UNDINA: UNderwater robotics with multi-moDal communIcation and Network-Aided positioning system

MarTERA Project Meeting

MarTERA call 2020
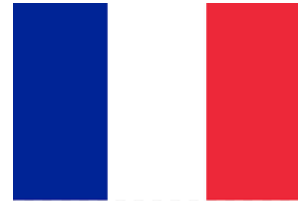
Brussels

22.11.2023

UNDINA Consortium

Presenter: Dr. Beatrice Tomasi

Partners

UNDINA objectives: enhance communication and positioning capabilities of underwater robots
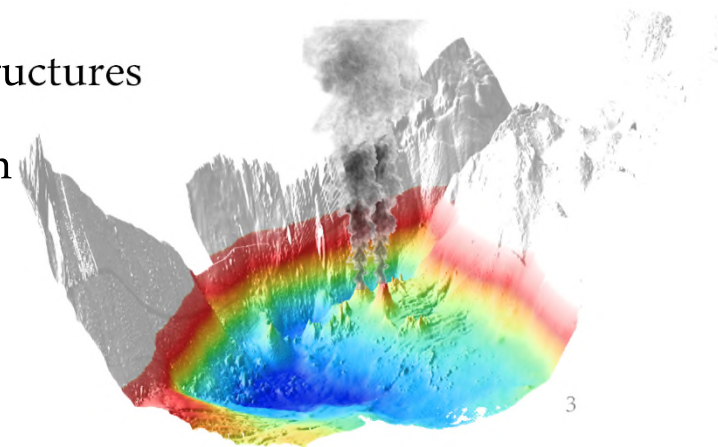
How?

- Multi-modalidity

- Hybrid communication and positioning system controlling multimodal communications
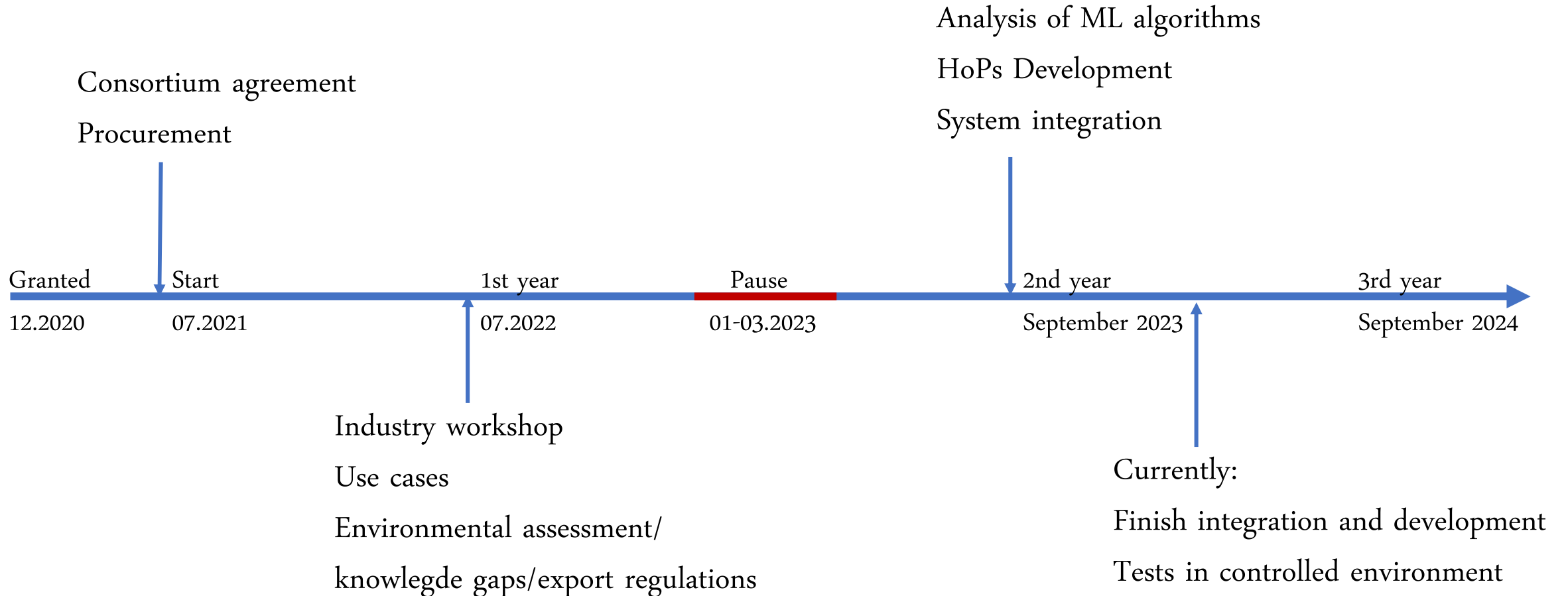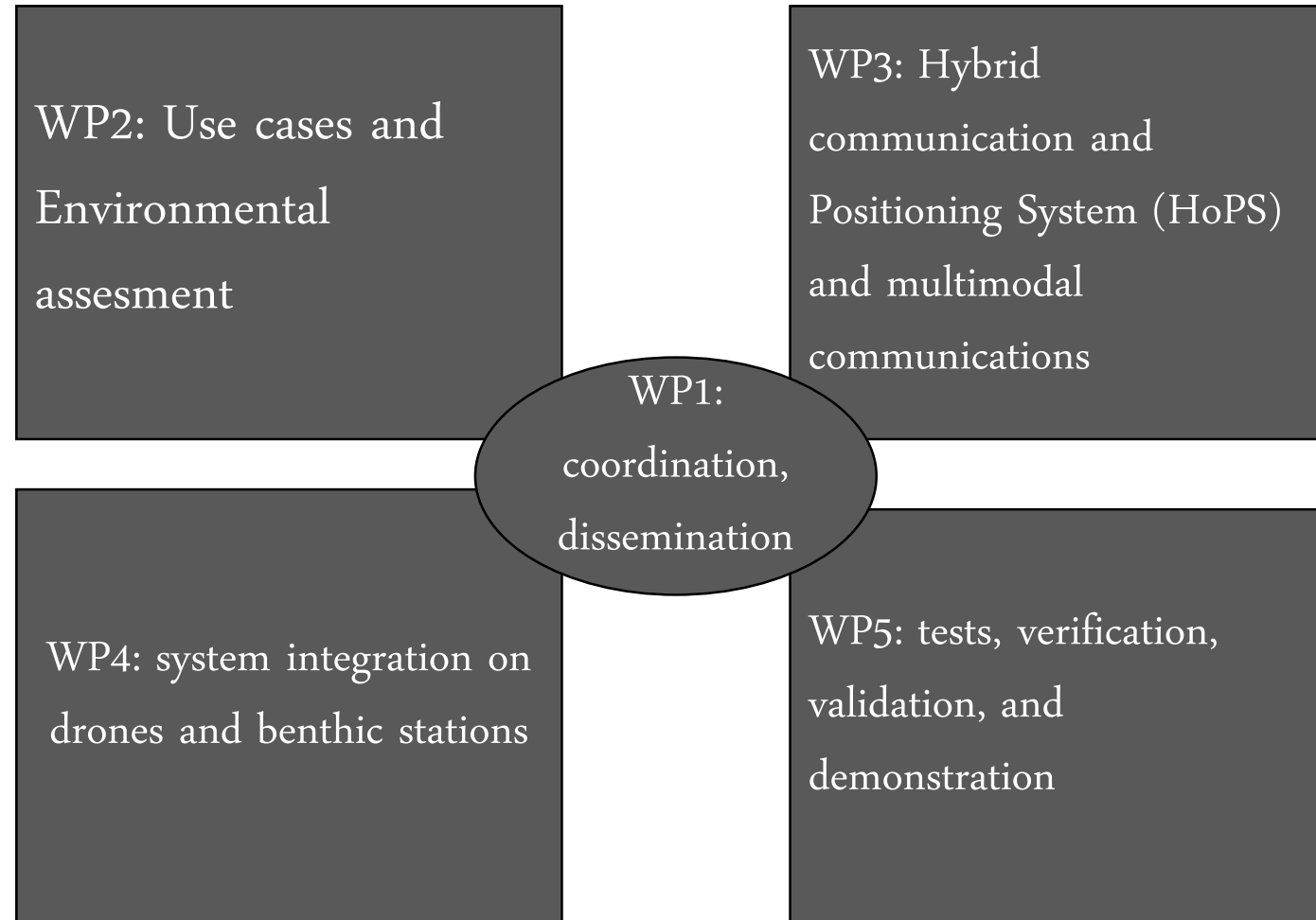
Why?

<u>Enabler of</u>

- Resident underwater robots for inspection and monitoring of offshore infrastructures

- Autonomous data collection from remote scientific ocean observatory in harsh environments

UNDINA timeline

Consortium agreement
Procurement

Analysis of ML algorithms
HoPs Development
System integration

Granted	Start	1st year	Pause	2nd year	3rd year
12.2020	07.2021	07.2022	01-03.2023	September 2023	September 2024

Industry workshop
Use cases
Environmental assessment/
knowlegde gaps/export regulations

Currently:
Finish integration and development
Tests in controlled environment

UNDINA structure

WP2: Use cases and Environmental assesment

WP3: Hybrid communication and Positioning System (HoPS) and multimodal communications

WP1: coordination, dissemination

WP4: system integration on drones and benthic stations

WP5: tests, verification, validation, and demonstration

UNDINA deliverable: environmental assessment

Cumulative Sound Exposure Level (SEL) was estimated for the relevant scenario for 5 classes of marine mammals.
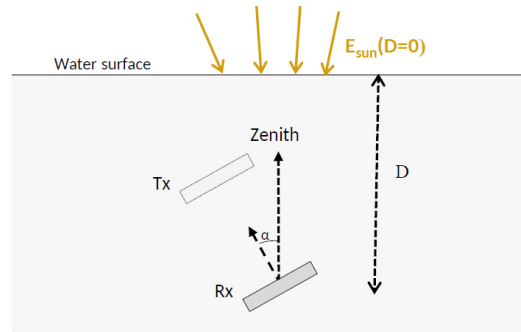
We computed the impact radius within which the animal can have Permanent Threshold Shift (PTS) and Temporary Threshold Shift (TTS), as a function of the mission duration and for two values of Source Level (SL).
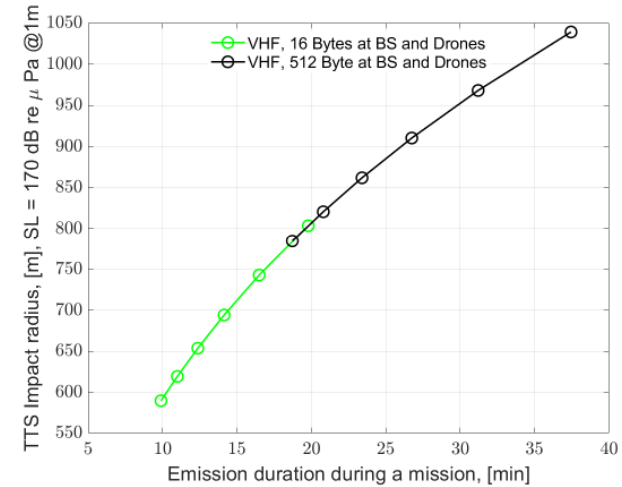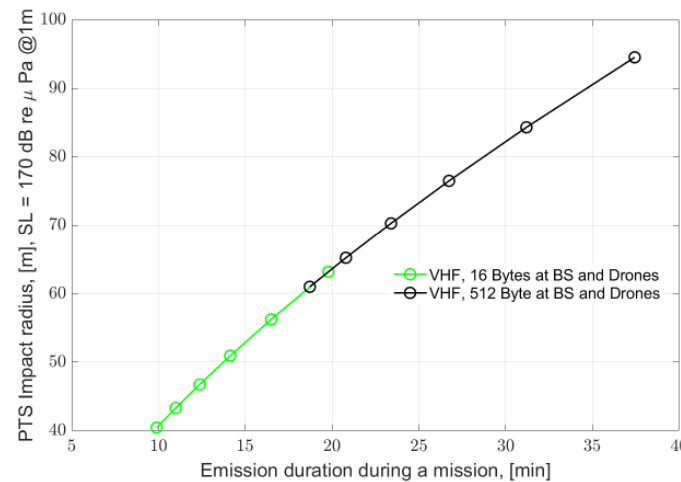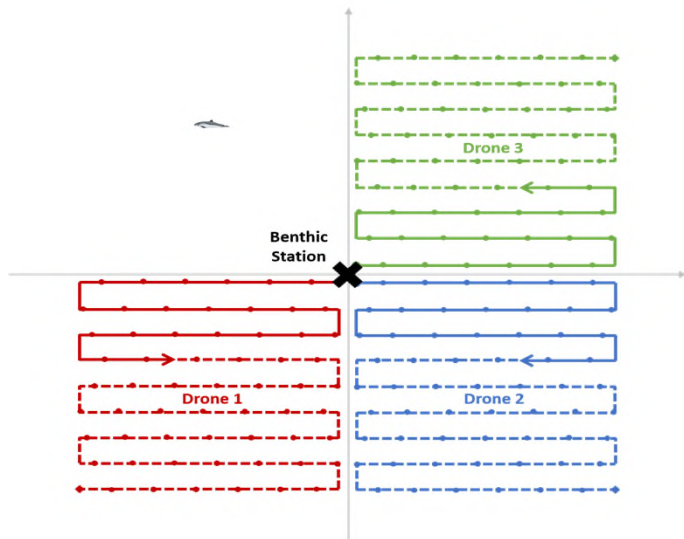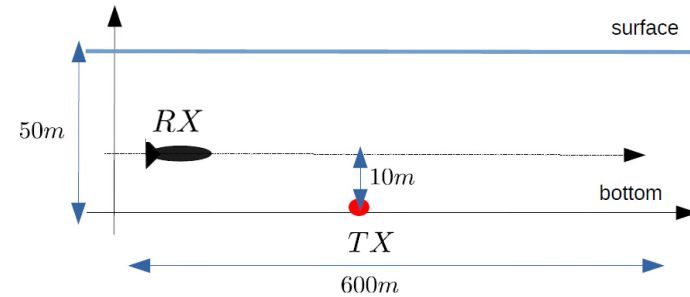
UNDINA deliverable: Analysis of Reinforcement learning algorithm for Multi-modal communications
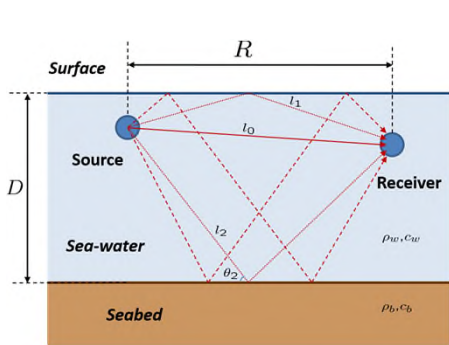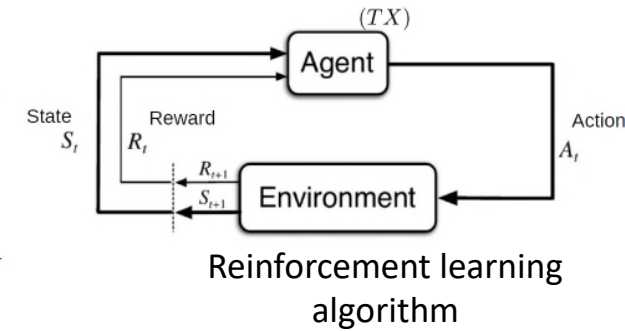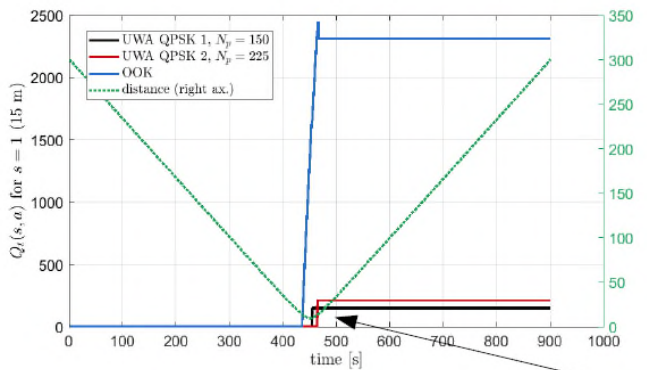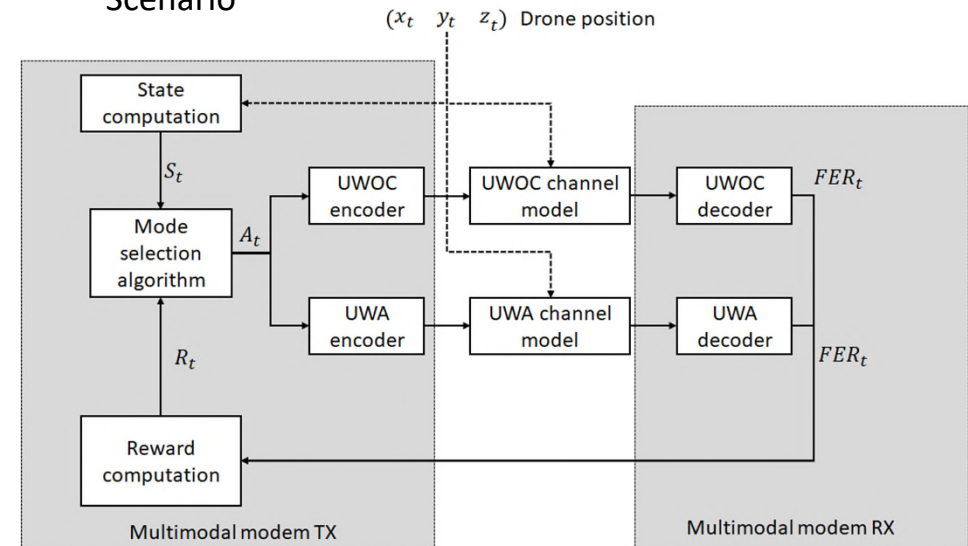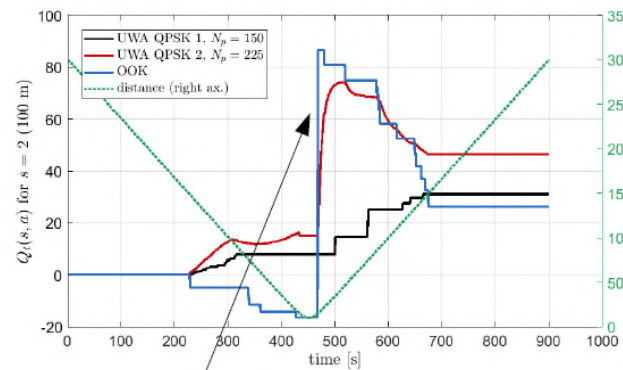

UWA channel model

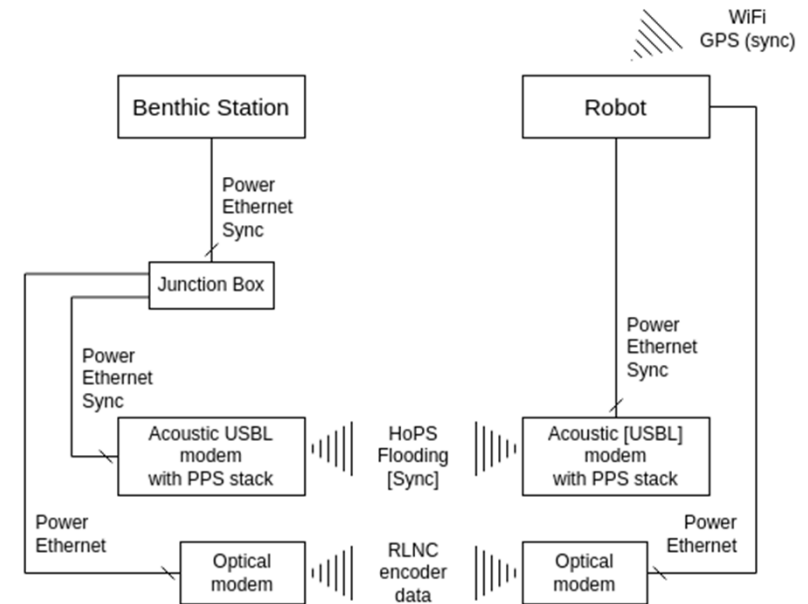UWOC channel model

Scenario
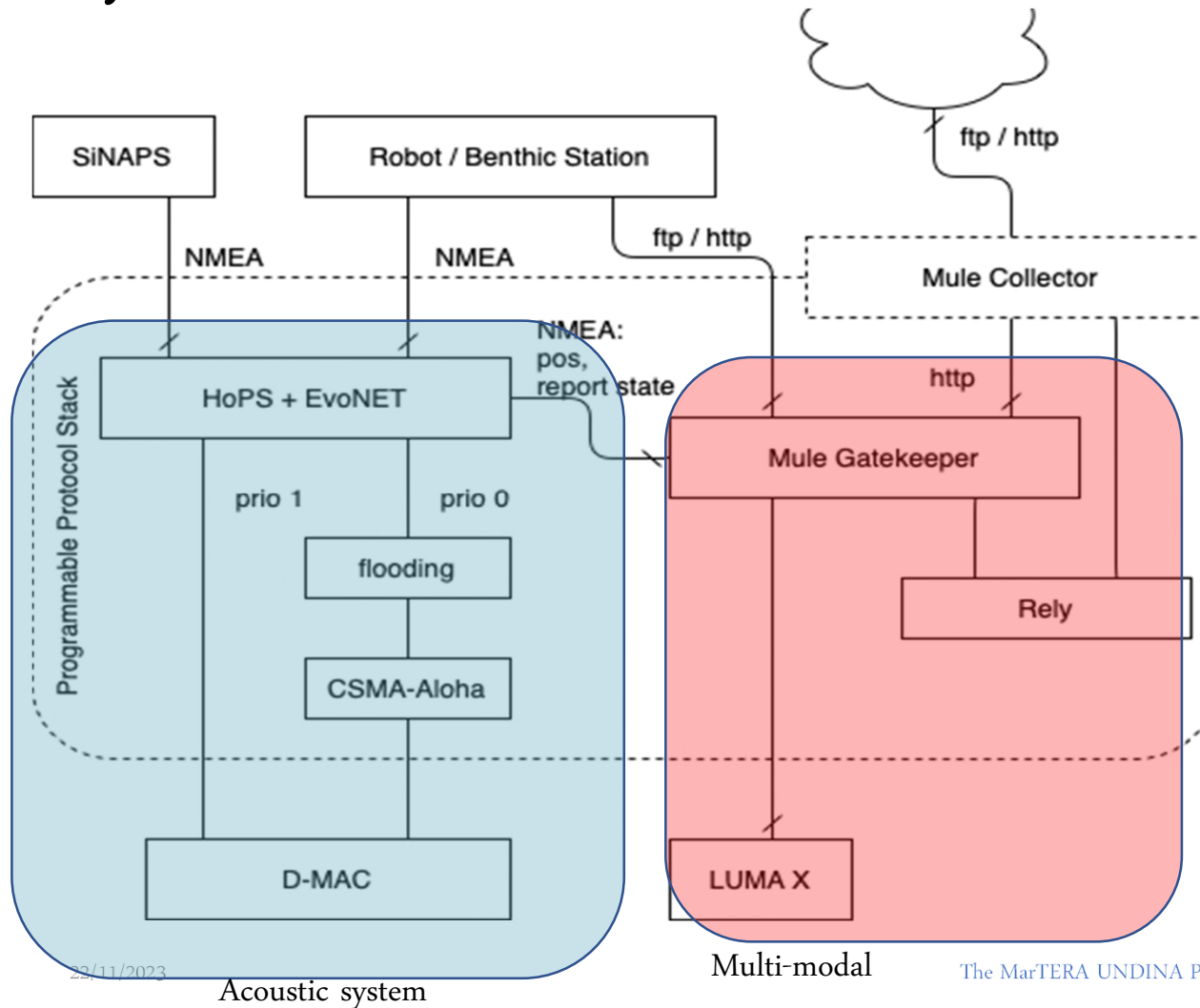

Reinforcement learning algorithm

Simulation performance

Simulation model

UNDINA deliverable: Programmable Protocol Stack for Automatic mode selection using the Hybrid communication and Positioning System (HoPS)

Physical interfaces

Acoustic system   Multi-modal

UNDINA milestone: Three payloads integrated into the robot with the first implementation of the programmable protocol stack

High data rate (Mbps)
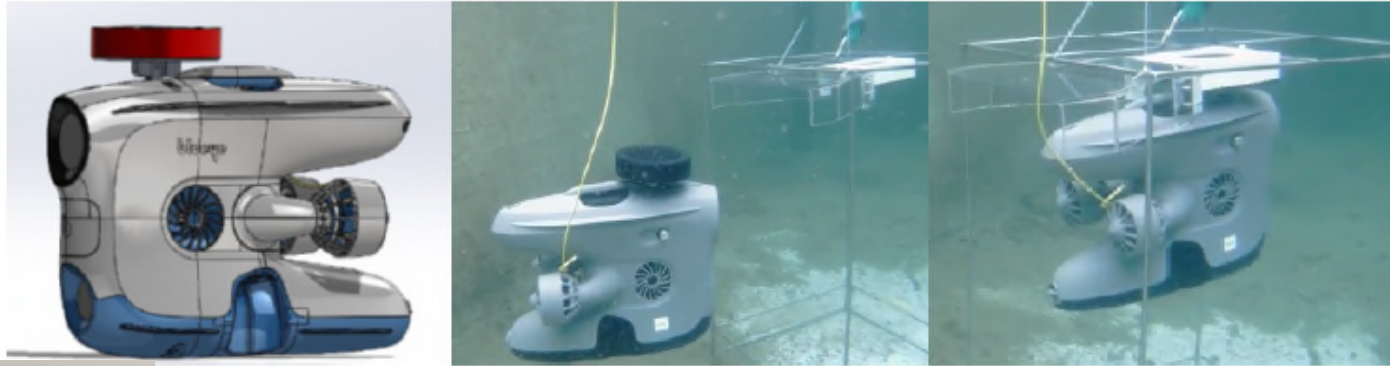
Recharge power (150 W)
upload-offload data (1Gbps)

Control channel
and positioning

Ambition: Docking strategy for recharging the drone and communication concept for remote operations
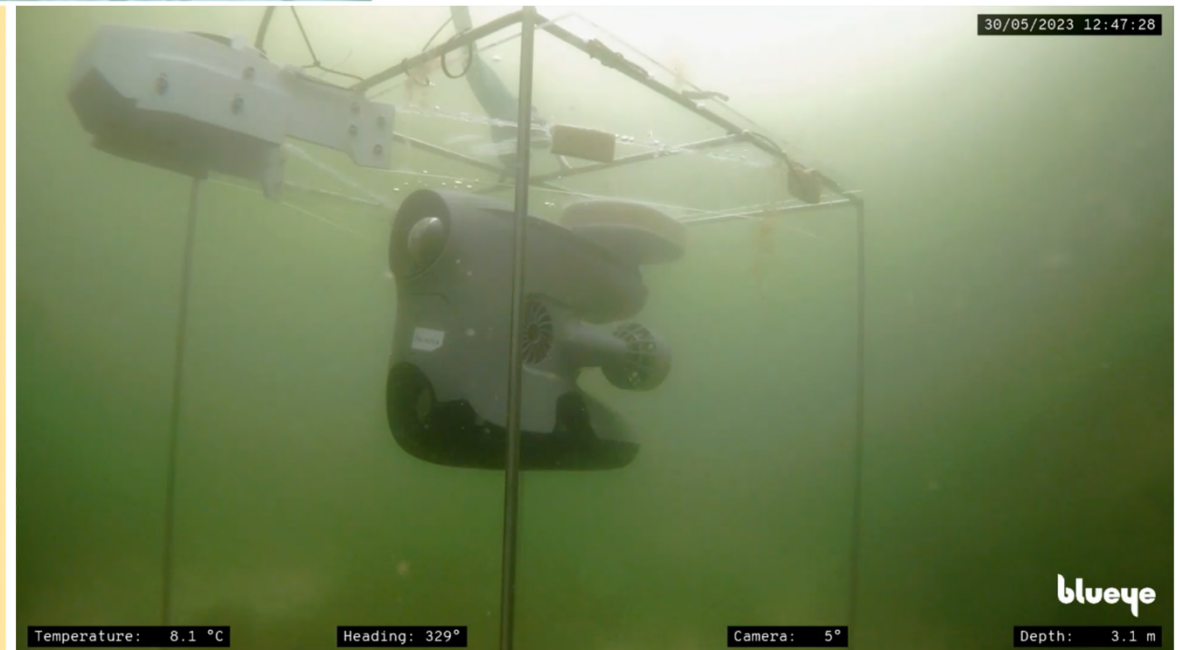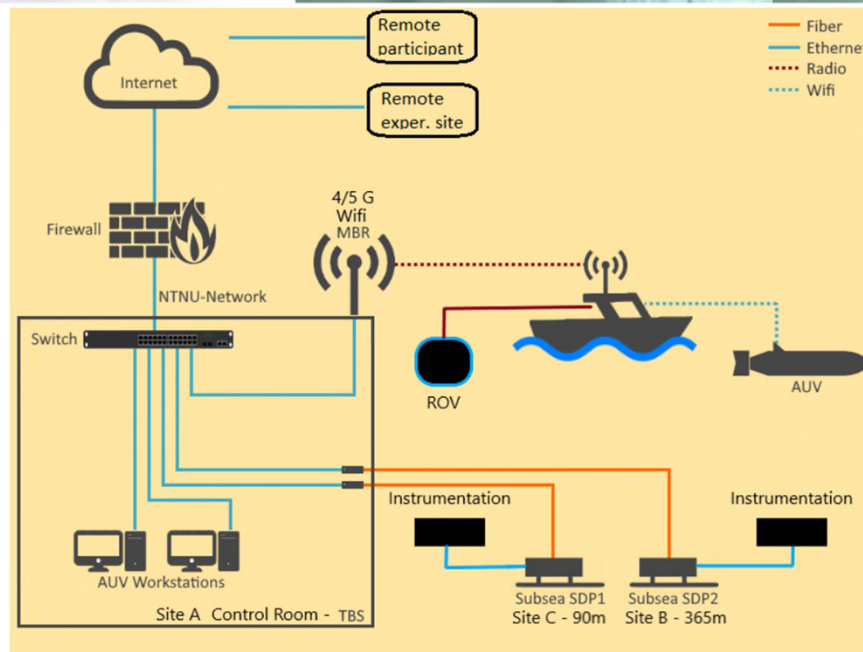
Ambition: Docking strategy for recharging the drone
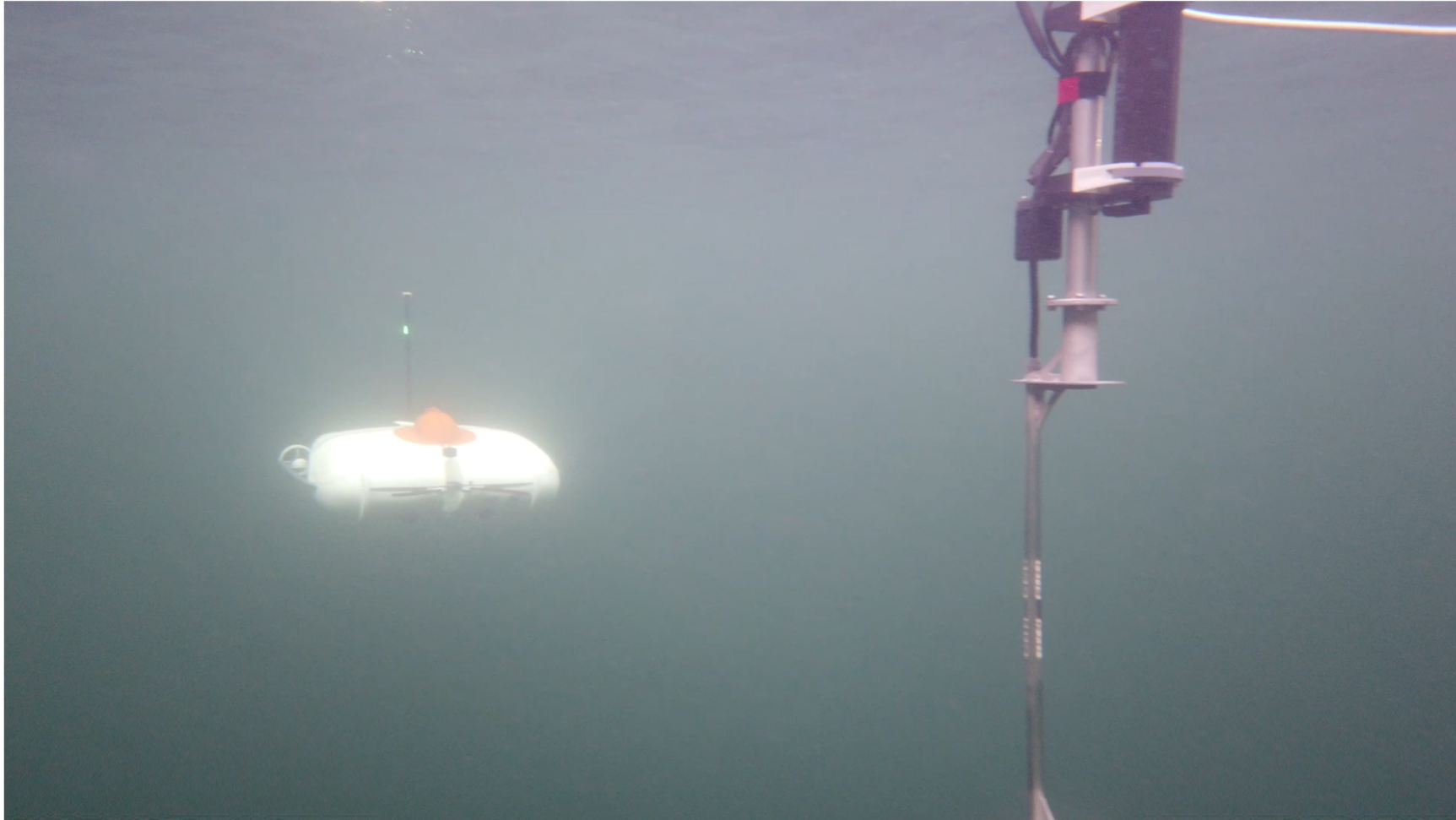
UNDINA milestone: Optical and acoustic communication and positioning system integrated into the benthic station, with the first implementation of the Programmable Protocol Stack

UNDINA milestone: Initial controlled validation tests of HoPS

Tests at sea with Celadon were scheduled on 6th November 2023, but storm Ciaran hit Britany region

193 km/h $\cong$ 53 m/s

UNDINA perspectives

- Complete the integration of the 3 modules in Blueye drone (by December 2023)

- Workshop on Random Linear Network Codes (Steinwurf, EvoLogics GmbH, Ifremer, NTNU, NORCE) (December 2023)

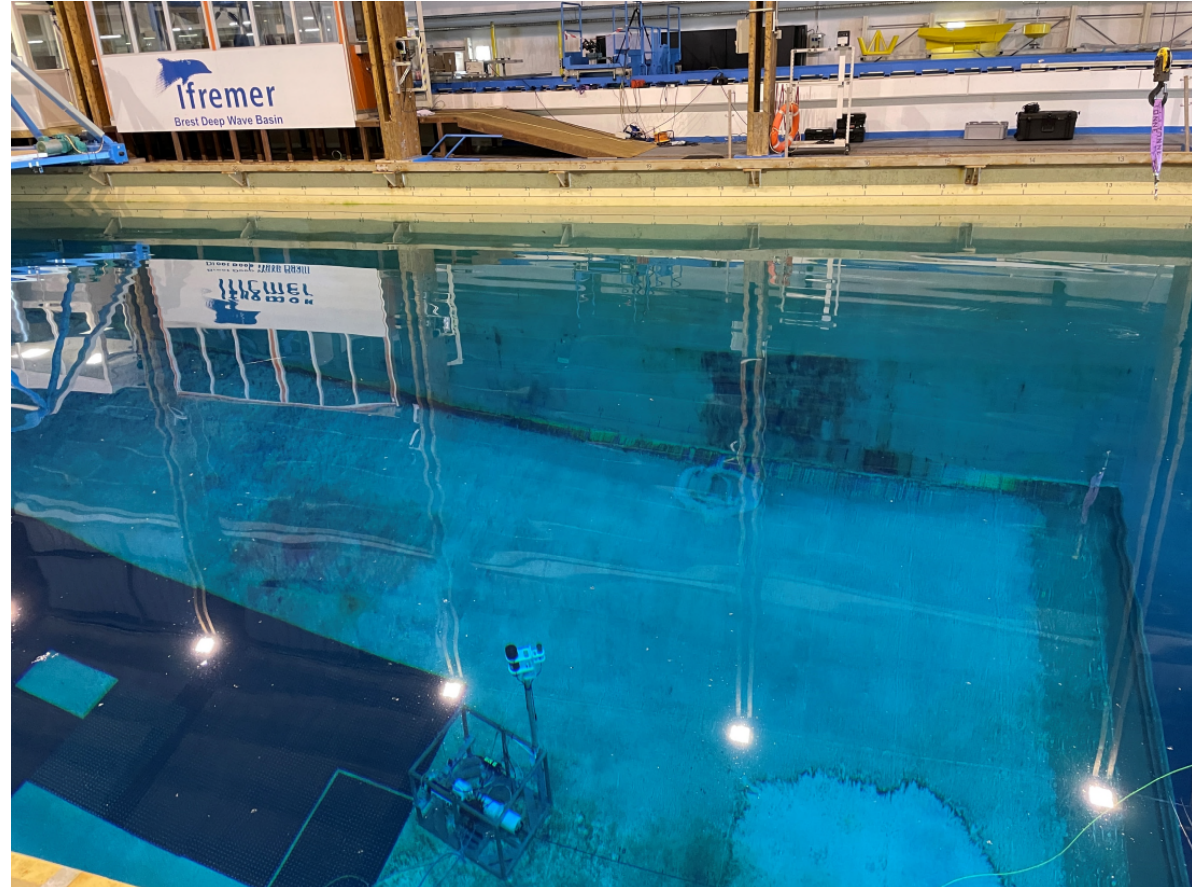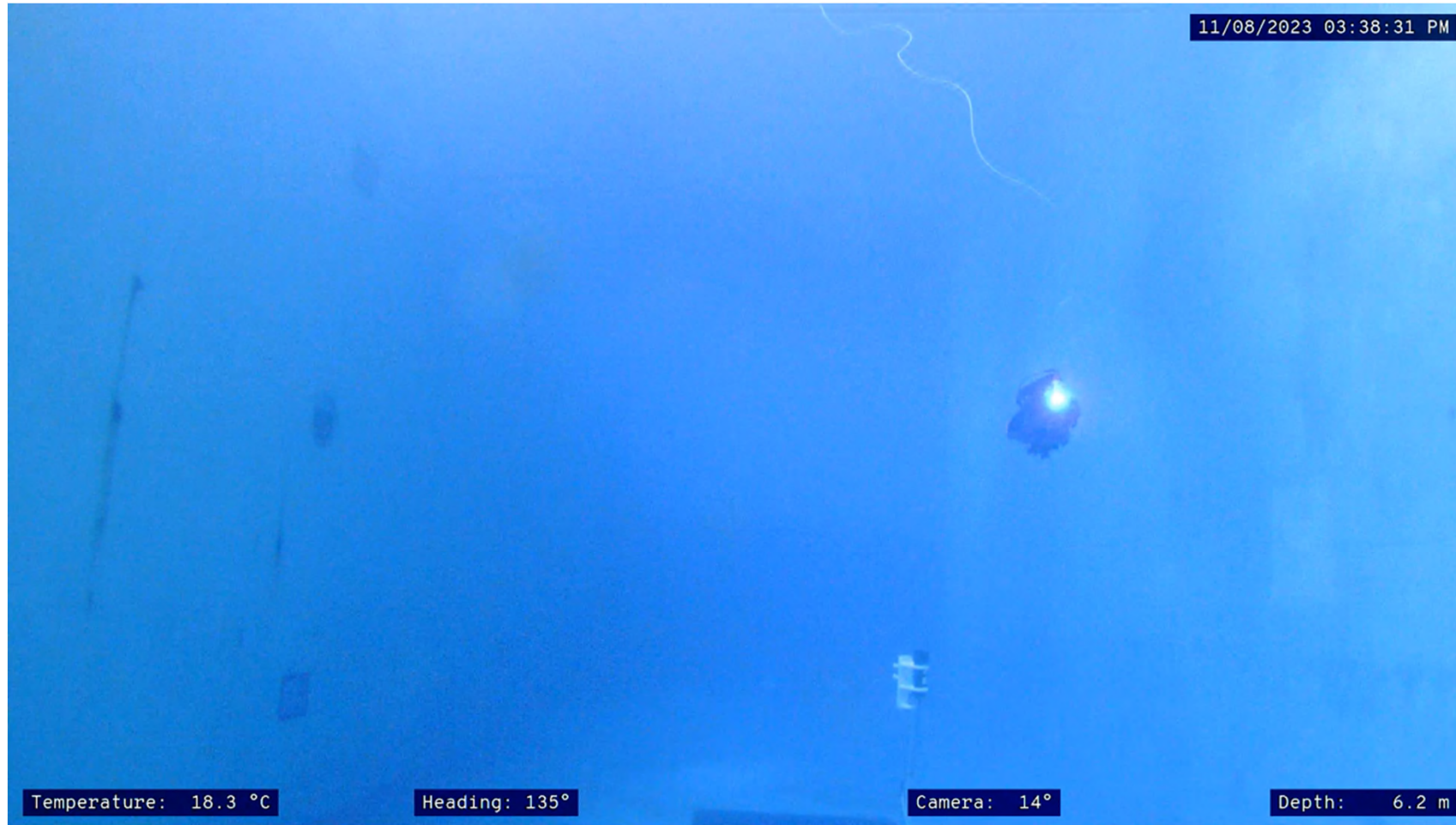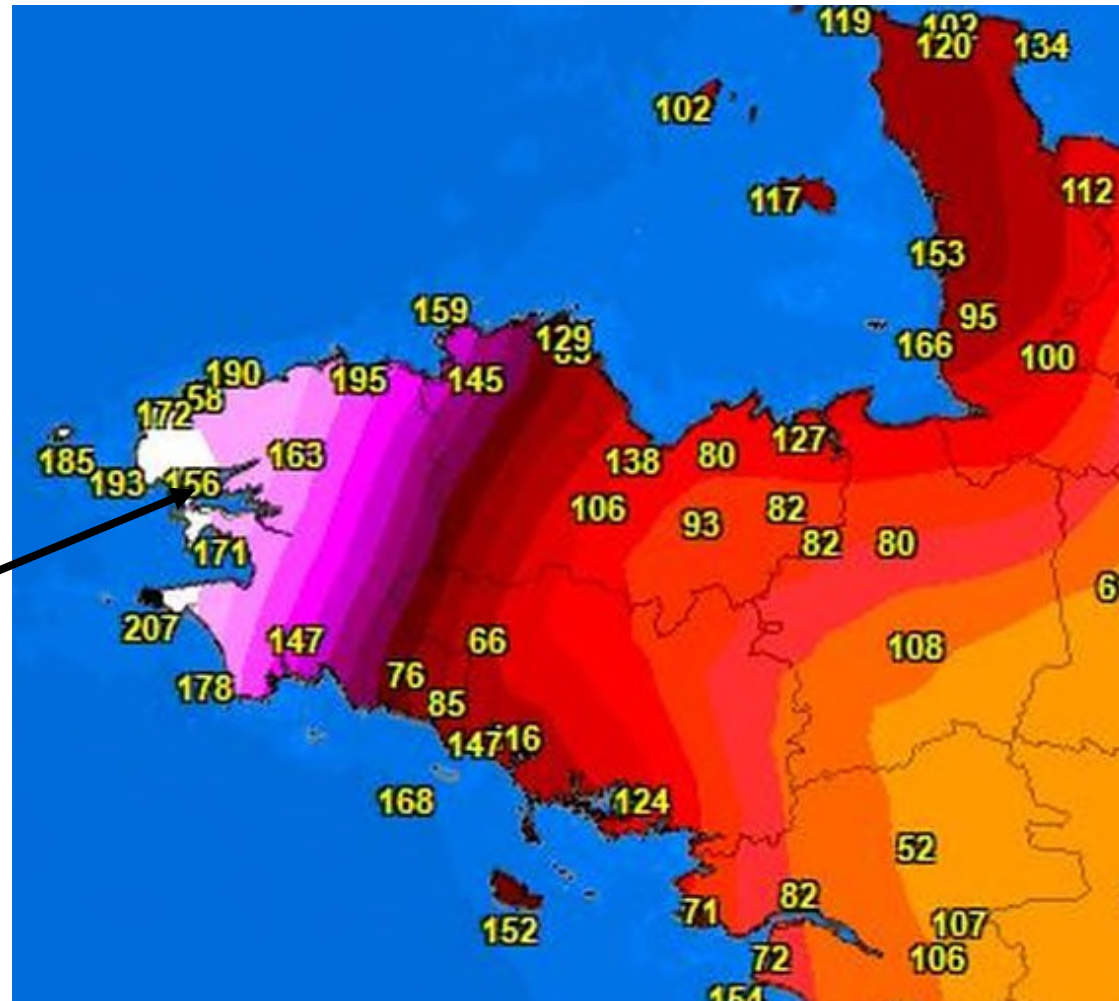- Workshop on docking strategies (NTNU, Ifremer, Bluelogic, Delair, Blueye, NORCE) – (January 2024)

- Test the integration of the 3 modules at NTNU benthic station in controlled conditions (January -February 2024)

- Conduct experimental performance tests at NTNU biological station for the optical communications while measuring solar radiation (noise), absorption coefficient, scattering, and turbidity (in collaboration with University of Bergen Institute of Physics and Technology) (January and June 2024)

- Resubmit the proposal UPULSE to the SBEP call 2024 if relevant, continuation and extension of UNDINA. (April 2024)

- Publish the results on the Reinforcement Learning algorithms (June 2024).

- Terminate the validation at NTNU and at Celadon. (May 2024)

UNDINA community and ecosystem

Suppliers

End users in industry and in research centers

Project partners technology developers
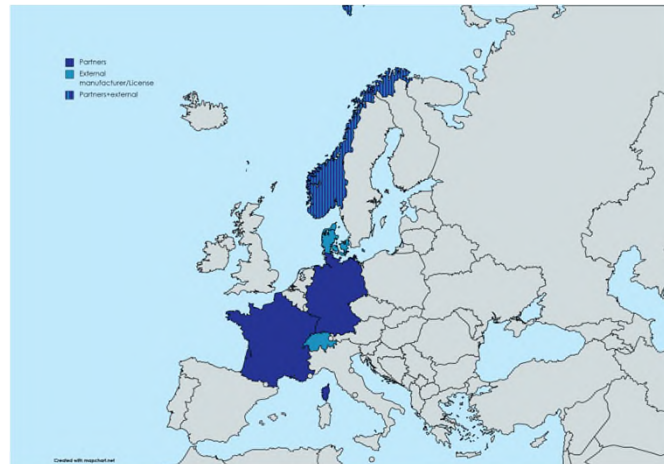
People acknowledgements:
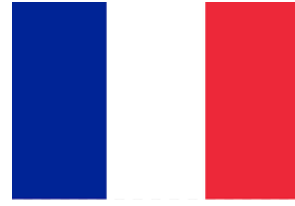
🇳🇴 Norway	🇫🇷 France	🇩🇪 Germany
Beatrice Tomasi	Jerome Blandin	Oleksiy Kebkal
Marie Bueie Holstad*	Pierre-Jean Bouvet	Emanuele Coccolo
Ingvar Henne*	Antony Pottier*	Sergey Yakovlev
Rune Øyerhamn	Thomas Paviet Salomon	Konstantin Kebkal*
Bård Henriksen	Leo-Paul Pelletier	Veronika Kebkal*
Frank Ådland	Gerard Guyader	
Anders Vahlin	Morgann Le Bot	
Martin Ludvigsen	Nicolas Mertz	
Antonio Vasilijevic	Sebastien Chalony	
Anna Vihovde	Sophie Chataing	
Karoline Barstein	Ivan Houly	
Jens Einar Bremnes	Pierre Budan	
John Mulholland	Nicolas Cadart	
	Marie Ponchart	

*From 07.2021 to 08.2022

Hydromea:
Alexander Bahr
Damien Doy

Blueye:
Jonas Follesø
Borja Serra
Andre Marquardt
Andreas Viggen

Bluelogic/Unplugged:
Helge Sverre Eide

Steinwurf:
Mikkel Højlund Larsen
Jeppe Pihl
Gianmarco Tasca
Morten V. Pedersen
Kavim Shroff

References

- B. Tomasi, M.B. Holstad, I. Henne, B. Henriksen, P-J Bouvet, A. Pottier, J. Mulholland, M. Ludvigsen, A. Vasiljevic, O. Kebkal, K. Kebkal, J. Blandin, P. Budan, "MarTERA UNDINA project: a multi-modal communication and network-aided positioning system for marine robotics and benthic stations", presentation at Underwater Technology Conference, Bergen 2022.

- B. Tomasi et al., "Environmental risk assessment of an underwater acoustic mobile network," 2022 Sixth Underwater Communications and Networking Conference (UComms), Lerici, Italy, 2022, pp. 1-5, doi: 10.1109/UComms56954.2022.9905696.

- A. Vasilijevic, K. Barstein and J. E. Bremnes, "Infrastructure for remote experimentation in the Trondheim fjord," OCEANS 2023 - Limerick, Limerick, Ireland, 2023, pp. 1-6, doi: 10.1109/OCEANSLimerick52467.2023.10244448.

- B. Tomasi, A. Pottier, P.-J. Bouvet, L.-P. Pelletier, H. Gazzah, "Adaptivity in Multi-Modal Underwater Mobile Networks", Invited talk, Underwater Acoustics Conference and Exhibition Series (UACE), Kalamata, Greece, June, 2023.

- Vasilijevic, A.; Bremnes, J.E.; Ludvigsen, M. Remote Operation of Marine Robotic Systems and Next-Generation Multi-Purpose Control Rooms. J. Mar. Sci. Eng. 2023, 11, 1942. https://doi:10.3390/jmse11101942

Acknowledgments

The UNDINA project is funded by