Topic	ICT-09-2019-2020 (H2020)
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Title	The Atlantic Testing Platform for Maritime Robotics: New Frontiers for Inspection and Maintenance of Offshore Energy Infrastructures.
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Third Publishable report

Written by INESC TEC

Actions

	Action	Organisation	Date
Technical Manager	Requested deliverable from the Deliverable Responsible.	VTT	01.12.2022
Deliverable Responsible	Prepared draft of the deliverable.	INESC TEC	15.12.2022
Technical Manager	Approved the updated draft as the first version.	VTT	22.12.2022
Quality Manager	Approved the updated first version as the second version.	UdG	28.12.2022
Project Coordinator	Approved the updated second version as the final version and sent to the European Commission.	INESC TEC	30.12.2022

Disclaimer

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1. Introduction

This report is the second internal report for the ATLANTIS project funded by the European Union's Horizon 2020 Research and Innovation program. During the project, three internal reports are prepared. This report covers months M19-M36 i.e. the period after reporting period one (M1-M18). The goal is to assess the progress of ATLANTIS in terms execution of the work plan and achievements and results. The report focuses on the activities done in the work packages towards the objectives of the project. The report also provides an updated risk assessment for the remaining project duration.

1.1. Work Packages and Tasks for the Reporting Period

For the reporting period M19-M30, work has been carried out in the following work packages:

- WP2 Adaptation of Robotic Platforms for O&M activities & IT systems for the Platform;
- WP3 Installation of the ATLANTIS Test Center in Viana do Castelo;
- WP4 Intelligent Services Supported by Robotics;
- WP5 Operation and Demonstration of the ATLANTIS Test Center;
- WP6 Long-term Strategy, Technology Industrialization and Business Case;
- WP7 Impact Analysis, Dissemination, Communication and Exploitation;
- WP8 Project Coordination

The tasks, deliverables and milestones ongoing and completed during the reporting period are summarized in Table 1-1.

Table 1-1: Tasks ongoing or completed and deliverables and milestones completed during the reporting period. Deliverables from the work package 9 ("Ethics") are not depicted in this table but they are discussed in in section 2.7.

WP (leader)	Task (leader)	Planned schedule	D/M (deadline)	Task status
WP2 (UdG)	2.4 Modification of robotic systems (IQUA)	M07-M25	D2.4 (M25), submitted	Completed
WP2 (UdG)	2.5 Communication links and interfaces for interoperability (SPACEAPPS)	M11-M27	M2.2 & D2.6 (M27), Submitted	Completed
WP2 (UdG)	2.6 Upgrade of a Shore control centre (SPACEAPPS)	M13-M30	D2.5 (M30), Submitted	Completed
WP2 (UdG)	2.7 Integration and Virtualisation of systems (Cyber-Physical Units) (VTT)	M17-M32	D2.7 (M32), Submited	Completed
WP3 (INESC)	3.1 Design and fabrication of the Floating structure system	M7-M27	M3.1 (M21) & D3.1 (M27) , Submitted	Completed
WP3 (INESC)	3.2 Installation of the Pilot in Viana do Castelo	M22-M32	M3.2 (M29)	Completed
WP3 (INESC)	3.3 IT systems & Shore control centre (SPACEAPPS)	M22-M34	D3.2 (M35), Submitted	Completed
WP3 (INESC)	3.4 Deployment of cyber-physical systems in the Pilot (UdG)	M29-M38		Ongoing
WP3 (INESC)	3.5 Tests for benchmarking technology (EDP)	M29-M38		Ongoing
WP4 (ABB)	4.1 Operation planning tool for IMR robotics (ABB)	M7-M30	D4.3 (M30)	Ongoing
WP4 (ABB)	4.2 Data mining & Predictive maintenance (VTT)	M13-M37		Ongoing

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WP5 (INESC)	5.1 Data collection in operational conditions (PPF)	M27-M40	D5.1 (M35), Delayed	Ongoing
WP5 (INESC)	5.2 Demonstrations in near-real environment (ABB)	M29-M41		Ongoing
WP5 (INESC)	5.4 Regulatory framework for new O&M methodologies (RINA)	M27-M41		Ongoing
WP5 (INESC)	5.5 Risk assessment and management for O&M activities using Robots (INESC)	M27-M38		Ongoing
WP6 (EDP)	6.1 Assessment of the impact of solutions on wind farm O&M Strategy and cost structure (EDP)	M16-M41		Ongoing
WP6 (EDP)	6.2 Integration of solutions in the offshore wind supply chain (EDP)	M9-M41	D6.2 (M23)	Ongoing
WP6 (EDP)	6.4 Business Cases for the different stakeholders (EDP)	M7-M19	D6.4 (M19)	Completed
WP6 (EDP)	6.5 Integration in the Industry Ecosystem & Stakeholder Engagement (INESC)	M22-M32	D6.5 (M32), Delayed	Delayed
WP7 (VTT)	7.1 Social, economic and environmental impact analysis (RINA-C)	M01-M42		Ongoing
WP7 (VTT)	7.2 Exploitation strategy & IPR management (INESC)	M01-M42	D7.8 (M20)	Ongoing
WP7 (VTT)	7.3 Dissemination and Communication activities (VTT)	M01-M42	D7.3 (M30)	Ongoing
WP7 (VTT)	7.4 Data management plan (INESC)	M01-M42		Ongoing
WP8 (INESC)	8.1 Project management (INESC)	M01-M42	D8.9 (M30) D8.4 (M36)	Ongoing
WP8 (INESC)	8.2 Quality assurance (UdG)	M01-M42		Ongoing
WP8 (INESC)	8.3 Technical management (VTT)	M01-M42	D8.9 (M30)	Ongoing

1.2. Objectives and Highlights for the Reporting Period

This section specifies the work carried out during the reporting period towards achieving the objectives of the ATLANTIS project.

#O1-KPI – *the completed installation of a maritime pilot infrastructure for showing the use of robots in a real offshore wind farm – the WindFloat Atlantis (WFA).*

The Coastal Testbed structure for the near-real environment demonstrations in the ATLANTIS Test Center has been acquired. The structure is a buoy that was transported and anchored to seabed. All legal permits were acquired. The interoperability of the Supervisory Control Center (SCC) with the remote assets has been achieved. **85% of this goal has been achieved.**

#O2-KPI – *a set of at least of 4 showcases formally defined for turbine maintenance, export and array cable maintenance, foundation inspection, and offshore logistics.*

This goal has been achieved.

#O3-KPI – *new modules for demonstrating several robots in real environments, designed and validated in at least 6 scenarios.*

Methodologies for robotics use in O&M activities were defined in WP1 and they will be verified and updated during the demonstrations in WP5. Three vehicles were developed from the scratch: one ASV

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(autonomous surface vehicle from INESC TEC), one UAV (unmanned aerial vehicle from INESC TEC) and one ROV (remotely-operated vehicle from ECA). Two AUVs (autonomous underwater vehicles from UdG and IQUA) were modified. All these vehicles were properly validated in the Coastal Testbed with additional two robotic platforms (commercially acquired by RINA) under the scenarios: Scenario 2: Inspection, maintenance and repair (IMR) of the transition piece or the floating structure; Scenario 3: Repair of underwater floating wind turbine cables protection systems; Scenario 4: Underwater monitoring over extended time periods; Scenario 5: Underwater close-range inspection of foundations; Scenario 6: Underwater monitoring of scour protection interventions; and, Scenario 7: O&M operations supported by crewless vessels.

75% of this goal has been achieved. The validation of some robotic platforms is being planned for the Offshore Testbed

#O4-KPI – *a set of at least of 5 mobile robots will be upgraded to operate over extended time periods on the surface, air and underwater, following a survey of user expectations for IMR activities completed by month 6 of the project.*

The robotic platforms that were modified include the ROOK, CROW and RAVEN UAVs, SENSE ASV and Raya AUV from INESC TEC, ROVING BAT from ECA, Girona 1000 and Sparus II from UdG.

This goal has been achieved.

#O5-KPI – *established an international IMR network for the offshore wind energy sector, open to all stakeholders to increase the adherence to robotic solutions for IMR activities in at least of 25% by 2025.*

The work related to this objective is ongoing. Stakeholders from the international offshore wind energy sector and robotics I&M have been and are engaged through key networking events such as the WindEurope Annual events and Sprint Robotics Seminars and the 2022 World Conference. WindEurope promotes wind energy in both Europe and globally with over 400 members from across the whole value chain of wind energy, including EDP, PPF and VTT. Sprint Robotics is an industry-driven initiative that promotes the development, availability, and application of Inspection & Maintenance Robotics around the world. Locally, INESC TEC is actively supporting a new stakeholder's ecosystem that is being built on Viana do Castelo and which is focused on offshore renewable energy and marine robotics.

30% of this goal has been achieved.

#O6-KPI – *established an infrastructure focused on functional validations to shorten the time-to-market of new technology and create business opportunities for SMEs that is supported by robotic-based products and intelligent services. The demonstration activities of up to 6 start-ups and SMEs will be supported free-of-charge.*

The work related to this objective started with launching the Open Call for SMEs and other technology developers to test and demonstrate their robotic technologies in the ATLANTIS Test Center.

35% of this goal has been achieved.

#O7-KPI – *creation of formal bridges between industrial and research projects and other actors such as, the WindFloat Atlantic Project, the TEC4SEA Research Infrastructure and the Robotics for Infrastructure Inspection and Maintenance (RIMA).*

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The work related to this objective is ongoing. The work has started by creating the first collaboration protocols. These now exist for the WindFloat Atlantic Project, where collaboration is ongoing, and the RIMA network. VTT is a member of the RIMA network that facilitates ecosystem building, technology development and commercialization in several sectors, including the energy sector.

50% of this goal has been achieved.

#O8-KPI – *Risk Index technically characterized in terms of safety, reliability, accuracy and robustness for distinct environment and weather conditions, will be integrated with risk assessment models derived from Oil and Gas offshore platform engineering and on-shore wind farm engineering.*

The work related to this objective will be initiated later.

1.3. Problems encountered

The pandemic also continued to negatively affect acquisition of materials and components, for the Coastal Testbed (WP3) and the upgrade of robotic platforms in WP2. The invasion of Ukraine caused a disruption of naval steel which has affected the WP3. In general, ATLANTIS project suffered impacts from

- Delay in Installing Floating structure due to Port Authority, Logistics and Weather conditions.
- Limitations of the supply chain caused by COVID19-pandemic situation
- Weather conditions for the testing campaigns in WP5 due to Autumn-Winter period.

There are no critical aspects to consider at this moment and no mitigation actions are being undertaken.

2. Work Package Objectives, Progress of Work and Achievements

2.1. WP2

WP2 Objectives: specifies the different marine robots already available through the consortium, the Shore Control Centre with its ICT infrastructure and the integration and virtualization of IoT devices into ATLANTIS. This work package intends to specify and adapt the robotic platforms to meet the O&M requirements that will be demonstrated in the showcases of WP1.

WP2 progress and achievements: During the reporting period, three tasks were completed (2.4, 2.5 and T2.6) and three deliverables (D2.4, D2.5 and D2.6) and one milestone (M2.2) were achieved.

Description of the main role of the partners:

Task T2.4 "*Modification of robotic systems*" was completed.

In this task, the partners adapted different robots, which were already available through the consortium, to improve their capacity to conduct IMR activities to be undertaken in the Coastal Testbed as well as in the Offshore Testbed during the Atlantis project. The adaptations and refinement of the platforms have been made to meet the O&M requirements in order to tackle the showcases defined in the context of the ATLANTIS project. The task had a duration of 21 months (M7 to M27) however, some partners are still encountering with several COVID-related delays, and the consequent shortage of components, that affected the development of the different robotic systems. The deliverable that reports the progress of this task was already submitted since all platforms were properly designed at

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that time but some components need to arrive in order to be possible the Consortium to conclude this task. This is the reason why the status of this task is still ‘ongoing’.

IQUA: During Task 2.4, IQUA Robotics has devoted its efforts to the development of two technologies:

The first one is an optoacoustic payload for the Girona 500/100 AUVs that works in combination with the software algorithms developed in Task 2.3 to enable the autonomous inspection of submerged structures. The payload is conceived around a multibeam sonar installed on a pan and tilt unit and a multi-camera system. The system is capable of sweeping the environment surrounding the vehicle with the sonar, and in this way, generating a point cloud of range measurements that can be then used for mapping and obstacle detection. Simultaneously, the cameras acquire images for the inspection of the structure from different vantage points. The payload was designed, fabricated, and integrated, both physically and via software, into the Girona 1000 AUV and tested in the field during preliminary experiments.

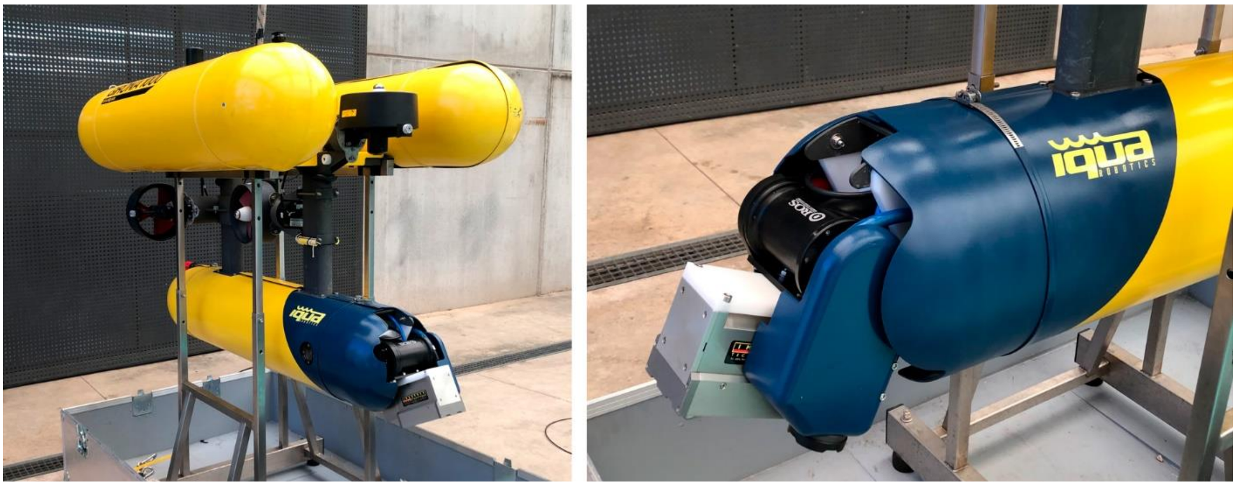

Figure 2-1: The optoacoustic payload installed on the Girona 1000 AUV.

The second technology that was completed during this period is a payload for the Sparus II AUV dedicated to the docking task that will be later demonstrated. This payload incorporates different equipment: a USBL/modem transponder and a camera required for the location and navigation of the vehicle towards the docking station; an inductive charge module provided by the INESCTEC team for the demonstration of wireless charging; and a forward-looking sonar for the execution of a demonstration survey task. The development of this payload included not only the design and fabrication of the mechanical components (frame, fairings, equipment supports, buoyancy modules, and ballasting) but also the integration of the equipment from the electrical and software point of view. The payload has been designed, built, and installed in the vehicle and has been delivered to the UdG to proceed with the development of the docking system.

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Figure 2-2: Payload for the docking task installed on the Sparus II AUV.

As leader of task 2.4, IQUA has also been responsible of the generation of D2.4 which was submitted for revision on M27 (March 2022).

INESC: In Task 2.4 INESC TEC developed technologies for platforms for the three different domains: aerial, surface and underwater.

In the aerial domain the work was centred in the improvement of UAV sensor technologies. The research work was centred on day/night operations - perception and navigation - robustness and reliability of the autonomous landing/take-off and resulted on the developing of a novel perception system to obtain multimodal data from the inspected offshore structures. The existing INESC TEC's UAV STORK does not have the necessary requirements to perform IMR operations. As a result, the developments were centred along three new aerial platforms: the ROOK, CROW and RAVEN UAVs. A new architecture was developed for the sensor payload that is used in the UAVs. The sensor payload, named TriOPS is composed of heterogeneous sensors that enhance its perception abilities in challenging conditions of operation. To match this new perception system, a multimodal fiducial marker was developed (named ArTuga), allowing a more robust and reliable detection and tracking of the landing target. Because of large distances that the UAV must travel to inspect wind turbines in an offshore wind farm, and the limited battery capacity, it was required to develop a mobile and floating landing platform (named NEST) that enabled the UAV to be transported and to land and take off in an offshore scenario.

In the surface domain, modifications were made in the Zarco ASV, leading to its renaming to SENSE ASV. The modifications made on the SENSE ASV to increase navigational safety required a higher power consumption since more sensors were included and the processing units were improved. The enhancement of SENSEs' battery payload was achieved through the upgrade of the battery technology to LiPo requiring almost the same space while increasing the available power. Thus, the improved endurance allowed an operation time of approximately 4 hours. Furthermore, SENSEs' sensor payload was enhanced both in terms of navigation and perception to acquire more accurate information and to allow the observation of both domains. Thus, providing a better situational awareness with a wider range of applications for the inspection of offshore wind farms, such as the inspection of the scour protection integrity or the state of the structures' transition piece. To ensure the safety and completeness of the inspection tasks new algorithms were developed, namely the multi-domain mapping and the data completion method. The first uses data from a multibeam and a Lidar to create a map of the surface and underwater domains into a single representation using registration-based algorithms which allows the simultaneous inspection of the scour conditions and the transition piece.

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In the underwater domain, the focus was the modifications of TRIMARES AUV, renamed Raya. These modifications included a new sensor payload, as well as changes to the mechanical structure of the vehicle. Additionally, an adaptation of the electrical components of the robot had to be performed, to account for the requirements of the new sensors.

UdG: In this task, UdG developed/adapted the following technologies to cope with the needs and requirements of the project:

- **Docking Station:** A new docking station was designed and developed for the SPARUS II AUV (see Figure 2-3), to tackle Scenario 4 defined in WP1 (Underwater monitoring over extended time periods). The docking station integrates the following subsystems:
    - A battery package.
    - A DVL sensor to measure the ocean current close to the docking station.
    - An underwater camera to record the docking manoeuvre (for testing purposes).
    - An acoustic transponder to be used together with a USBL device installed on the SPARUS II AUV, for the relative localization of the docking station with respect to the robot.
    - An inductive charger (developed by INESCTEC team).
    - A 1 DOF rotator with a friction brake, allowing to align the docking station with the measured currents.
    - An AUV latching mechanism to secure the AUV within the docking station.
    - An underwater WiFi antenna to transmit data between the docking station and the AUV once it has been docked (short range transmission through water).
    - A computer system to control the docking station subsystems.

Figure 2-3: Docking station: final design (left), manufactured and assembled in CIRS (right).

- **GIRONA1000 I-AUV intervention payload:** A new intervention payload was designed and implemented to face the requirements of Scenario 2 (IMR of the transition piece or the floating structure), see Figure 2-4. The payload consist of:
    - A 5 DOF ECA 5E Micro manipulator, equipped with a permanent magnet end-effector for docking the I-AUV on the floating piece of the wind mill.

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- A 7 DOF Blueprint Bravo manipulator, to be used for generic manipulation purposes including surface cleaning, CP testing and anode inspection.
- A marinized force/torque sensor, installed in the end-effector of the Bravo manipulator, to control the interaction forces between the tools and the inspected surface.
- A cathodic protection testing tool and an electric brush tool.
- A laser scanner able to provide 3D point clouds in real time, aimed to be used for the 3D reconstruction of the protection anodes.
- A colour camera.
- A stroboscopic lighting system.
- A set of new thruster mounting hardware to enable use of vectorial configuration.

Figure 2-4: GIRONA1000 I-AUV with dual manipulator payload: final design with cleaning brush tool (left) and real system during the experiments in the pilot structure, equipped with CP probe (right).

- **Testing Rig:** A curved panel, representing a part of the main surface of the ATLANTIS pilot infrastructure (see Figure 2-5), which can be placed in the CIRS test tank to validate the developments in the IMR operations, using the GIRONA 1000 I-AUV. The aim of this rig is to allow testing the developed algorithms and systems in laboratory conditions, prior to the deployment in the pilot infrastructure.

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Figure 2-5: Testing rig on its trailer (left) and inside the CIRS test tank (right).

ECA : In the task 2.4, during the reporting period of M19 (July 2021) and M36 (December 2022), ECA has focused its effort on the end of the design of the Roving Bat MK3 to upgrade its functionality with the goal to perform the planned demonstrations for IMR operations in offshore condition during WP5 - scenarios 2 and 3. Design was completed. Supply and manufacturing of mechanical parts and electronic boards were completed, as well of the assembly of all equipment of the system: Control Unit, Power Supply Unit, Umbilical cable and winch. The system was then tested in our water tank facilities in ECA. The main problem encountered is the frequent trip of the power converters due to the lack of capacitors inside the horizontal thrusters. This problem was overpassed using software filtering but must be fixed definitively by a HW modification inside the thrusters. During this period we also finalize the communication links and interfaces for interoperability.

To achieve these tasks the following designs have been performed:

- **Electrical design:** Design of a new electrical architecture using an underwater 8KW – high voltage input - embedded power converter. This technology allows firstly to use a thinner umbilical cable, reducing its resistance to the sea current, and secondly deliver full power to the thrusters making the Roving Bat to cope with offshore conditions, especially the strong currents that are present in the area where the wind turbines are installed. To minimize its weight and volume, each converter is packaged in an oil filled housing. The following task have been completed: power boards design and control board interface design, thermal test, mechanical integration, manufacturing of the 2 mechanical enclosures, manufacturing of the electronic boards. Test of the converter on a bench test under 1200Vdc/8.5KW. Test of the converters at full power on the Roving Bat through the umbilical cable first in a water tank then on the field during coastal trials
- **Mechanical design:** Design of the Roving Bat MK3 mechanical structure. The original design of the RB was too small to integrate the new power converters, the 3D camera, the Reach Bravo manipulator, a CP probe and a new cleaning tool for marine growth removal. The following task have been completed : the crawlers used to move the RB while it is attached on the vertical structure during the IMR operation have been ruggedized. The vertical thrusters to keep the robot attached on the structure have been changed by a powerful model (4 thrusters of approx. 3KW each). This new design will allow to increase the sensor payload of this ROV. A specific pod for the thrusters control and a specific pod for the crawlers control design have been design,

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manufactured and pressure tested. Integration of Full HD camera, Ethernet Telemetry, and led light have been completed.

- **Electronic, control SW and HMI:** Integration of a new electronic and software architecture using an Ethernet transmission. This digital architecture allows adding potential payload, in terms of control and data transmission. Particularly it will make possible to use the Reach Alpha 7 electric manipulator arm and the MARESye 3D camera developed by the INESC TEC. The goal is to verify the ability of the camera to work on the real condition. The integration of the MARESye camera on the Roving Bat has been retained as the KER n°1 during the exploitation seminar organized in April 2021 and so, a particular attention is paid on this development and potential partnership. This new electronic architecture combined with a powerful supply system will also be used to stabilize the ROV during its operation on scenario 3 (the inspection of export and array cables on the ATLANTIS Test Centre).
- **Interoperability:** Development and test of communication links and interfaces for interoperability. Test on the were done on SPACEAPPS VPN to validate and amend the proposed HW and SW architecture for connection with the SCC. These tests have been completed successfully on the field during the coastal trials in Viana do Castelo.

The second ongoing task is T2.5 "*Communication links and interfaces for interoperability*".

SPACEAPPS: During this reporting period task T2.5 was completed. The last activities that were part of this work were:

- Remote integration with all software required to be used in the project. SPACEAPPS have set a VPN connection to which IQUA, UdG, INESC, ECA have connected with. The tests showed the viability of the interoperability system over a delayed network. In addition, the data was successfully displayed in the SCC views.
- The interoperability layer has been successfully connected with different configurations like:
  - ROS1 on Linux
  - ROS2 on Linux
  - Proprietary Software on Windows
- Compile and deliver D2.6 - *Communication links and interfaces for interoperability*

Task T2.6 "*Upgrade of a Shore control centre*" was completed.

During this reporting period SPACEAPPS finalized the development for the SCC software and compiled D2.5 Shore control centre with the help of the other partners involved. The main activities that took place within the scope of this task were:

- Updating the mission planning software to be compatible with the ATLANTIS scenarios and test it with the involved partners
- Stabilizing the code base to be used in the Pilot by bug fixing and increasing the robustness of the deployment.
- Automation of the deployment scripts using docker.
- Launching a cloud version of the SCC for test, validation and remote supervision. This will be kept alive during the project at http://atlantis.c4i.spaceapplications.com
- Several integration sessions with the partners for the scope of utilizing the SCC software from the Pilot
- Reporting the activities in D2.5.

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Task T2.7 "*Integration and Virtualisation of systems (Cyber-Physical Units)*" was completed.

During the reporting period **VTT** and **SPACEAPPS** defined the virtualization layer framework and its role in the ATLANTIS software architecture. The virtualization layer will be a part of the O&M module (developed in Task 4.2 "*Data mining & Predictive maintenance*") and it will handle communication between the O&M module and the other assets, including the SCC, the robots and external sensors installed in the Coastal Testbed structure. An integral part of this layer is the virtual representation of the Coastal Testbed based on ANSYS AQWA/CFD and FEM analysis and the external measurements from the Testbed. This virtual representation is used e.g. for wave loading estimations for evaluating critical loadings at different locations of the Testbed. The virtualization layer communication needs and requirements, preliminary connectivity testing with the SCC, and the components of the Coastal Testbed virtualization were reported in the deliverable D2.7 - *Virtualization layer for robotics*.

2.2. WP3

WP3 Objectives: To establish the ATLANTIS Coastal Testbed at the shore of Viana do Castelo. This will be accomplished by: (1) designing, developing and installing the structures that compose the testbed; (2) providing an IT infrastructure that ensures connectivity between the control center and the equipments in the testbed; (3) deploying the systems and technologies developed in WP2; (4) conducting preliminary validations of these systems and technology.

WP3 progress and achievements: During the reporting period, work package tasks T3.2, T3.3 and T3.4 were finalized. One deliverable (D3.2) was submitted and two milestones (M3.2 and M3.3) were achieved.

Description of the main role of the partners:

Task T3.1 *"Design and fabrication of the Floating structure system" was completed.*

INESC TEC submitted the final structure design in the call for tender that was launched in October 2021. Multiple revisions of the documentation were written with support of RINA to accommodate all the technical and legal requirements, protecting the interests of the consortium and guaranteeing the project's objectives are met. Following the publishing, discussions were held with the tenderer to clarify identified issues and agree on some technicalities (e.g. paint scheme, protection systems, extras, etc). Due to the ever-rising price of commodities (steel in this case), the tenderer requested a change of plans due to the inability to acquire steel in the markets, especially after Russia's invasion of Ukraine. They proposed us the acquisition of an offshore buoy previously deployed off the coast of Porto, Portugal. This structure was being decommissioned at the time, but fulfilled all of the requirements that were identified in the D3.1 report and therefore considered a valid alternative. For sure there weren't many alternatives given that the project was already delayed and could not be further delayed without endangering the testing activities that were already scheduled. Thus, the tender was modified to allow this changes and the structure was bought. The acquisition process was executed by the tenderer, which acted as an intermediary between the parties.

Task T3.2 *"Installation of the Pilot in Viana do Castelo" was completed.*

The floating structure was installed as planned, in the area determined by the Viana do Castelo port authority. The only modification we were asked to perform was on the signalling system, which was

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deemed inadequate by the port authority. Contacts were already established with the entity which was awarded with the contract to tackle this issue.

As it is now, the structure was proven already suitable to perform the experiments described within this project. Nevertheless, updates are already being discussed within the consortium to improve the potential of this test location.

Figure 2-6: Floating buoy installed in the ATLANTIS Test Centre

Task T3.3 *"IT systems & Shore control centre" was competed.*

SPACEAPPS and INESC worked together on the installation of the IT system for supporting communications between robotic assets and the SCC on the pilot.

In the current reporting period, the following activities have been done:

- Configuring robotic systems to use the interoperability layer;
- Testing connectivity between robotic systems and local/remote server;
- Testing IT infrastructure to ensure connectivity and solve occasional problems.

Task T3.4 *"Deployment of cyber-physical systems in the Pilot" was completed.*

For the deployment of cyber-physical systems in the Pilot, ATLANTIS follows an experimental driven methodology based on 3 phases: 1) Hardware In the Loop (HIL) simulation, 2) water tank experimentation and 3) sea trials. For the HIL simulation, we are using the Stonefish[1] simulator developed at UdG and made available under a GNU GPL v3 license. Water tank trials are being conducted at the different water tanks available through the consortium. And sea trials include: 1) trials at each partner site, 2) trials in the ATLANTIS pilot infrastructure and 3) trials in the ATLANTIS offshore infrastructure.

[1] Patryk Cieślak, "Stonefish: An Advanced Open-Source Simulation Tool Designed for Marine Robotics, With a ROS Interface", In Proceedings of MTS/IEEE OCEANS 2019, June 2019, Marseille, France

This project has received funding from the European Union's Horizon 2020 research and innovation programme, under the Grant Agreement no. 871571.

At UdG, the work carried out in this task include the HIL simulation of the inspection tasks related to the Scenario 2 (CP testing and anode inspection) as well as the docking tasks related to scenario 4. Figure 2-7-a shows an RViz visualization of the GIRONA 1000I-AUV during a HIL simulation. A simulated mission taking place in a virtual CIRS water tank including the testing rig developed in WP2 is shown. Figure 2-7-b show the same trial being performed in the actual water tank while preparing the demonstrations to be carried out in the ATLANTIS pilot at the of July 2022.

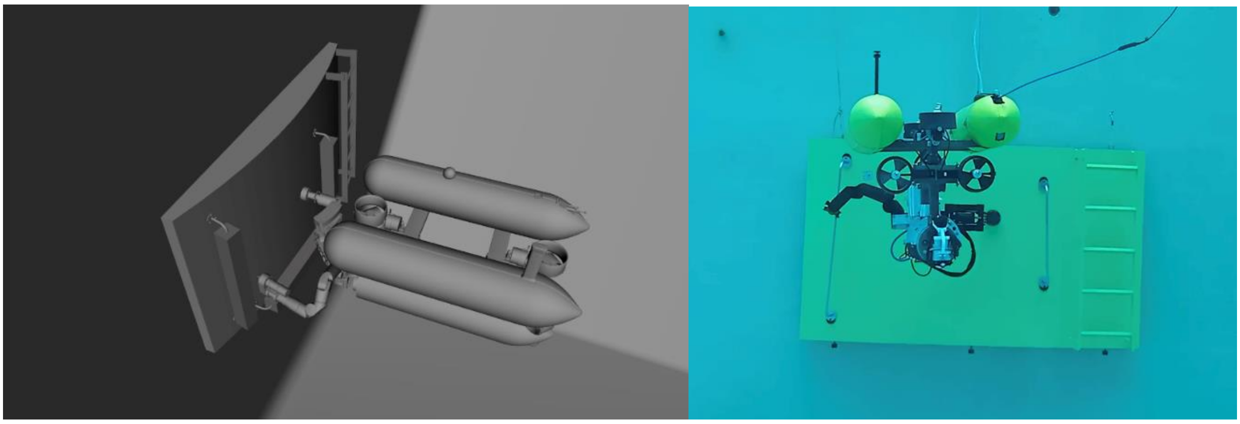

Figure 2-7: a) Rviz visualization of a HIL simulation of the autonomous Cathodic protection task using G1000 dual arm I-AUV; b) Actual GIRONA1000 I-AUV during the water tank testing of the autonomous Cathodic protection task.

At the time of writing this report, the validation and testing of the developed systems has already began (see Figure 2-8). The SPARUS II AUV and the Docking station are being tested at Sant Feliu Harbour prior to the deployment in the ATLANTIS pilot infrastructure. The GIRONA 1000 I-AUV is being tested at CIRS water tank using the testing rig.

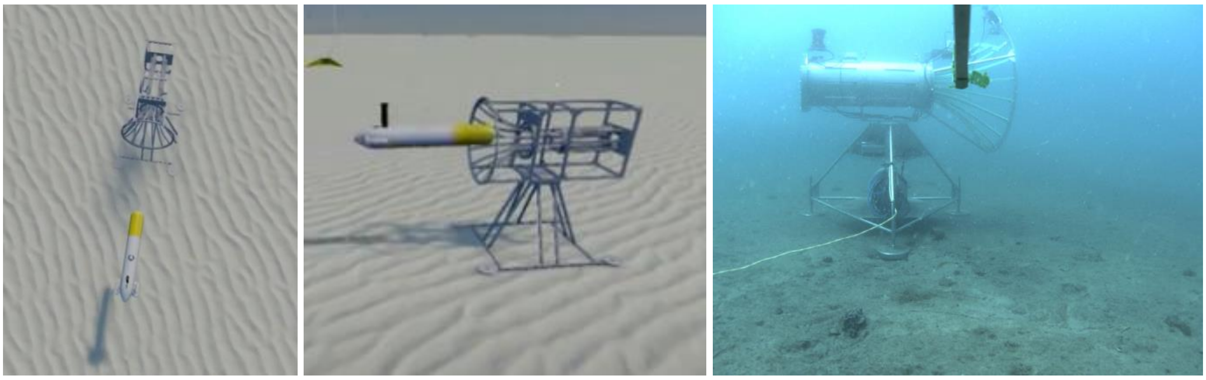

Figure 2-8: a) HIL simulation of the autonomous docking manoeuvre corresponding to scenario 2. Actual Docking Station deployed at Sant Feliu Harbour in Girona coast.

The RINA team was present in the ATLANTIS Test Centre Coastal Testbed on November 2022, performing tests with their Fifish ASV, and DJI MATRICE M210 UAV. The main objectives of the tests performed was the calibration of the systems, collection of data, definition of improvement like: installation of sensors to detect equipment position during activity for ROV and installation of ultrasonic bollard for drone.

At IQUA, the efforts prior to the trials that took place at the coastal testbed in November 2022 were focused on the testing and refinement of the new planning algorithm for the autonomous inspection of submerged infrastructures developed during Task 2.3. The work was done first in simulation using

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virtual scenarios representative of the task at hand. With the technology validated in simulation, and once the required hardware development was completed as part of Task 2.4, the experiments were moved to more realistic scenarios.

The first set of tests were performed in a natural environment, attempting the autonomous exploration of an islet that rises 12m from the seafloor to the surface. The operation was executed in two steps: First, the vehicle circumnavigated the islet from a safe distance to map and locate it with sufficient precision and then, executed a close-range inspection following a path that ensured full camera coverage of the scene (see Figure 2-9).

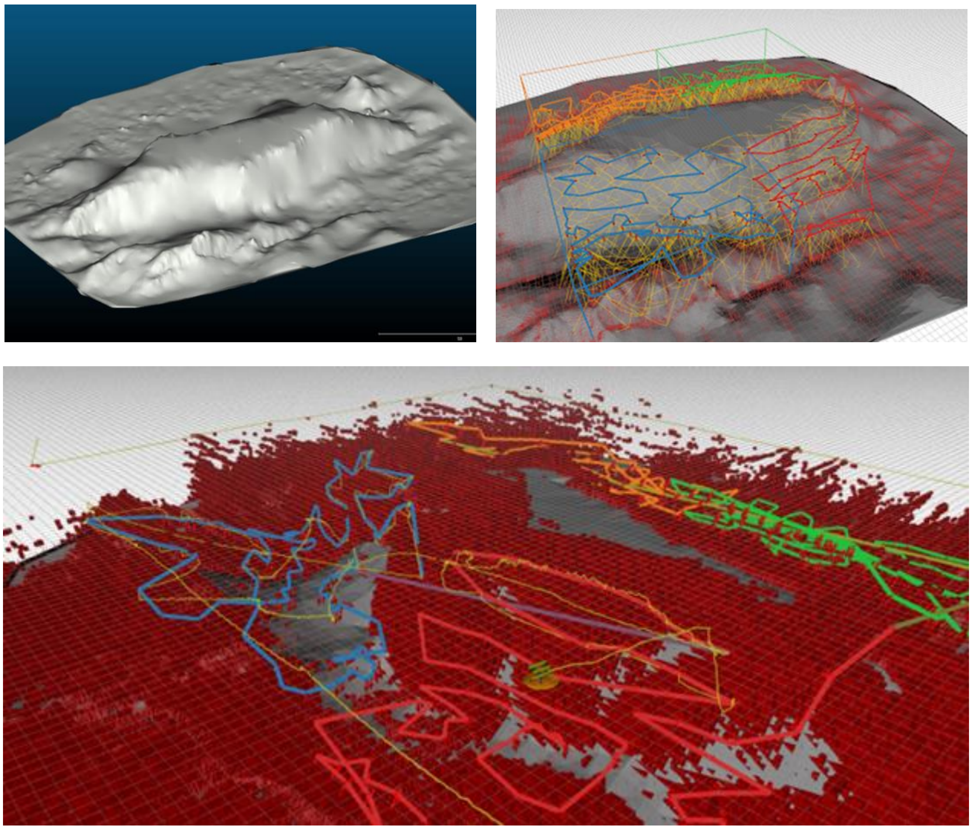

Figure 2-9: Top left: 3D model obtained during the initial mapping. Top right: Pre-planned trajectory to ensure full coverage. Bottom: Mapping and planning during the execution of the close-range inspection.

During a second round of experiments, the inspection of a breakwater structure was attempted using the same approach (see Figure 2-10). In this occasion, the AUV also managed to successfully complete the mission. The vehicle navigated at a few meters from the structure (see Figure 2-11) and was capable of acquiring images with enough detail to assess the state of the breakwater elements. After post-processing the data, it was possible to reconstruct the environment in the form of a 3d photomosaic (see Figure 2-12).

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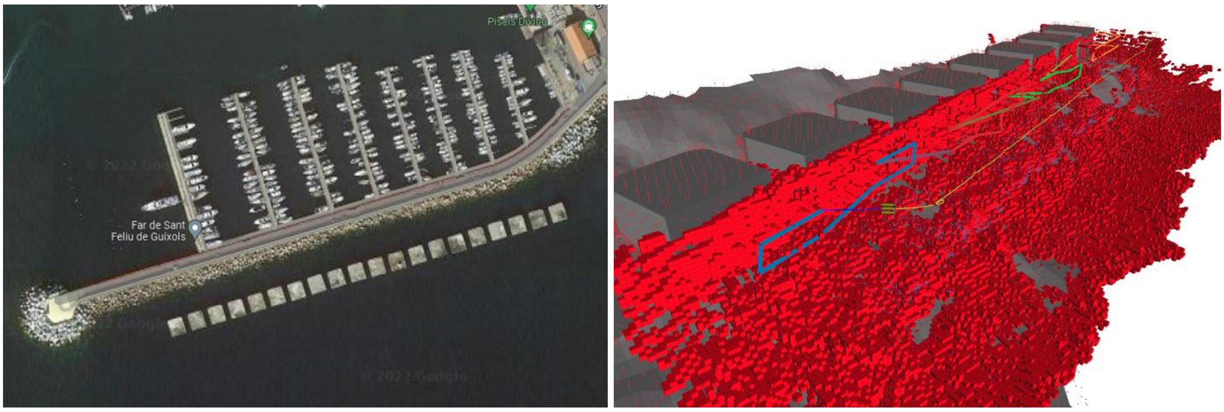

Figure 2-10: Left: Location of the breakwater. The mapping and planning taking place during the execution of the mission.

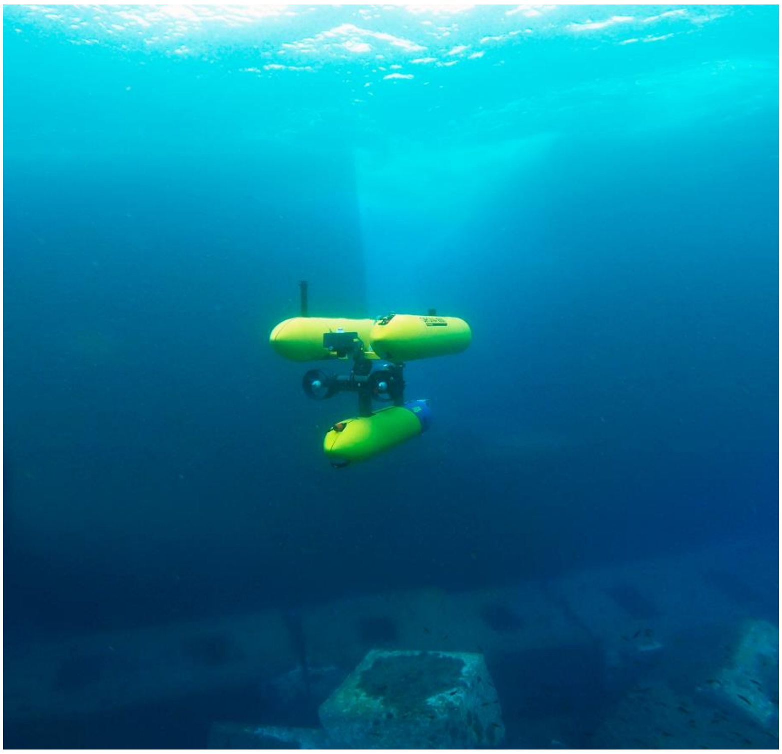

Figure 2-11: The Girona 1000 AUV with the optoacoustic payload performing an autonomous close range inspection of the submerged breakwater.

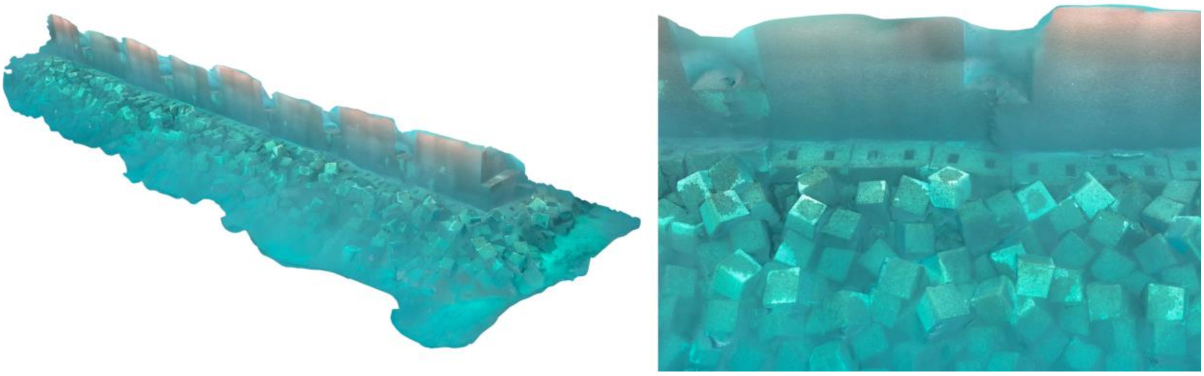

Figure 2-12: 3D photomosaic of the breakwater built from the optical data acquired during the autonomous inspection

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Task T3.5 “Tests for benchmarking technology”. This task started in month 29, and is still on its early stages.

2.3. WP4

WP4 Objectives: to develop an operations planning tool considering vessel response forecasting and performance model. The purpose of the tool is to support the wind farm operator during daily maintenance tasks; planning the support vessel visits to the wind farm with as safe and efficient operations as possible.

WP4 progress and achievements: Tasks T4.1 and T4.2 were ongoing. Three deliverables: D4.1, D4.2 and D4.3 “*Press releases about the Decision-making 1, 2 & 3*” where delivered. These press releases on the ATLANTIS consortium have been distributed to the offshore industry media. The coverage of the press releases has been proximately 450.000 potential readers (150.000 by twitter and 300.000 by website coverage). The press release had the main focus on the public awareness of the potential savings related to the robotic operations and the establishment of the ATLANTIS Test Centre.

Description of the main role of the partners:

The task T4.1 “*Operations planning tool for IMR robotics*”(led by ABB) has started and it is currently ongoing. The Octopus software can then supply an overview of the expected mission execution with respect to the expected weather and the specific responses of the vessel equipment. Octopus will collect the high resolution weather forecast for the mission and will calculate the each individual stage of the mission. This enables the user to optimize the operation and improve the anticipation on weather standby. The main target of the Octopus mission planner is increased safety and efficiency during planning and execution of offshore work. During the reported period, the initial development of the ATLANTIS operational planning tool has started. Initial user interface design and software architecture development is ongoing and industry stakeholders have been consulted for fine-tuning of the user interface and industry requirements. For the design process, the double diamond process is adapted. Design, functional requirements and stakeholder input is prepared for rapid prototyping and demonstration with a proof of concept. During this reporting period the software is under development. In the reporting period internal sub tasks have been completed. This enhances system interfacing (weather forecast) for importing local operation conditions. Furthermore the industry specific ‘offshore mission’ setup has been developed. This will be used for configuring robotic driven maintenance missions. When ready, the software will be implemented for the use in the ATLANTIS project, integrating the robotic limitations of the equipment of the other ATLANTIS stakeholders and the specific service vessel of the Atlantis offshore testbed will be analysed for hydrodynamic improvements. At the current stage the reporting features are under development for conversion of hydrodynamic result to operational windows.

Task T4.2 “*Data mining & Predictive maintenance*” is ongoing.

The focus of the task is to develop tools for windmill operation and maintenance (O&M) analytics. The analytics development follows the ATLANTIS project showcases and scenarios defined in WP2, meaning that the main interest is outside the windmill turbine internal power transmission line. In addition, the ATLANTIS Coastal Testbed, deployed in June 2022 in the harbour of Viana do Castelo, is used as a case for targeted analytics development. A virtualization layer, described in D2.7, brings together the data from robots, external measurements from the Coastal Testbed and the O&M analytics. A virtual

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representation of the Coastal Testbed allows for development of both short-term and long-term predictive maintenance analytics.

A specific scenario that is being targeted is automatic marine growth identification based on subsurface robotic visual inspection data. Marine growth cleaning is a crucial first step in inspection activities and marine growth identification is needed for planning the cleaning procedure. Another possible scenario based on visual inspection is the use of aerial drone inspection data for frame inspection to identify abnormalities based on data pattern recognition methods. Aerial inspection developments can be later targeted for real turbine rotor - blade and frame - wear and delamination fractures analytics. The visual data from robots (provided by **partners**) is available through an interface to the SCC and its database (provided by **SPACEAPPS**), where the robots upload their data after the inspection missions.

During the reporting period **VTT** has instrumented The Coastal Testbed with an external measurement system including accelerometers, a state of motion sensor, an anemometer, a wave buoy and cameras. Based on these measurements and a priori knowledge of the structure, its material properties and dimensions, a virtual representation of the Testbed can be made. This virtual representation is used e.g. for wave loading estimations for evaluating critical loadings at different locations of the Testbed. Both short (e.g. 3 hours) and long-term (whole lifetime) predictions for the loads and stresses affecting the structure can be made. Both frequency and time domain approaches are utilized. Simulations are also due to support operative criteria/limits analysis, and to estimate, based on the movements in different areas, the suitability for onboard operation and maintenance work. In addition, certain stochastics loading analytics are planned to be carried out for deterministic decision making, e.g. to support for the deployment of robots for further inspections.

The instrumentation was carried out in August/September 2022 by VTT personnel and by using VTT's measurement sensors and systems. The setup functions as an external DAQ system running separately on the Testbed edge 24/7. The measurement system is located both on the Coastal Testbed structure, its close vicinity and the pier. There are three 3D vibration acceleration sensors and one state of motion sensor on the floating Testbed structure that measure its movements. For wave monitoring, there is a camera and a wave buoy measurement unit. Wind direction and speed are measured from the Testbed. All the measurements except the data from the wave buoy are sampled simultaneously with separate DAQ units connected to a PC for data storage and measurement management, including remote access. The wave buoy data are synchronized with the rest of the data offline, based on time stamps. Applied sampling frequency depends on the measurements. At maximum, it is 100 Hz, which is suitable for structural and movement analysis. The data analysis and model development from the external data acquisition system at the Coastal Testbed is carried offline. First data samples from fall 2022 have been analysed to check the quality of the data. The state of motion sensor data shows inconsistencies. However, the accelerometer data can be used if the motion data shows to be unusable. One service visit to the site was done in late November 2022 to collect data, change batteries to the wave buoy, adjust the state of motion sensor measurement and to install an additional camera. The measurements started in the beginning of September and will continue at least until early 2023.

2.4.WP5

WP5 Objectives: To field test and demonstrate the showcases defined in WP1 and scenarios defined in WP2 in the Coastal and Offshore Testbeds of the ATLANTIS Test Center. In this way, the WP provides

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insights about the use of sophisticated robots to perform IMR operations in offshore wind farms at different TRLs and for multiple domains (e.g. aerial, surface and underwater).

WP5 progress and achievements: Four tasks were started during the reporting period: T5.1, T5.2, T5.4, and T5.5.

Description of the main role of the partners:

Task T5.1 "Data collection in operational conditions", led by PPF, started during the reporting period. In the short period since the start of this task, the selection of data to be collected is being undertaken. Additionally, the planning of the operations for the tasks 5.2 and 5.3 was done taking into account the potential data to be collected.

Task T5.2 "Demonstrations in near-real environment", led by ABB, Stated during the reporting period. From the start of this task, the planning of activities was undertaken, to ensure all ready technologies are able to be tested in the ATLANTIS Test Centre Coastal Test Bed until the end of the task. For the testing period of this summer, the activities were planned according to the needs of the partners.

Three testing campaigns were conducted in 2022 in the ATLANTIS Test Centre, during the months of July, September and November. The campaigns lasted from one to two weeks each, with all partners involved in the development of robotic technology participating (INESC TEC, ECA, RINA, UdG, and IQUA). The main objectives of these campaigns were the testing and validation of the technologies developed within ATLANTIS in the near-real environment provided by the ATLANTIS Test Centre Coastal Testbed. As an additional aim, was an initial attempt to perform offshore demonstration of some of the more mature technologies.

<u>First Testing Campaign</u>

The first campaign took place between the 18th and 29th of July (duration of two weeks) and had the participation of the team from INESC TEC, with three distinct robotic platforms: SENSE ASV, Nautilus ASV and RAVEN UAV (coupled with the NEST landing platform). SPACEAPPS was present to start the testing and integration of the interoperability library.

INESC TEC

In regard to the RAVEN UAV, the main objective of this testing campaign was to perform a precise landing maneuver of an UAV in a floating landing platform. To detect and locate NEST landing platform. The ArTuga marker, which is a multimodal marker developed within the project (patent pending), was place in the landing platform, while the heterogeneous perception system TriOPS was mounted on RAVEN UAV. Each individual TriOPS sensor was able to successfully detect the ArTuga marker, and using the developed algorithm, that information was fused to obtain a single and reliable localization. This allowed the RAVEN to land with both accuracy and precision. Multiple successful ground tests were performed that allowed to tune the algorithm. After that, landings of RAVEN on NEST in water were successfully performed, which allowed to validate the developed system, in its intended environment.

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Figure 2-13: Autonomous landing trial of the RAVEN UAV

For the Nautilus ASV, systems validation and testing was the main focus, as the vehicle was designed and built from scratch for these tests. This included the testing of the complete system architecture, as well as the localization, navigation and perception systems. After the complete and successful systems validation, the Nautilus ASV as used, in conjunction with the RAVEN UAV and NEST landing platform, to perform a coordinated autonomous landing and take off operation. The aim was to have the RAVEN perform landing and take-off operations autonomously to and from the NEST attached to the ASV, in a free-floating situation. In addition, the RAVEN, after landing was transported by using the ASV as a tow vehicle. The coordinated mission was fully successful.

Figure 2-14: Testing of the Nautilus ASV

The validations pertaining the SENSE ASV were focused on autonomous navigation, in particular of its new, the skill-based architecture. The tasks considered were navigation to a target point (go-to) and docking, both in an autonomous manner. These tasks were based on GPS positioning (with the use of LiDAR sensors to support the docking). During the testing campaign, significant development was made in the autonomous algorithms, particularly in the calibration of parameters related to navigation, that led to the successful validation of the go-to task.

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Figure 2-15: Autonomous Navigation test of the ZARCO ASV

Second Testing Campaign

The second campaign took place between the 12th and 16th of September (duration of one week), and had the participation of the teams from of INESC TEC and SPACEAPPS. INESC TEC participated with three distinct robotic platforms: SENSE ASV, Nautilus ASV and RAVEN UAV, mostly focused on preparations for the first attempt of going offshore. SPACEAPPS was focused on the integrations of robotic platforms with the ATLANTIS Supervisory Control Centre.

INESC TEC

With respect to the SENSE ASV, the objectives were to validate the improved autonomous navigation, that allows for multiple waypoints during navigation, and validate the hardware modifications performed after the first testing campaign to overcome the identified limitations for the docking. The validations were successfully performed.

SPACEAPPS

The main objective was the complete integration of the vehicles present at the ATLANTIS Test Centre, into the ATLANTIS SCC. For this testing campaign this included the SENSE and Nautilus ASVs, the RAVEN UAV and the Control Centre developed by the INESC TEC team. The integration of all vehicles was successfully performed and tested in both Testbeds (Coastal and Offshore).

Third Testing Campaign

The third campaign took place between the 7th and 18th of November (duration of two weeks) and had the participation of the teams from of ECA, RINA, IQUA, UdG and SPACEAPPS. ECA participated with the ROV Roving Bat. RINA participated with the DJI MATRICE M210 UAV and Fifish ASV. IQUA and UdG participated with the Girona 1000 and Sparus II AUVs. SPACEAPPS participated in order to conclude the integrations of robotic platforms with the ATLANTIS SCC.

ECA

The ECA Team was present in the ATLANTIS Test Centre Coastal Testbed on the first week for testing with their Hybrid ROV, the Roving Bat. These tests consisted of the first sea trials of the ROV, focused on navigation of the vehicle and the attachment to the floating structure. Due to the slope and lack of

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floatability of the floating structure, and, there were significant challenges in performing the attachment to the structure. In addition to these tests, integration and calibration of the MARESye technology with the Roving Bat, from INESC TEC was successfully performed. The trials were also the opportunity to finalize the link between the Roving Bat system and the SCC in order to allow the remote reception of images and the future interoperability. The manipulator arm was installed on the and functional during all the tests as well as the cleaning tool and the cathodic potential measurement probe. However, this equipment was not operational because the Roving Bat could not be placed correctly on a vertical structure. During these tests we also have used successfully the newly designed 8KW power converters installed on the Roving Bat and the new dedicated umbilical cable. Some pictures and video was recorded by a divers team allowing to show the Roving Bat in a real harbor environment.

Figure 2-16: a) Roving Bat launching and recovery b) Roving Bat in navigation mode

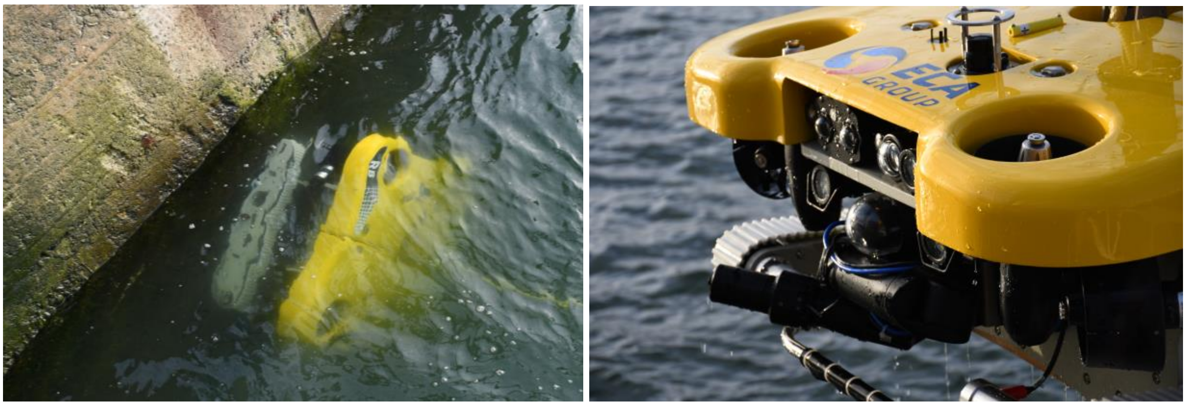

Figure 2-17: a) Roving Bat attempting landing on a wall of the harbour b) Camera MARESye on the Roving Bat

IQUA Robotics

The IQUA team was present in the ATLANTIS Test Centre Coastal Testbed on the first week of the November trials, performing tests with the Girona 1000 AUV (see Figure 2-18). The focus of the tests was the autonomous close-range navigation and inspection of the floating structure. The mapping of the structure was performed using the newly developed optoacoustic payload and algorithms that were already tested and validated during the experiments reported in task 3.4.

For this occasion, the multibeam sonar was installed on the pan & tilt in two different configurations, one scanning forward and another scanning sideways. The purpose of these configurations was to explore different strategies for the circumnavigation of the floating structure. During the experiments

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conducted on the site, the vehicle was able to navigate autonomously, and at close range of the structure, while simultaneously building and maintaining an occupancy map, and using it to feed the path-planning algorithm to avoid unexpected obstacles such as small buoys which were present on the site (see Figure 2-19 and Figure 2-20). Unfortunately, the poor water visibility during the period made it impossible to capture optical images with which to perform a reconstruction of the submerged section of the CALM buoy (see Figure 2-21).

During the trials, IQUA Robotics had also the opportunity to successfully test the integration of its vehicle with the SCC using the interoperability software developed by SPACEAPPS in task 2.5.

Figure 2-18: The Girona 1000 AUV with the optoacoustic payload performing an autonomous inspection of the CALM buoy.

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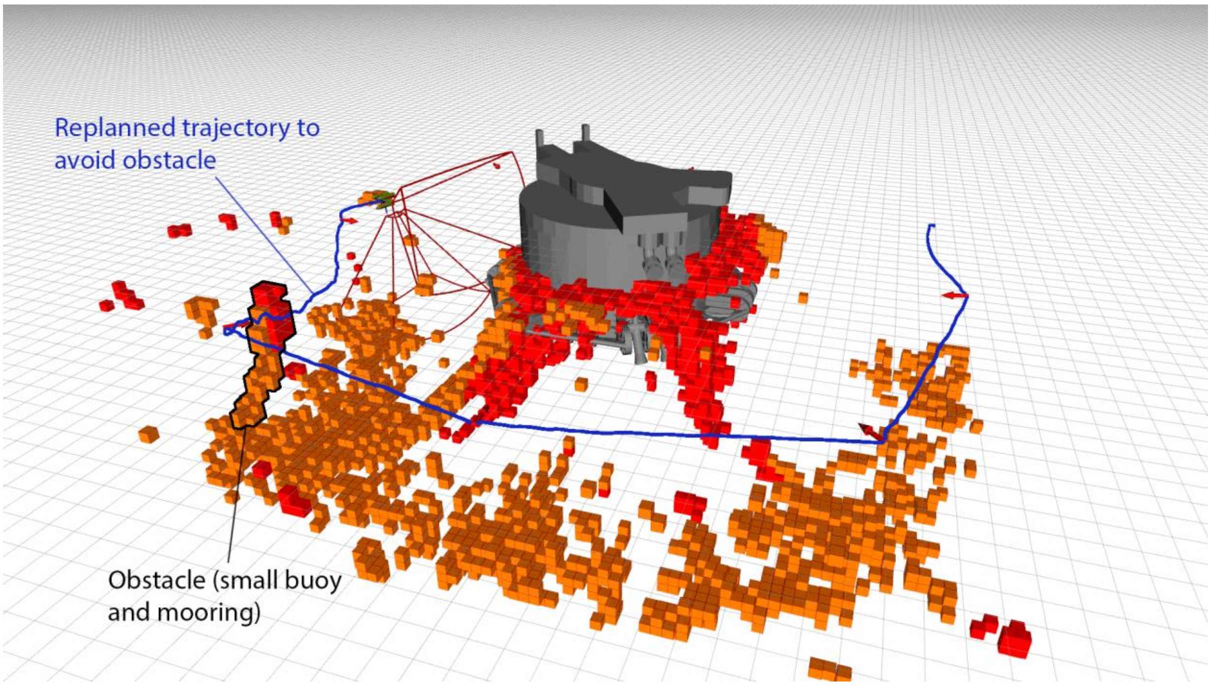

Figure 2-19: An obstacle was present in the inspection trajectory. Once detected in the map, the vehicle replanned the mission to follow a safe trajectory around it.

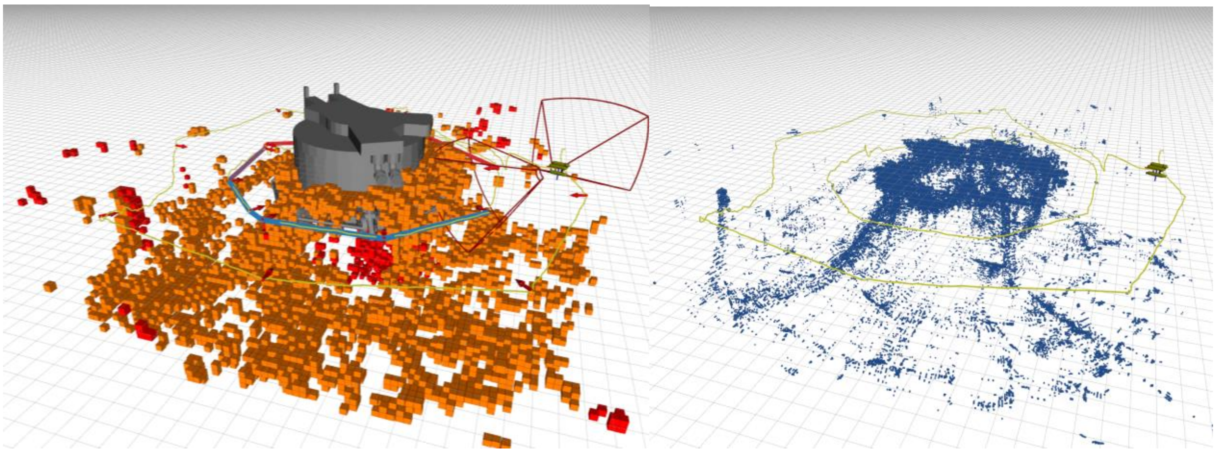

Figure 2-20: (Left) Occupancy map after completing the close range inspection. (Right) Cloud point from the acoustic sensor in which the CALM buoy and the moorings can be appreciated.

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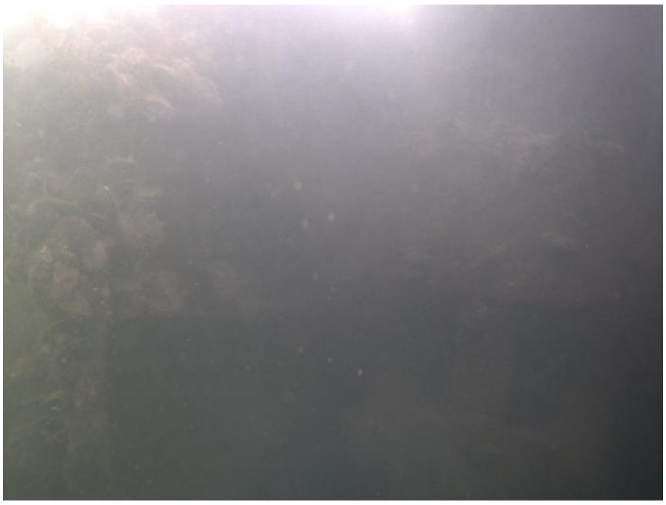

Figure 2-21: Visibility at less than one meter from the structure.

UdG

The UdG team was present in the ATLANTIS Test Centre Coastal Testbed on the first week in order to deploy and prepare the logistics for the experiments, and in the second week for testing. Performing test with the Girona 1000 and Sparus II AUV.

The objectives for the Sparus II AUV consisted of the autonomous survey and docking operation. The installation of the docking station was performed by divers, ensuring its correct deployment, during the first week, see Figure 2-22.

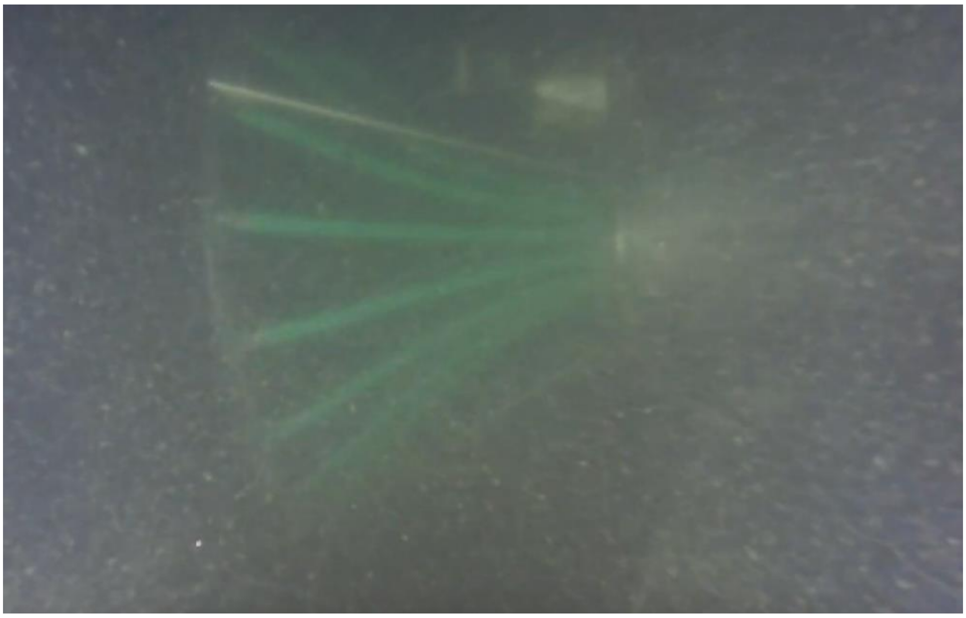

Figure 2-22: Docking Station deployed in the ATLANTIS Test Center Coastal Testbed

In the second week the experiments started. The first task was to calibrate the position of the Docking Station. After that, the first autonomous docking was developed successfully, obtaining consistent results.

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Once the autonomous docking process was achieved, it was tested and developed several surveys with the forward-looking sonar, obtaining the results of Figure 2-23.

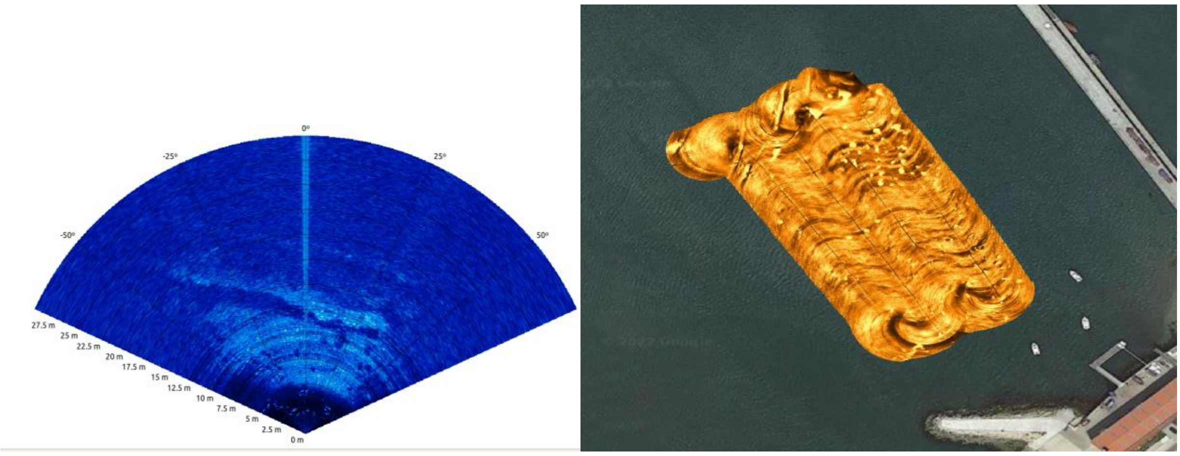

Figure 2-23: Representation of the results obtained with the forward looking sonar.

With both technologies tested, finally we developed the autonomous operation of survey with docking, see Figure 2-24.

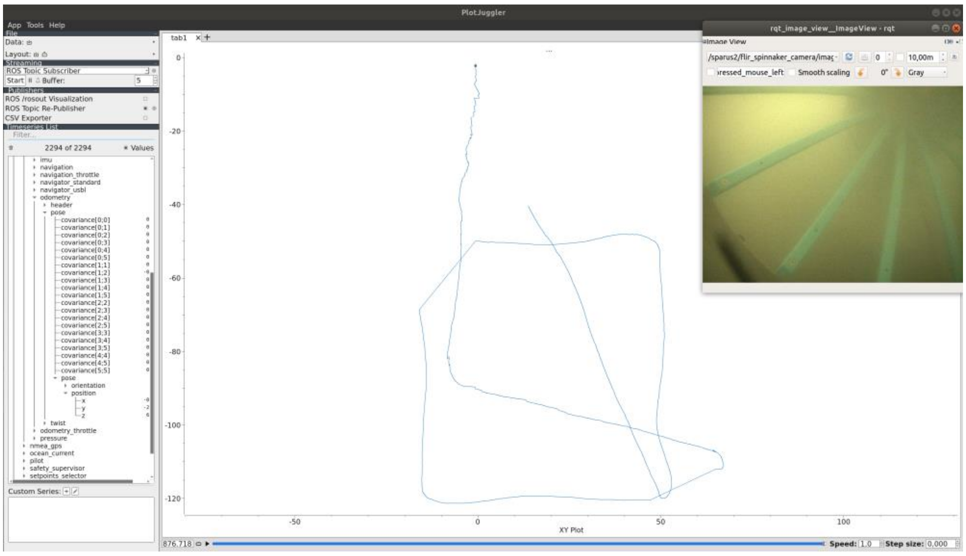

Figure 2-24: Representation of the full autonomous mission. An autonomous survey finalized with an autonomous docking.

The tests with the Girona 1000 AUV were focused on underwater manipulation and cathodic protection testing of the floating structure. Due to the sharing of the vehicle with IQUA, a payload change and buoyancy trimming was required. In a similar situation to ECA, the validation of this technology required the use of the pilot structure simulating the floating structure. However, the workspace limitations of the pilot structure, due to its insufficient submergence, and its significant tilt, prevented its utilization in the planned experiments. UdG has been forced to use a backup plan, which involved installing the testing panel developed for the CIRS test tank, on an underwater part of the pier, close to the pilot. Unfortunately, the installation method used by the divers and the environmental conditions lead to the detachment of the structure from the wall. It was attempted multiple times to fix the panel without success. The team has approached the panel using teleoperation and decided that it is too risky to

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perform the manipulation trials. The panel was oscillating with a significant amplitude, and even the magnetic docking attempts would surely result in the damage to the robot. Moreover, the whole experiment was designed for a fixed or very slowly moving structure, so the basic assumptions were not met.

Apart from manipulation, the UdG team has planned to test the laser scanning technology. Unfortunately, due to extremely low visibility conditions this technology had no chance of functioning, as can be seen in Figure 2-25. The first step before using the laser scanner is its calibration in the sea, which requires registering a series of images of a calibration plate from different distances. In the existing conditions it was not possible to perform the aforementioned calibration procedure.

Figure 2-25: Visibility conditions in the ATLATNIS Test Centre waters, close to installed test rig.

During these trials, telemetry data from Girona 1000 AUV as well as Sparus 2 AUV was send to SCC. Also it was possible to send SCC basic commands from the web APP to control the vehicles.

RINA

The RINA team was present in the ATLANTIS Test Centre Coastal Testbed on the second week of testing, performing tests with their Fifish ASV, and DJI MATRICE M210 UAV. The main objectives of the tests performed was the calibration of the systems and collection of data.

Using the UAV, the collection of images of the floating structure was performed. The inspection was planned using an aeronautical drone that supports 2,7K (Z30 Model) optics and thermographic sensors (DJI XT) to verify the condition, construction, and integrity of the structure through thermographic and visual analysis. All the sensors and systems were tested (optics and thermographic sensors, wind resistance and stability during flight operations, electromagnetic fields interference). During flight operations, the possibility of equipping the drone with an ultrasound sensor to keep seagulls and birds away was also evaluated. Test of Control signal (long distance ~7-8 km). Visual inspection and verification of the semi submergible structure was conducted. From the testing performed, it was identified that the major limitations of the operation was interference due to the presence of gulls, for which it is a potential solutions is the installation of ultrasonic bollards.

With regards to the ASV, the focus was the collection of data on the state of the seabed. The planned activity was an analysis of the seabed of the area surrounding the floating structure conducted with the

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help of a drone that mounts a sonar chip. This sonar with a continuous flow of frequencies from bottom to top allows the reading of the seabed and in association with bathymetric surveys allow to monitor the interference of the structure with the coastline. With the captured images it will be possible to monitor the development of benthic flora and fauna developed around the system to evaluate the possible impact/effect of the structure in the coastal environment. However, due to the adverse weather conditions and the poor visibility, the activity has been limited to the use of the sonar for depth characterization.

Lastly for the ROV, the focus was the capture of images of the submerged section of the floating structure. The purpose of the activity was to determine the state of the art of the structure especially the erosive state to which the material is subjected. However, in a similar manner to the ASV, due to the adverse weather conditions, the operation was limited.

SPACEAPPS

For the SPACEAPPS team, the objective was the conclusion of integration of the vehicles and robotic technologies belonging to the consortium, into the ATLANTIS SCC. For this testing campaign this included the ROVING BAT, the Girona 1000 and the SPARUS II. The integration of all vehicles was successfully performed and tested in the Coastal testbed.

Task T5.3 "Demonstrations in a real offshore wind farm", led by EDP, started during the report period. Although in an early stage of the task, many tasks and diligence related to the preparation of the offshore activities have taken place. Among these tasks, it should be highlighted the preparation of the required meta statements to conduct the offshore activities and the planning and coordination of the work with Windplus to streamline the demonstration in WFA.

One attempt to perform activities offshore was performed, with both the Nautilus ASV and RAVEN UAV. The objectives of this operation were the validation of the vehicles deployment methodology and the collection of early data pertaining to the offshore wind turbines. The Nautilus ASV aimed to collect data using both visual cameras, a LiDAR sensor and an underwater multibeam sonar, for multidomain mapping. The RAVEN UAV aimed to collect data of the offshore wind turbines, using the TriOPS sensor payload mounted on RAVEN, to validate and reconstruct the model. No data collection was performed in the offshore tests due to issues in the testing and validation of the deployment methodologies, somewhat associated to the sea state conditions. A complete revision of the deployment methodologies for the different robotic platforms (considering also the platforms from the partners not involved in this test) is underway, to ensure no similar issues arise in the next offshore testing.

Task T5.4 "Regulatory framework for new O&M methodologies", led by RINA, started at M27. Preliminary materials have been collected for the regulatory framework, including internal and customer procedures. Test Center activities will be analysed for guideline development.

Task T5.5 "Risk assessment and management for O&M activities using Robots", led by INESC TEC, started during the reporting period, and is at its early stages. A preliminary assessment of the potential risks of the use of robotics in O&M is undergoing. This assessment will be complemented with data collected from the tests and demonstrations that will take place in M31 and M33.

This project has received funding from the European Union's Horizon 2020 research and innovation programme, under the Grant Agreement no. 871571.

2.5.WP6

WP6 Objectives: to understand the long-term and industry-wide effects of the ATLANTIS Test Center, which is done by assessing how the solutions developed through ATLANTIS will impact the European offshore wind industry and, more specifically, the Operation and Maintenance strategies and costs. Moreover, WP6 aims at promoting the engagement of stakeholders at different levels: for industrial players by studying the most appropriate stakeholders to develop ATLANTIS-enabled solutions, for SMEs in the O&M robotics business by providing a free-of-charge option to test and validate their technologies, for the broader community by ensuring that the ATLANTIS Test Center is a story of acceptance and support from all stakeholders impacted.

WP6 progress and achievements: Tasks T6.1 and T6.2 continued during this reporting period with deliverable D6.2 submitted at M23. Task T6.4 was finished and resulted in deliverable D6.4, submitted at M19. T6.5 was started during the reporting period.

Description of the main role of the partners:

Task T6.1 "Assessment of the impact of solutions on wind farm O&M Strategy and cost structure" started on M16 and partners (EDP, PPF and RINA) have already developed a preliminary assessment of the offshore industry's Operation and Maintenance activities and strategies. For this purpose, the benchmarking used for T6.2 and T6.4 was used to compile and assess the current state of play and the most pressing challenges of the industry. The challenges are also taking into account the recent offshore generation targets which will impact the industry and its costs.

Task T6.2 "Integration of solutions in the offshore wind supply chain" is ongoing and produced its first deliverable D6.2 "Offshore wind O&M Supply chain needs and opportunities". The activity in the task started with the consolidation of the ATLANTIS showcases to be used in the analysis and their high-level requirements (defined in WP1) and technical specifications and boundaries (defined in WP2). In particular, the goal of this task is to identify timings and resources allocated to current O&M practices and their drawbacks, pinpointing the benefits and the areas where ATLANTIS solutions can play an important role. In this sense, a comparison between the costs of the scenarios/tasks addressed within ATLANTIS, performed by robots or human operators, was carried out for both planned and unplanned activities. To perform this analysis, information about costs of the human resources, logistics and equipment involved in the activities has been retrieved from publicly available reports and database and fine-tuned with the direct experience of the end-users (EDP and PPF). Moreover, a literature review of different methodologies commonly adopted in the scientific community to compute the cost of O&M activities in offshore wind farms was performed. Out of this study, the architecture of the O&M tool was defined and a first version of the O&M tool, to compute the costs of the specific mission, was developed and implemented in Python. A thorough screening of costs (for logistics, manpower, and equipment) was carried out and it led to the creation of an "internal database" used alongside the developed tool. Furthermore, following the outcome of WP1, the expectations and needs of end-users related to O&M were identified and by comparing them with the results obtained from the cost/timing comparison of the two alternatives, the possible area and benefits that ATLANTIS might bring were pointed out in line with the task's ultimate goal. Moreover, the second deliverable of the task is being prepared, where the combination of different tasks and more complex scenarios will be analysed. A revision of the costs assessment (considering also different projects in the short and mid-term) is being conducted.

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Task 6.4 "*Business Cases for the different stakeholders*" was completed during the reporting period. This task dealt with the layout and the validation of a set of business cases addressing different stakeholders in the offshore wind industry. The purpose of the proposed business case methodology was to point out the benefits that ATLANTIS could bring to the identified stakeholders, compared to the traditional inspection procedures. A global overview of offshore wind installations (with a focus on the European context and its latest trends) was performed to delineate the environment where ATLANTIS is called to operate. The second step was conducting a segmentation - and subsequent analysis - of the offshore wind sector-major stakeholders (Technology providers, Operators, Owners, Investors, IMR Services providers and Offshore logistics service providers) to better understand the *modus operandi* of each party. A business modelling methodology was chosen, after performing a literature review, to build a business case for ATLANTIS solutions, for each of the involved stakeholders. This methodology analyses for each stakeholder, their needs and objectives, and performs a cost-benefit analysis for the two alternatives assessed in this case, i.e. O&M activities performed by human operators or robots. A risk assessment completed this exercise. Afterwards, a techno-economic tool developed in Python was implemented. This tool was used to compute financial indicators of interest for some stakeholders (Owners and Investors), namely the IRR (Internal Rate of Return), the NPV (Net Present Value) and the Payback period. The developed tool was used also to compute other metrics for other stakeholders (Operators and IMR players). The results obtained from the computational analysis made it easy to compare both alternatives for each stakeholder, analysing their strengths and weaknesses. Finally, RINA replicated the same exercise for a specific use case of the O&G (Oil & Gas) industry, i.e. 'Cathodic protection system for steel jacket offshore platforms'.

This task, which was led by EDP NEW had the important contributions of: RINA, which developed the specific calculus and business case for a specific scenario of the Oil & Gas industry, but also contributed for the assessment of the business drivers and barriers of each group of stakeholders as well as the identification of the effects, costs and risks in the conventional O&M procedures and the robotic-based one; INESCTEC contributed towards the business case for offshore logistics for service providers. The business drivers were identified and used to derive the objectives and perform the analysis of effects, costs and risks, for both human and robot base interventions; PPI assisted in the overall assessment of the effects, costs and risks, with special focus on the business cases for the technology providers and IMR services providers.

Task T6.5 "Integration in the Industry Ecosystem & Stakeholder Engagement" is ongoing and delayed. Following the work performed in work package 3, engagement with (mostly) local stakeholders from Viana do Castelo has been conducted. Engaged stakeholders included Polytechnic Institute of Viana do Castelo, a shipyard, a port authority, and a blade manufacturer. Several meetings were organized with these stakeholders (some of these meetings generated press releases or news articles). In fact, INESC TEC is actively supporting a new stakeholder's ecosystem that is being built on Viana do Castelo focused on offshore renewable energy and marine robotics. Additionally, contacts have been established with international stakeholders in order to increase their engagement either through testing or demonstration of robotic technologies. The project also participated in multiple events to increase the acceptance of the ATLANTIS Test Centre within the local and robotics community, and organised visits with key end-users to the Test Centre. The task was expected to conclude in M32. However, as there are still events planned by the project to increase acceptance of the test centre and create an ecosystem around it, the task is still ongoing.

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2.6. WP7

WP7 Objectives: to engage with wider stakeholders, to disseminate and communicate the project mission, progress and results. The consortium will perform an analysis of the potential impact of the ATLANTIS developments. Communication strategy is developed for exploiting the outcomes of the project during and beyond the project lifetime.

WP7 progress and achievements: All four tasks continued during the reporting period and two deliverables were submitted. The first submitted deliverable was D7.8 - *ATLANTIS IPR Manual* as part of the task T7.2 "*Exploitation strategy & IPR management*". The second submitted deliverable D7.3 - *Second dissemination strategy and report* as part of the dissemination and communication activities task T7.3.

Description of the main role of the partners:

Task T7.1 "Social, economic and environmental impact analysis", led by RINA, is ongoing. No deliverables were submitted during the reporting period. The impact analysis work focuses on regulatory aspects, including environmental impact, and analysing issues in acceptability of robots for industrial stakeholders in the offshore sector.

In Task T7.2 "Exploitation strategy & IPR management", led by RINA, D7.8 "ATLANTIS IPR Manual" was submitted at the beginning of the reporting period. The document provides strategies and recommendations for assuring and protecting the IPR of partners produced within the ATLANTIS project. After that, the activities were devoted to the continuous update of the IP competitive scenario, in order to map current alternative solutions provided/patented by competitors and identify the best way to exploit project results.

Task T7.3 "Dissemination and Communication activities" is led by VTT but includes the efforts of all partners. During M19-M36 the focus of these activities has been on sharing the ATLANTIS showcases to be demonstrated at the Test Centre, the launch of the Test Centre itself to target groups and stakeholder engagement as a part of ecosystem building. The full list of events for M19-M36 is provided in Section 3.3. The showcases and the Test Centre have been shared in key events for the offshore wind and robotic industries, through videos shared online, and via professional media publications. Robotic technology developments have been published in scientific journals and intelligent service development has been shared via press releases. The dissemination and communication strategy and report has also been updated with current achievements and more detailed plans for the remaining project duration with a focus on engaging the stakeholders by sharing the showcase demonstrations and robotic technology validations that take place at the ATLANTIS Test Center. Four more scenario videos have been prepared and the updated ATLANTIS Test Center and Open Call launch videos have been shared and promoted via the project social media channels (ATLANTIS H2020 Project LinkedIn and Twitter accounts) and they have attracted new followers in the academia and in the industry. In particular, the Test Center has attracted interest in robotic developers both in and outside the marine I&M robotics sector. The social media channels have also been used to inform stakeholder groups of published articles and press releases. The project website provides links to these where possible. The list of publications is given below. A total of 14 publications have been published in scientific and professional journals and online media. Public deliverables are also provided through the website.

The "*Second dissemination strategy and report*" (D7.3) was submitted at M30. Regular WP7 meetings covering in particular T7.3 activities were held during the reporting period.

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Table 2-1 – Scientific Journals and Online Media Articles

#	Title	Contributing partners	State
1	"Modular Multi-Domain Aware Autonomous Surface Vehicle for Inspection," in IEEE Access, vol. 10, pp. 113355-113375, 2022, doi: 10.1109/ACCESS.2022.3217504, by D. F. Campos, A. Matos and A. M. Pinto,	INESC TEC	Published scientific journal article
2	"Multi-criteria metric to evaluate motion planners for underwater intervention", in Auton Robot (2022). https://doi.org/10.1007/s10514-022-10060-x, by Silva, R., Matos, A. & Pinto, A.M.	INESC TEC	Published scientific journal article
3	"A Practical Survey on Visual Odometry for Autonomous Driving in Challenging Scenarios and Conditions", in IEEE Access, vol. 10, pp. 72182-72205, 2022, doi: 10.1109/ACCESS.2022.3188990, by L. R. Agostinho, N. M. Ricardo, M. I. Pereira, A. Hiolle and A. M. Pinto	INESC TEC	Published scientific journal article
4	"Application of a Design for Excellence Methodology for a Wireless Charger Housing in Underwater Environments", in Machines 2022, 10, 232. https://doi.org/10.3390/machines10040232., by P. Pereira, R. Campilho, A.M. Pinto	INESC TEC	Published scientific journal article
5	"Linewise Non-Rigid Point Cloud Registration," in IEEE Robotics and Automation Letters, vol. 7, no. 3, pp. 7044-7051, July 2022, doi: 10.1109/LRA.2022.3180038, by M. Castillón, P. Ridao, R. Siegwart and C. Cadena	UdG	Published scientific journal article
6	"Underwater 3D Scanner to Counteract Refraction: Calibration and Experimental Results," in IEEE/ASME Transactions on Mechatronics, doi: 10.1109/TMECH.2022.3170504, by M. Castillón, J. Forest and P. Ridao	UdG	Published scientific journal article
7	"Multi-domain inspection of offshore wind farms using an autonomous surface vehicle", in SN Appl. Sci. 3, 455 (2021). https://doi.org/10.1007/s42452-021-04451-5, by Campos, D.F., Matos, A. & Pinto, A.M.	INESC TEC	Published scientific journal article
8	"Underwater 3D Scanner Model Using a Biaxial MEMS Mirror," in IEEE Access, vol. 9, pp. 50231-50243, 2021, doi: 10.1109/ACCESS.2021.3069189, by M. Castillón, A. Palomer, J. Forest and P. Ridao	UdG	Published scientific journal article
9	"Docking of Non-Holonomic AUVs in Presence of Ocean Currents: A Comparative Survey," in IEEE Access, vol. 9, pp. 86607-86631, 2021, doi: 10.1109/ACCESS.2021.3083883, by J. Esteba, P. Cieślak, N. Palomeras and P. Ridao,	UdG	Published scientific journal article
10	"Advancing Autonomous Surface Vehicles: A 3D Perception System for the Recognition and Assessment of Docking-Based Structures," in IEEE Access, vol. 9, pp. 53030-53045, 2021, doi: 10.1109/ACCESS.2021.3070694, by M. I. Pereira, R. M. Claro, P. N. Leite and A. M. Pinto,	INESC TEC	Published scientific journal article
11	"ATLANTIS: Shaping future robotised O&M in Offshore Wind", in Hydrolink, vol. 3, 2021, by S. Langiano, C. Verrecchia, M. Marques, J. Formiga	EDP CNET	Published professional journal article
12	Overcoming rough seas hurdle in offshore wind farm maintenance @ https://cordis.europa.eu/article/id/430428-overcoming-rough-seas-hurdle-in-offshore-wind-farm-maintenance		Online media article
13	The man from ATLANTIS: driving the offshore wind power transformation @ https://new.abb.com/news/detail/81426/the-man-from-atlantis-driving-the-offshore-wind-power-		Online media article

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	transformation		
14	Atlantis H2020 European Project: ECA GROUP modernises its hybrid ROV for inspection and maintenance of offshore wind turbines @ https://www.ecagroup.com/en/business/atlantis-h2020-european-project-eca-group-modernises-its-hybrid-rov-for-inspection-and-maintenance-of-offshore-wind-turbines		Online media article

Task T7.4 “Data management plan” led by INESC is ongoing. During the reporting period constant monitoring of the activities of ATLANTIS was performed, ensuring any and all data generated is dealt with in accordance with the Data management manual, presented during the previous reporting period.

2.7.WP8 & WP9

WP8 Objectives: to preserve an adequate administrative financial and management structure. Moreover, this work package aims to develop mitigation strategies to risks (e.g., COVID19) and to evaluate their implications on activities planned and conducted within ATLANTIS framework.

WP8 progress and achievements: The work package 8 is consisted by 3 tasks:

1. Project management;
2. Quality assurance;
3. Technical management.

The work carried out in WP8 for the period of M19 to M36 includes: the communication with the EC, the organization of Consortium meetings, Consortium video conferences, the internal communication and coordination regarding technical and financial issues as well as, the quality review of deliverables and internal progress report.

The responsibility of the work package 8 and 9 is of INESC TEC (project coordinator), which has been supported by the Project Management Team and Project Coordination Board.

During this reporting period, three deliverables were submitted, D8.3 “*Second publishable report*”, and D8.9 “*Second internal report*”, and D8.3 “*Final publishable report*” (this document).

Description of the main role of the partners:

Task T8.1 “Project management” ensures that all partners are working towards the same objectives by maintaining a clear vision for the ATLANTIS project through a concrete set of guidelines.

The task aims to coordinate the partner’s work and analyse their dependency to on-going/forthcoming activities as well as, the expected impact for the achievement of milestones or deliverables, as described in the Grant Agreement. Moreover, the task manages the alignment of this action with other important events or initiatives across Europe to strengthen coordination and synergies among their coordinators (e.g., PILOTING H2020 project), which have been continuously implemented. INESC TEC has managed regulatory/legal, administrative and budgetary issues in close coordination with the Consortium, the EC and the project coordinator. Management of progress, technical and financial reporting is continuously implemented.

The document repository and technical progress is managed by a project management system (Intranet) from INESC TEC, which is being used for depositing files related to deliverables produced within

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ATLANTIS, risk management, IPR management and minutes of meetings as well as, to get the project schedule, track the progress and responsibilities for each person/partner and to follow up the execution status of potential contingency plans. The project management manual presents more details about this systems and management methodology.

Task T8.2 “Quality assurance”. UdG as Quality Manager controls the quality of the generated deliverables to ensure their conformance with the adapted templates, readability, clarity of information, proper formatting, referencing of external sources, captioning of images and tables. UdG has designed the aforementioned templates to ensure uniformity of the generated documents.

Task T8.3 “Technical management” is led by VTT as the Technical Manager. The Technical Manager supervises the workflow in the different work packages and monitors risks. Effective risk management requires an informed understanding of the work conducted in each work package. The whole Consortium is in regular contact via email and bi-weekly virtual meetings and, in case of communication between the single partners via email, the Project Coordinator is always in copy. The Project Coordinator attends ad-hoc virtual meetings between a part of the Consortium regarding special task or urgent topics. VTT has managed technical issues in close coordination with the Consortium. Management of technical progress, external and ethical risks is continuously implemented. During this period, D8.9 “*Second internal report*” gathering project achievements from the period M19-M30 and reporting the use of resources was submitted at M30.

3. Project progress report

3.1. Deliverables and Milestones

WP2

Table 3-1: Deliverables and Milestones submitted in WP2 during M19-M36

No	Title	Description	Lead Benef.	Date Day & Month	Status
D2.4	Modification of Robotic Systems	A report describing the list of changes that were performed to different robotic units namely: ROVIN BAT, SPARUS II AUV, GIRONA 500, TriMARES and EVA. The report includes a description of the major features that must be introduced in those vehicles for O&M activities and to meet some of the requirements that were established by the stakeholders of the offshore energy sector.	IQUA	*31, March, 2022* *Delayed*	**Submitted**
D2.5	Supervisory Control Centre	A report describing the adaptations made to the Supervisory Control Center (SCC) in terms of the visual interfaces for IMR and	SPACEAPPS	*30, June, 2022* *On time*	**Submitted**

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		decision making features for human operators supervising the mission. This report presents a SCC that should be deployed onshore and able to manage robotic assets for IMR of offshore wind farms.			
D2.6	Communication links and interfaces for interoperability	A report presenting the middleware that can be used by institutions or companies to deploy their heterogeneous (aerial and marine) robots in the ATLANTIS pilot site. It also describes the communication links that will be made available in pilot site (in both Costal and Offshore Testbed). This report will be a relevant document for describing how the functional interoperability is assured between the (infrastructure of) ATLANTIS pilot site and potential mobile robots featured for IMR activities.	SPACEAPPS	*31, March, 2022* *On time*	**Submitted**
D2.7	Virtualization layer for robotics	A document presenting the virtualization of the physical assets though an IoT infrastructure/systems to act as an abstraction layer to facilitate the integration of heterogeneous robots, sensors and actuators from different suppliers. This document will present the cloud database as well as the necessary middleware (or a hardware module that may be installed in each physical asset) to make possible to virtualize the ATLANTIS pilot site (with special focus on the Coastal Testbed).	VTT	*31, August, 2022* *On time*	**Submitted**
M2.2	Interoperability between robotic systems achieved	Success on a preliminary test field, using two robotic vehicles	SPACEAPPS	*31, March, 2022* *On time*	**Achieved**

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WP3

Table 3-2: Deliverables and Milestones submitted in WP3 during M19-M36

No	Title	Description	Lead Benef.	Date Day & Month	Status
D3.1	The Floating Structure System	A document describing the technical aspects for a floating structure system (FSS) will be presented. This document intends to specify the FSS that will be installed in the Coastal Testbed - aims to simulate the near-real conditions for the IMR operations of an offshore wind farm. A preliminary version of this document may be considered as an annex for the international call that should be launched (at an early stage of T3.1) for the fabrication of such structure (…)	INESC	*31, March, 2022* *On time*	**Submitted**
D3.2	IT Systems and SCC	Type: Technical Report A document reporting the results obtained from the deployment of the Supervisory Control Center that may be interlinked with an existing wind farm monitoring infrastructure. Moreover, this report will include the tests that will be conducted for validating the communication link, interoperability and the data exchange mechanism between robots, SCC and legacy wind farm systems.	SPACEAPPs	*31 Oct 2022* *On time*	**Submitted**
M3.1	Floating system structure designed and international contract launched	An international contract with conditions and terms specified.	INESC	30, September, 2021 *Delayed*	**Achieved**
M3.2	Coastal Testbed deployed	Physical floating structure installed on a location in Portugal	INESC	*30, May, 2022* *Delayed*	**Achieved**
M3.3	Cyber-physical assets integrated on the Test Center	Successful validation of at least 2 robots integrated in ATLANTIS	UdG	*31, Jan, 2023* *In advance*	**Achieved**

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WP4

Table 3-3: Deliverables and Milestones submitted in WP4 during M19-M36

No	Title	Description	Lead Benef.	Date Day & Month	Status
D4.3	Press releases about the Decision-making 3	A document containing the 3rd press release about the operations planning tool for IMR robotics.	ABB	*30, June, 2022* *On time*	**Submitted**
D4.4	Lectures programme for training	Type: Technical Report A set of lecture notes will be presented in a technical document describing a full course aiming to teach potential users of the ATLANTIS pilot site. This document will aggregate information of some technical reports that were previously obtained, e.g., D1.2, D2.2, D2.6, D3.2 and D3.3.	UdG	*30 Nov 2022* *Delayed*	**Delayed**
MS8	Data collected from Coastal Testbed	Successful acquisition of data from a UAV	VTT	*30, September 2022* *On time*	**Achieved**

WP5

No deliverables were submitted, and no milestones were achieved in WP5 during the reporting period. One deliverable (D5.1) was expected but is delayed since improvements need to be conducted for deploying robotic platform offshore.

WP6

Table 3-4: Deliverables and Milestones submitted in WP6 during M19-M36

No	Title	Description	Lead Benef.	Date Day & Month	Status
D6.2	Offshore wind O&M Supply chain needs and opportunities	A document describing how the technological solutions validated/demonstrated in ATLANTIS can be integrated the offshore wind supply chain – by identifying the bottlenecks, constraints and opportunities for that robotic-based IMR solutions.	EDP	*30, November, 2021* *Delayed*	**Submitted**
D6.4	Assessment of Business Cases for the ATLANTIS	Technical report. The validation of business cases of the ATLANTIS infrastructure will be presented in this technical	EDP	*31, July, 2021* *On time*	**Submitted**

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	stakeholders: financial and strategic considerations for the major stakeholders	report. A Cost-Benefit analysis contemplating several stakeholders will support a techno-economic model for ATLANTIS.			
D6.5	Report on the actions undertaken to ensure the wide acceptance of ATLANTIS	Type: Technical report A list of actions undertaken to assure the integration and a wide acceptance of ATLANTIS in the industry ecosystem at European and regional level will be explained in this report.	INESC	*31st of August of 2022*	**Delayed**

WP7

Table 3-5: Deliverables and Milestones submitted in WP7 during M19-M36

No	Title	Description	Lead Benef.	Date Day & Month	Status
D7.3	Second dissemination strategy and report	The second report containing a summary of the dissemination activities enrolled by the ATLANTIS project. This report will also update the dissemination roadmap for the most significant events that were planned for the project.	INESC	*30, June, 2022* *On time*	**Submitted**
D7.8	ATLANTIS IPR manual	Strategies and recommendations for assuring and protecting the IPR of partners that produced relevant outcomes within the ATLANTIS project are described in this document.	RINA	*31, August, 2021* *On time*	**Submitted**

WP8

Table 3-6: Deliverables and Milestones submitted in WP8 during M19-M36

No	Title	Description	Lead Benef.	Date Day & Month	Status
D8.3	Second publishable report	A report describing the activities that were conducted during the M13 to M24, which include the technical and non-technical aspects of the project, the achievement of milestones, potential deviations to the schedule/plan, envisioned contingency actions and the	INESC	*31, December, 2021* *On time*	**Submitted**

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		update of the list of critical risks.			
D8.9	Second Internal report	A document providing a follow up for technical and scientific aspects of all WPs, including the actions/outcomes that were planned, executed or changed.	VTT	*30, June, 2022* *On time*	**Submitted**
D8.4	Final Publishable report	Type: Document The final report of the project describing the activities that were conducted during the M15 to M36, which include the technical and non-technical aspects of the project, the achievement of milestones, potential deviations to the schedule/plan, envisioned contingency actions and the update of the list of critical risks.	INESC	*31 Dec 2022* *On time*	**Submitted**

3.2.Project meetings

WP2

Table 3-7: List of meetings of WP2 during the reporting period

Date	Place	Meeting	Comments
02-07-2021	Online	Adaptation of Robotic Platforms for O&M activities & IT systems for the Platform	Slides: ATLS_Technical/ATLS_WP2/WP meetings/WP2_ATLANTIS_2ndJuly_Meeting.pdf
15-07-2021	Online	Workshop: Interfaces for interoperability	Slides: ATLS_Technical/ATLS_WP2/WP_meetings/WP2_ATLANTIS_INTEROP_WORKSHOP_15th_July.pdf
09-09-2021	Online	Platform interfaces	Slides: ATLS_Technical/ATLS_WP2/WP_meetings/WP2_ATLANTIS_9thSeptember_Platform Interfaces.pdf
20-09-2021	Online	Workshop: Interfaces for interoperability	Slides: ATLS_Technical/ATLS_WP2/WP_meetings/WP2_ATLANTIS_INTEROP_WORKSHOP_20th_September.pdf
01-	Online	Adaptation	Slides:

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10-2021	e	of Robotic Platforms for O&M activities & IT systems for the Platform	ATLS_Technical/ATLS_WP2/WP_meetings/WP2_ATLANTIS_1stOctober_Meeting.pdf
12-11-2021	Online	Adaptation of Robotic Platforms for O&M activities & IT systems for the Platform	Slides: ATLS_Technical/ATLS_WP2/WP_meetings/WP2_ATLANTIS_12November_Meeting.pdf

WP3

Table 3-8: List of meetings of WP3 during the reporting period

Date	Place	Meeting	Comments
16-07-2021	Virtual meeting	Status report	
30-07-2021	Virtual meeting	Status report	
03-09-2021	Virtual meeting	Status report	
15-10-2021	Virtual meeting	Status report	
27-10-2021	Viana do Castelo Sailing Club	Negotiate office rental near the Coastal Testbed	
29-10-2021	Virtual meeting	Status report	
12-11-2021	Virtual meeting	Status report	
26-11-2021	Virtual meeting	Status report	
10-12-2021	Virtual meeting	Status report	

The subjects related to WP3 were combined in the same meetings of WP8.

WP4

Table 3-9: List of meetings of WP4 during the reporting period

Date	Place	Meeting	Comments
06-10-2011	Online	Marine growth data Workshop	Formulation of inspection data collection procedure related to marine growth
29-10-2021	online	Progress presentation (VTT) 4.2 for Atlantis stakeholders.	
26-11-2021	online	Progress reporting 4.1 for Atlantis (ABB) stakeholders.	
18-02-2022	online	Progress reporting 4.1 for Atlantis (ABB) stakeholders.	All participants
04-03-2022	online	Progress reporting and software Demo 4.1 for Atlantis (ABB) stakeholders.	All participants
22-04-2022	online	Progress reporting and software Demo 4.1	All Participants

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		for Atlantis (ABB) stakeholders.	
12-05-2022	online	Demo meeting with Windplus	Windplus operation team attendance

WP5

Table 3-10: List of meetings of WP5 during the reporting period

Date	Place	Meeting	Comments
08-02-2022	Virtual	Meeting to discuss access to the WFA	With Windplus
07-03-2022	Virtual	Meeting to discuss the Method statements	
13-04-2022	Virtual	Meeting to discuss testing in WFA	With WindPlus
19-04-2022	Virtual	Operation planning meeting	
11-05-2022	Virtual	September tests meeting	
27-05-2022	Virtual	Meeting to discuss training for offshore	
23-06-2022	Virtual	Meeting to discuss installation of measurement system	
29-06-2022	Virtual	Meeting to discuss installation of measurement system	
13-07-2022	Virtual	Meeting with RINA to discuss the required documents for the realisation of the testing campaigns	
12-09-2022	Virtual	Meeting with EDP on the documentation needed for operations offshore	
12-09-2022	Virtual	Paritcipation in Windplus meeting to shedule offshore activities	
13-09-2022	Virtual	Meeting with EDP on the documentation needed for operations offshore	
20-09-2022	Virtual	Meeting to discuss installation of measurement system	
21-10-2022	Virtual	Meeting to discuss the instalation of UdG's Docking station and Pilot structure	With Multisub (diver company)

WP6

Table 3-11: List of meetings of WP6 during the reporting period

Date	Place	Meeting	Comments
02-07-2021	Virtual	T6.4 Progress meeting with all partners	

WP7

Table 3-12: List of meetings of WP7 during the reporting period

Date	**Place**	**Meeting**	**Comments**
17-09-2021	virtual	WP7 meeting	
29-10-2021	virtual	WP7 meeting	
12-11-2021	virtual	WP7 meeting	
16-11-2021	virtual	Test Centre video meeting	With BubbleCS

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19-01-2022	virtual	Meeting on Sprint World Conference	INESC, VTT, SPACEAPPS
04-02-2022	virtual	WP7 meeting	
07-02-2022	virtual	Meeting on Sprint World Conference	INESC, VTT, SPACEAPPS, EDP
04-03-2022	virtual	WP7 meeting	
18-03-2022	virtual	WP7 meeting	
25-03-2022	virtual	Showcase videos meeting	With BubbleCS
06-05-2022	virtual	WP7 meeting	
16-05-2022	virtual	Showcase videos meeting	With BubbleCS
03-06-2022	virtual	WP7 meeting	
01-07-2022	virtual	WP7 meeting	
05-07-2022	virtual	Meeting on Sprint World Conference	INESC, VTT
12-08-2022	virtual	WP7 meeting	
02-09-2022	virtual	WP7 meeting	
21-10-2022	virtual	WP7 meeting	
04-11-2022	virtual	WP7 meeting	

WP8

Table 3-13: List of meetings of WP8 during the reporting period

Date	Place	Meeting	Comments
16-07-2021	Virtual meeting	WP8 meeting	
30-07-2021	Virtual meeting	WP8 meeting	
03-09-2021	Virtual meeting	WP8 meeting	
15-10-2021	Virtual meeting	WP8 meeting	
29-10-2021	Virtual meeting	WP8 meeting	
12-11-2021	Virtual meeting	WP8 meeting	
26-11-2021	Virtual meeting	WP8 meeting	
10-12-2021	Virtual meeting	WP8 meeting	
10-11-2021	Virtual meeting	Coordination meeting (PCB)	
07-01-2022	Virtual meeting	WP8 meeting	
21-01-2022	Virtual meeting	WP8 meeting	
04-02-2022	Virtual meeting	WP8 meeting	
03-04-2022	Virtual meeting	WP8 meeting	
18-03-2022	Virtual meeting	WP8 meeting	
01-04-2022	Virtual meeting	WP8 meeting	
03-06-2022	Virtual meeting	WP8 meeting	
02-09-2022	Virtual meeting	WP8 meeting	
09-09-2022	Virtual meeting	WP8 meeting	
02-11-2022	Virtual meeting	WP8 meeting	
09-12-2022	Virtual meeting	WP8 meeting	

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3.3. Conferences, Workshops, Demonstrations, and Other Events Attended/Organized

The table below summarizes the major events that were under preparation or took place for the reporting period.

Table 3-14: Major events summary

Type	Title	Date	Description	Partner
Conference	EMRA2021	07 Jul 21	Presentation of ATLANTIS in the EMRA2021 conference	INESC TEC
Conference	Jornada CEA – Automar	1-3 Sept 21	Presentation of ATLANTIS project in the Automar thematic group of Spanish automatics committee	IQUA
Exhibition	WindEurope Electric City 2021	23-25 Nov 21	ATLANTIS stand at the exhibition - Innovation Park	VTT, INESC TEC, EDP
Conference	SPRINT Robotics, the seminar "Focus on Clean Energy: The Impact of Robotics for I&M"	10 Dec 21	Presentation of ATLANTIS	INESC TEC
Seminar (virtual)	SPRINT Robotics and RIMA Seminar: Wind Energy and I&M Robotics - Discover the latest trends	23 March 2022	INESC promoted the ATLANTIS Test Center and Open Call launches	EDP
Seminar (virtual)	LEADVENT – 20th OFFSHORE WIND OPERATIONS & MAINTENANCE FORUM	21 April 2022	EDP presented "ATLANTIS: Shaping the Future of Robotized O&M in Offshore Wind	
Conference	Belgian Offshore Days 2022	23-24 March 2022	SPACEAPPS promoted the Open Call launch	SPACEAPPS
Conference	WindEurope Annual Event 2022	5-7 April 2022	EDP participated with a poster titled: "Robotic technologies to increase site accessibility and reduce downtime in offshore wind farms"	EDP
Conference (virtual)	2nd Annual Excellence in Wind Turbine Life-Cycle Management Forum	20 June 2022	EDP presented ATLANTIS	EDP
Seminar (virtual)	Sprint Robotics North American Regional Chapter meeting	15 June 2022	INESC presented ATLANTIS	INESC
Conference & exhibition	Sprint Robotics World Conference for INSPECTION & MAINTENANCE ROBOTICS	7-8 September 2022	Promotion of ATLANTIS Test Centre and demonstrations	INESC, VTT, SPACEAPPS, EDP
Conference	ROBOT2022 - Fifth Iberian Robotics Conference	23-25 November 2022	Promotion of ATLANTIS Test Centre and technology development	VTT

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4. Impact of the Project

The impact of the project can be evaluated based on different components.

Demonstrated the potential for robotics to impact at scale the O&M activities of the offshore wind energy.

The work completed in this project have greatly impacted the outcomes of the ATLANTIS project by defining the technical demonstrations of IMR operations in the ATLANTIS project as well as all of the system's requirements. Analyzed data at the ATLANTIS Offshore Test Center location, establishing that wave heights are on average below these limits 34 percent of the time. Acceptable wave heights for wind farm vessel maintenance personnel transfer are given as 1.5m. Deploying robotics-based maintenance solutions would allow a tighter acceptable safety margin, and operational wave heights to be raised to 2m. In this case, safe vessel operations could take place 46% of the time, raising workable vessel hours 35% over the original weather windows.

Apart from the scenarios that will be demonstrated in the ATLANTIS Test Centre, the consortium has imagined other possible scenarios and created a detailed description of all of them, the ones actually demonstrated and the ones left for future research. These descriptions include the problem statement, the review of the currently used technologies and the proposed new solutions, together with their impact on the costs and safety of the offshore operations. It is a valuable source of inspiration for the research community and companies in the offshore industry, especially ones focused on robotic solutions.

Within the ATLANTIS project, demonstrations will take place demonstrating the capabilities of robots when performing IMR operations. ATLANTIS is crucial in this context since it involves the actual design and installation of the Coastal Testbed where robots at low TRL will be deployed. During the structure's design process, both the IMR requirements and the capabilities of existing robotic technologies were taken into account, creating the ideal scenario where technology can be benchmarked and new developments can safely be evaluated in a representative manner. In particular, the Testbed was envisaged to include all 3 domains (aerial, surface and subsea), integrating specific structural features that enable that representativeness to be implemented. In the aerial domain, including an wind turbine in the Testbed was considered for the purpose of inspecting its blades and tower. Although one could not be physically installed in it due to prohibitive costs, several turbines currently in use nearby can be inspected and therefore considered included in the initiative. In the surface domain, several features were included, namely on the upper sections of the structures which stand above water. The integrity of the hull, the coating, ladders, hadrails and other equipment can be assessed since they were included in the design according to industry standards. Finally, in the subsea domain the underwater section of the same structures was carefully designed to allow the execution of important IMR activities such as assessing the integrity of the hull, coating, corrosion protection system and the mooring system. The inspection of underwater energy cables was also considered by adding a real cable suspended from the monopile structure (although unpowered). Therefore, this activity gives a decisive contribution towards showcasing the potential of robotics in O&M activities by considering the most representative industry challenges for IMR.

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Reduced technical and commercial risk in the deployment of services based on robotic actors within the selected application area.

The work developed in ATLANTIS clearly demonstrated how offshore wind industry might benefit from the deployment of robotic-based technologies. Moreover, it is clearly demonstrated how the ATLANTIS project can assume a pivotal role in the offshore wind operation and maintenance activities either by de-risking technologies or offering a new set o robot-based services. In T6.4, the carried work highlighted the potential benefits of the robotic solutions, stressing, nevertheless, the need that these technologies have to prove their maturity to efficiently at site. In this sense, it was pinpointed that the ATLANTIS test center will provide the technology developers with the instruments to test their technologies in a unique environment, thus reducing the technical and commercial risk of each solution.

The project is demonstrating how the ATLANTIS solutions may contribute to eliminate O&M bottlenecks, thus contributing to the solutions' safety. The performed analysis of IMR scenarios allows the identification and prioritization of actual needs of the industry. ATLANTIS is lowering the technical and commercial risk for technology developers. The commercial risk is reduced mostly by putting high focus on the technologies that can practically impact the offshore wind energy industry in the long term, ones that are really needed and can be implemented to replace the current solutions. The technical risks are reduced due to the future availability of the ATLANTIS Pilot infrastructure to the companies developing the technologies, which will allow them to thoroughly test their products in realistic environment. Moreover, the defined scenarios can be considered benchmarks, which can be used in the development and testing phases of new solutions.

Greater understanding from the application stakeholders of the potential for deploying robotics.

When computing the LCOE for an offshore wind power plant where O&M activities are performed accordingly to the ATLANTIS methodology, the annual O&M costs will be reduced by a 10% factor. The T6.4 provides a global overview of the current offshore wind installations, with a focus on the European context and its latest trends, and details a set of key stakeholders, namely: technology providers, operators, owners, investors, IMR service providers and offshore logistics' services providers. The ATLANTIS Testbed design accounts for representative showcases where the robotic technologies can be deployed. Thus, the validation of these technologies in the Testbed helps to establish its trustworthiness, by increasing the level of trust demanded by relevant industry players and leading them to integrate these technologies in the scope of their operations. Likewise, by considering specific industry requirements, operating robotic assets in such, a Testbed will provide a better understanding to the application stakeholder of the potential of robotic operations, reducing the technical and commercial uncertainty related to the deployment of such technologies.

The project is providing a greater understanding of what are the offshore wind industry requirements. The consortium stakeholders understand the potential of such deployments and well as where the gap in the available technology is and therefore, where the development opportunity lies. This information is supporting the release of showcase videos in order to widespread the knowledge that was gathered.

Demonstrated platforms operating over extended time periods in near realistic environments and promotion of their use.

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The ATLANTIS team has designed and built a new docking station for the SPARUS II AUV, to demonstrate the capabilities of autonomous underwater robots to perform multi- day missions as well as enable future permanent deployment solutions. The SPARUS II AUV will autonomously dock, undock, perform underwater inspection with a sonar, charge, and report data to the surface, during a multi-day experiment located around the ATLANTIS Offshore Testbed. ATLANTIS has developed and provided an inductive wireless charging device. This device is able to recharge the batteries of underwater vehicles, e.g., the SPARUS II AUV, in order to keep them operating underwater by long period of times. The current prototype of this inductive wireless charging is functioning for 36W however, it is expected to be obtained +100W.

Developed new robotic technologies for IMR.

The work in WP2 have also focused on more technical work, related directly to the implementation of the demonstrations. The consortium has created a common list of systems' requirements and functionality related to the interoperability and cooperation with the Shore Control Centre. The technology partners have agreed on common software and hardware interfaces to allow simultaneous and effective work of multiple teams in the same testing field. The project has started development of the software solutions that will allow for intercommunication between robotics systems and the SCC, as well as the user interface of the SCC itself. Finally, all robotic technology developers have substantially upgraded their systems, built new robots and equipment, and/or tested the purchased equipment.

The project is working on developing multiple robotic platforms, ranging from underwater to aerial robotics, as well as new technology to support the O&M operations through marine robotic platforms such as, an underwater imaging system MARESye, an inductive charger, new payloads for the SPARUS II AUV and GIRONA1000 AUV (prepared for autonomous docking, monitoring and inspection). Moreover, the project team has been focused on developing a new docking station for the SPARUS II AUV as well as on upgrading the GIRONA1000 I-AUV to a dual arm configuration with multiple end-effector options. Moreover, the project is redesigning the ROVINGBAT ROV, to prepare it for the new payload composed of the MARESye camera and an electric 7 function manipulator, including major revision of the robot structure, communication and power systems.

Developed an ecosystem around the prioritised application areas to stimulate deployment.

The project has contacted local stakeholders in the area of Viana do Castelo, where the pilot will be installed. This has also led to engagement with Viana do Castelo City Hall, which has supported the project from early on, as it is considered one of the pillars of the agenda 2020-2030 for the Blue Economy of Viana do Castelo. The engagement and involvement of local stakeholders allows the promotion of a local ecosystem that contributes to the deployment of the pilot by facilitating not only potential infrastructures but also services. The project has also established links with other initiatives, such as the RIMA framework, and other Horizon 2020 projects, such as Piloting2020. These links allow not only the increase of interest in the project, but also a wider exposure to potential users and partners, contributing this way to the development of an international ecosystem. Following the developments in WP3, engagement with local stakeholders from Viana do Castelo has been conducted, from which stand out the Polytechnic Institute of Viana do Castelo, a shipyard, a port authority, and a blade manufacturer. Moreover, ATLANTIS project is actively supporting the creation of a new

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stakeholders’ ecosystem that is being built in Viana do Castelo, focused on offshore renewable energy and marine robotics.

Improved international rules or regulations.

All the robotics O&M activities in the scope of this project has been analysed from a regulator point of view also considering the naval, maritime and aerial regulation, even if this part is subject to EU Member States/countries differences. The activities provided a solid assessment (see deliverable D1.2) around regulatory requirements to be met and to enable the deployment of robotic solutions in offshore wind farms. Moreover, all regulations, laws and guidelines at both international and national level have been considered to ensure that all business models associated with new or improved robotics-based services were developed considering the operations’ safeness. With this basis, and considering the expected technical developments that will take place during the project lifespan, the project has created a good ground for accomplishing yet another objective related with the promotion of guidelines for certified autonomous drones based IMR applications.

Actions will contribute to UN Sustainable Development Goals & 2030 Energy Strategy

The work produced by ATLANTIS is actively contributing to SDGs since activities of this project are increasing efficiency of offshore operations and decreasing the LCOE of offshore energy. Activities are already demonstrating that ATLANTIS has a pivotal role in reinforcing the sustainability of the Offshore Wind Industry. In that sense, tasks 6.4 and 6.2 clearly demonstrate the impact that the ATLANTIS Test Center and the different robots’ solutions have in the European offshore wind industry, thus demonstrating that this project could yield important drivers both at financial and safety streams, which will clearly foment the role of offshore wind in the decarbonization of the electric sector and contribute to the UN sustainable goals. One of the benefits of the use of robotics in O&M actions comes not only from the increased efficiency of operations, but also reduced safety concerns. This directly impacts operators safety, by significantly reducing risks of loss of operator’s lives. Additionally, with the reduction of required human resources, crewless, autonomous support vessels can be used, reducing the environmental impact of I&M activities. All of these factors, combined with the described above contribute to the competitiveness of renewable energies over more traditional non-renewable energy sources, contributing this way towards the UN sustainable goals. Specifically, the results of the project are expected to contribute to goal 7, by not only reducing energy costs but increasing the competitiveness of renewable energies, and goal 14, by reducing the impact of offshore activities on the environment and marine ecosystems.

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