



# I-MASTER

Italian Maritime Autonomous Surface ships TEst Range

The future Italian MASS test area

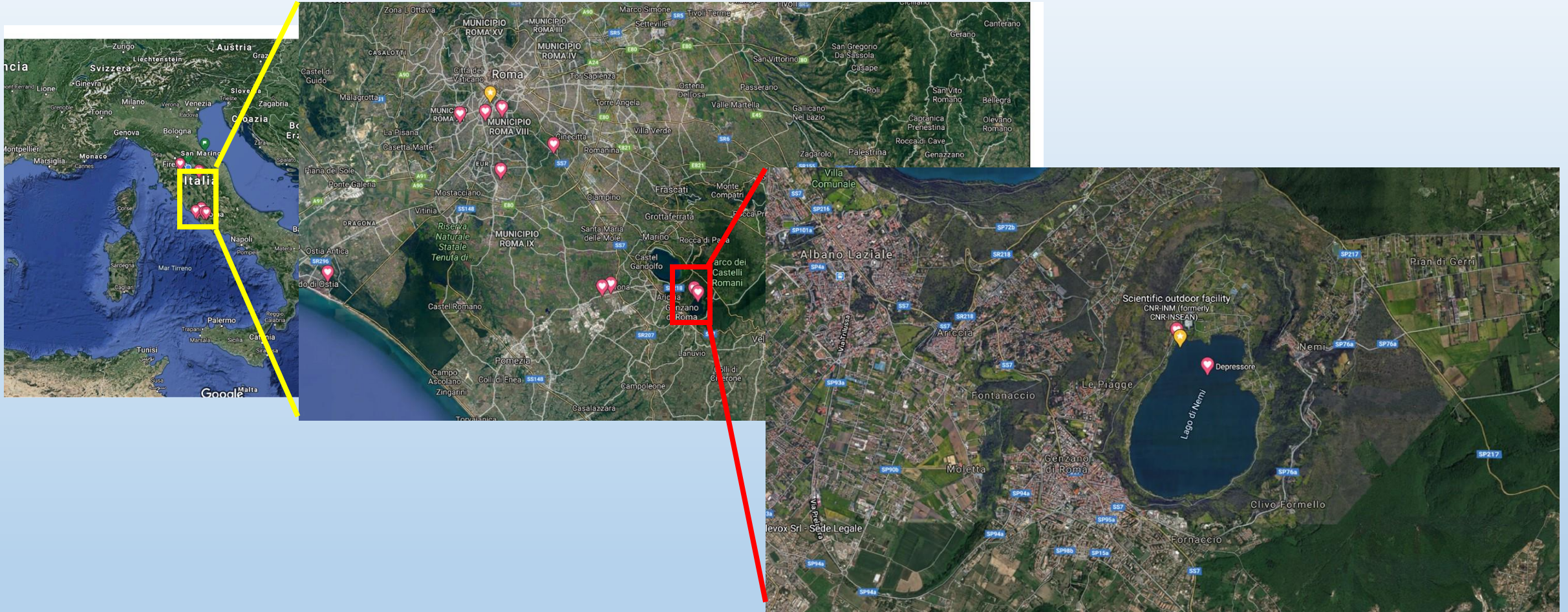
Dr. Salvatore Mauro, PhD

# Synopsis

- **The Outdoor Facility**
- **Experimental activities at the Nemi Lake (Manoeuvrability)**
- **Future activities as MASS test area**
- **Experimental activities at the Nemi Lake (UW acoustic)**

## The CNR-INM's outdoor facility on the volcanic lake of NEMI

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- **Since 1937** is the Outdoor Maneuvring Basin at INSEAN
- Database of more than 5000 test carried out on more than **50 ship models manned**
- **From 1960** is part of the **ITTC's** (International Towing Tank Conference) catalog of facilities

Type of tests:

Experimental meth.:

Sep-up of the meth.:

Activities carried out:

R&D:

Database:

What we verify  $[\nabla, V, \Delta, (r-a), d\delta/dt]$

What we measure (standard)

**Manoeuvrability/Controllability (IMO/ANEP)**

Free running self-propelled **unmanned** surface ship's models

1998

new ships/existing ships of the Italian Navy and other Navies (NATO and extra NATO)

PNRM (Prossima, Prossima II), EDA (FLOWIS)

**More than 10000 test carried out with unmanned ship's models**

Rudder's effectiveness/efficiency (size, shape, position, etc.)

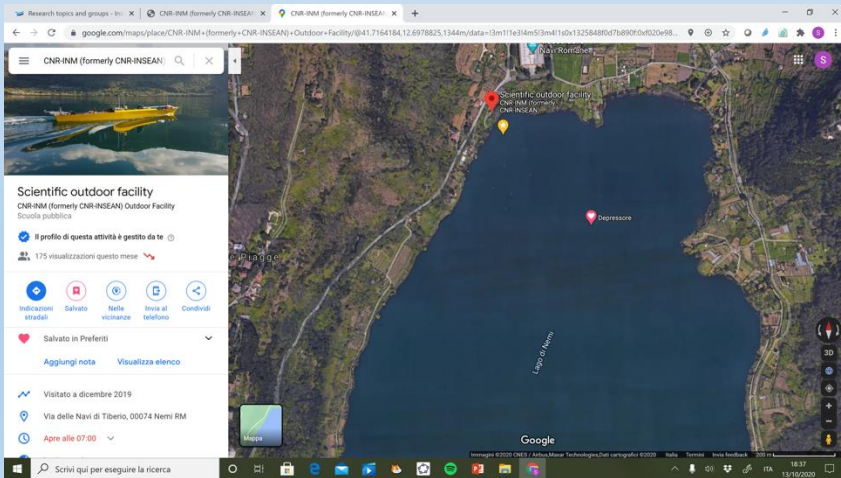
DGPS (xg, yg, speed), gyro ( $\psi, d\psi/dt$ ), IMU (6 DOF), nr, Tr, Qr, ni, Ti, Qi, Q $\delta$

**Constrains on the size of the model and on the tests conditions**

Max dimension of the ship's model	<b>10m</b>
$\Delta_{max}$	1500 Kg
Speed max.	10 m/s
Speed min.	0.05 m/s

**Any restriction on the duration in time of the single test (irrespective of the speed of the test)**

**Any waiting time between consecutive tests (irrespective of the speed of the test)**



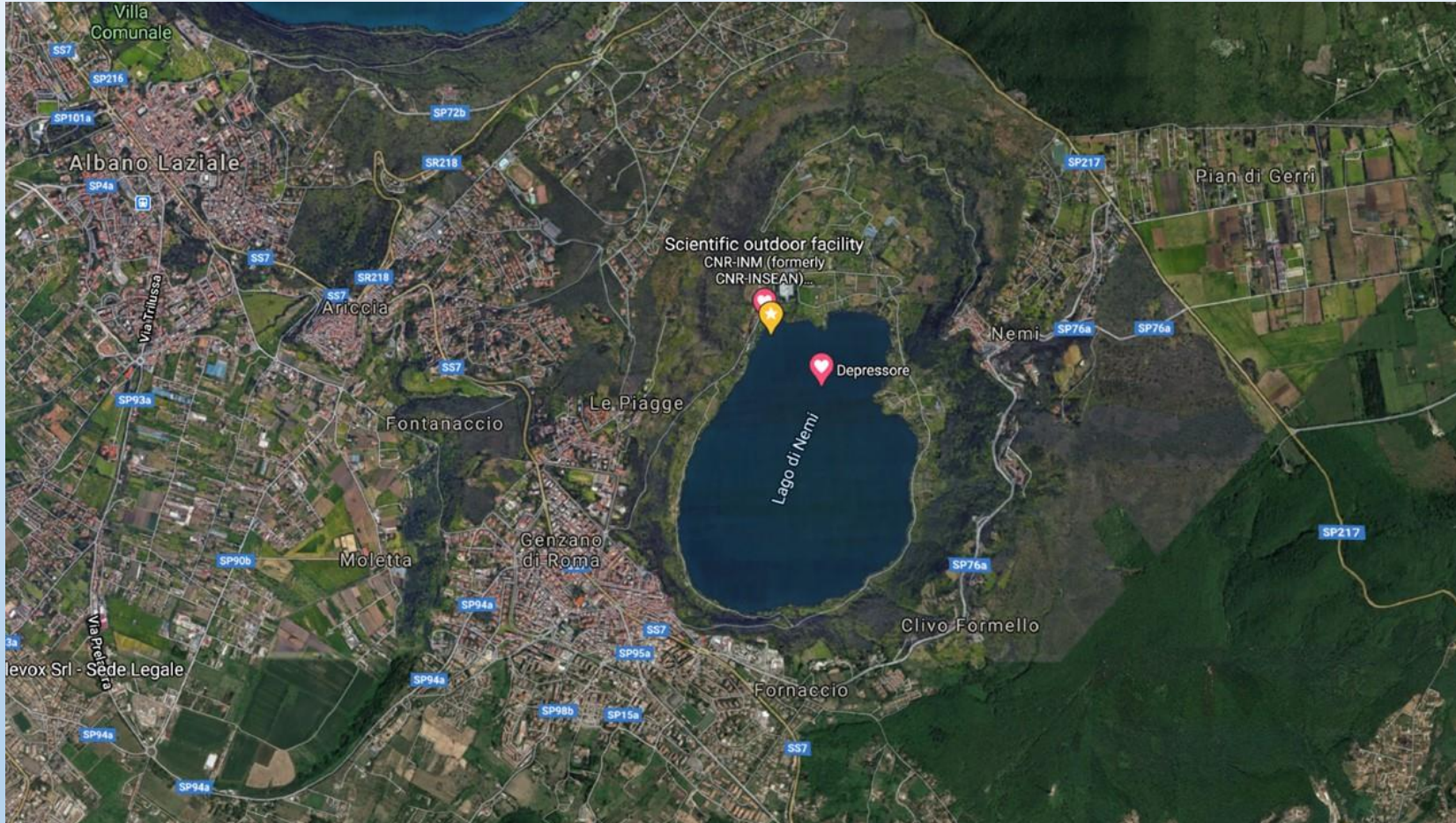
## The CNR-INM Outdoor Facility at the Lake of Nemi

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The future of global navigation is focused on raising MASS (Maritime Autonomous Surface Ships) level

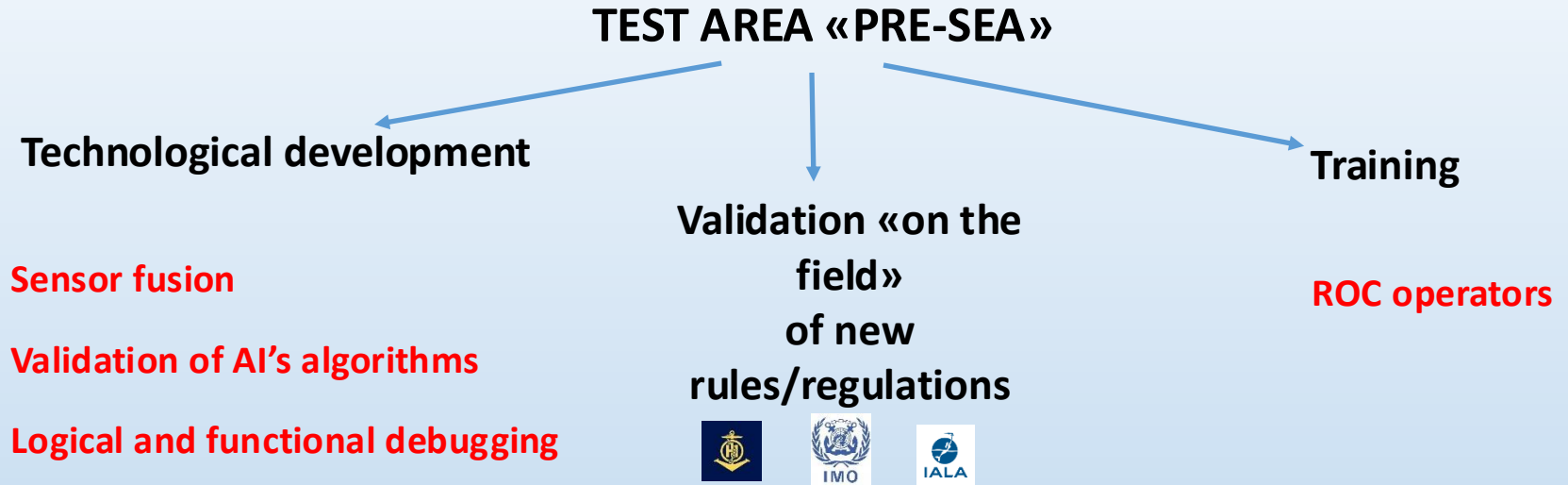
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Our idea is to realize an operative MASS=4 test area

In fresh waters  
**(volcanic lake)**

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# ADVANTAGES (lake vs sea)

**Absence of manned traffic**

**Logistic area already existing (to be adapted)  
+  
No permission required**

**Testing of a large number of scaled autonomous vessels already at MASS=4 level (multidomain technological cooperative ecosystems both surface & underwater)**

**Great cost-effectiveness and higher safety levels compared with an equivalent test area at sea**

**Scalability**

## International Relationships on MASS

Member of the SSC (Smart Ship Coalition) Network <https://smartshipscoalition.org/>



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Member of the INAS (International Network for Autonomous Ships)  
<http://autonomous-ship.org/index.html>



Member of the MASS People (International Working Group for Remote and Autonomous Training Standards)  
<https://www.fugro.com/media-centre/news/fulldetails/2021/02/18/fugro-launches-masspeople-international-working-group-for-remote-and-autonomous-training-standards>



Member of IMO\_MASS CG\_Italy (led by Italian Coast Guard)



Scientific project ongoing financially supported by  
in the framework of NAVISP EL 3 program



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Italian Maritime Autonomous Surface ships Test Range

**NAVISP EL 3 - 30**

**ESA Contract No. 4000143254/23/NL/GP/dg**

In partnership with:



- The Outdoor Facility
- Experimental activities at the Nemi Lake (Manoeuvrability)
- **Future activities as MASS test area**
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## Expected contribution of an Italian MASS Test Range



- Increase the contribution of the Italian scientific and industrial community to the proposition in international context of requirements, procedures and certifications for MASS
- Support the expansion of national industrial expertise related to the shipbuilding, aerospace, naval, electronic and telecommunications sectors in the development of new products and skills for MASS
- Create new professional figures and lines of research in the MASS sector
- Test and validate new vessels, devices, subsystems, apparatuses and procedures for MASS
- Contribute to the certification of boats, devices, subsystems, apparatuses and procedures for MASS, according to present and future international regulations
- Train ground personnel for MASS operations
- Activate international cooperation and contribute to the dissemination of best practices and national technologies in the MASS sector

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# Project Phases

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Co-funded by ESA NAVISP – Element 3

**PHASE 1**

**PHASE 2**

Kick off of PHASE 2 → **09-07-2025**

12 months

24 months

...continued

...continued

Design and preliminary MASS demo

Complete Test Range Set-up

MASS Demonstrations

Open Sea Validation

Operational phase

- ↑ Analysis and definition of the requirements
- ↑ Detailed design of the Test Range
- ↑ Algorithms Analysis
- ↑ Preliminary set up and MASS Demo

- ↑ Preparation and setup of buildings
- ↑ Development
- ↑ Complete Test Range Installation & validation

- ↑ MASS Demo
- ↑ Initial exploitation
- ↑ Standards & Procedures
- ↑ International cooperation

- ↑ Validation in open sea scenario in specific controlled areas

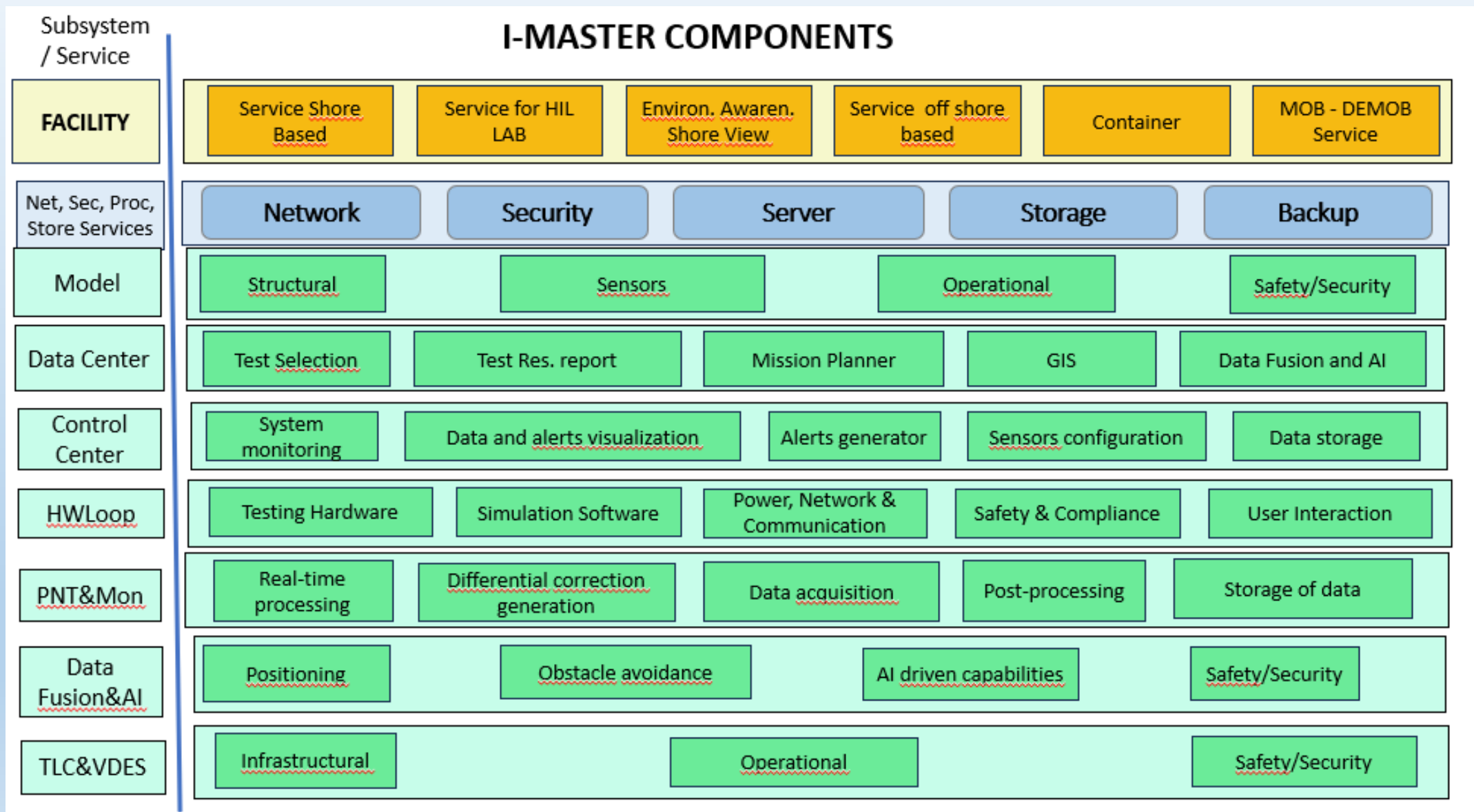
- ↑ Certification of technologies, devices and systems
- ↑ Validation of innovative technologies and equipment

NAVISP EL 3 - 30

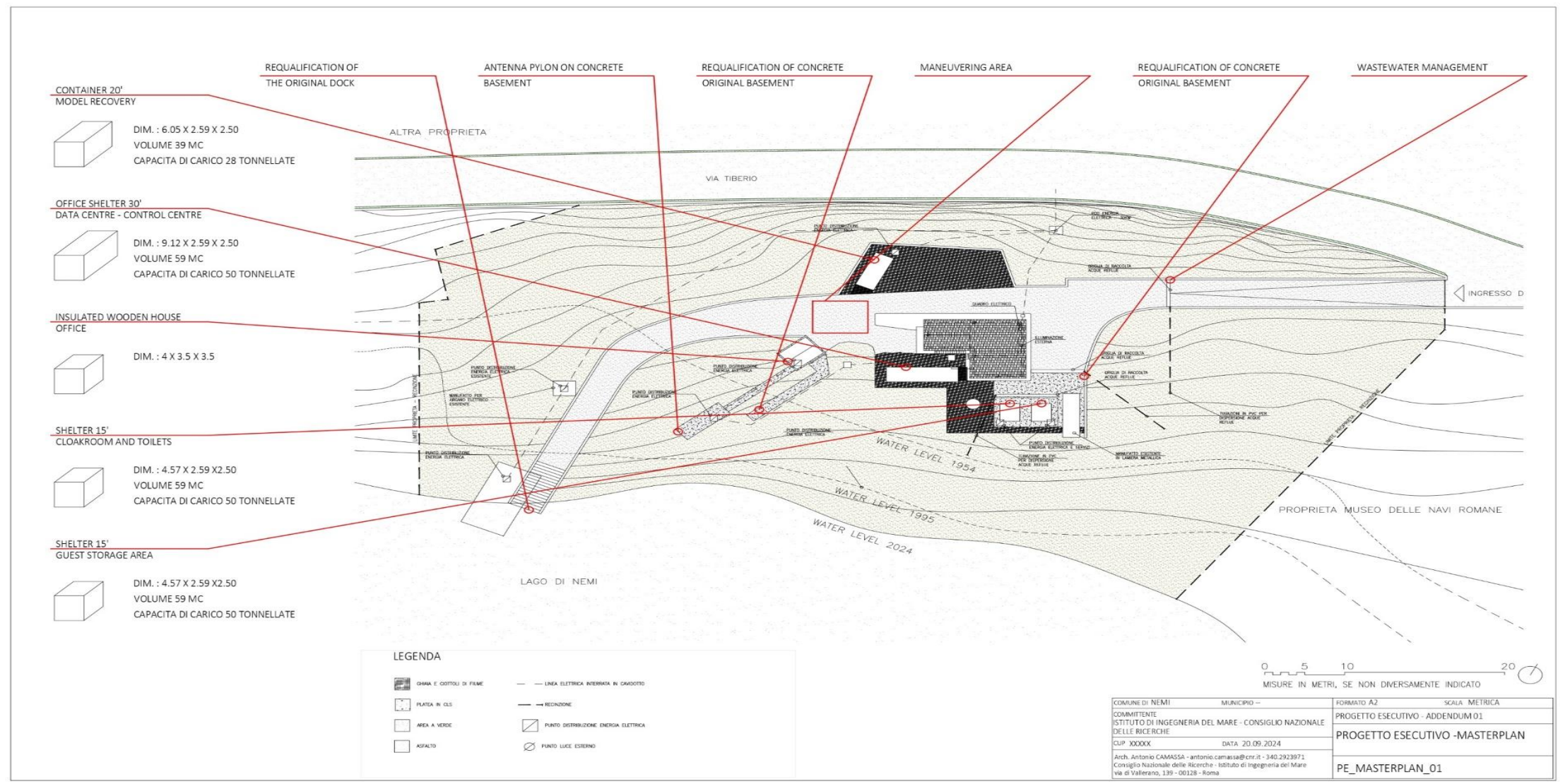
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# Key Components

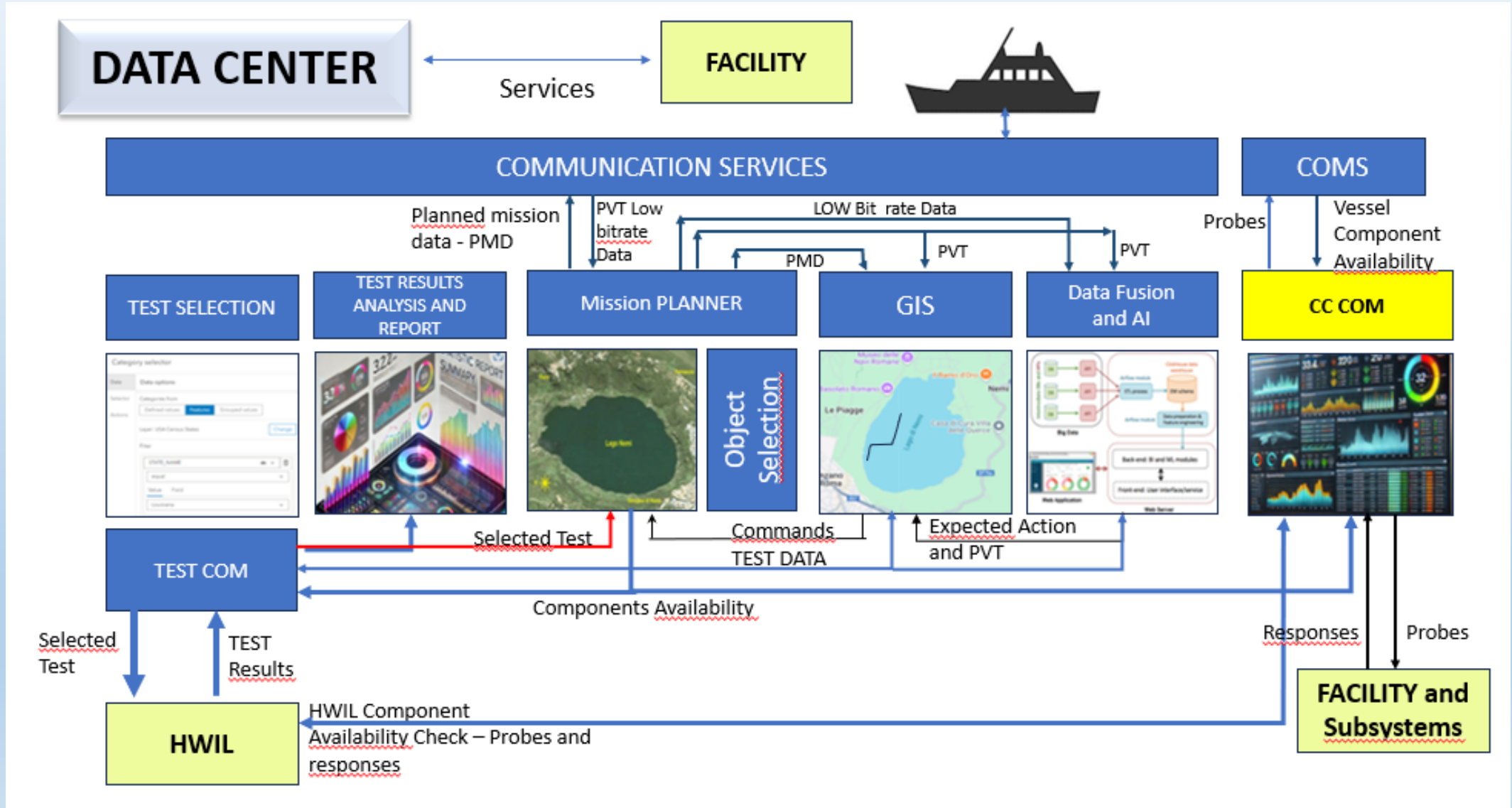
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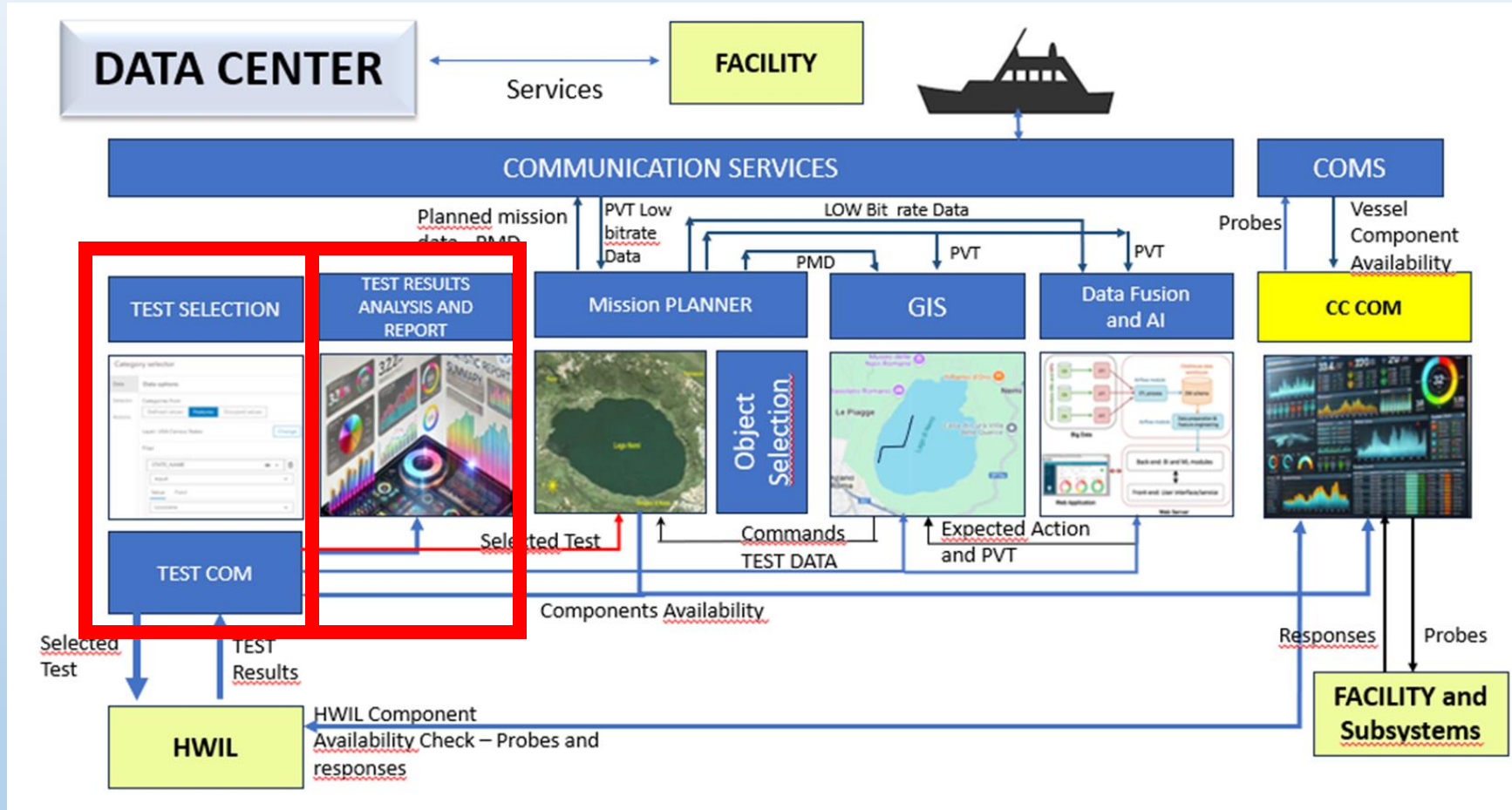
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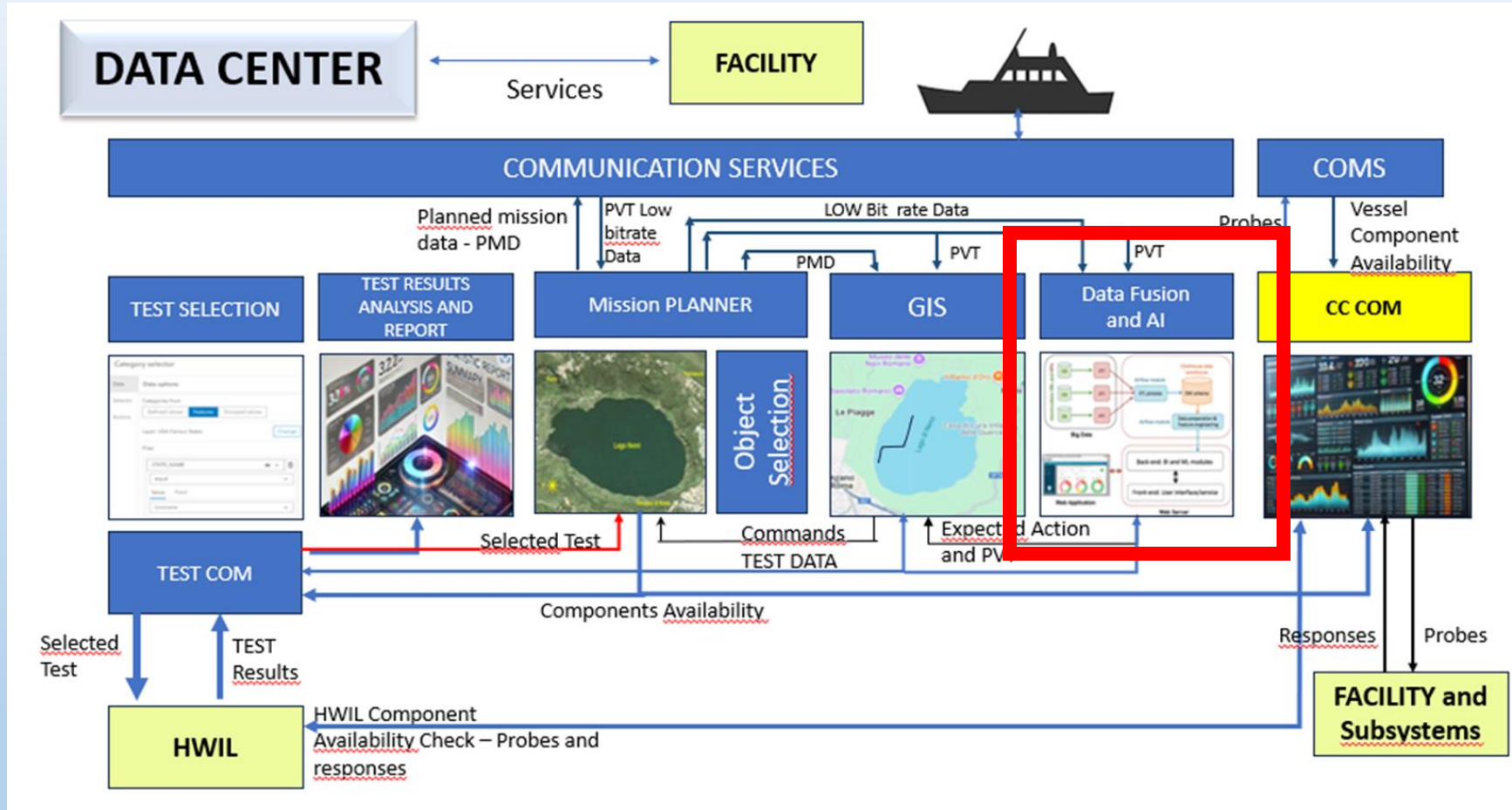
The Data Center interface allows the user to select the type of device to be tested, specifying the desired verification method: a laboratory test or an operational environment test, i.e., on the lake.

A test result analysis component evaluates statistical values (e.g. maximum value, minimum value, average value, variance, standard deviation) of displacements in terms of spatial distance from obstacles of the executed trajectory for all sets of tests carried out.



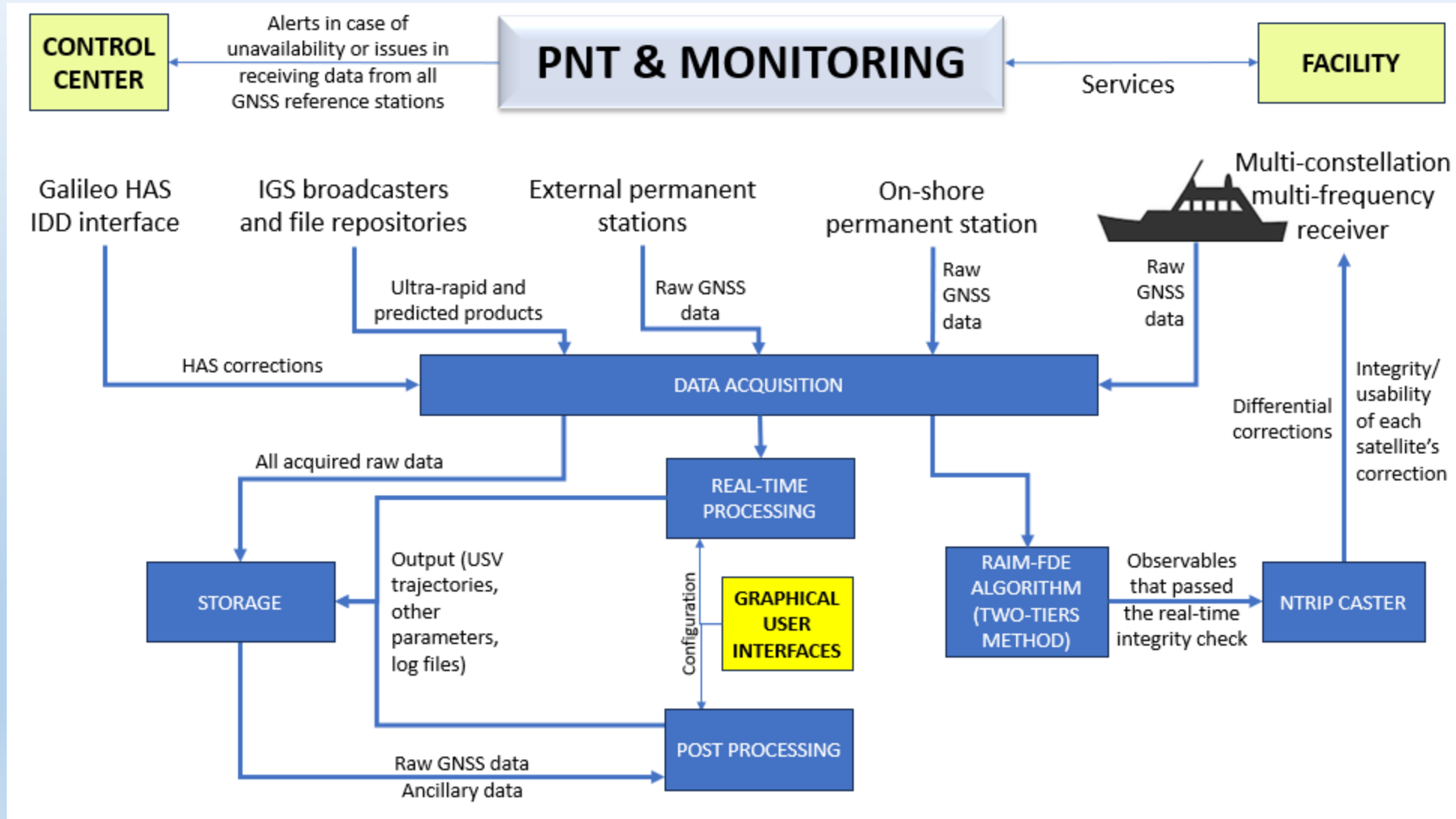


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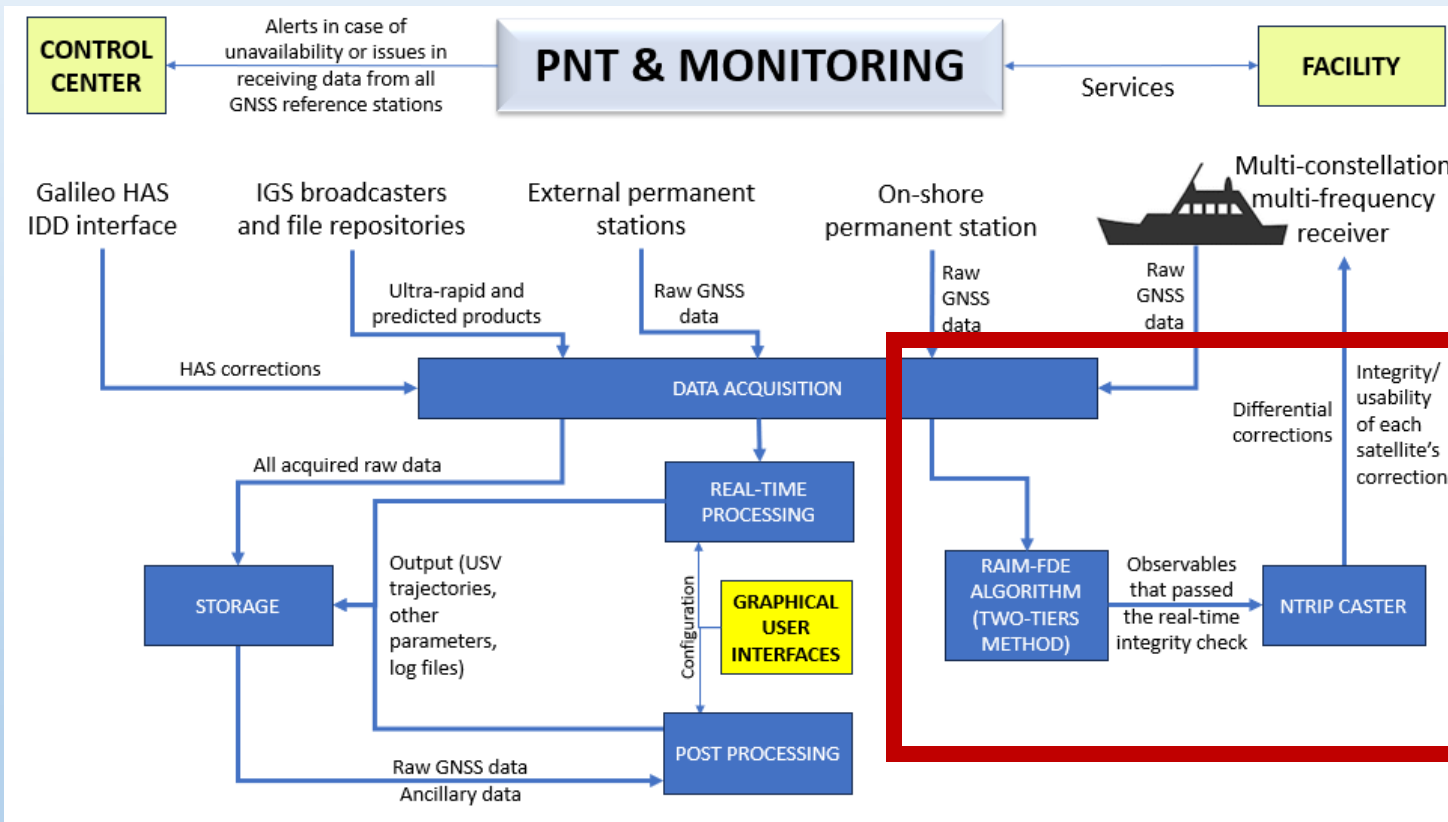


Data Fusion and AI, by acquiring PVT and low-bit-rate data from the vessel, will be able to assess the expected maneuvers based on the planned mission, allowing for an evaluation of whether they align with those actually performed by the vessel.

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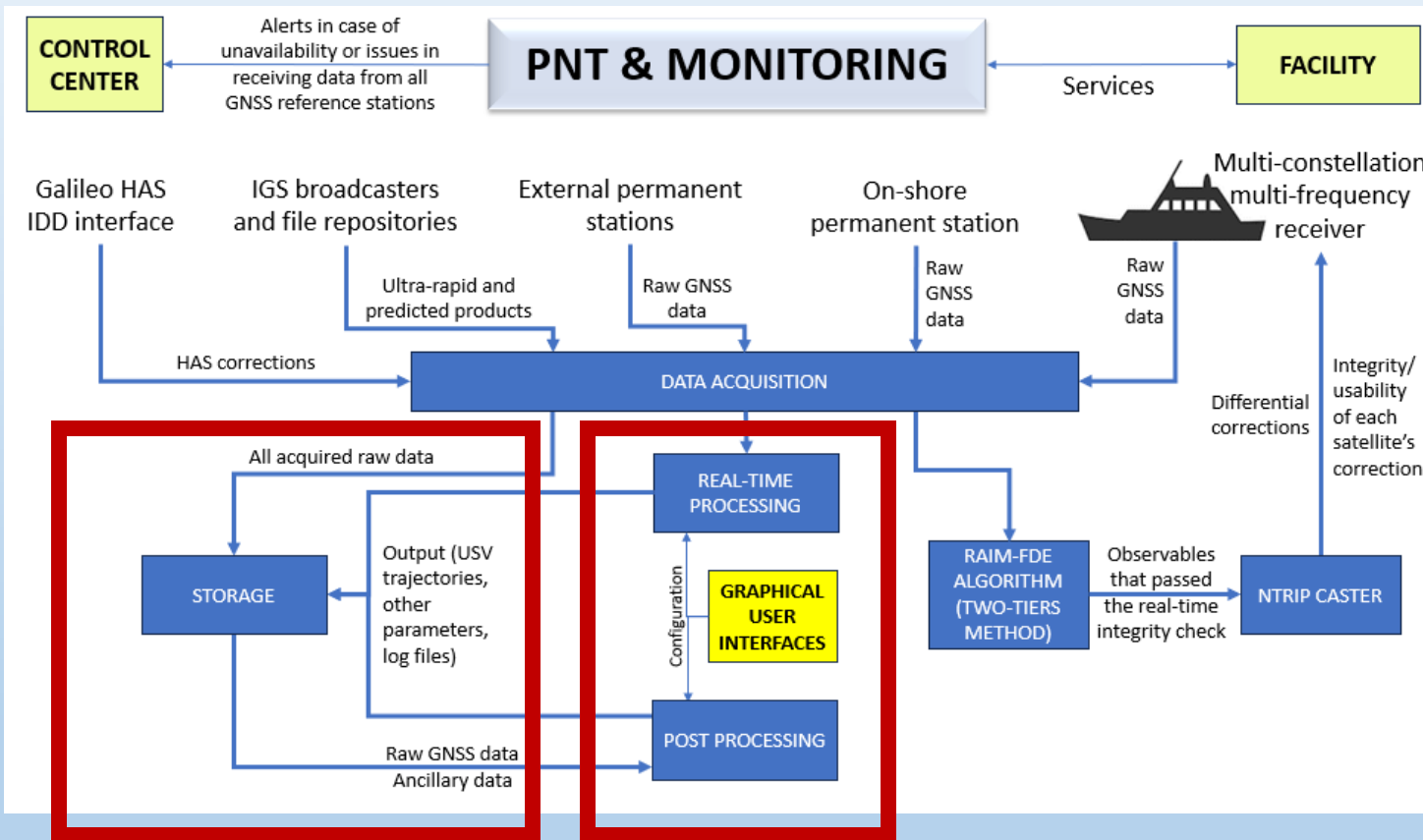


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- Real-time analysis and integrity check of GNSS data
- Generation of corrections to be broadcast to the USV

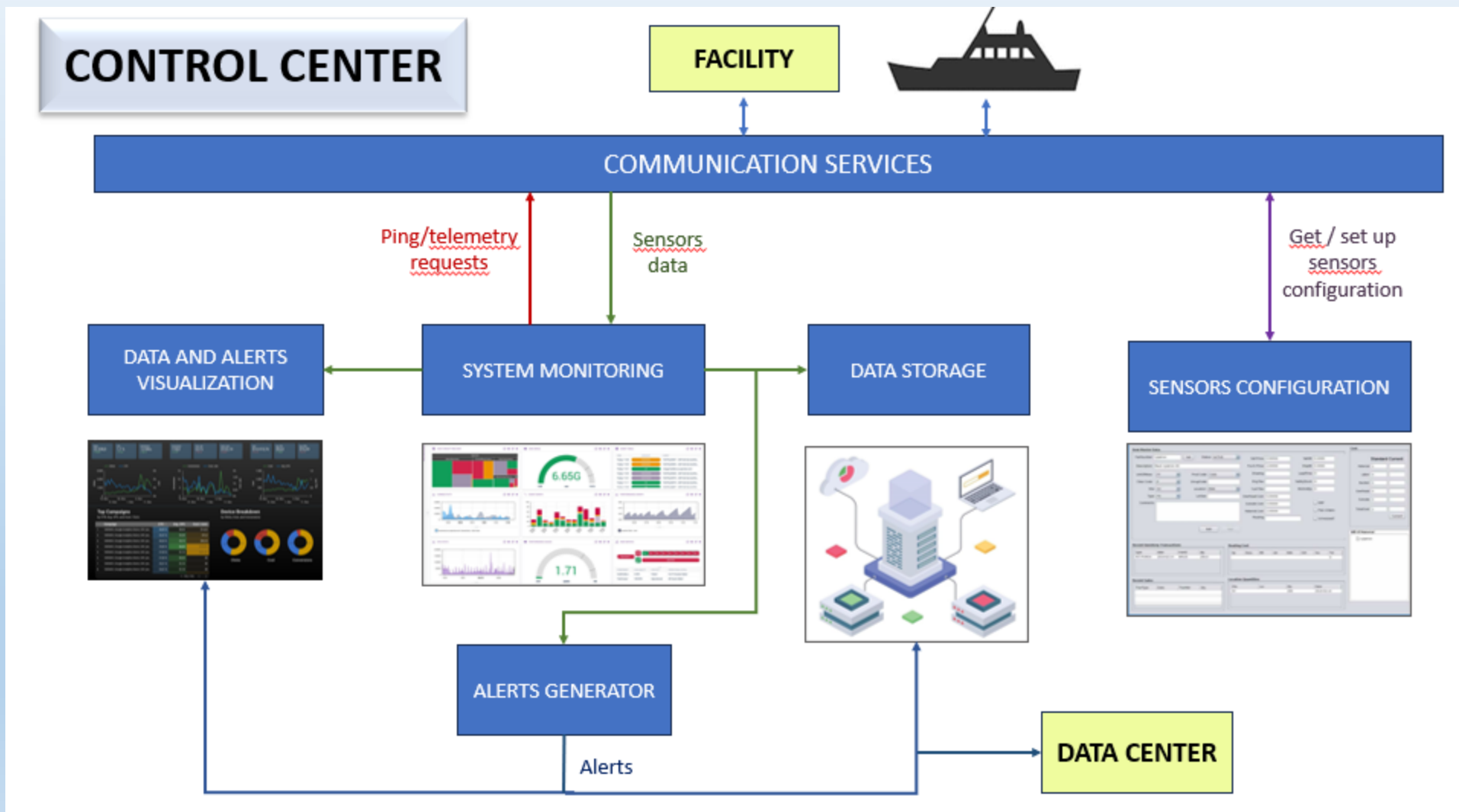
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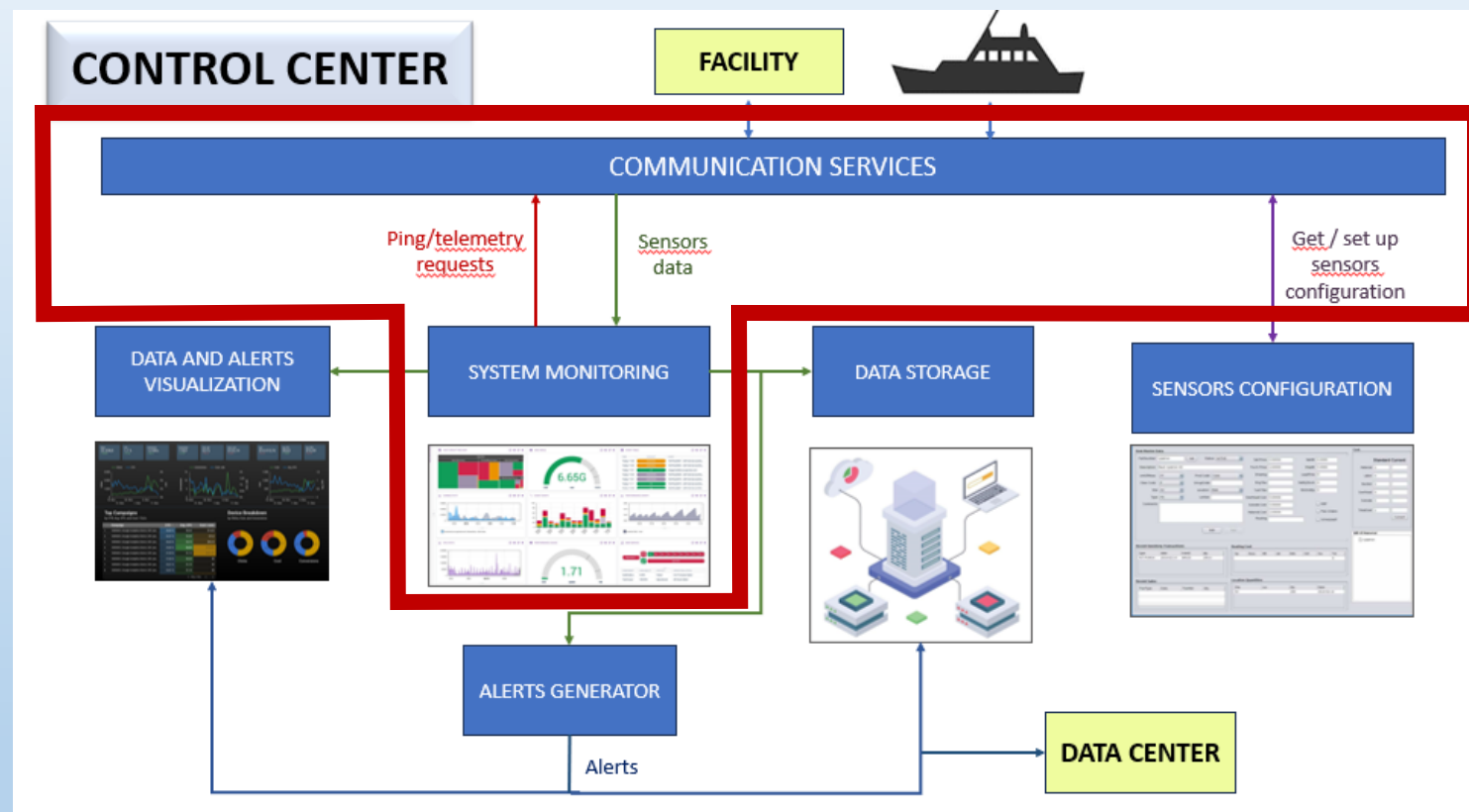
- SW environment for real-time and post-processing of USV position/trajectory with several techniques (SPP, PPP, DGNSS, RTK) and exploiting all available GNSS products

- Storage of all input (raw GNSS data and products) and outputs for ex-post analysis

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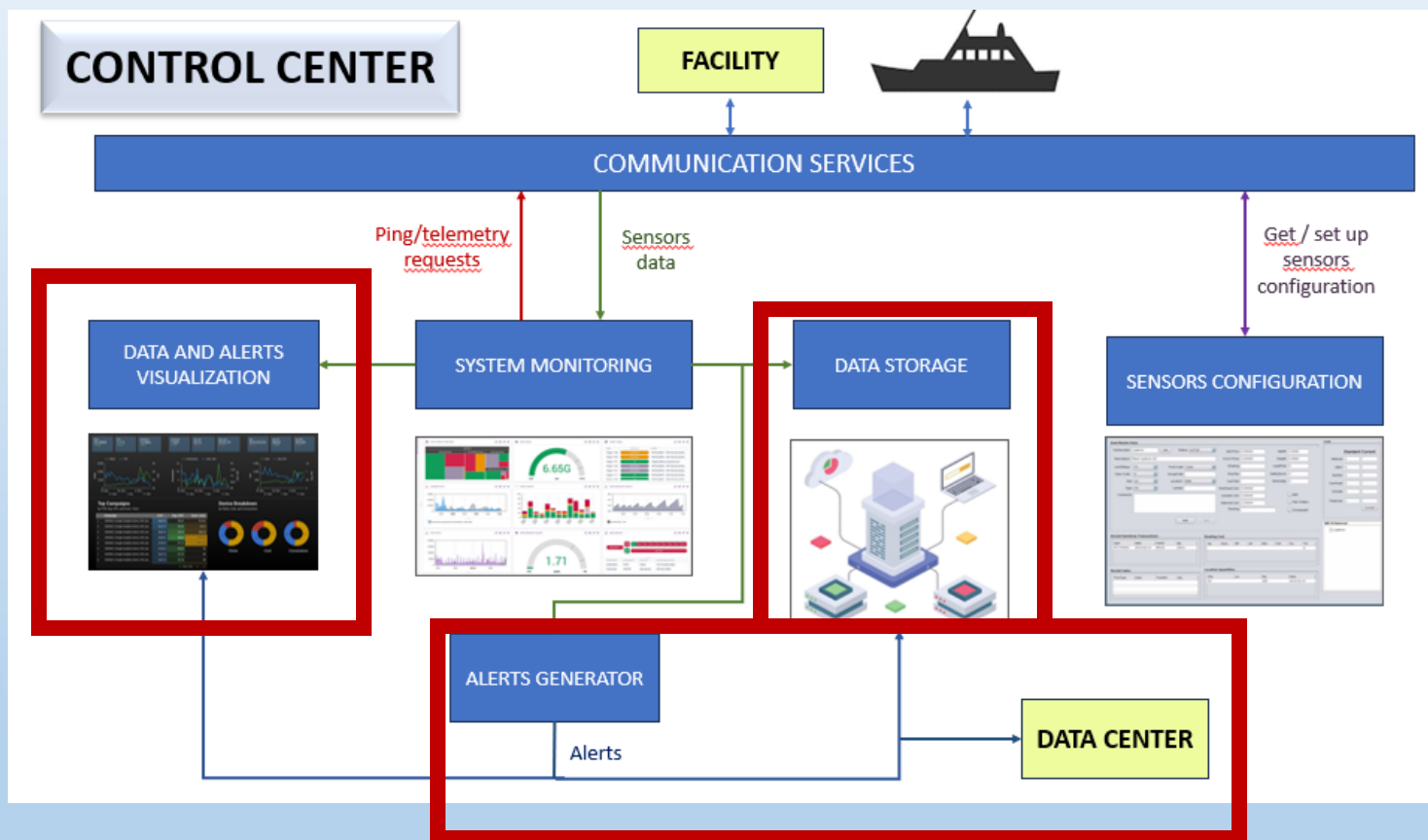


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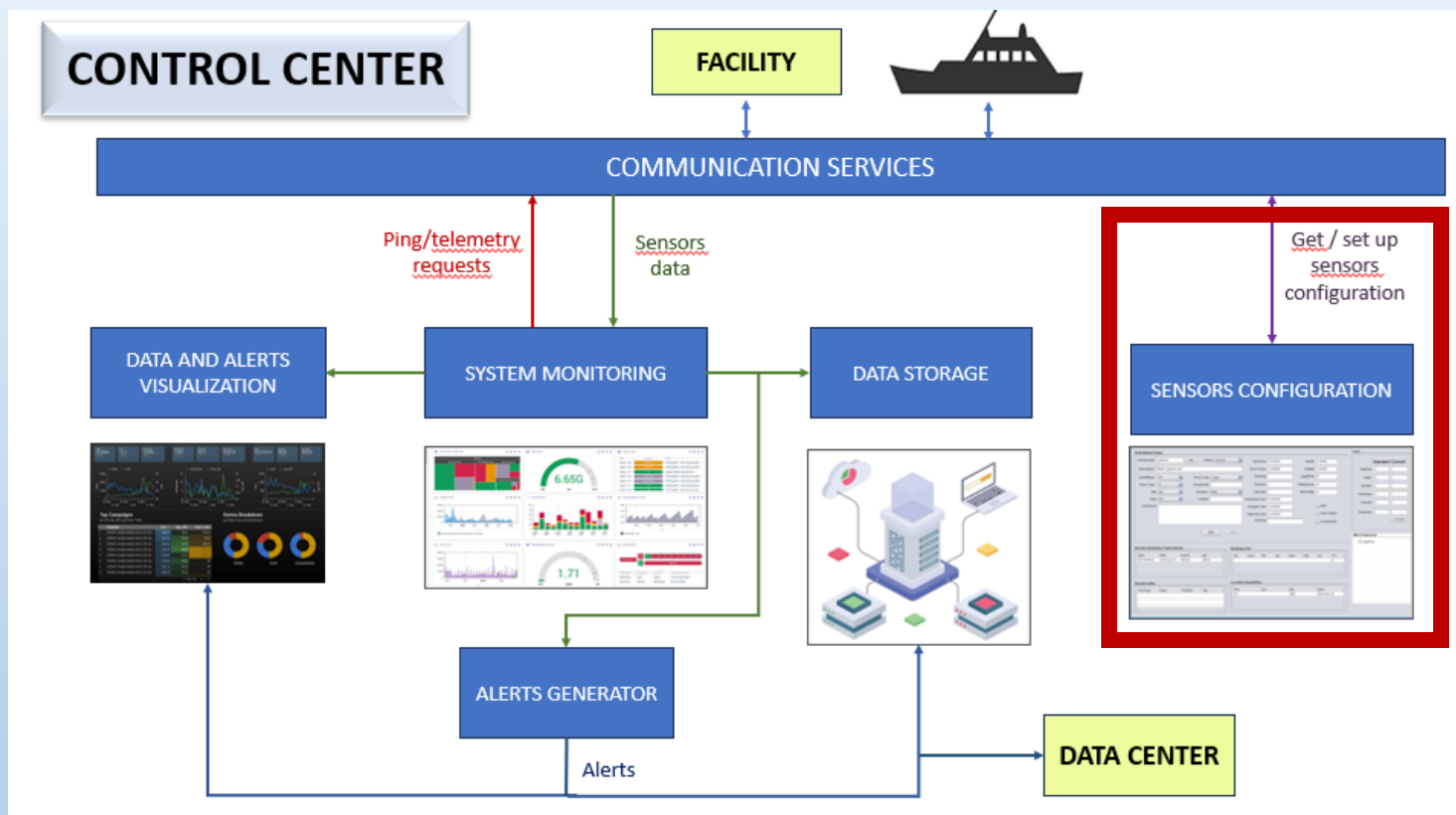
- Real-time acquisition of telemetry and SOH data from all hardware and software tools part of the I-MASTER system: communication infrastructure, USV, on-shore sensors, external services, etc.

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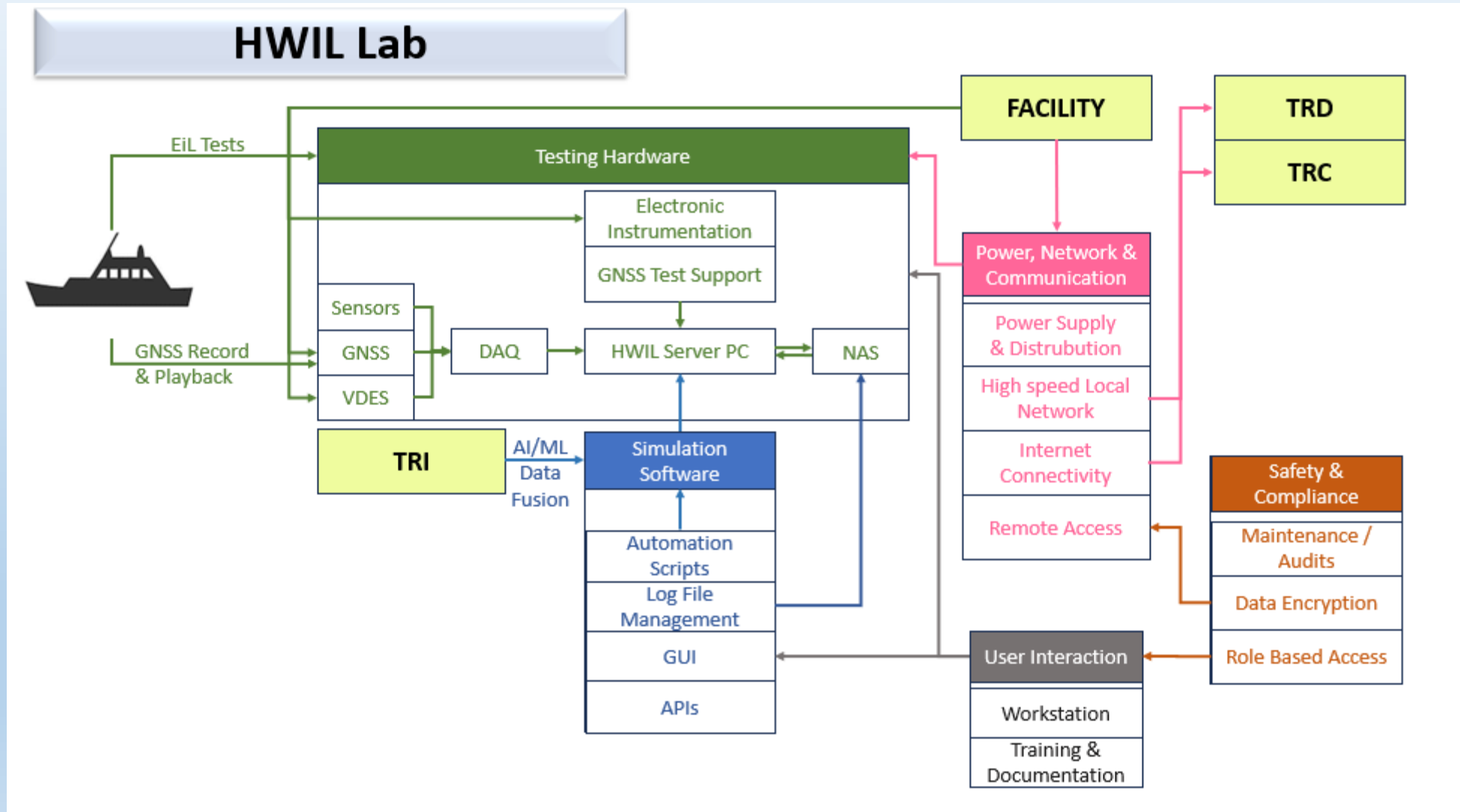
- Real-time generation of alerts in case of failures, to be visualized on a dedicated dashboard and transmitted to the Data Center (aggregated info)
- All inputs (SOH data) and output (logs, alerts) stored for ex-post analysis

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- Dedicated dashboard for on-shore sensors configuration (e.g. GNSS reference station)

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# UW Noise measurements



Data collected at the outdoor basin

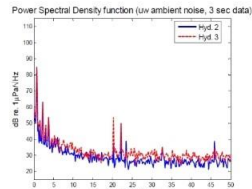


Figure 1. PSD function of 3 seconds of "test" data file, recording lake ambient noise around 10.46 AM.

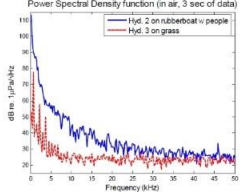
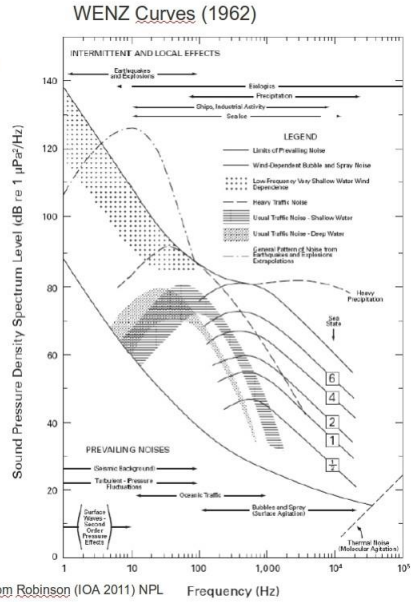
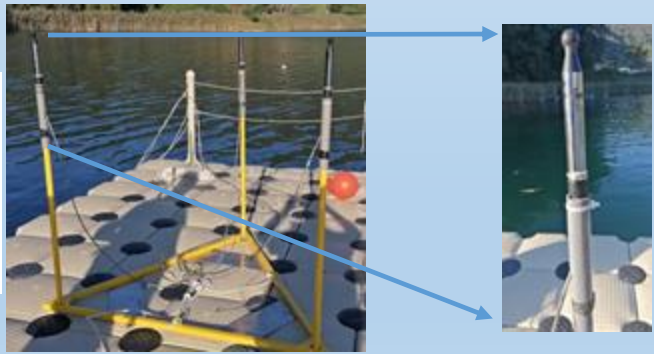
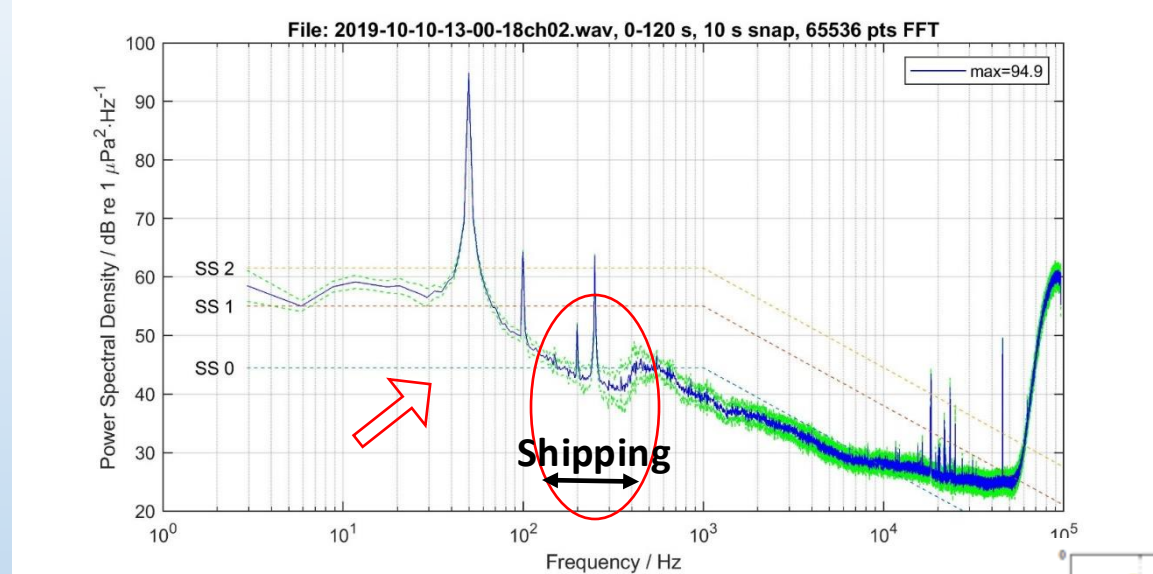


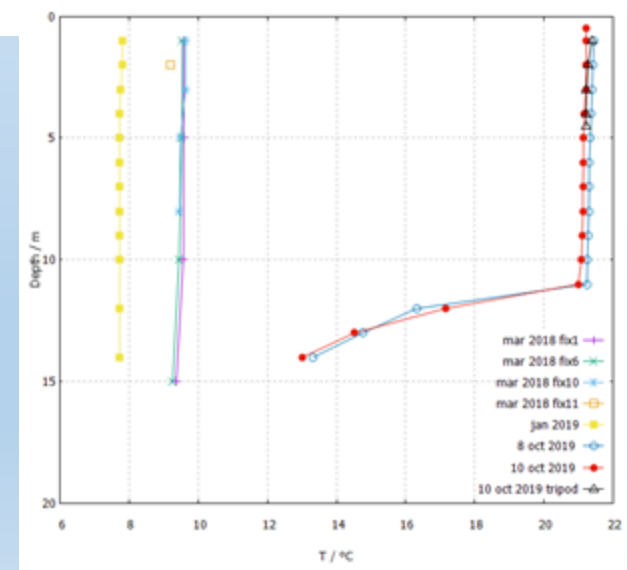
Figure 2. PSD function of 3 seconds of "12:33:09\_01" data file, recording ambient noise in air.



From Robinson (IOA 2011) NPL



1m < depth < 11m → ΔT ≅ 13°C



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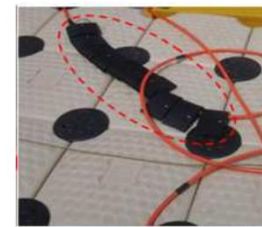
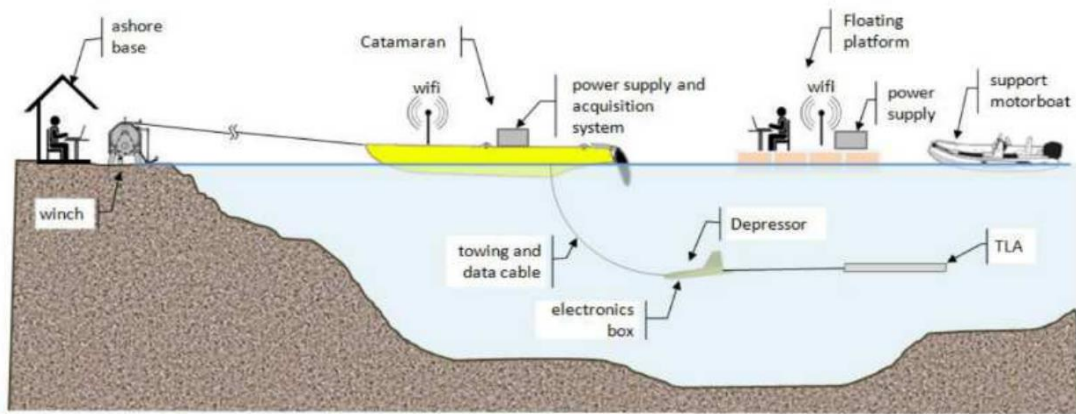
ETLAT I Project (<https://www.cnr.it/it/progetti-di-ricerca/progetto/13945/etlat-dit-ad019-012>)

Evaluation of State of the Art Thin Line Array Technology

Financially supported by EDA (European Defence Agency) → **budget 4 Meuro**

- 8 European partners:   **Leonardo** + CNR-INM,  PATRIA + FNRI,  WDT71,  FFI,  SAAB + FOI  
2015-2019

## SETUP for flow noise measurements at the Lake of Nemi



## ETLAT II Project

Evaluation of State of the Art **Thin Line Array Technology**

Financially supported by EDA (European Defence Agency)

- 12 European partners:  **Leonardo** + CNR-INM

2025-2028

# Kick off: February 2025


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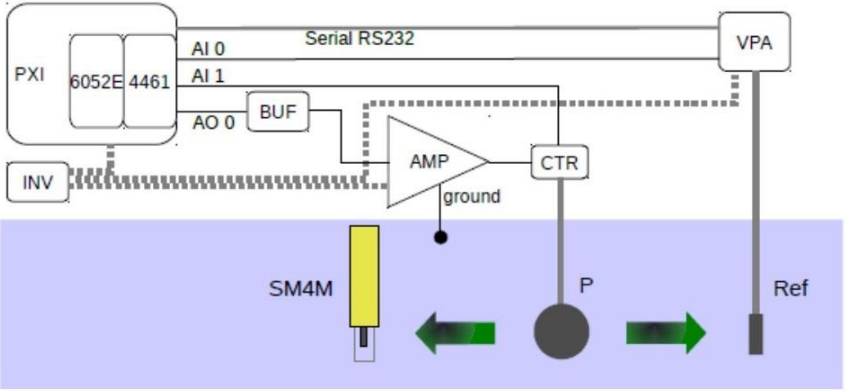
## UNAC-LOW (EURAMET)


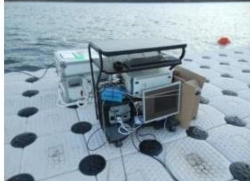

- TUBITAK (TUR) coord.
- NPL (UK)
- **CNR-INM (ITA)**
- ISPRA (ITA)
- DFM (DAN)
- FOI (SWE)

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**EURAMET – UNAC-LOW**





3



1.  TUBITAK MAM
2.  NPL
3.  DFM Danish National Metrology Inst.
4.  Consiglio Nazionale delle Ricerche
5.  ISPRA Istituto Superiore per la Protezione e la Ricerca Ambientale
6.  FOI

  
 TC-AUV  
Association, Ultrasound and Vibration  
• EURAMET Technical Committee

  
 International  
 Organization for  
 Standardization

  
 INTERNATIONAL  
 ELECTROTECHNICAL  
 COMMISSION

  
 REPUBLIC OF TURKEY  
 MINISTRY OF ENVIRONMENT  
 AND URBANISATION

  
 NATIONAL UNDERSEA WARFARE  
 CENTER

  
 RTSYS

  
 National Metrology Institute of Japan

  
 National Institute of  
 Standards and Technology  
 U.S. Department of Commerce

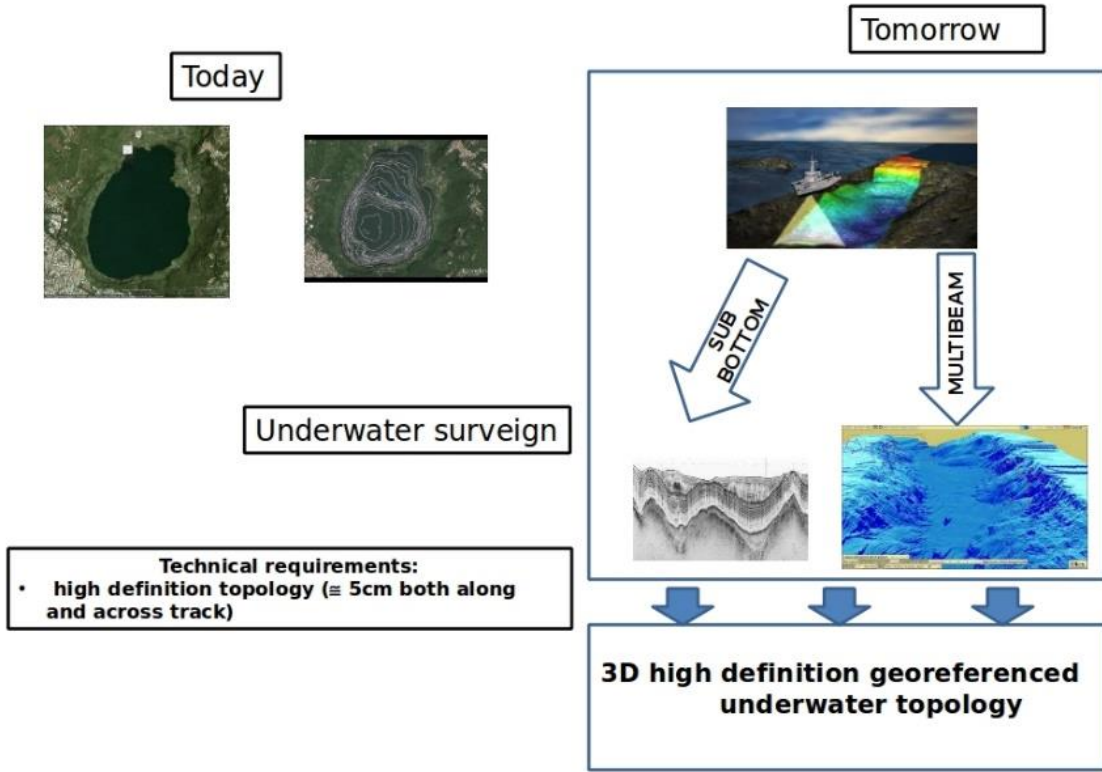
  
 Brüel & Kjær

  
 bakerconsultants

Underwater acoustic calibration standards for frequencies below 1 kHz

[https://iris.cnr.it/retrieve/747d3361-a5de-4572-86f1-ffc722767153/prod\\_388513-doc\\_133765.pdf](https://iris.cnr.it/retrieve/747d3361-a5de-4572-86f1-ffc722767153/prod_388513-doc_133765.pdf)

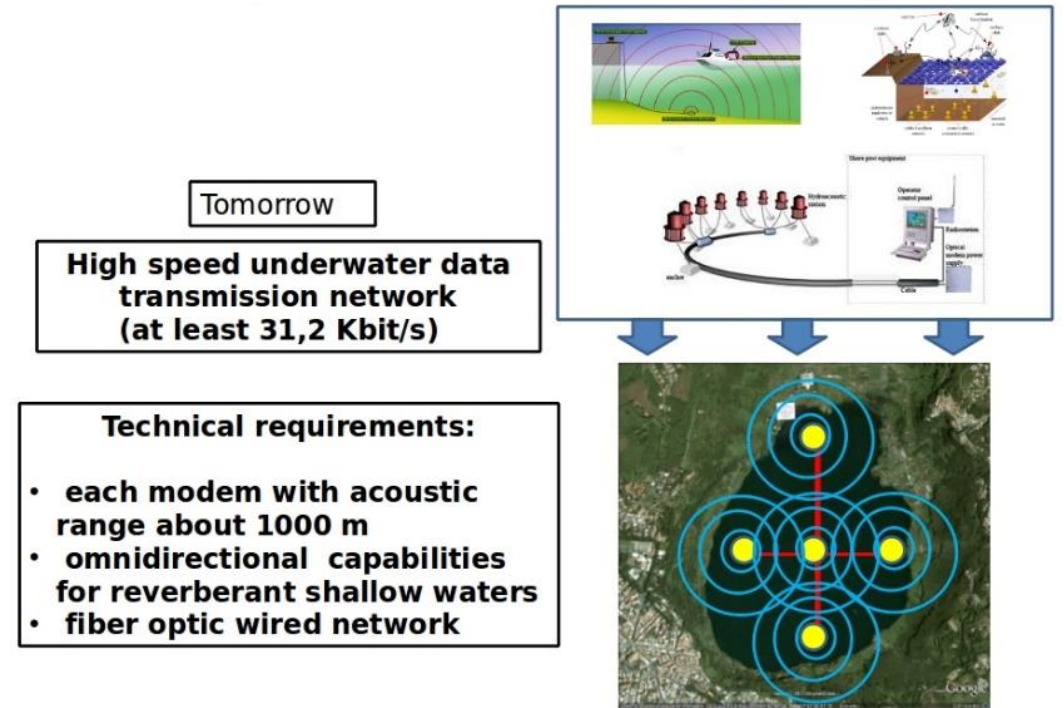
## OBJ: To gain the UW topology of the lake



- Fully financially supported with a INM's internal project
- Multibeam campaign: carried out in April 2025
  - Sub bottom campaign: carried out in July 2025

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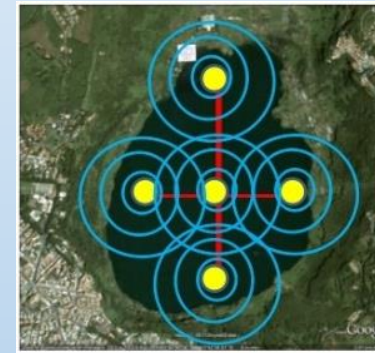
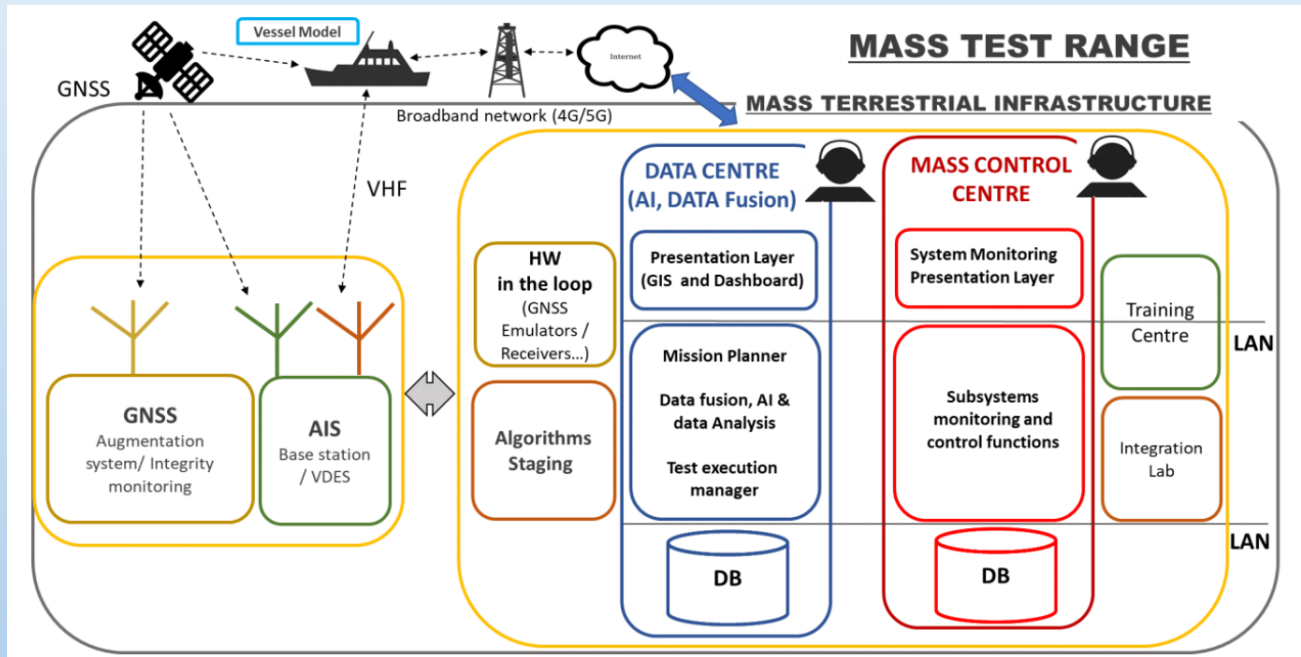
## OBJ: To realize the UW TLC network



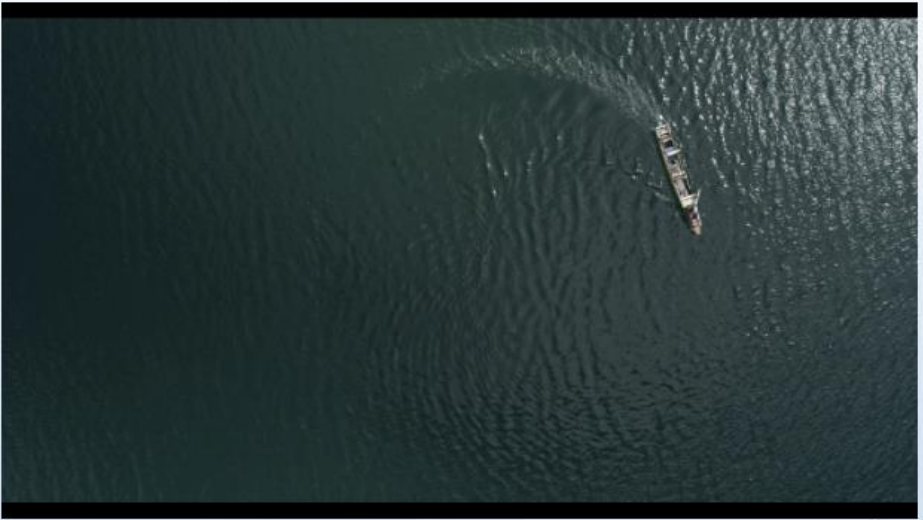
- The Outdoor Facility
- Experimental activities at the Nemi Lake (Manoeuvrability)
- Future activities as MASS test area
- Experimental activities at the Nemi Lake (UW acoustic)

Future challenges for combined crossdomain surface & UW experimental activities:

- I-MASTER TLC surface network (4G/5G, VDES, VHF, Wi-fi) integrated to the UW TLC Network to be installed



Cooperative realtime interlinked surface (UAVs), air (UAVs) and underwater (UUVs) activities



Thanks for your attention



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