ISRMM 27

From Space Cybersecurity to Resilient PNT
GMV Romania's Experience

gmv
INNOVATING SOLUTIONS

CYBERCUBE

Cybersecurity Context

- Part of the **Cyber Security Resilience Programme**, an ESA cross-directorate initiative to support the development of solutions aiming at increasing the security posture of ESA
- **Cyber Security Operational Center** monitors ESA Space missions
- CyberCUBE addresses a space-security gap: many satellite communication links remain unprotected
- The current risks:
  - Unauthorized access to satellite command & control and communication links
  - Communications jamming and spoofing
  - Attacks on the onboard systems

The CYBERCUBE endeavor

- The overall **CYBERCUBE** endeavour kicked-off in August 2024 with the overall objective of providing a robust and reliable infrastructure for both the flight segment and ground for ESA cyber security

Phase B2
- Requirements consolidation
- Platform & Payload preliminary design

Phase C/D
- Critical Design
- MAIT for space & ground segments

Phase E
- LEOP (finalized)
- Platform and Payload commissioning (ongoing)

ESA proposed cybersecurity experiments:

- Detection & protection against unauthorized access
- Detection, protection and response against communication jamming or spoofing
- Monitoring of onboard OT systems
- New cryptographic algorithms
- RF monitoring (S-band)
- Others TBD

➢ **Call for ideas#01 by ESA → Closed Nov 2025:**

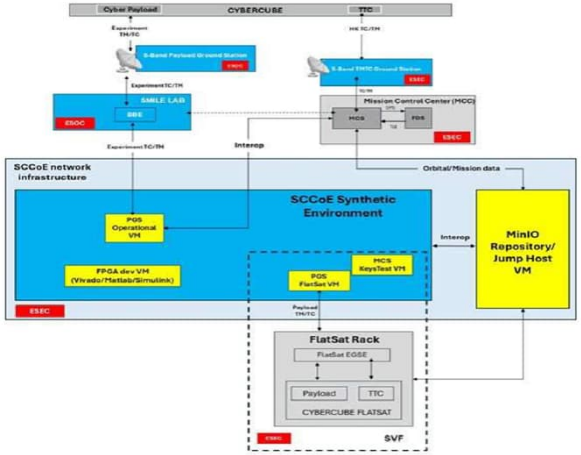
1. Space Public Key Infrastructure (PKI) Experimentation and Testing
2. Secure 2-way ranging with LEO satellites.
3. Quantized in-orbit fingerprinting for uplink authentication
4. In orbit comparative implementation and testing of QUIC-MLS and BPSec-MLS
5. Delegated Certificate Validation for Federated Space Public Key Infrastructure
6. Quantum and cryptanalysis secure remote software update system to enable cryptographic agility in space systems

➢ Call for ideas#02 by ESA → Closed July 2026

TBA

CyberCUBE Concept

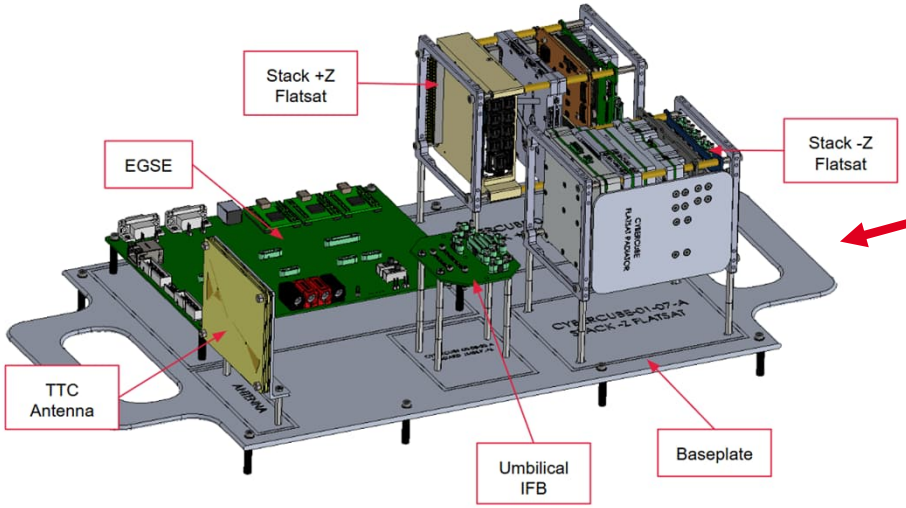
- **Full GMV consortium**
- **Highlights**
  - → **SIZE :** 3U Cubesat
  - → **ORBIT :** SSO~500km (590km final)
  - → **COMMUNICATIONS :** S-band transponder
  - → **PAYLOAD :** S-band Transponder + X-band Transmitter (SDR)
  - → **CAPABILITY :** OnBoard Processors + FPGA + Real Time Core
  - → **GROUND INFRASTRUCTURE :** ESEC + ESOC + ESTRACK (Kiruna)



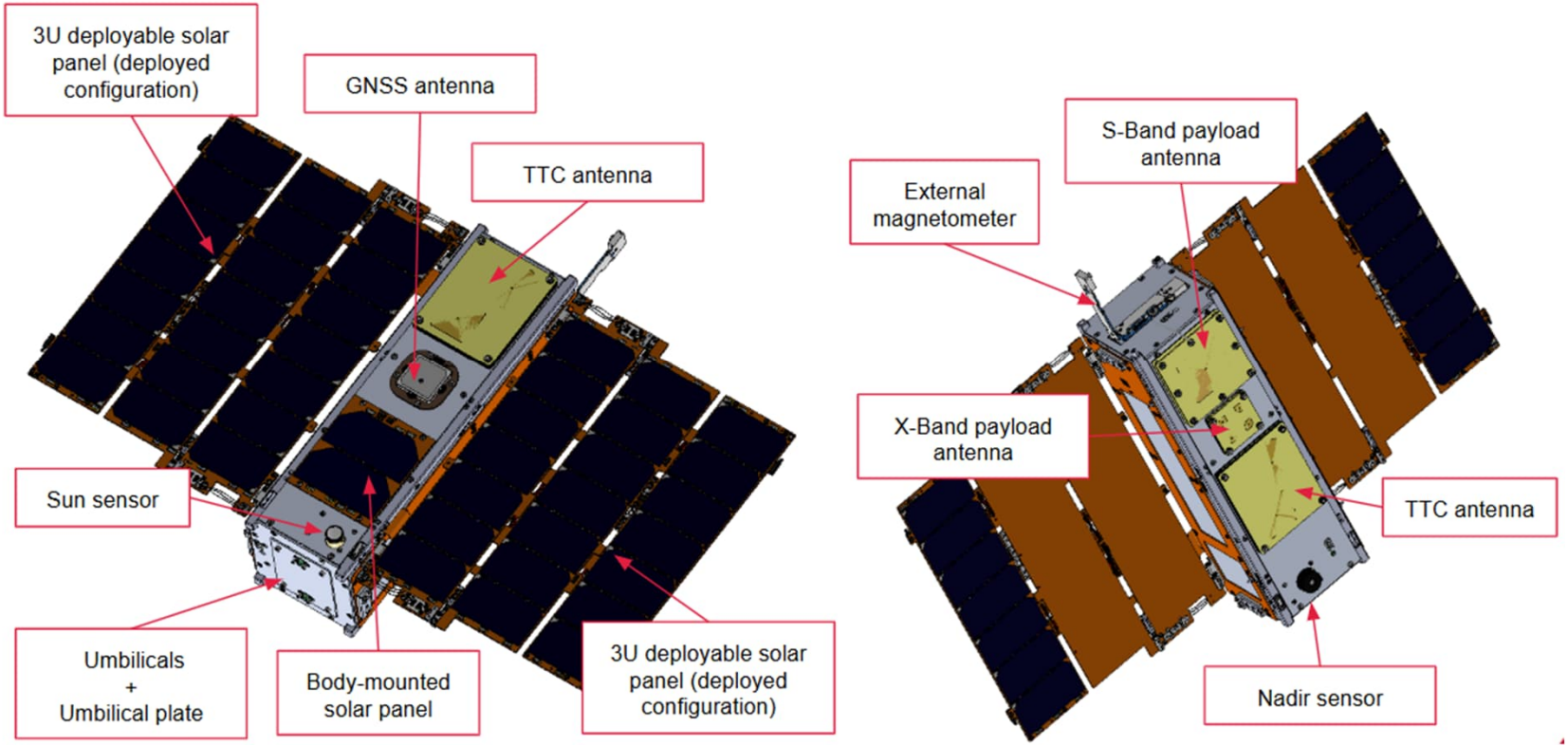
Experiment preparation tools:
- Flatsat
- FPGA Tools
- SCCoE Environment
- MCS & PGS

The CyberCUBE processing platform allows for a **full reconfigurability** and the cyber SW can exploit onboard data:
- OBDH data
- Radio Frequency I/Q samples
- Sensor data

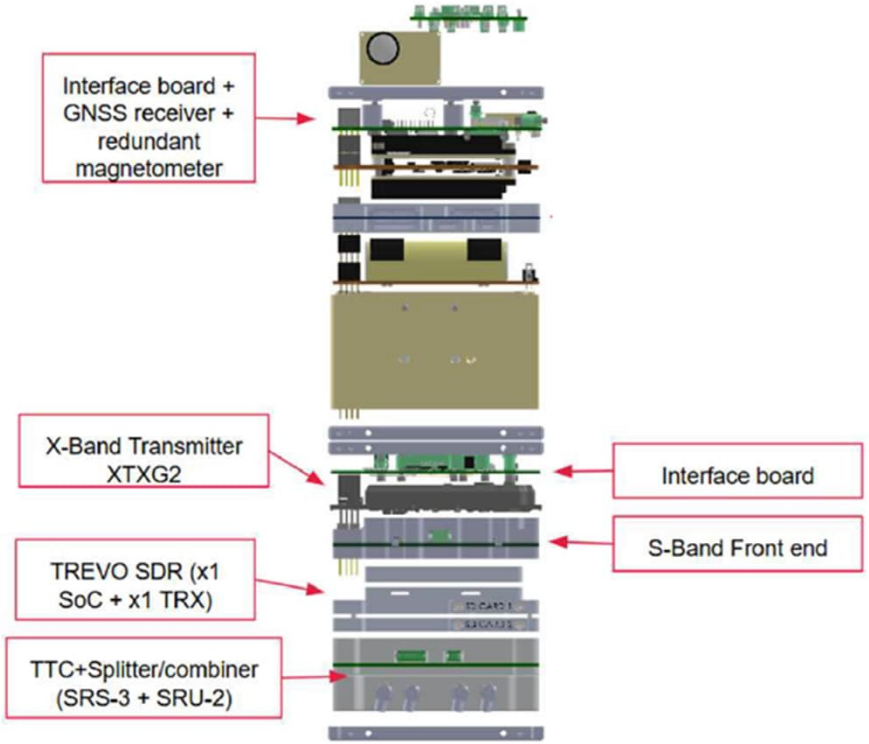
FLATSAT & EGSE



SATELLITE



TTC& PAYLOAD



TTC

- S-band Front-end full duplex RF, up to 512 kbps
- CCSDS & PUS
- Framing, Error detection and correction, AES-256-GCM encryption, Authentication, MAC

Payload architecture

- TREVO – Main core of the Payload
- S-band Front-end full duplex RF
- X-band transmitter – high performance DVB-S2 transmitter (8.025 - 8.4 GHz and up to 250 Mbps)
- S-band antenna
- X-band antenna

Trevo firmware:

- Security functionalities with Crypto algorithms
- Reconfigurable
- Highly flexible – allows distributed implementation between PS and PL
- ECSS, CCSDS aligned

Satellite Operations from ESEC (Redu)

Operations from ESOC (SMILE)

TREVO PAYLOAD

TREVO Features Highlights

- COTS Alén Space product
- Modular high performance SDR platform
- Up to 4 external modules (2SoC + 2TRX, 1SoC + 1TRX and more options)
- SoCs based on Zynq Ultrascale+ family with embedded Linux and GNURadio compatible
- Multi-core processing and FPGA flexibility
- Wideband transceivers:
  - TX band: 47 MHz to 6.0 GHz
  - RX band: 70 MHz to 6.0 GHz
- Plugging of different RF FrontEnds: UHF, VHF and S-band
- Multiapplication capabilities
- In-orbit reconfiguration
- AD9361 transceiver

LAUNCH & NEXT STEPS

Satellite Launch

- Falcon-9 rocket, Transporter 17, 07.07.2026
- LEOP successfully completed 08.07.2026
- Comissioning completness Expected mid September

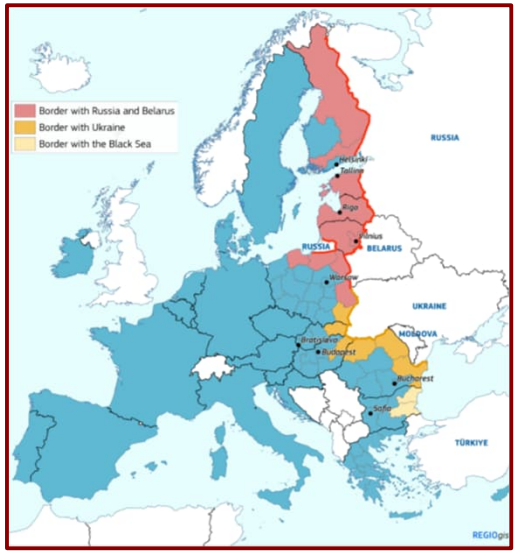
Next Steps

- IOCR & System handover to ESA
- Operational/ routine Phase 1 year after hadover (ESA)

RIPTIDE

Context

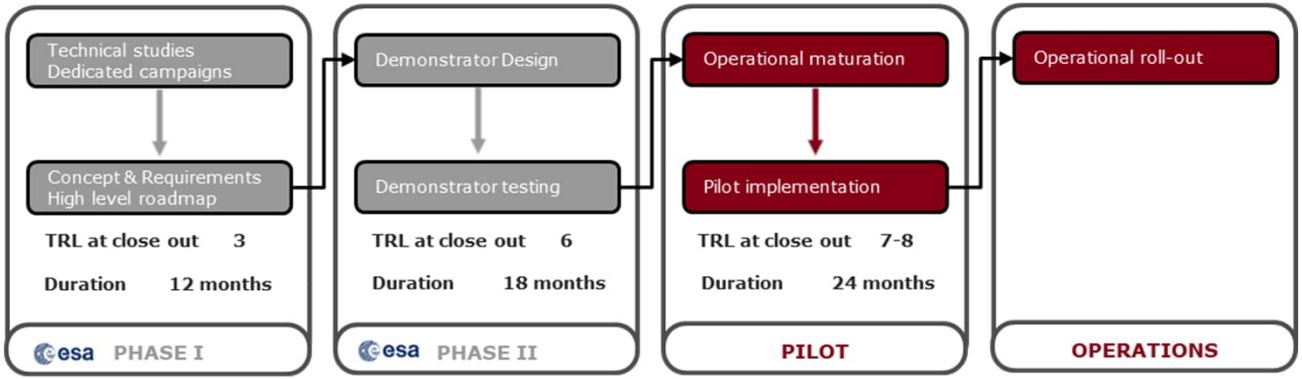
- **The Black Sea sets the Eastern borders of both the EU and NATO**
- **Complex geopolitical context**
- **Important oil and gas resources**
- **Link between Europe, Asia and Middle East**
- **Recently recognized by the EC as part of the Strong regions for a safe Europe**
- **Currently**
  - → Increased risk of electronic warfare in the Black Sea area
  - → Warnings about jamming/spoofing in the area issued by authorities
  - → Mining activities – adrift mines in RO waters
  - → New energetic needs involving offshore gas exploitation platforms in the Black Sea



Source: EC COM(2025) 82: Strong regions for a safe Europe

The RIPTIDE endeavor

- The overall **RIPTIDE** endeavour kicked-off around 2019-2020 with the overall objective of developing a resilient PNT solution for the Black Sea and Lower Danube area
- **RIPTIDE PHASE 1** closeout recommended an integrated Monitor & Protect solution for resilient PNT.
- **RIPTIDE PHASE 2** was the continuation of the study with a demonstrator development phase which underwent laboratory and field testing.
- **RIPTIDE PILOT** will tackle the implementation of a pilot at the Black Sea targeting a specific area of interest
- **RIPTIDE** should close with an operational roll-out of the system along the Black Sea Romanian coastline and extend it



RIPTIDE PHASE 1

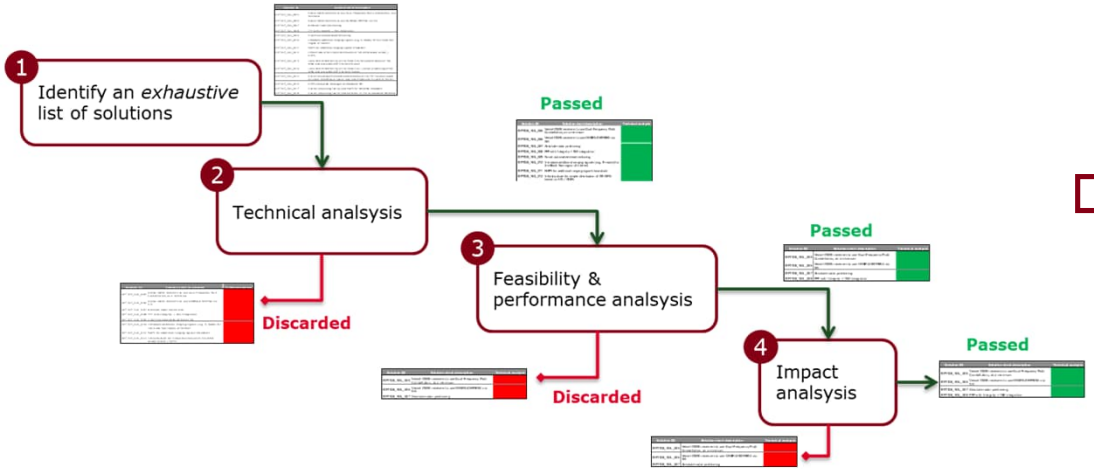
TASKS PERFORMED

Cascade approach covering:

- SotA and preliminary requirements
- Campaigns to analyse efects, generate showcase and ensure involvement of stakeholders
- Refinement of potential solutions and analysis
- Roadmap of adoption and connex activities

RIPTIDE PHASE 1: Initial Awareness Campaigns

RIPTIDE PHASE 1 – Solution identification & analysis



Integrated *Monitor & Protect* approach based on:

Applicable at authority level:

- GNSS interference monitoring of coastal areas and ports
- Provision of additional ranging signals, such as VHF R-mode based on AIS/VDES infrastructure
- Distribution of authentic/verified NM based on a SIS NMA(OSNMA/CHIMERA) or AGNSS approach using the AIS/VDES infrastructure

Applicable at vessel/user level:

- Usage of DF-MC or MF-MC GNSS receivers
- Usage of NMA-enabled GNSS receivers as soon as they will be available
- Usage of R-mode receivers or GNSS/R-mode multi-system receivers to benefit from the additional ranging signals
- Usage of vessel level interference detection and mitigation techniques

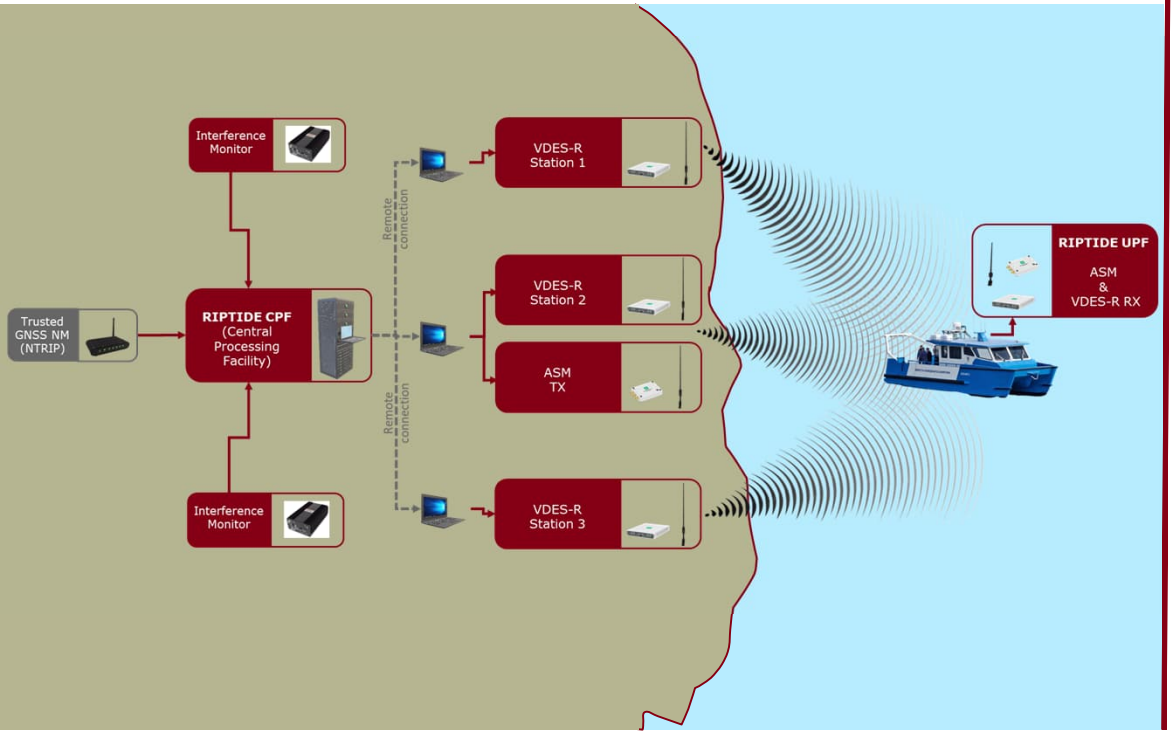
RIPTIDE PHASE 2 Project

- The RIPTIDE Phase 2 project targets the **second phase in the development of a resilient PNT solution** dedicated to the particularities of the Black Sea and Danube Lower Basin region.

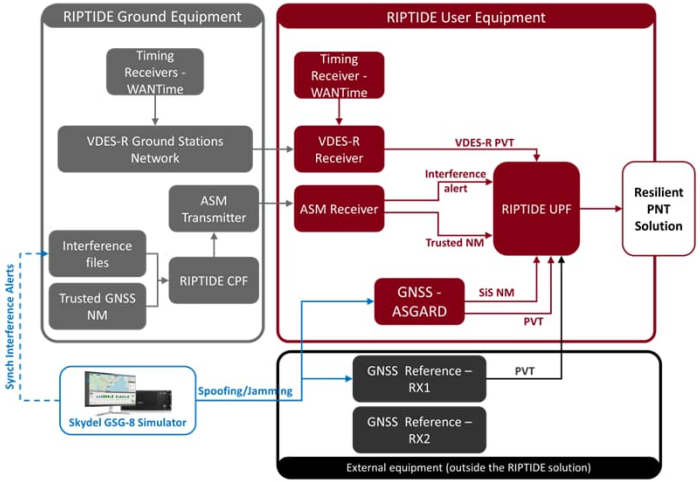
- Specific objectives:
  - Review and consolidate the requirements for the resilient solution
  - Propose solution architecture and system design
  - Iteratively assess alignment with regulatory, standardization, and operational frameworks
  - Implement the *Monitor* and *Protect* components of the system
  - Test in laboratory and Black Sea field environment to assess the performance
  - Evaluate the technology readiness and update the operational roadmap
  - Assess applicability in other domains – non-maritime applications
  - Engage stakeholders and plan future steps towards operational development

RIPTIDE PHASE 2 - Design and Implementation Overview

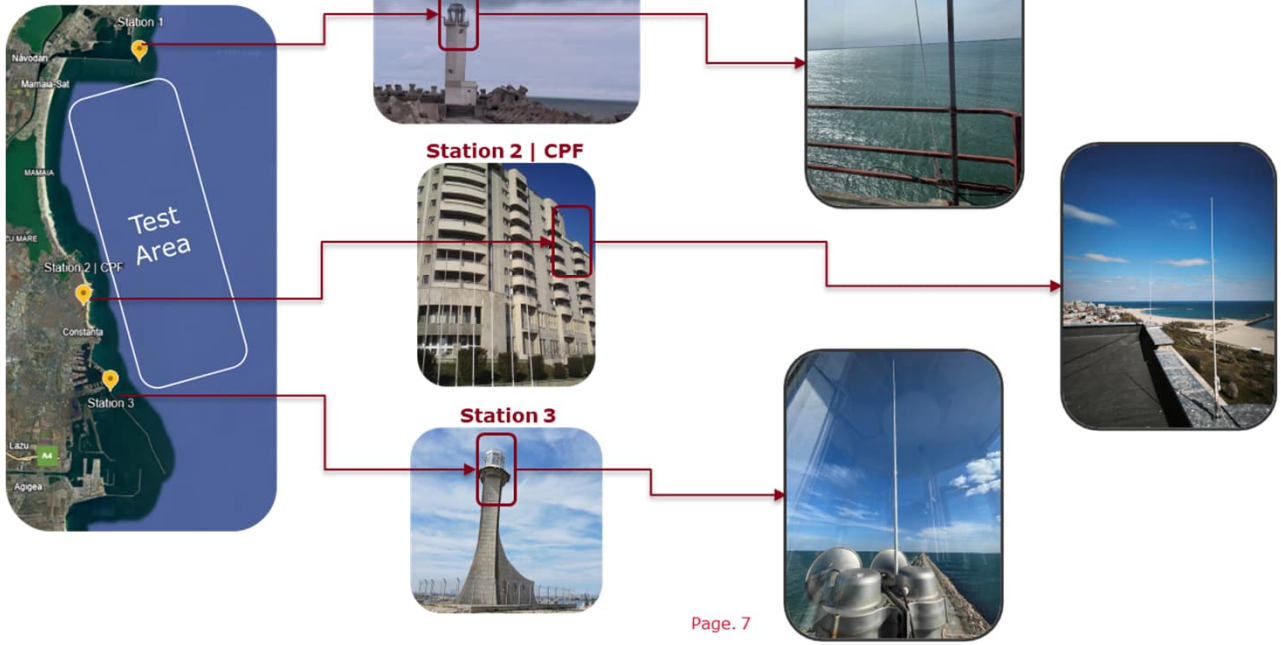
High Level Architecture

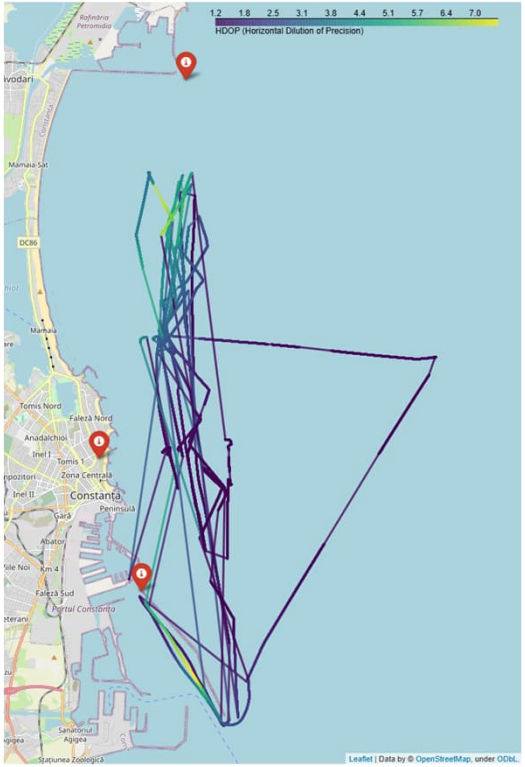


Functional Blocks Diagram



Test area and transmitter stations



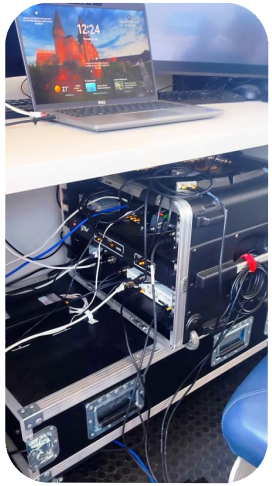


Test Equipment Configuration

- Test vessel Ocean 2, owned and operated by MHD
- Hydrography equipped research vessel
- Dedicated project equipment deployed on board

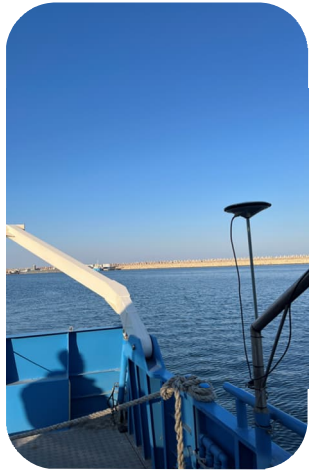
Ocean 2 Vessel Antenna locations

UPF, GNSS and VDES-R Receivers

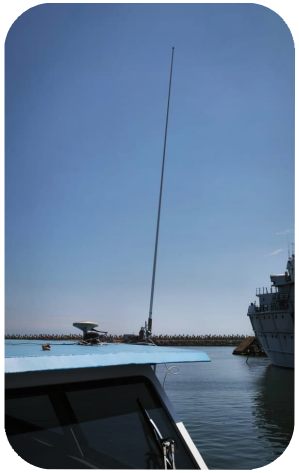


Skydel Simulator

GNSS Antenna



VHF Antenna



Live demonstration events

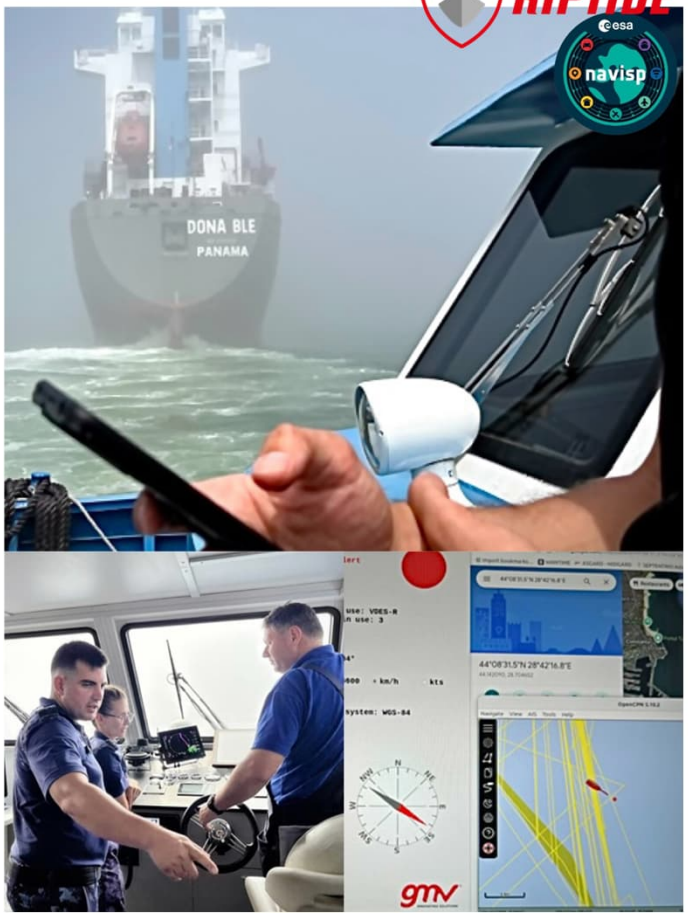
The consortium organized live demonstration events to showcase the capability of the RIPTIDE Demonstrator in the Black Sea waters.

ESA, **ROSA** and **RNA** joined the live demonstration events onboard **MHD**'s Ocean 2 vessel.

Live GNSS Jamming and Spoofing conditions were encountered during one of these events, corresponding to a Localized Degradation Scenario**.**

The demonstrator detected and mitigated the threats thanks to its **Alternative PNT capability.**

The **VDES-R / R-Mode** system consistently delivered accurate position fixes, with errors remaining below 10 meters in the conditions of strong **GNSS** interference and very poor visibility.



BLACKOUT

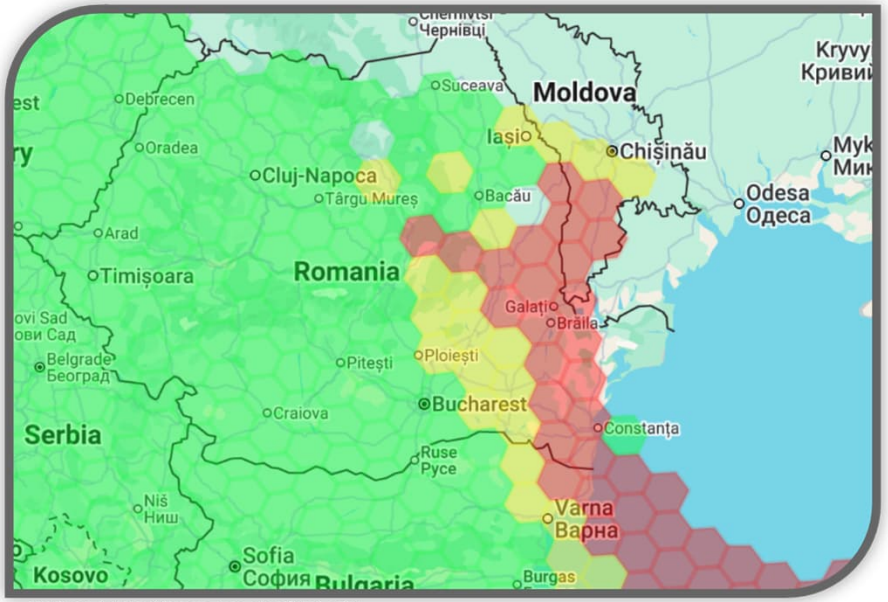
BLACKOUT: Background and Objectives

Background and relevance:

- Quasi-permanent GNSS RF interferences in the Black Sea area
- Strong interest at national level in the topic of PNT resilience and GNSS interference
- High consortium expertise in the field
- Many new technologies under development
- Possible national military / dual-use interest for new technologies

Scope:

- Implementation of a **Black Sea Test Range** to test and evaluate different PNT solutions in GNSS signal degradation and denial

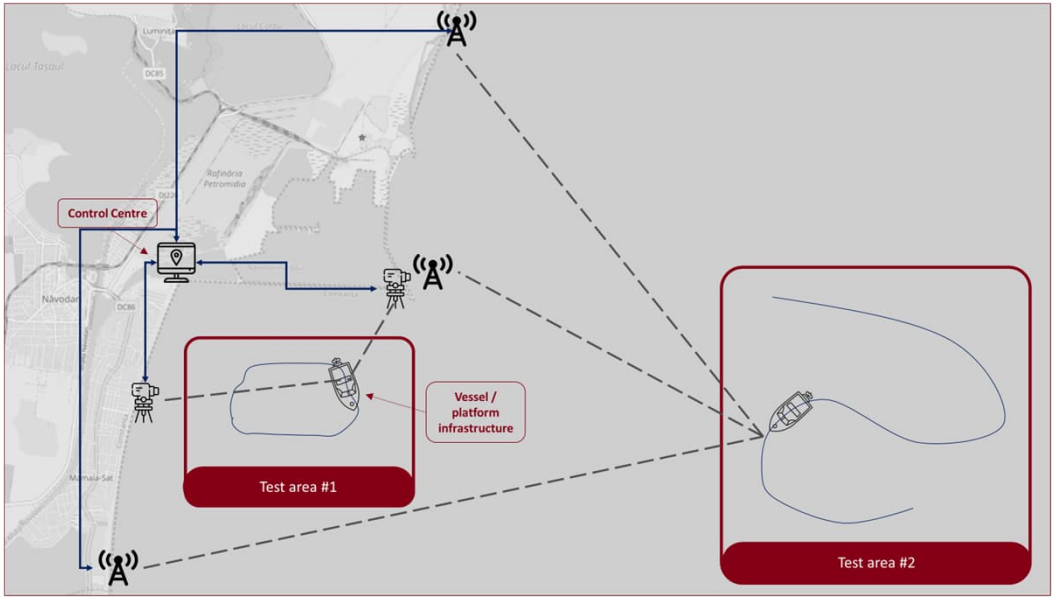


Source: https://waas-nas.stanford.edu

BLACKOUT: High-Level Approach

What it comprises?

- a **dedicated testing area**
- the **necessary logistics** to test different PNT technologies
- access to **vessels** and/or other platforms to deploy terminals for PNT
- a **monitoring and control center**
- monitoring of environment conditions
- **ground truthing** system
- an **emulator** for different GNSS RF situations in different setups
- streamlined **performance analysis** based on first technology/-ies under test
- opportunity for **joint demonstrations, trials, or cross-border collaboration**
- exploration of **dual-use** technologies



BLACKOUT

What's next ?

Main highlights of the upcoming activities

→ 🛡️ **completion of the deployment** by Q3'26. Testing expected Q4'26 – Q1'27. Open for testing Q1-Q2'27

→ 🤝 our view is that the test range will be **open to all interested actors** which want to test PNT systems

→ ⚖️ position the test range as a **neutral platform for testing** and evaluating navigation solutions

→ ✒️ targeting **frameworks of cooperation** with national and European institutions, academia, R&D sector and industrial players

→ 📢 disseminate in relevant events

→ 🚢 national stakeholders **demo event**

→ 🔀 roadmap for exploitation and self-sustainability

Thank you!

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INNOVATING SOLUTIONS