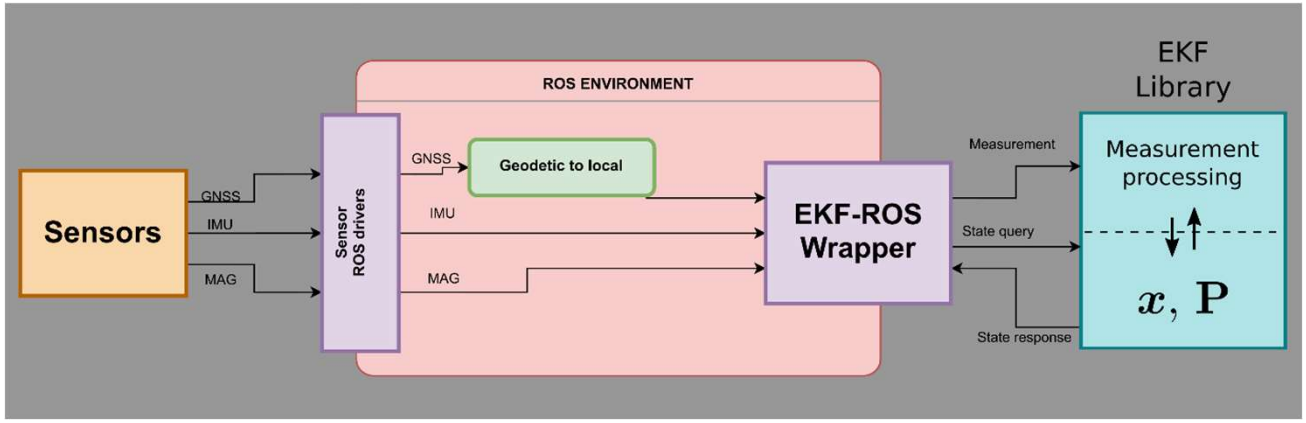
- UAV localization solution developed by Eurecat
- ESKF-based localization
- Combining different sources
  - IMU
  - Multi-band GNSS + differential corrections (2 antennas, with heading)
  - Magnetometer

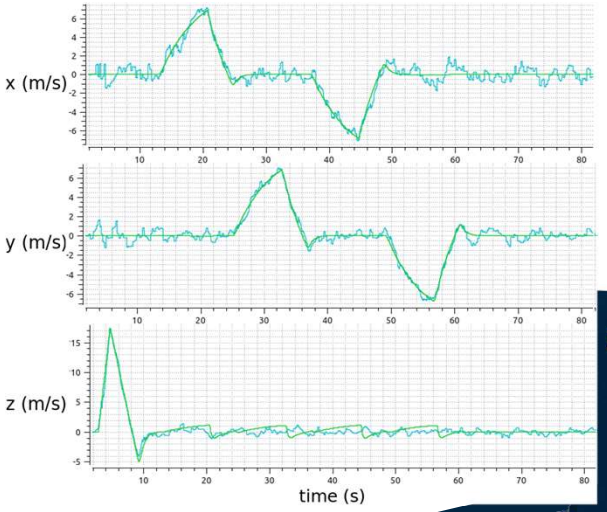


Septentrio Mosaic-H



Xsens IMU





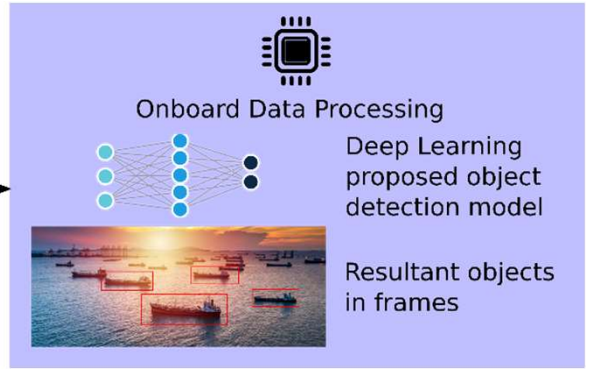
PASSport (2020-2023)

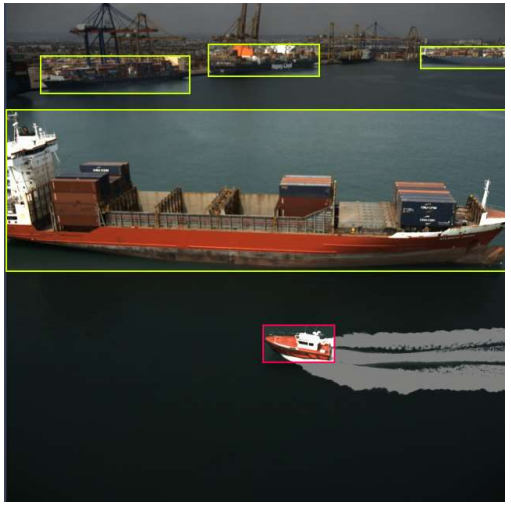
- Target Detection + Tracking

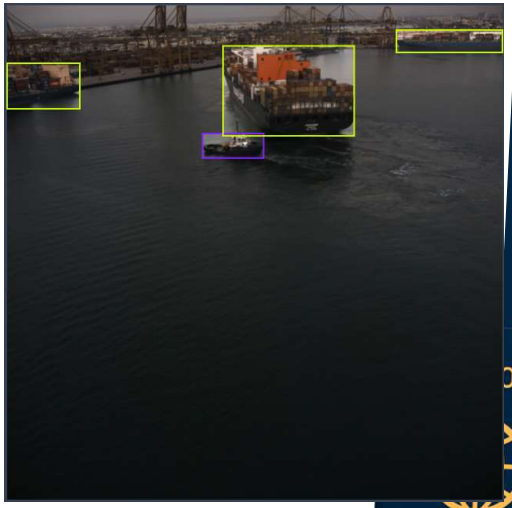
- Real-time inference with NVIDIA Jetson Orin AGX

- YOLOv5 for Object Detection
  - Trained different models
  - Detection and classification
    - Boats (*Container, Passenger, Chemical, Ro-Ro, Tugboat, Pilot*)
    - Other targets (*Buoy, Person*)
  - Trained with own Dataset gathered in Valencia Port

- SORT algorithm for Object Tracking
  - Assign an ID to each detection
  - Estimate future position of objects in images



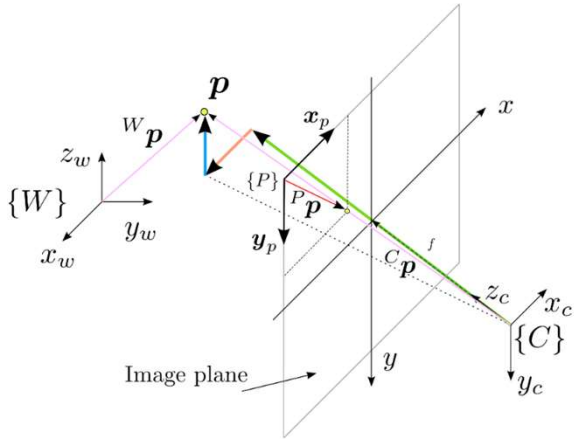




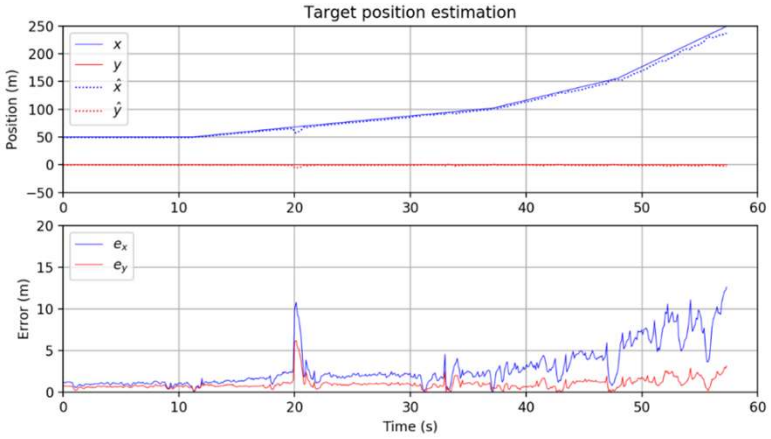
PASSport (2020-2023)

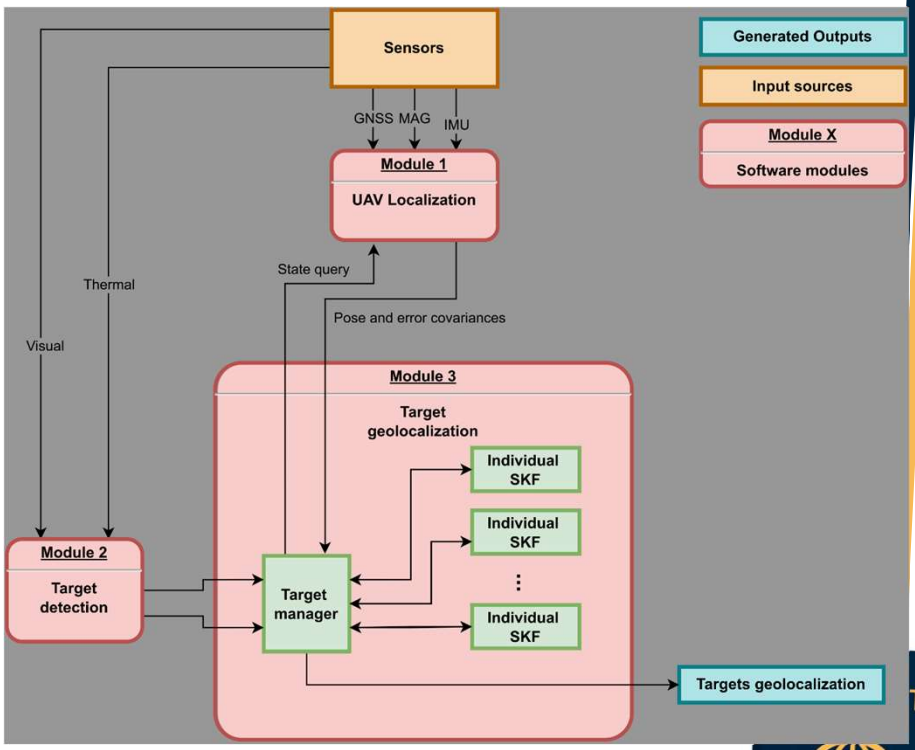
- Target Georeferentiation

- Estimation of position and velocity of Vessel
  - From UAV localization + Target detection modules
- Own solution based on SKF
- A filter for each detected vessel



- Validation in simulation:





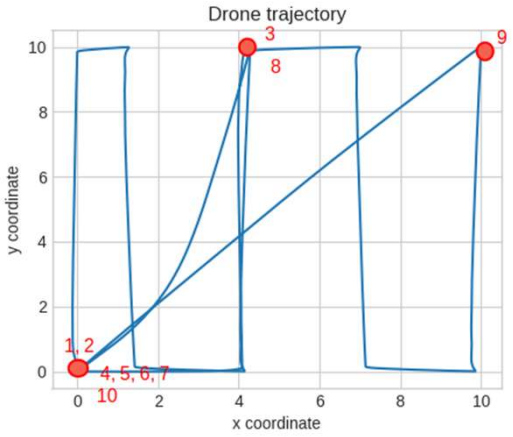
PASSport (2020-2023)

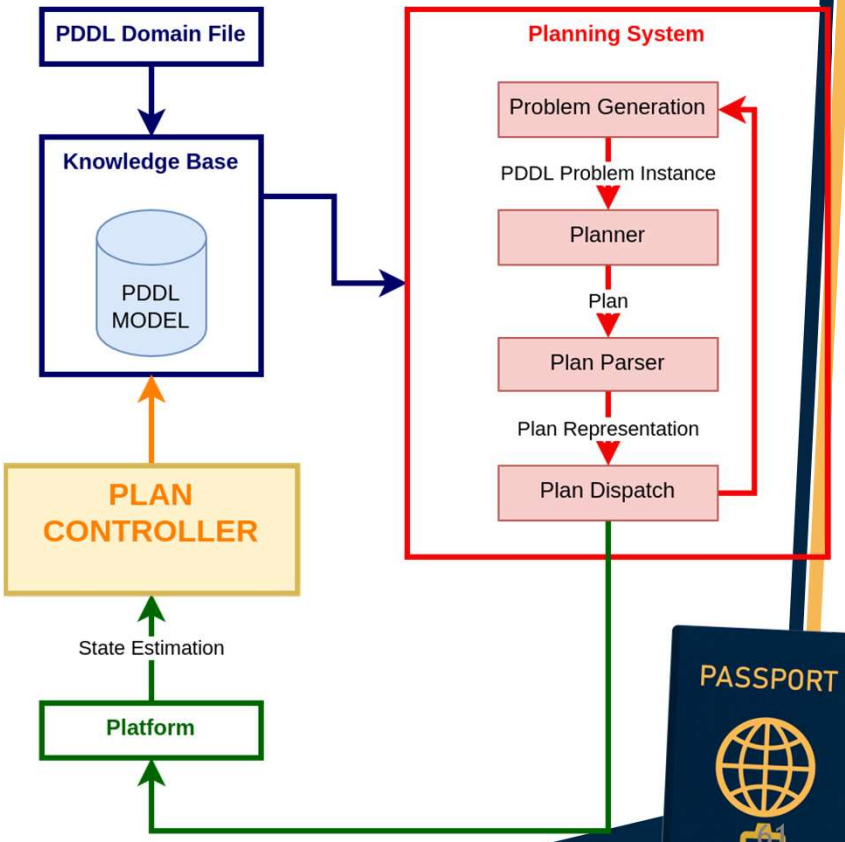
- Mission Planning

- AI-based mission planning with high-level behavioral decisions
- Agent monitoring the environment for the possible events:
  - Vessel detected
  - Target vessel out of range
  - Battery low
  - High localization error detected
- Different mission actions:
  - Take-off
  - Land
  - Move
  - Coverage
  - Follow Vessel
  - Hover
  - Recharge

1: (takeoff wp_land wp_takeoff)
2: (coverage wp_takeoff wp3)
3a: (move wp3 wp_takeoff)
4a: (land wp_takeoff wp_land)

Replan after low battery event:
3: (move wp_coverage wp_takeoff)
4: (land wp_takeoff wp_land)
5: (recharge wp_land)
6: (takeoff wp_land wp_takeoff)
7: (move wp_takeoff wp_coverage)
8: (coverage wp_coverage wp3)
9: (move wp3 wp_takeoff)
10: (land wp_takeoff wp_land)





PASSport (2020-2023)

- Implementation

NVIDIA Jetson Orin AGX

docker
ROS
- **ROSCORE**

docker
ROS
- **Sensor Drivers**
- **UAV localization**
- **Object Tracker**
- **Georeferentiation**
- **Mission Planner**

docker
ROS 2
+
- **Object Detector**

docker
ROS 2
+
ROS
- **ROS BRIDGE**

ROS

Monitoring

&

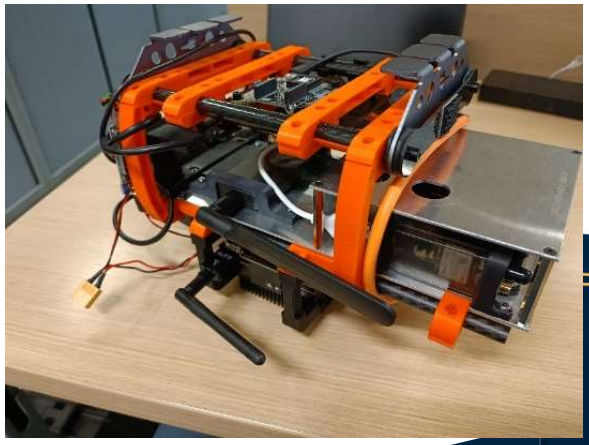
Visualization

Passport (2020-2023)

- Integration of GMV GNSS systems

- Magic-UT PPP system
  - High-precision GNSS (Std: ~0.15-0.2m)
  - Own battery
  - Independent from drone
  - Data post-processed off-line

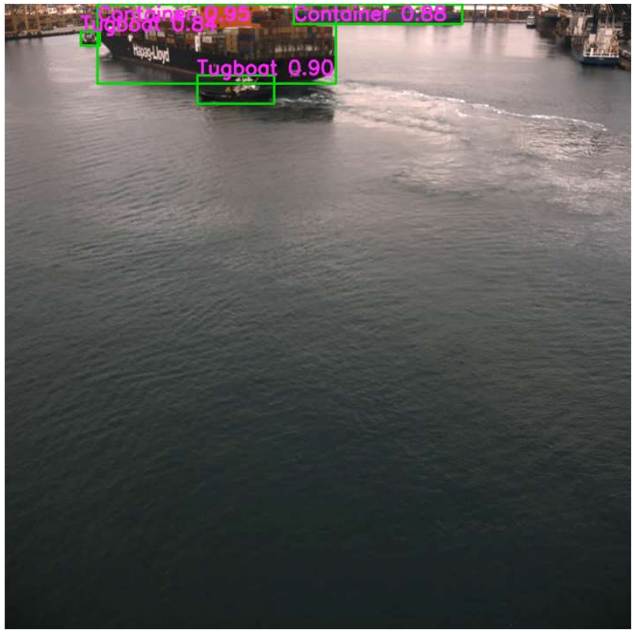
- Magic-UT OSNMA system
  - Anti-spoofing system
  - Need to be plugged to the drone
  - On-line processing
  - Not as precise as PPP (Std: ~1-1.75m)



PASSport (2020-2023)

- Results

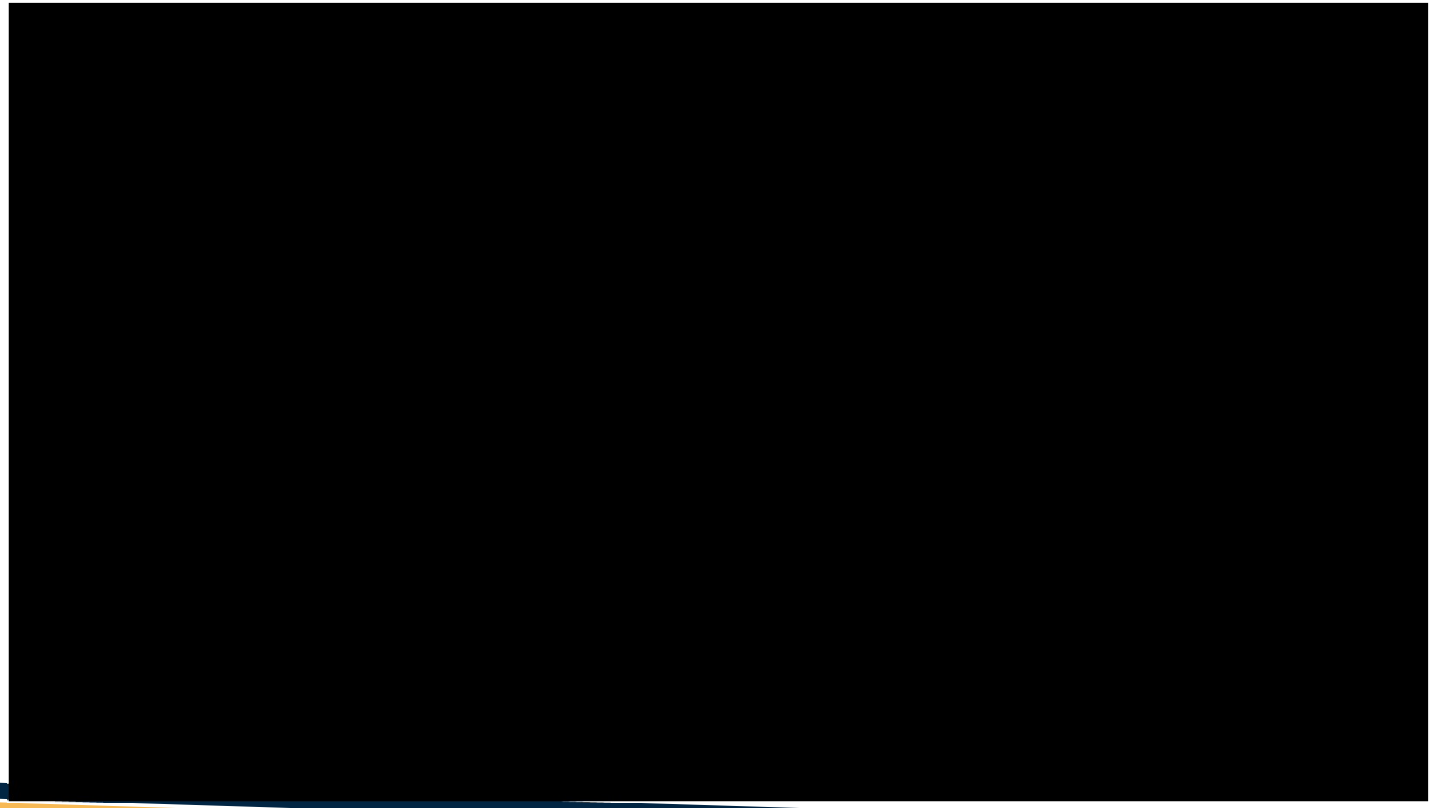
- Pre-campaign in June in Valencia Port
  - Data gathering for training AI algorithms
  - Validation of localization system



PASSport (2020-2023)

- Integration with PASSport platform

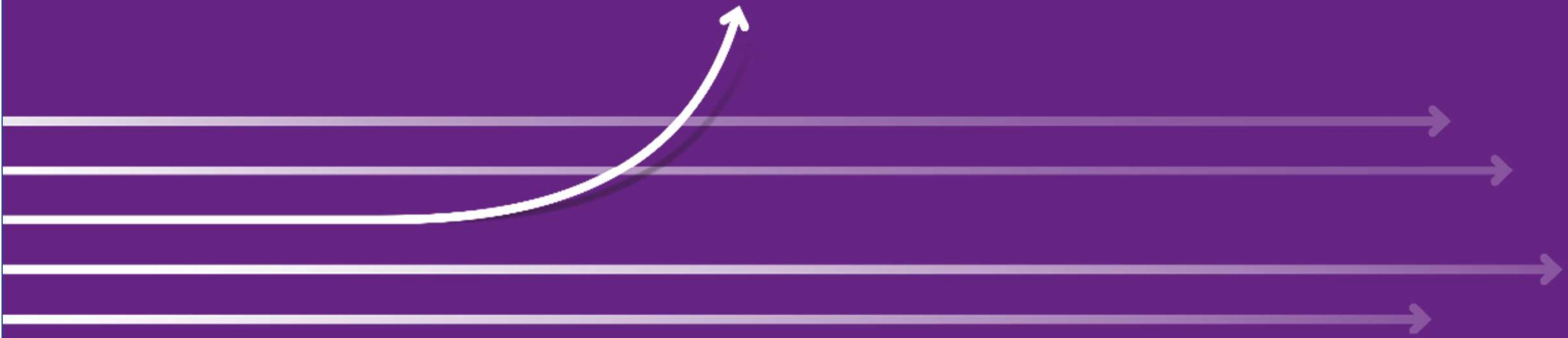
- Validation on the field:
  - UAV localization + Target detection + Target georeferentiation



"innovating with businesses"

Thank you for your attention.

Julián Cayero
Julian.cayero@eurecat.org



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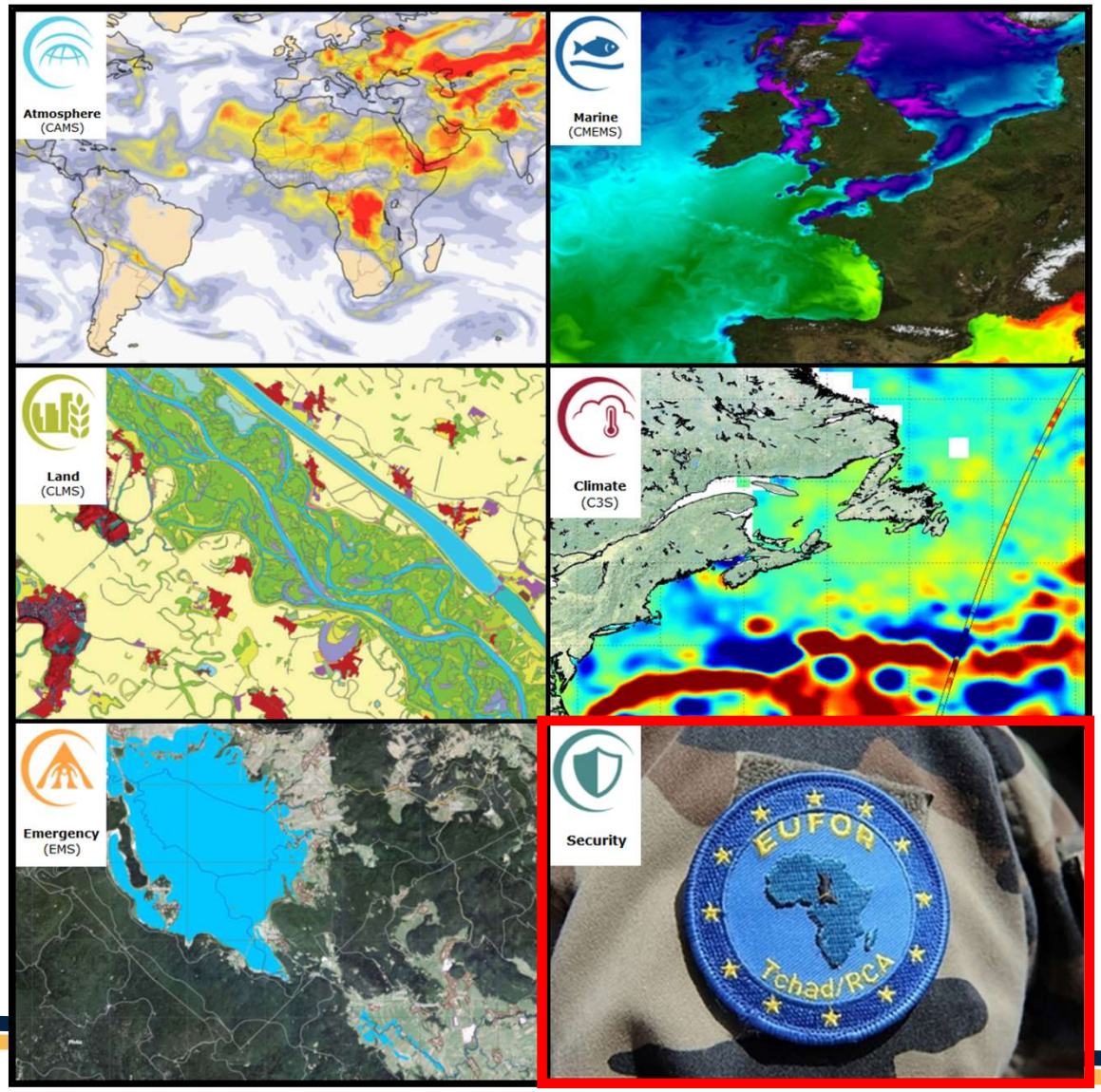
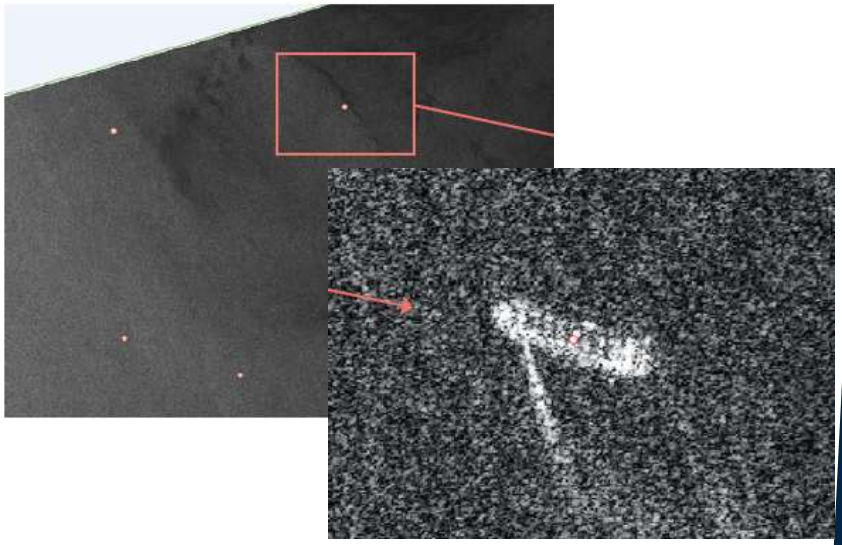
Copernicus products for the safety of port facilities – Valencia

Earth Sciences Department of the University of Florence

The Copernicus programme

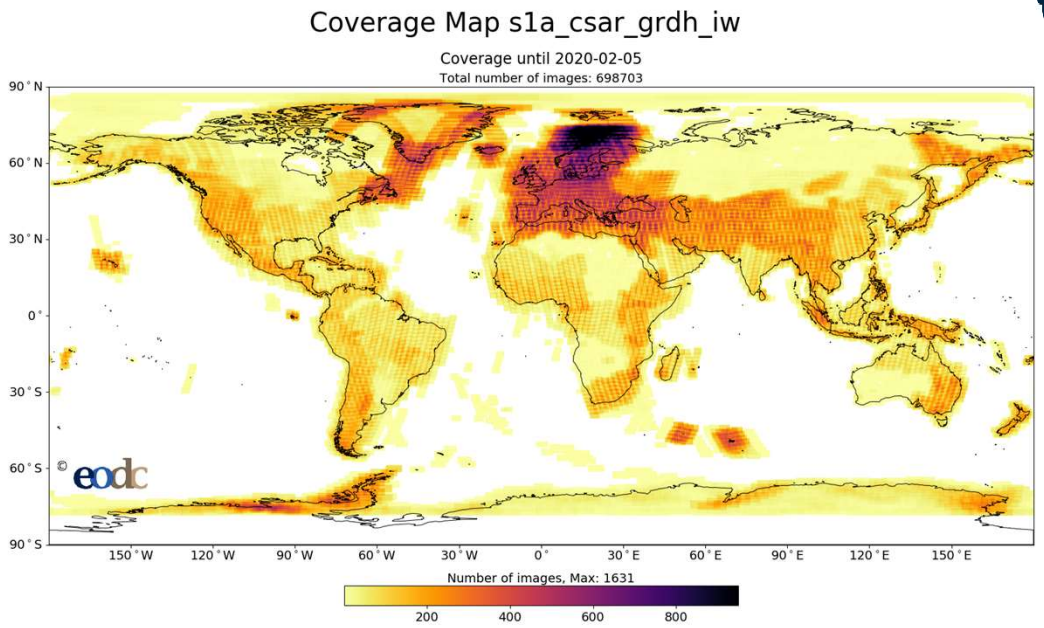


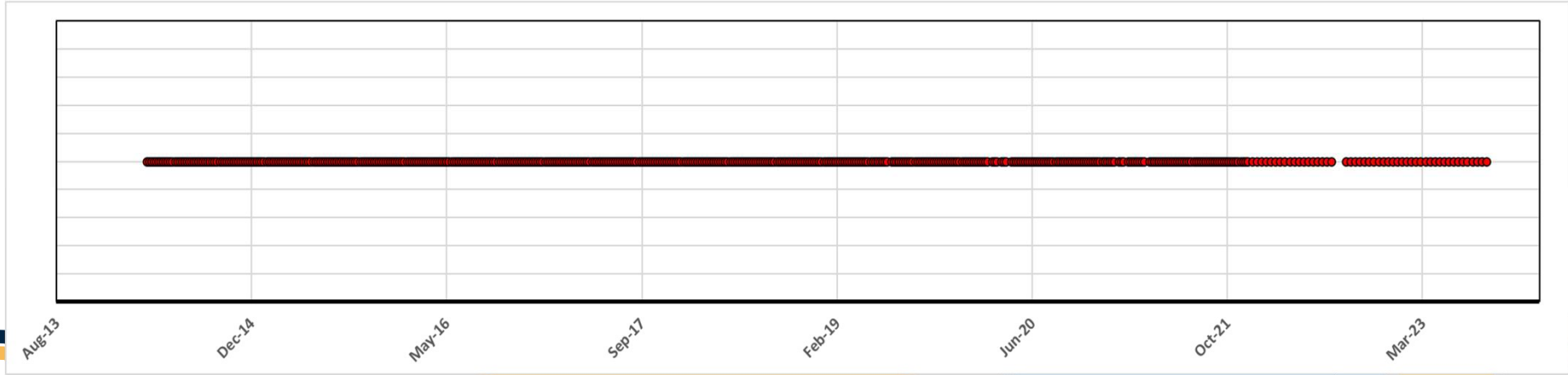
European Maritime Safety Agency entrusted with the operation of the maritime surveillance component of the Copernicus Security Service



The EMSA product catalogue: on demand ship detection. Example on a C-band RADARSAT-2 image.

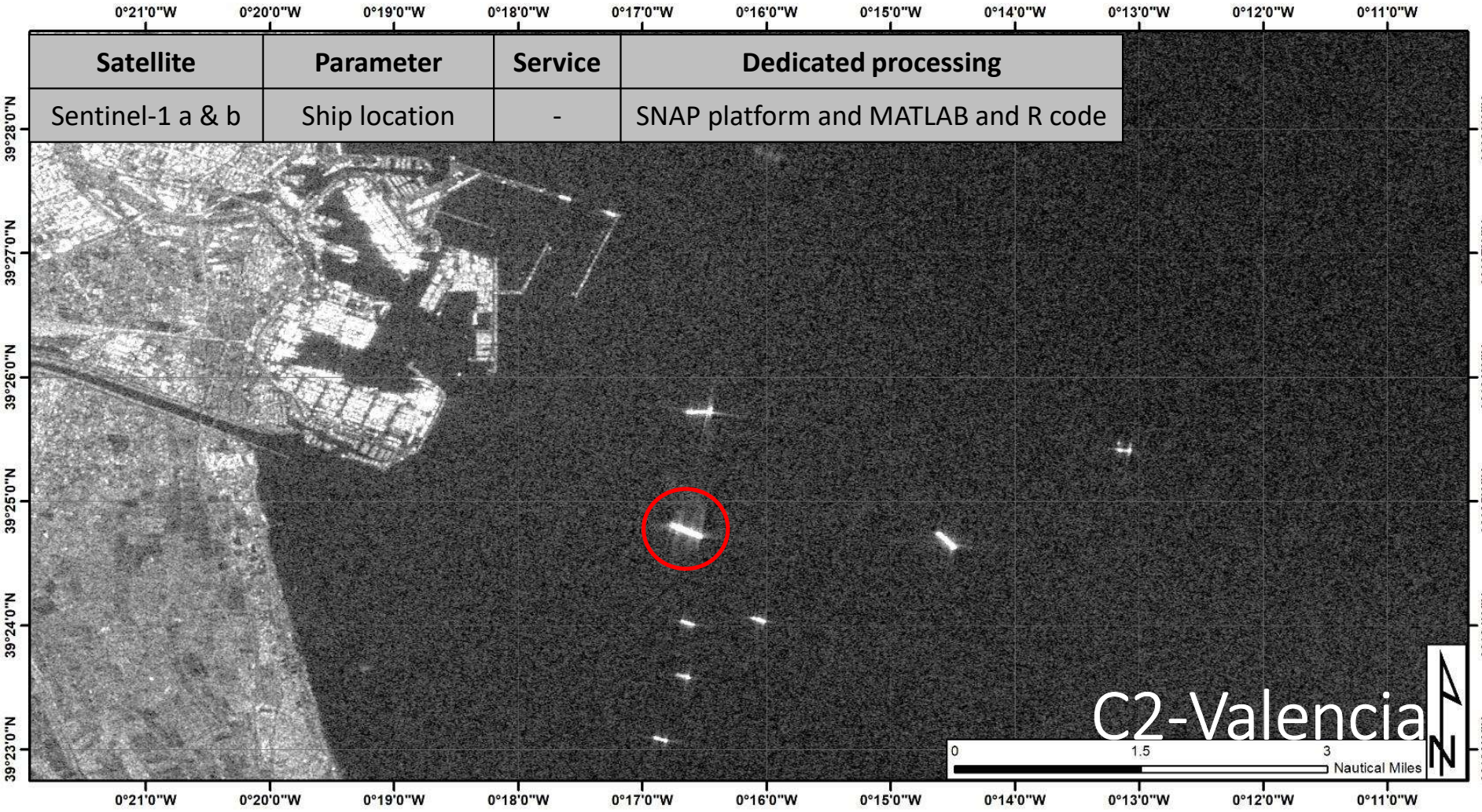
The Copernicus programme





Earth Observation (EO) usage to support port operation monitoring

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



PASSPORT

Sentinel-1A data for vessel detection

Satellite	Data	Image code	Processing level	Orbit	Track
Sentinel-1A	2021 October 30	E99A	SLC (14x5 m of pixel resolution)	Ascending	30
Sentinel-1B	2021 October 24	90A9	SLC (14x5 m of pixel resolution)	Ascending	30
Sentinel-1A	2021 October 18	E92F	SLC (14x5 m of pixel resolution)	Ascending	30
Sentinel-1B	2021 October 12	DB24	SLC (14x5 m of pixel resolution)	Ascending	30
Sentinel-1A	2021 October 06	0D85	SLC (14x5 m of pixel resolution)	Ascending	30
Sentinel-1B	2021 September 30	4568	SLC (14x5 m of pixel resolution)	Ascending	30
Sentinel-1A	2021 September 24	DAF8	SLC (14x5 m of pixel resolution)	Ascending	30
Sentinel-1B	2021 September 18	8E5D	SLC (14x5 m of pixel resolution)	Ascending	30
Sentinel-1A	2021 September 12	F2CB	SLC (14x5 m of pixel resolution)	Ascending	30
Sentinel-1B	2021 September 06	B80E	SLC (14x5 m of pixel resolution)	Ascending	30
Sentinel-1B	2021 October 30	DCDC	SLC (14x5 m of pixel resolution)	Descending	110
Sentinel-1A	2021 October 24	9C21	SLC (14x5 m of pixel resolution)	Descending	110
Sentinel-1B	2021 October 18	D5DD	SLC (14x5 m of pixel resolution)	Descending	110
Sentinel-1A	2021 October 12	AF75	SLC (14x5 m of pixel resolution)	Descending	110
Sentinel-1B	2021 October 06	9CE4	SLC (14x5 m of pixel resolution)	Descending	110
Sentinel-1A	2021 September 30	7F00	SLC (14x5 m of pixel resolution)	Descending	110
Sentinel-1B	2021 September 24	12DB	SLC (14x5 m of pixel resolution)	Descending	110
Sentinel-1A	2021 September 18	336C	SLC (14x5 m of pixel resolution)	Descending	110
Sentinel-1B	2021 September 12	4BA5	SLC (14x5 m of pixel resolution)	Descending	110
Sentinel-1A	2021 September 06	40C7	SLC (14x5 m of pixel resolution)	Descending	110

10 ascending and 10 descending S-1 images acquired between September and October 2021

Sentinel-1 is a **game changer** in Earth Observation applications:

- regional-scale mapping capability,
- systematic and regular SAR observations;
- rapid product delivery (typically in less than few hours from data acquisition).

Possibility to continuously (every 6 days) recognize, identify and extract the coordinates of vessels for the creation of density maps and for the tracking of most frequent routes.

Semi-automatic methodology for vessel detection

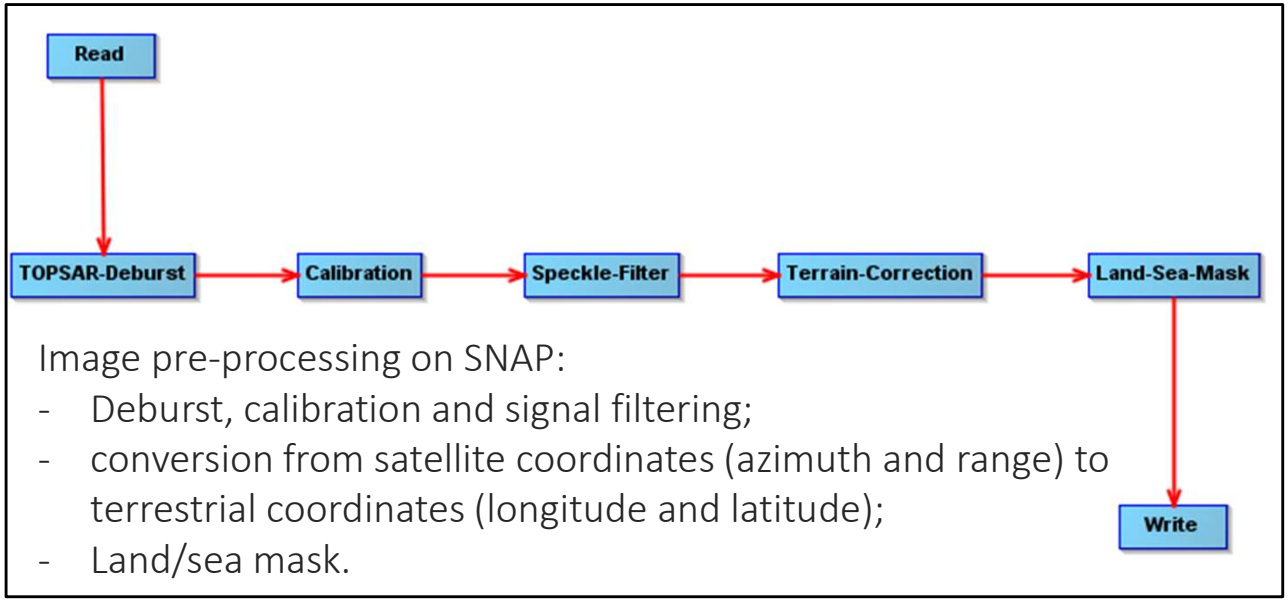
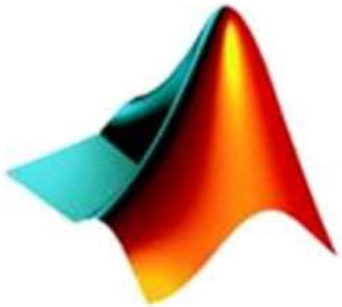


Image pre-processing on SNAP:

- Deburst, calibration and signal filtering;
- conversion from satellite coordinates (azimuth and range) to terrestrial coordinates (longitude and latitude);
- Land/sea mask.

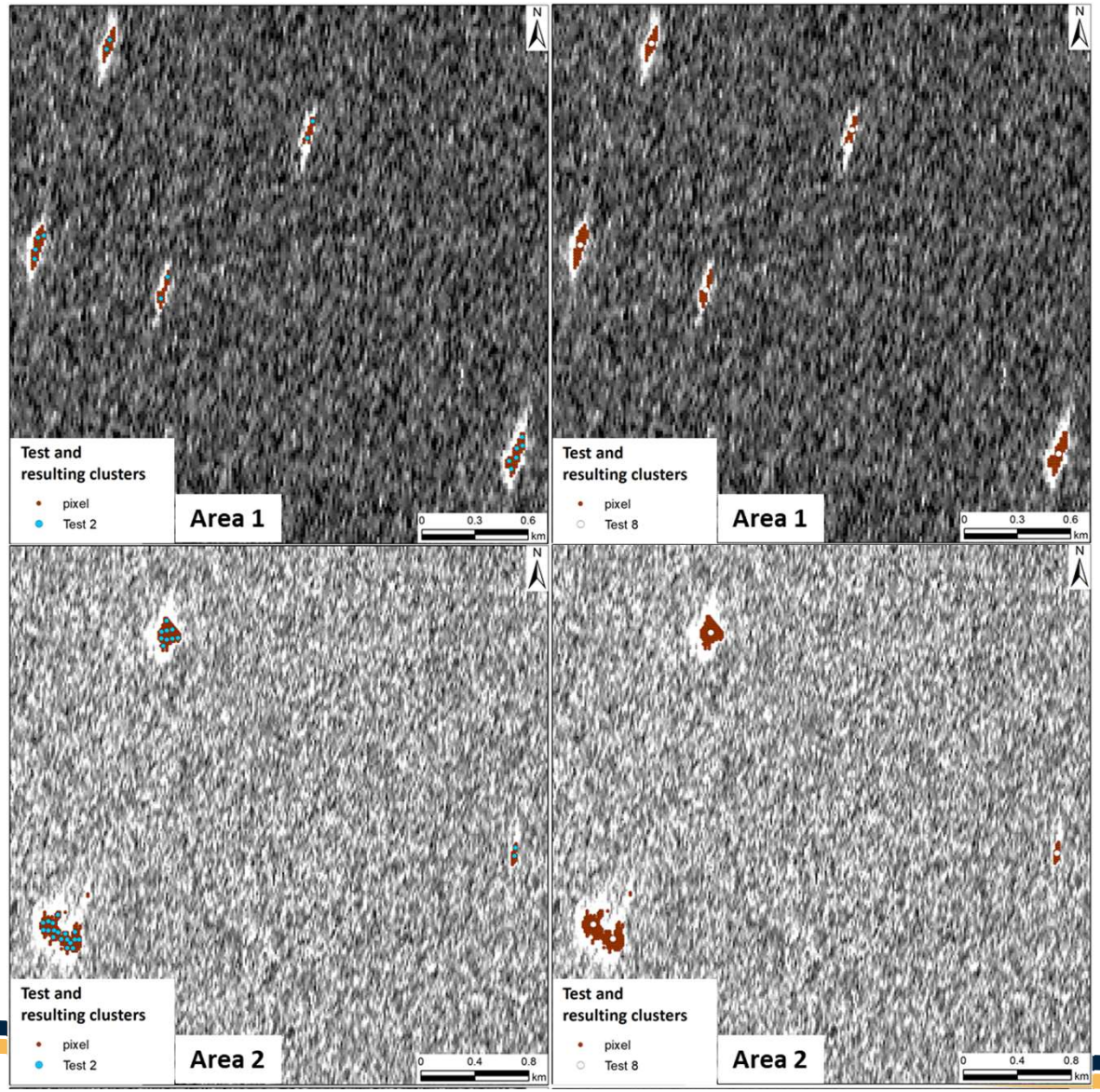
$$Reflecting\_element = 255 * (Amplitude\_image > the\_threshold)$$



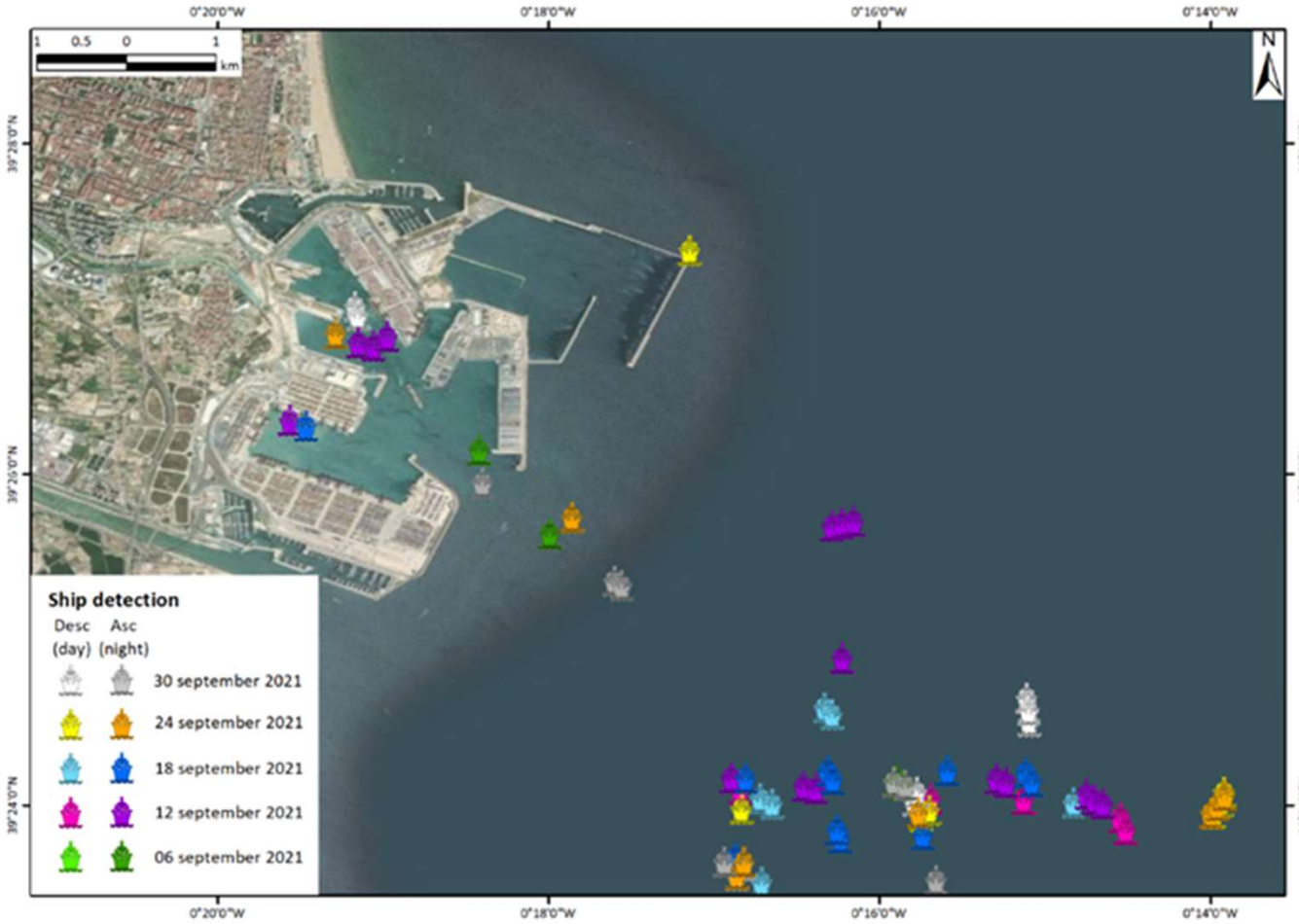
MATLAB

MATLAB codes and tools to extract and cluster reflecting pixels (that likely correspond to boats) and discard the non-reflecting pixels.

Automatic vessel detection with MATLAB

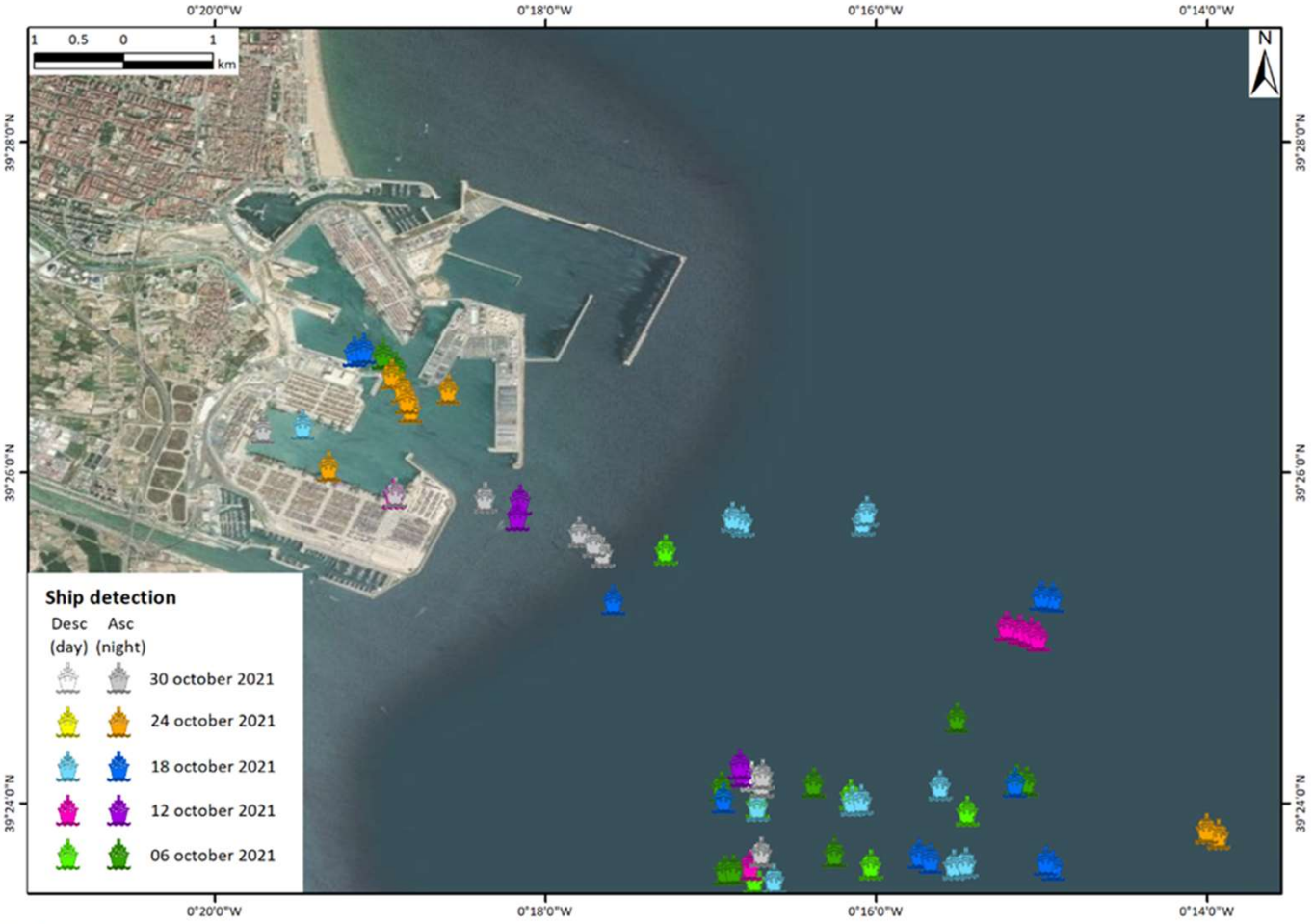


Results: cluster of reflecting points and possible boats



Data	Image code	Orbit	N° of points	N° of cluster in AoI
2021 September 06	B80E	Ascending	101	7
	40C7	Descending	144	8
2021 September 12	F2CB	Ascending	429	20
	4BA5	Descending	193	7
2021 September 18	8E5D	Ascending	498	17
	336C	Descending	371	12
2021 September 24	DAF8	Ascending	196	17
	12DB	Descending	896	17
2021 September 30	4568	Ascending	193	12
	7F00	Descending	402	13

Results: cluster of reflecting points and possible boats



Data	Image code	Orbit	N° of points	N° of cluster in Aol
2021 October 06	0D85	Ascending	228	13
	9CE4	Descending	177	10
2021 October 12	DB24	Ascending	130	7
	AF75	Descending	148	6
2021 October 18	E92F	Ascending	385	21
	D5DD	Descending	324	17
2021 October 24	90A9	Ascending	240	13
	9C21	Descending	137	4
2021 October 30	E99A	Ascending	319	12
	DCDC	Descending	355	11

Earth Observation (EO) usage to support port operation monitoring

- The developed procedure demonstrates that Sentinel-1 satellite images allow the recognition of the ships navigating close to infrastructures
- Sentinel-1 frequent acquisitions may serve as security check and for identifying the non-authorized boats not detected by other systems.

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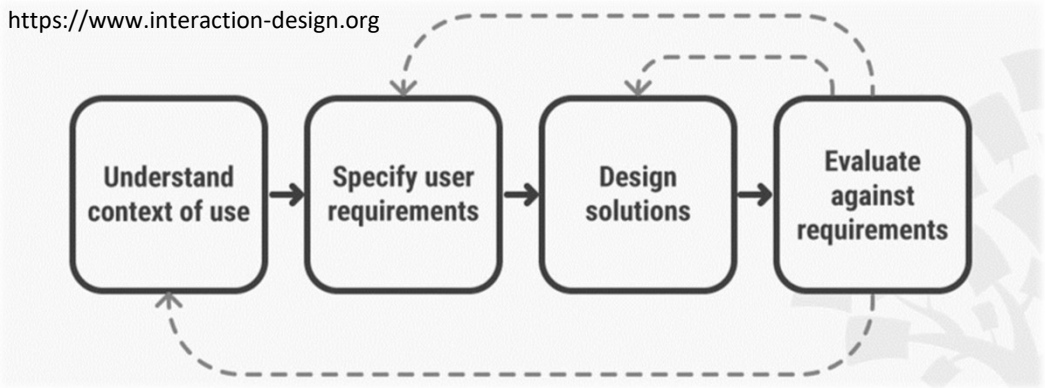
Our vision: Users are at the center

- User centered design (development and deployment) of a solution is a key enabler for its success and adoption

https://www.interaction-design.org



"…is an iterative design process in which designers focus on the users and their needs in each phase of the design process."

Users involvement in PASSport

- Qualified stakeholders and users (project partners, Advisory Board) are integral part of the team designing, developing and demostrating the PASSport solutions:
  - Actively involved in the collection of **requirements** and in the definition of the **use cases**;
  - Constantly informed and asked for qualified **feedback** in the iterative design and development phases;
  - Hosting the **demonstrations**, tailored for the specific use case of the user

Two essential tools for the users

- PASSport produced two essential products targetting the final users of its outcomes:
  - The PASSport Ground Segment User Manual (D3.2)
    Objective: create in the user a detailed understanding of what the PASSport platform is, how it works, its prerequisites, its functionalities and limitations, etc.
  - The PASSport Professional User Training package (D5.14)
    Objective: make the user proficient with the usage of PASSport platform (From Know-How To Do-How)

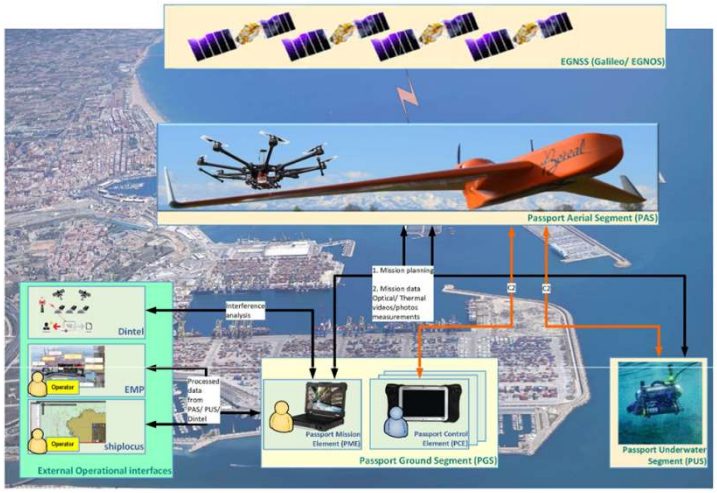
- The Manual and the Training are complementary and inseperable pals

PASSport Ground Segment User Manual

- Focussed on the the Passport Ground Segment (PGS) platform:
  - core platform including the MRP (Mixed Reality Platform)
  - external interfaces connecting to the already operative systems
- Tailored on the needs of target users:
  - **Admin**: Superuser for administration and maintenance purpose
  - **Platform administration Operator (PAO)**: Back-end (Service centre) Operator, in charge of platform accounting (part of core module)
  - **On field Operator (OFO)**: Aerial/ Underwater Operator allowed by pertinent authorities (e. g. CAA) to perform specialized aerial work

PASSport Ground Segment User Manual

- Section3: PASSport Architectural Context (includes interface with external systems)



- Section 4: Installation Manual (includes pre-requisites and software dependencies)
- Section 5: Administration Manual (includes access policies, profile management, settings, configurations and indications on how to create new «projects»).

PASSport User Training Package: target groups

Tailored for various stakeholders crucial to the success of the PASSport solution:

1. **Port Authorities:** As responsible of port operations, their thorough understanding and effective utilization of the PASSport solution are paramount in ensuring the safety and security of maritime activities.
2. **Harbour Masters:** Their pivotal role in overseeing port operations necessitates a comprehensive grasp of the PASSport system to integrate it seamlessly into existing protocols.
3. **Security and Safety Personnel:** These frontline operatives play a pivotal role in implementing safety and security protocols. The training plan equips them with the expertise required to utilize the PASSport solution effectively.
4. **Drone Operators:** Given the semi-autonomous nature of the drone fleet, specialized training is essential for operators, including regulatory aspects. This segment of the audience will receive focused instruction on drone operations within the context of the PASSport solution.
5. **Underwater Vehicles Operators:** Their role in monitoring underwater threats adds a critical dimension to port security. This training plan ensures they are prepared to operate underwater vehicles in coordination with the PASSport system

PASSport User Training Package: learning objectives

PORT AUTHORITIES

- Understand PASSport Technology
- Integrate with Existing Operations
- Emergency Response Proficiency

HARBOUR MASTERS

- GNSS Technology Proficiency
- Drone Fleet Management
- E-navigation Implementation

SECURITY AND SAFETY PERSONNEL

- Operational Procedures Expertise
- Pollution Monitoring Skills
- Infrastructure Protection Proficiency

DRONE OPERATORS

- Technical Drone Operation
- Task-Specific Drone Operations
- Emergency Response and Safety

UNDERWATER VEHICLES OPERATORS

- Underwater Threats Monitoring
- Integration with Port Security
- Response to Underwater Threats

Learning objectives are specific for target users, but knowledge is shared and training is conducted with a strong «team spirit»

PASSport User Training Package: training modules

	Module Title	Description
Module 1	Introduction to PASSport Solution	Overview of the PASSport project objectives and its significance in port safety and security.
Module 2	Technical Components and Capabilities	In-depth exploration of GNSS high Accuracy and Authentication, drone fleet management, and underwater vehicle operations.
Module 3	Applications and Use Cases	Detailed examination of specific applications, including pollution monitoring, e-navigation support, critical infrastructure protection, and threat response.
Module 4	Operational Procedures and Safety	Hands-on training on operating and managing the PASSport solution, emphasizing safety protocols for both aerial and underwater operations.
Module 5	Compliance, Regulatory Considerations, and Integration	Overview of relevant regulations and directives, ensuring compliance with legal requirements in port operations, and techniques for seamless integration of PASSport with existing systems.

Each module is designed to last 1.5 hours (two days), allowing for a dedicated Q&A session after each session. The course content includes engaging elements such as presentations, videos, and interactive exercises.

PASSport User Training Package: measure the effectiveness

Means to measure the effectiveness of the training:

- **Knowledge Assessments**: Conduct quizzes or assessments after each module to evaluate understanding.
- **Hands-On Exercises**: Evaluate adopters' ability to operate and manage the PASSport solution in simulated scenarios.
- **Scenario-based Simulations**: Create realistic scenarios to test adopters' response to various safety and security situations.
- **Feedback and Surveys**: Collect feedback from adopters to gauge their satisfaction and understanding of the training.
- **Post-Training Evaluation**: Assess adopters' performance in actual port operations post-training.

Conclusions

- Users have been deeply involved in the development and demonstration of PASSport solutions
- Proper documentation and training targetting the early adopters are fundamental enablers to users engagement and proficiency
- Next steps:
  - User Manual is consolidated;
  - Training plan defined, users' feedback under collection collected, final content currently being refined to include lessons learnt from the demonstration activities
  - Training report will accompany the plan with final recommendations for the exploitation phase

Questions?

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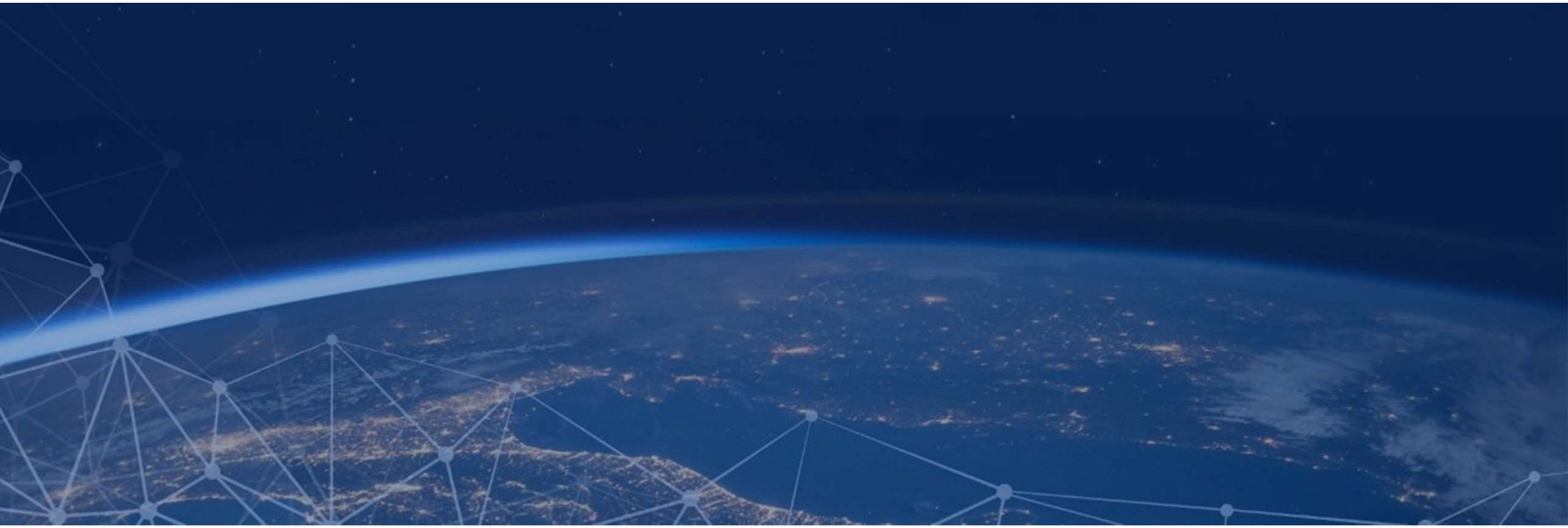


PASSport - Valencia campaign

The OSNMA service

Pablo Haro, Manuel López, EUSPA

19th October 2023, Valencia, Spain

Role of GNSS PVT in UAS

GNSS PVT plays a central role for drone' operations

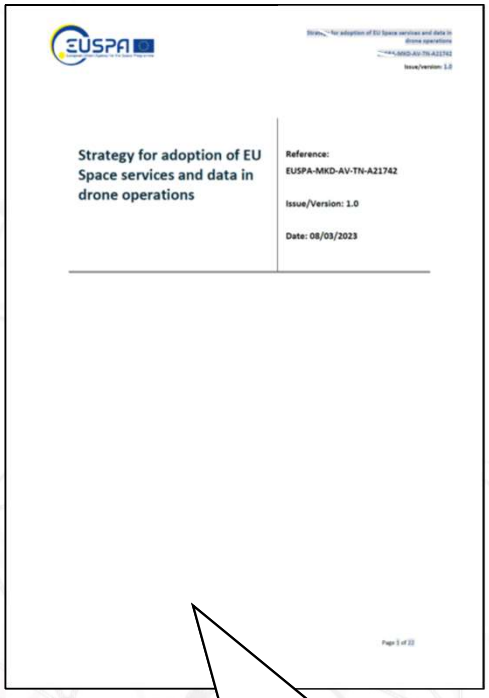
- position determination for navigation, to fly an intended trajectory within and outside U-space airspace, in all risk categories;
- reporting of positioning for e-identification, geo-awareness and collision avoidance functions;
- mission-specific needs, such as geo-tagged images/data collected with other sensors/payload onboard drones.

EGNOS/Galileo is already integrated in most commercial receivers for UAS

- MCMF GNSS including Galileo open service on E1/E5, with increased performances and robustness;
- EGNOS enabling improved positioning accuracy and reliability thanks to the integrity feature;
- Galileo High Accuracy Service (HAS) on E6, enabling new opportunities for navigation solutions with higher accuracy;
- position's authentication with Galileo's Open Service Navigation Message Authentication (OSNMA) will further strengthen the system resilience against spoofing events.

EUSPA strategy on Space for UAS & EC's Drone Strategy 2.0

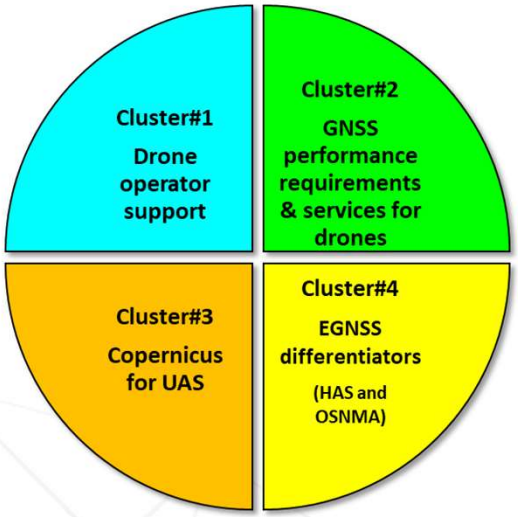
'Strategy for adoption of EU Space services and data in drone operations', March 2023


Strategy for adoption of EU Space services and data in drone operations

Reference: EUSPA-MKD-AV-TN-A21742

Issue/Version: 1.0

Date: 08/03/2023



Considers relevant OSNMA use cases.

'Drone Strategy 2.0 for a Smart and Sustainable Unmanned Aircraft Eco-System in Europe', Nov 2022


EUROPEAN COMMISSION

Brussels, 29.11.2022
COM(2022) 652 final

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

'A Drone Strategy 2.0 for a Smart and Sustainable Unmanned Aircraft Eco-System in Europe'

{SWD(2022) 366 final}

Objective_A1 *'Improving airspace capabilities'*

- *[…]* ***leveraging services and data of the EU Space programmes (EGNOS, Galileo, Copernicus and Secure Connectivity***
- ***[…] synergies with the EU Space Programme will be further explored*** *… to support* ***resilient and robust drone navigation****.*

Objective_B2 *'Identifying strategic technology building blocks and technology enablers'*

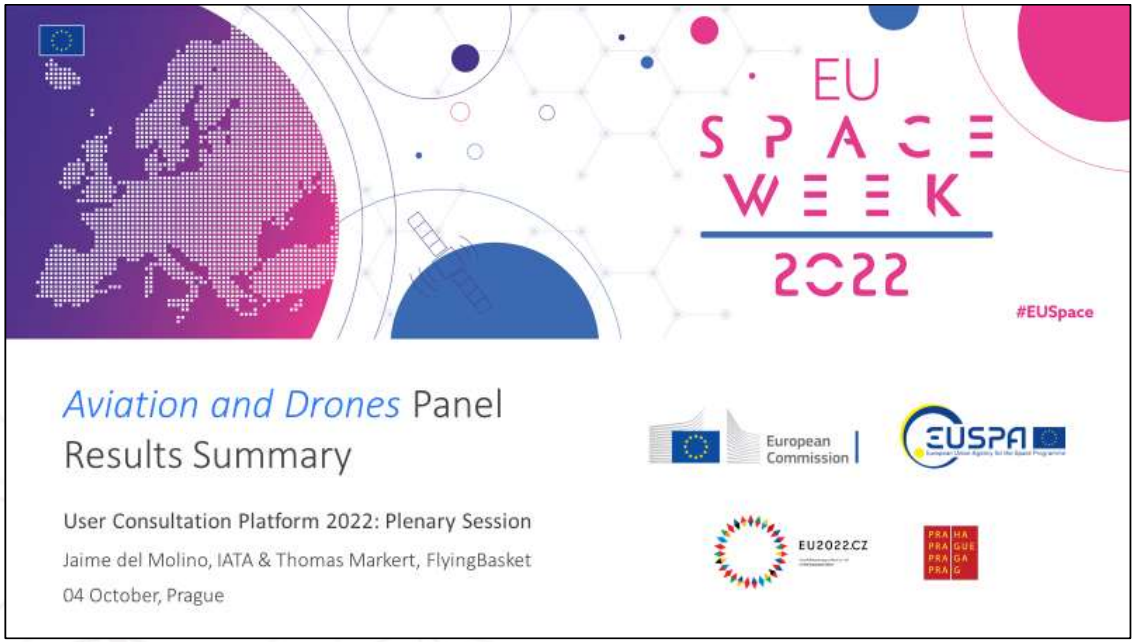
- ***key underlying technology enablers such as […] EU space services***

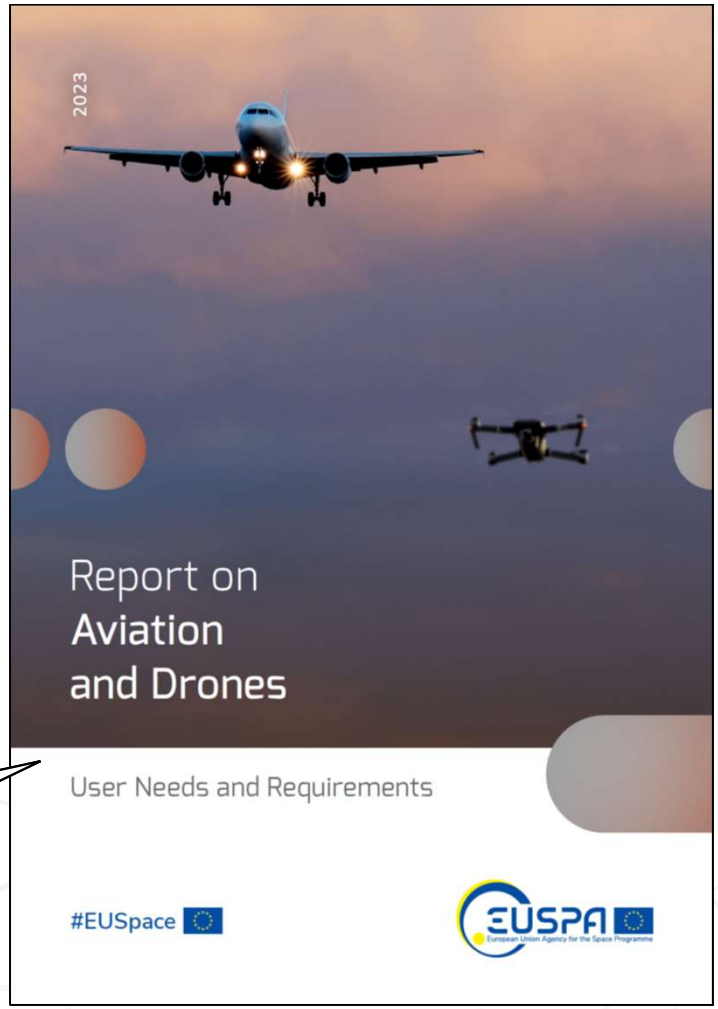
Objective_B5 'Increasing counter-drone capabilities and system resilience'

- ***leverage resilient navigation enabled by EU space services***
- *Drones could be eligible for a* ***voluntary "European Trusted Drone" label.***

The Galileo OSNMA service can support robust and resilient navigation and positioning.

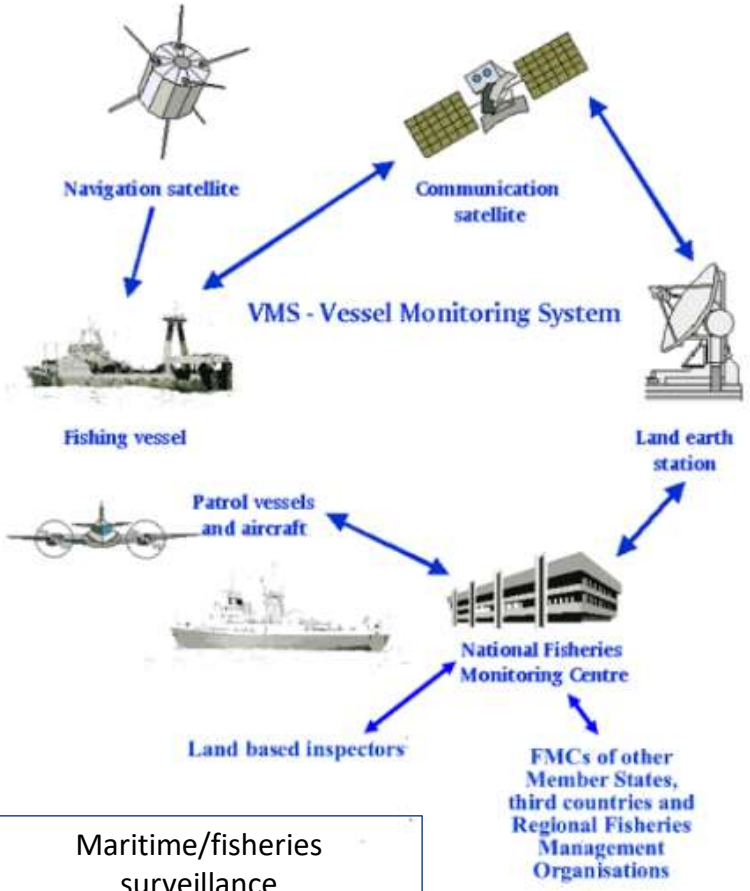
User Consultation Platform 2022 – Aviation and Drones



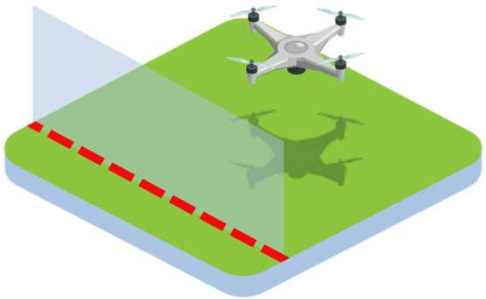


https://www.euspa.europa.eu/sites/default/files/report_on_aviation_and_drones_user_needs_and_requirements.pdf

Galileo OSNMA provides additional trust in drone position reporting: use cases



Maritime/fisheries surveillance



Airspace Infringement / E-Conspicuity

Last mile delivery

Some ***OSNMA use cases***:

- 4D authentication of image's position and time; legal value highlighted by EFCA for fisheries control;
- authentication of the path for BVLOS operations;
- last mile authentication of position as proof of delivery.

DEGREE & GEODESY - prototyping of Galileo OSNMA drone receivers and integration in autopilot

Two projects DEGREE and GEODESY targeting for commercial solution in a box.

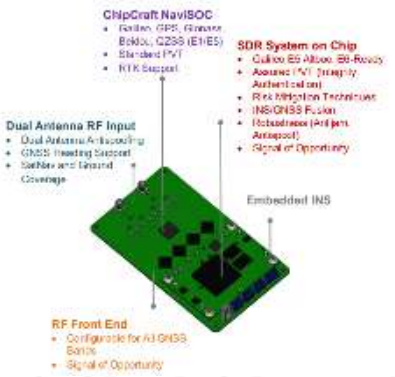
Objectives:

- Integrate OSNMA in a receiver suitable for drone operation.
- Define contingency operational procedures in case of authentication failure.
- Contribute to standardization.

DEGREE
DronEborne Galileo RecEivEr

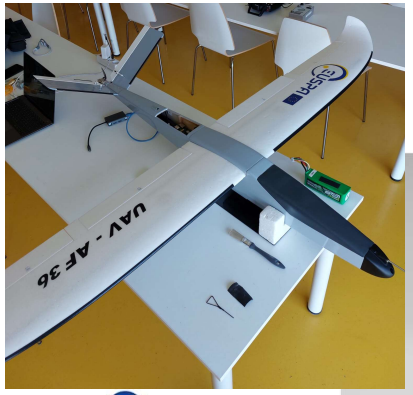
Fundamental Elements

GEODESY

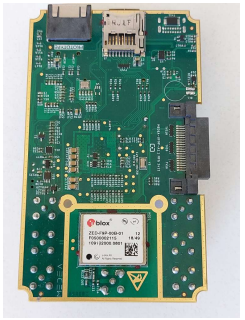


Rokubun drone OSNMA & HAS flight demo

BCN Drone Center, 29th March 2023 https://www.rokubun.cat/

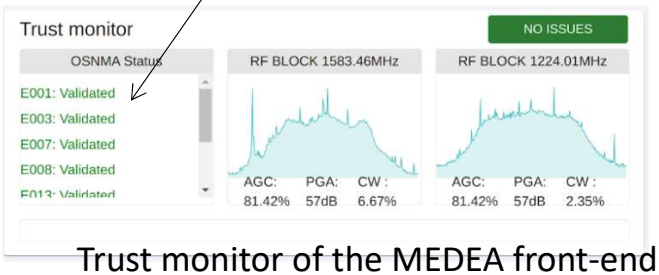


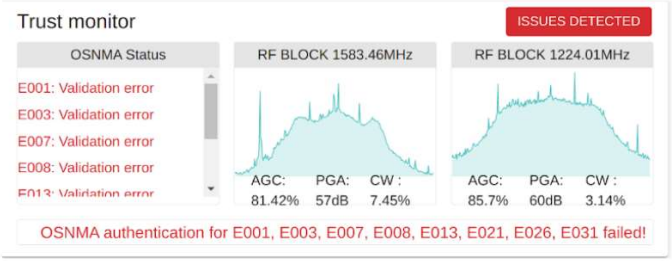
EUSPA ATMOS-8 fixed-wing drone



MEDEA GNSS receiver (onboard the drone)

Galileo satellites with authenticated navigation message





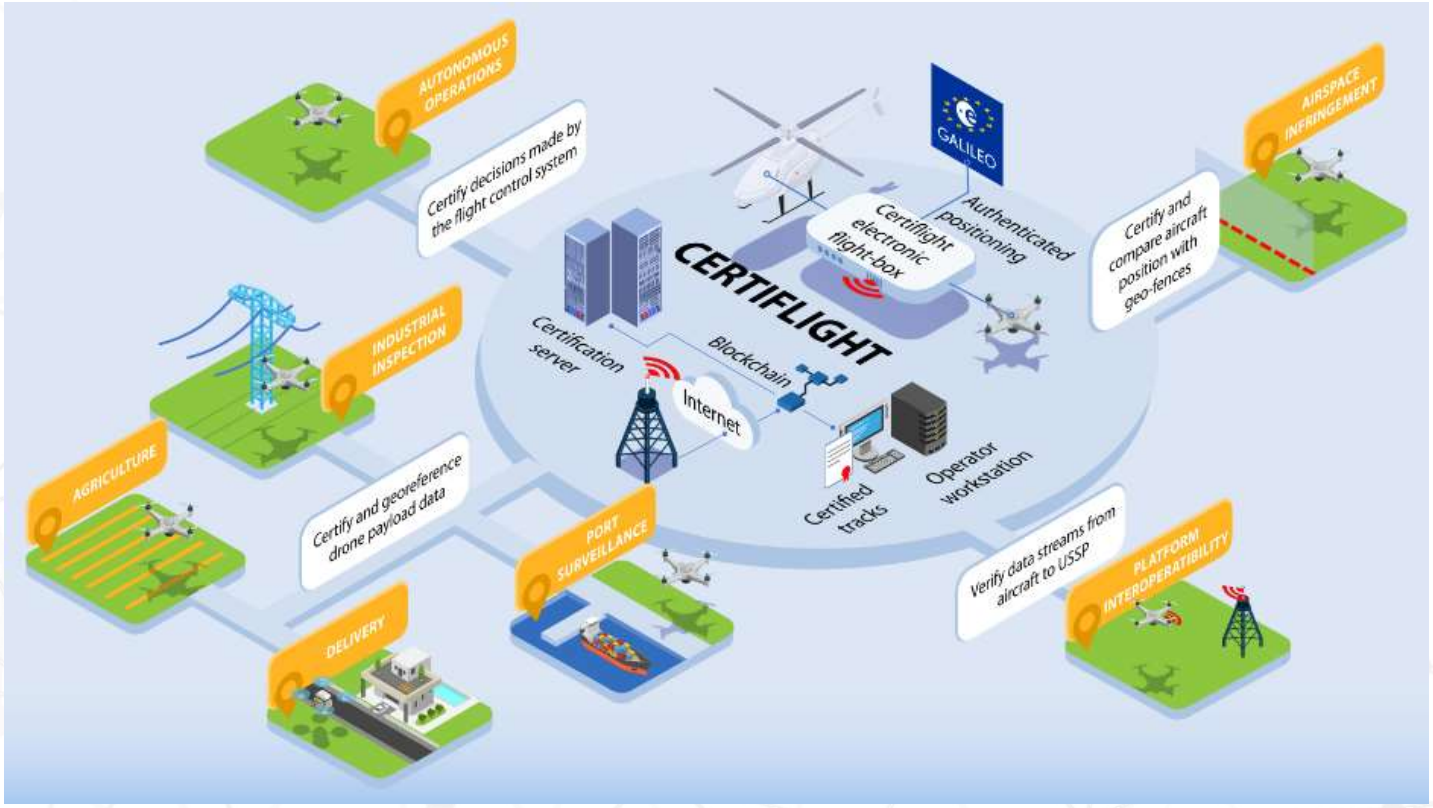
Trust monitor of the MEDEA front-end

Next steps:

- 'Guidelines for OSNMA position reporting and images timestamping in drones' applications' under consolidation.
- Drone's HAS positioning being derived in post-processing.
- Information to be made available by GSC at the User Space platform.

CERTIFLIGHT- Certified E-GNSS remote tracking of drone and aircraft flights

Galileo OSNMA feature to certify the flight tracks of drones and ultralight aircraft inside VLL airspace.



Objectives:

- Liability chain for UAS operations
- UAS mission data traceability
- Safety enhancement for operations at VLL
- Interoperability with several UTM/U-space platforms

https://certiflight.info/

PASSport - Operational Platform managing drones exploiting GNSS high Accuracy and Authentication to improve Security & Safety in port areas

Campaign 2 (C2): Support to e-navigation (safety), Valencia, Spain

https://h2020-passport.eu/

Linking space to user needs

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