atlantis The Atlantic Testing Platform for Maritime Robotics

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Second Publishable report

Written by INESC TEC

Actions

	Action	Organisation	Date
Technical Manager	Requested deliverable from the Deliverable Responsible.	VTT	01.12.2021
Deliverable Responsible	Prepared draft of the deliverable.	INESC TEC	15.12.2021
Technical Manager	Approved the updated draft as the first version.	VTT	22.12.2021
Quality Manager	Approved the updated first version as the second version.	UdG	28.12.2021
Project Coordinator	Approved the updated second version as the final version and sent to the European Commission.	INESC TEC	30.12.2021

Disclaimer

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

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1. Introduction

This report is the second publishable report for the ATLANTIS project funded by the European Union's Horizon 2020 Research and Innovation program. The second reporting period covers the period M13-M24 and its goal is to provide an assessment of the project in terms execution of the work plan, resources allocated, achievements and results.

The second publishable report is concentrated on the activities conducted in work packages, the objectives of the project which includes its vision, organization aspects (e.g., meetings) and concrete results such as deliverables and milestones. Moreover, this report also provides a risk assessment and presents countermeasures and contingency management for the COVID-19 pandemic situation that society is living with.

1.1.Work Packages and Tasks for the Reporting Period

Regarding the reporting period M01-M12, the ATLANTIS project activities have been focused on 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;
- WP6 Long-term Strategy, Technology Industrialization and Business Case;
- WP7 Impact Analysis, Dissemination, Communication and Exploitation;
- WP8 Project Coordination.

Table 1 shows the WPs and tasks for this period.

Table Erro! Utilize o separador Base para aplicar Heading 1 ao texto que pretende que apareça aqui.**-1 - Tasks started during the reporting period. The last column denotes the outcome; deliverable and milestone. Deliverables from the work package 9 ("Ethics") are not depicted in this table but they are discussed in section 2.7.- - Tasks started during the reporting period. The last column denotes the outcome; deliverable and milestone. Deliverables from the work package 9 ("Ethics") are not depicted in this table but they are discussed in section 2.7.**

WP (leader)	Task (leader)	Planned schedule	D/M (deadline)	Status
WP2 (UdG)	2.3 Technologies to increase the awareness of robots in marine scenarios (INESC)	M07-M15	D2.3 (M15)	Completed
WP2 (UdG)	2.4 Modification of robotic systems (IQUA)	M07-M25		Ongoing
WP2 (UdG)	2.5 Communication links and interfaces for interoperability (SPACEAPPS)	M11-M21		Ongoing
WP2 (UdG)	2.6 Upgrade of a Shore control centre (SPACEAPPS)	M13-M30		Ongoing
WP2 (UdG)	2.7 Integration and Virtualisation of systems (Cyber-Physical Units) (VTT)	M17-M32		Ongoing
WP3 (INESC)	3.1 Design and fabrication of the Floating structure system	M7-M27	M3.1 (M21)	Ongoing
WP3 (INESC)	3.2 Installation of the Pilot in Viana do Castelo	M22-M32		Ongoing

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WP3 (INESC)	3.3 IT systems & Shore control centre (SPACEAPPS)	M22-M34		Ongoing
WP4 (ABB)	4.1 Operation planning tool for IMR robotics	M7-M30	D4.2 (M14)	Ongoing
WP4 (ABB)	4.2 Data mining & Predictive maintenance (VTT)	M13-M37		Ongoing
WP6 (EDP)	6.1 Assessment of the impact of solutions on wind farm O&M Strategy and cost structure	M16-M41		Ongoing
WP6 (EDP)	6.2 Integration of solutions in the offshore wind supply chain	M9-M41	D6.2 (M23)	Ongoing
WP6 (EDP)	6.4 Business Cases for the different stakeholders	M7-M19	D6.4 (M19)	Completed
WP6 (EDP)	6.5 Integration in the Industry Ecosystem & Stakeholder Engagement (INESC)	M22-M32		Ongoing
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	D7.5 (M18) D7.8 (M20)	Ongoing
WP7 (VTT)	7.3 Dissemination and Communication activities (VTT)	M01-M42		Ongoing
WP7 (VTT)	7.4 Data management plan (INESC)	M01-M42		Ongoing
WP8 (INESC)	8.1 Project management (INESC)	M01-M42	D8.3 (M24)	Completed
WP8 (INESC)	8.2 Quality assurance (UdG)	M01-M42	D8.6 (M18)	Completed
WP8 (INESC)	8.3 Technical management (VTT)	M01-M42		Ongoing

1.2. Objectives and Highlights for the Reporting Period

In this section, the specific objectives of ATLANTIS are listed, and the work carried out during the reporting period towards the achievement of each objective is described.

#O1-KPI - *the completed installation of a maritime pilot infrastructure for showing the use of robots operating in a real offshore wind farm - the WindFloat Atlantic (WFA).*
The work related to this objective is ongoing**.** INESC TEC team attended multiple meetings with key entities at Viana do Castelo. Many discussions were held with the City Hall, Port Captaincy, Port authority, and Governmental bodies to integrate the ATLANTIS Testbed in a technology park focused in innovation and technology development. Finally, a final contract specification was produced considering all the local stakeholders requests. This document provides clear technical guidelines and specifications in order to limit scope of the proposed tenderer's proposals, guaranteeing that the requirements and objectives of the ATLANTIS project are met. INESC TEC published the tender notice and include this document specifying all the requirements and the financial and technical conditions of the procurement.
The Coastal Testbed is designed to host the communication infrastructure to accommodate the link between the Supervisory Control Center (SCC) and the deployed vehicles. The SCC has the role of providing an onshore facility where operators can plan, deploy and analyze the IMR operations. So far the consortium has provided the specifications of the SCC, the communication paths with the robots. The work in adaptation of the SPCAEAPPS control center is underway. The

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adaptations include introducing new data types in the control center database, including CAD models or types handling specific robot telemetry. Additional ongoing adaptations include creating specific domains that will be used in the planning algorithms to create autonomous operations. The SCC is being integrated with an interoperability layer for the communication with the remote assets.

#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 was achieved.

#O3-KPI - *new methodologies 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 of WP5.

#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 work related to this objective is ongoing and the survey of user expectations was completed (legal part in WP1 and user interfaces in WP2). A total of six robots are currently being modified: one autonomous surface vehicle (ASV), one unmanned aerial vehicle (UAV), one remotely operated vehicle (ROV) and three autonomous underwater vehicles (AUV). The Zarco ASV, with the modification of sensor payload, is capable of performing multi-domain mapping autonomously, capable of performing inspection of elements both below and above surface. The STORK-I UAV is also undergoing sensor payload modification to be able to inspect the tower and blades of the windmill. The ROVING BAT ROV is capable of performing underwater inspection and cleaning operations remotely. The TRIMARES and SPARUS-II AUVs will allow autonomous underwater inspection of foundations and underwater elements, while the GIRONA-500/1000 AUV will be able to perform structure cleaning operations before performing inspections. The modifications required for these vehicles are on going. Additionally to this, other support technology was planned and its development has been complete. One of the included developments is an underwater docking station for the SPARUS-II AUV, which will allow the robot to dock and charge. To allow the charging of the robot underwater a wireless charger was developed to be included in the docking station. Lastly, a hybrid imaging system, the MARESye, to increase underwater robot awareness has been developed.

#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 started by engaging different stakeholders from the offshore wind energy sector which will continue during the next eighteen months.

#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.*

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The work related to this objective will be initiated later.

#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).*
The work related to this objective has started by creating a few collaboration protocols. More international collaborations will be implemented during the second half of the project.

#O8-KPI - *performance indicators 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 COVID-19 pandemic evoked major lockdowns throughout Europe. This pandemic also introduced consequences to ATLANTIS project since a significant number of conferences, expositions and other events were cancelled, new working methodologies were implemented, access restrictions to offices, laboratories and infrastructures, and limitations in acquiring materials and components. All these factors led to some changes in the work conducted during this reporting period.

2. Work Packages 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 one task of the WP2 was completed and two other tasks were started. The activities of WP2 culminated in one deliverable (D2.3).

The D2.3 “Technologies to increase the robot awareness” was delivered on the 30th of March.

Description of the main role of partners:

The completed task was T2.3 “*Technologies to increase the awareness of robots in marine scenarios*.

The MARESye sensor is an optical imaging device capable of retrieving high fidelity data from harsh underwater environments, enabling the close-range reconstruction and inspection of submerged structures. During the early months of 2021, MARESye saw its first demonstration in

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a controlled environment. The work on this prototype during the remainder of the year was focused on improving the optical setup, guaranteeing stability; less optical distortions; and a better active imaging system. Furthermore, MARESye has been equipped with an embedded GPU that is currently being used to support more demanding algorithms and will in the near future enable the use of machine learning techniques. Finally, the housing of the prototype has been re-designed and improved to support high pressure depth ratings up to 300 meters.

IQUA: In task 2.3, IQUA Robotics has developed path planning algorithms to enable a hovering AUV to inspect a submerged structure (e.g. the float of a wind turbine) using optical sensors to obtain images while ensuring complete coverage of its surface. Simultaneously, to navigate the scene, the AUV builds and updates a map using an acoustic range sensor. As detailed in D2.3, the works towards this goal comprised the preparation of a realistic simulation environment for the testing and development of the new algorithms. Then, using this tool, the team developed and integrated a 3D path planning algorithm, a view planning exploratory strategy, and a suitable mapping system to accomplish the autonomous exploration of a given area. The inspection procedure has been divided into two main stages: a preliminary exploration at a safe distance from the structure to determine its exact location, and an in-detail inspection at a close distance where the vehicle moves around the structure acquiring inspection images for its posterior evaluation. The resulting algorithms have been extensively tested in the simulator using different mock-up environments, including a wind turbine float, as well as in field tests using the Girona 1000 AUV equipped with a sensing payload specially developed for the application as part of Task 2.4. These experiments were performed in a natural environment and consisted of the exploration of the walls in a 12 m height islet. The algorithms proved to work as expected and enabled the collection of images over the area.

UdG: In task 2.3, UdG has been developing planning algorithms for an I-AUV equipped with two manipulators, to perform the required IMR operations. This work was based on another recent work of the team that has demonstrated the use of a Multi-representation, Multi-heuristic A* search-based motion planning algorithm for floating underwater vehicle manipulator systems, using motion primitives, in an unknown environment. The approach exploits the loose coupling between the base (robot) and the arm, when performing mobile manipulation tasks. Given the floating mobile nature of the system and the limited but highly accurate positioning of the manipulator, the proposed planner promotes the movement of the AUV in long displacements and the use of the arm when close to the manipulation target. The algorithm is able to decide, in a deterministic and sub-optimal search, when to move the robot and when to use each one of the arms, to accomplish their own tasks (e.g., attaching using the magnetic end-effector with one arm and then performing cathodic protection measurements with the other one). The use of deterministic planners is very valuable, especially when the human supervision is involved, since it provides consistent and predictable trajectories. The developed planning algorithm was tested to assess its performance, by setting up simulated scenarios within the scope of this project and running multiple planning problems, given different goals and start configurations. Results show the ability of the planner to solve the floating-base manipulation problem, by generating consistent, low-cost motion trajectories, in a reasonable amount of time, while providing guarantees on completeness and bounds on sub-optimality.

The second technology actively developed during the reporting period is related to the autonomous docking of the SPARUS II AUV. The UdG team has first performed a detailed survey

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of the existing docking systems and algorithms used in autonomous docking, which was published under the ATLANTIS project. An advanced dynamic simulation environment based on Stonefish simulator and COLA2 architecture was used to test the docking algorithms on a model of the SPARUS II AUV. After the analysis of the behaviour of the robot a new docking algorithm was designed, mathematically proved, and tested in the same simulation environment. It delivers improved performance and successful docking manoeuvres independent on the water current direction.

The first ongoing task is T2.4 “Modification of robotic systems". In this task all technological partners have presented their plans and progress in upgrading their robotic platforms (GIRONA500, SPARUS2, ZARCO, STORK II), as well as creating new designs, like the new docking station for the Sparus II robot, needed to demonstrate permanent deployment ideas, and an underwater wireless charger.

INESC: During the reporting period, the INESC TEC team has worked on modifying three existing robotic systems, coupled with the development of equipment to be used in systems for other consortium members, i.e., the wireless charger. The achieved wireless charger design is a modular housing able to lodge wireless charging systems with capacity to reach either 100 W or 200 W. This housing is completely independent from any other structure and of simple geometry thus, it is easy to integrate anywhere desired. The wireless charger was tested and able to withstand 30 bar in a hyperbaric chamber, which is the equivalent to 300 meters depth underwater. Plus, efficiency tests demonstrated that the 100 W module and the 200 W module were able to reach a Power efficiency of 46% and 56% respectively.

The autonomous surface vehicle (ASV) Zarco was upgraded to include a new sensor payload and increase the system endurance. Initially the battery solution was upgraded to increase the operation time from 1h to 3h. Moreover, Zarco's observability was enhanced with the introduction of multi-domain sensors, namely GPS, IMU, 3D LiDAR and a multibeam echosounder, allowing the ASV to perceive both the surface and underwater regions simultaneously. This solutions were integrated and validated through several field missions in Leixões and Viana do Castelo harbors.

INESC TEC has also been working on the integration of the 6 DoF manipulator (Bravo 7) into an AUV. Real environments as well as simulated ones were developed to perform tests and validate all the methods developed. The manipulator was evaluated in underwater environment using different planners of the state-of-the-art that were previously developed for surface manipulators. A new metric was developed capable of quantifying the solutions obtained by the planners, allowing the comparison between them.

With regard to the TRIMARES AUV, a new perception pipeline was developed, that was tested in Leça Harbour, along with new algorithms capable of detecting, identifying and locating underwater structures using sonar technologies. Subsequently, grasping pose detection methods and close-range navigation and manipulation algorithms is being developed with the objective of later performing the vehicle docking using the available manipulator on the vehicle.

With respect to the STORK-I unmanned aerial vehicle (UAV), it is a quadrotor with a maximum flight time of 40 minutes and a maximal payload of 1Kg. It is endowed with a precise landing system that is able to effectively detect the landing target marked with an infrared beacon,

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allowing an accurate relative position estimation. The UAV was also equipped with a triple-sensor perception system, composed by a Visual Camera, a Thermal Camera and a 3D LiDAR. This perception system collects both visual and range data, which is essential for inspections tasks, and also contributes to the situational awareness of the UAV.

UDG: In task 2.4, during the reporting period, the UdG team has mainly focused on the mechanical and electrical design of the new equipment, necessary to perform demonstrations of autonomous docking and IMR operations.

To perform the autonomous docking of the SPARUS II AUV, with a new payload designed by the IQUA Robotics, the UdG team has designed a completely new, funnel-shaped, docking station which can actively rotate to adjust its orientation to the local water currents. The docking station is equipped with a suite of sensors, including: a DVL with compass, a high resolution camera, optical and acoustic modems, a light beacons system, an underwater WiFi antenna, and an inductive charger developed by INESCTEC. The power management, device control and communication is achieved using a custom built main board with an embedded computer. The docking station can be powered from the surface or from its built in battery, which should allow for at least 10 days of autonomy, thanks to smart power management. The mechanical and electrical design of the docking station was completed and the mechanical part was manufactured and assembled. Moreover, entrance of the robot to the docking station was checked in a mechanical sense, using the newly equipped SPARUS II AUV.

For the second group of demonstrations, consisting of a few IMR tasks performed by the GIRONA500/1000 I-AUV, a few different designs had to be prepared, namely: a test rig that will be used for the development stage in the CIRS test tank, a new dual manipulator payload combining the Blueprint Lab Reach Bravo and the ECA 5E Micro manipulators, a set of new end effectors for both of the manipulators, and new thruster mounts allowing for vectorial configuration. The design of the test rig is based on the dimensions of the floating structure designed for the ATLANTIS test centre. It includes a curved steel surface, representing part of the main pillar, a standard access ladder and a few anodes. The design was completed and the test rig manufactured and painted.

The dual manipulator payload for the GIRONA500/1000 I-AUV allows for attaching two different manipulators to the front of the vehicle: the 7 function Blueprint Lab Reach Bravo arm and the 5 function ECA 5E Micro arm. It consists of a mechanical structure used to attach the arms to the frame of the robot as well as a control cylinder, housing all of the necessary electronics and an embedded computer. To be able to use the arms in the IMR scenarios the UdG team has designed new end-effectors for both manipulators. For the ECA manipulator, which is to be used as an attachment arm, a permanent magnet gripper was designed, able to easily attach to the steel structures. For the Blueprint manipulator, three different end-effectors were designed: a cathodic protection probe holder, a cleaning tool based on an underwater drill, and a laser scanner mount. Moreover, the arm was equipped with a 6 axis force-torque sensor, located at its wrist. The payload and the end-effector designs were completed and most of the parts manufactured. The aforementioned laser scanner is a new prototype, described in a paper published under ATLANTIS project, which is now being extensively tested. Finally, new mounting system for the robot's thrusters was developed to enable utilising a vectorial configuration of the thrusters, preferred when performing manipulation tasks. Apart from design tasks and assembly of already

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manufactured components, the UdG team has completed a set of tests of the newly acquired hardware, including extensive testing of the Blueprint Subsea Seatrac X150 USBL system. The latter is important for the autonomous docking scenario, where it will be used as the homing device. The USBL was tested in the harbour of Sant Feliu de Guixols, using fixed mounting points at the shore and later using a stationary buoy and a boat. In the second phase the boat was performing a simulated approach to the docking station, which allowed for the assessment of performance of the acoustic localisation. To enable these tests as well as for the integration of all of the equipment into the architecture of the robots, the UdG team has implemented a set of hardware drivers working in the Robot Operating System (ROS).

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 100 AUV and tested in the field during preliminary experiments.

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.

ECA : In the task 2.4, during the reporting period 2021, ECA has focused its effort on the mechanical and electrical design of the new Roving Bat to upgrade its functionality in terms of NDT and inspection capabilities and necessary to perform the planned demonstrations for IMR operations in offshore condition during WP5 - scenarios 2 and 3.

To achieve this task the following modification have been performed: Electrical design. Design of a new electrical architecture using an underwater 8KW – high voltage input - embedded power converter. This technology makes it possible to use a much thinner umbilical cable, reducing its resistance to the sea current, and making the robot far more agile. This embedded converter will also result in notable gains in terms of the power delivered to the thrusters – to ensure that the robot withstands the strong currents that are present in the area where the wind turbines are installed. To minimize its weight and volume, the converter is packaged using oil filled housing. For this reason, a set of components and electronic boards have been tested in a pressure chamber to check their ability to work until 100 bars. The converter specification and design have

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been completed as well as the thermal simulation, the mechanical integration the design of control boards. Request for quotation for the mechanical enclosure is done. Manufacturing will start in January. Design of the, electronic boards are on the finish (80% done). The progress of this task is estimated at 70%.

Mechanical design. Design of the new 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 crawlers used to move the RB while it is attached on the wind float structure during the IMR operation have been ruggedized. The vertical thrusters to keep the robot sticked 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. Enhanced modelling of the system is still on going to guarantee the proximity of the COG (Center of Gravity) and the COB (Center of Buoyancy) since it is essential for ensuring the stability of the RB while it is crawling on the vertical structure. The progress of this task is estimated at 80%.

Electronic, control SW and HMI. Integration of a new electronic architecture using an Ethernet transmission instead of the existing analog transmission. Design of an electronic POD for the thruster control. Design of an electronic POD for Crawler control. This digital architecture will allow 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). The progress of this task is estimated at 80%.

Interoperability. Development of communication links and interfaces for interoperability. The progress of this task is estimated at 30%. Several technical meetings were done with SpaceApps to validate and ammend the proposed HW and SW architecture for connection with the SCC.

The second ongoing task is T2.5 "*Communication links and interfaces for interoperability*". **SPACEAPPS:** The work carried on this task was based on the inputs from the definition of the platform interfaces performed during task 2.2 . The stages that followed included the design of the communication links, definition of the interfaces and the prototyping. SPACEAPPS collaborated with the technology providing partners regarding the best approach to accomplish the interoperability between all the assets involved in the project: robots, vessels, floating structures, control centres and data processing units. Two core elements have been identified: the requirement of building a communication specification using a robust protocol that will allow to control the data exchanges in various communication contexts and the provision of a software library easy to integrate with the involved systems. After these tools were in place, the partners will collaborate to perform remote integration settings, with the final purpose of integrating at least two robots and accomplish the corresponding milestone.

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SPACEAPPS propose DDS as the communication method between all the assets due to it acceptance as a standard in the industry and the compatibility with the new version of robotics middleware ROS2. Based on this technological choices a specification was developed. It includes interoperability specific aspects as asset discovery, inter-vehicle discovery, supported data types and sequence of operations for data publishing and commanding. The interoperability interfaces and specification are 90% defined.

The second part of the task involved engineering a software library that can be easily integrated with the software modules running on each of the involved systems. The library was developed by SPACEAPPS using the C++ programming language and share using git repositories with the rest of the partners. The development of the library is now at 85%. The partners providing the robotic systems have done together with SPACEAPPS a workshop in which the interoperability library have been tested on their computers while being discovered from the remote locations. At this point successful tests for publishing test data was performed with 4 out of 5 partners. INESC, IQUA, UdG and ECA are working on integrating the software with their robotic assets, integration planned to be tested in the first two months of 2022.

A background parallel component of this task was related to the designing of the hardware communication architecture that will link the Pilot, unmanned and manned vehicle, local control centres and the supervisory control centre. The design is finished and the list of hardware has been provided for procurement.

The third ongoing task is T2.6 "*Upgrade of a Shore control centre*".

SPACEAPPS: This task was kicked off in the beginning of 2021 and included the extension of the SPCAPCEAPPS existing control center. The task is heavily related to the work done in the task T2.5. The shore control centre has a supervisory role over the system and receives data from all the assets launched in the ATLANTIS demonstrators. The major steps taken to fulfil this task were to create a software architecture adaptation, create the integration with the interoperability software stack, extend the SCC data store and create new user interface elements.

The architecture adaptation consisted in introducing an interoperability component called the "data gateway" and an AI Mission planning component meant for generating specific operational plans for the ATLANTIS robots. This work was done by SPACEAPPS in the first quarter of 2021. The data gateway development has happened in parallel with the development of the interoperability layer design and development. The system is build to be deployed on a server and has been tested remotely within SPACEAPPS and together with the other partners. The data management system includes a live signalling server for real time data visualization coupled with a time series storage unit and a http server capable of showing past data. The architecture of the backend is done in a modular and contained way. A new deployment procedure has been included using docker images and the whole system has been adapted to be launched on a managed server either locally or in the cloud. The HTTP server also includes an API that can be used by other ATLANTIS subsystems like the O&M to retrieve data.

The last part of the task included software development on the user interface side. The most significant enhancement are including the 3D map visualization for the ATLANTIS environment together with the 3D models of all the robots. The final step still ongoing is validating the AI

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Mission Planning component that will receive the state of the system from the remote vehicles and a goal from the operator specific for a defined scenario and generate a sequence of tasks for the robot to execute autonomously for achieving the goal. The progress of the tasks is estimated ad 80%.

The fourth and last ongoing task is T2.7 "*Integration and Virtualisation of systems (Cyber-Physical units)*". **VTT:** Task 2.7 started in June 2021 and is ongoing. Before and after the Kick-off meeting on June 28th, the scope has been to discuss together with partners on views regarding a framework for the virtualisation of physical hardware and generated data. The idea of the virtualisation layer is to provide virtualised data from robots and/or sensors for the scenario (predictive maintenance) models. In order to study the connectivity of a virtualised environment and the O&M module, a dummy simulation was created by VTT to import image data from simulation to the MIMOSA data-model within the O&M via Django framework. The idea of the virtualisation layer was then refined to comprehend data generation instead of a virtualisation of the testbed from which the data would be generated from virtualised robots and/or sensors. In this context, it is to emphasize that real data is required as a source to produce useful virtualised data for the scenario models developed in T4.2. The relevant data will be provided by the partners. The current view is that the SCC user decides whether to use physical or virtual asset. If the user decides to use virtual asset, they manipulate the configuration file on the virtualisation layer (through SCC) to set parameters on the virtual asset. The virtual asset starts outputting data towards the O&M module developed in T4.2, where a scenario model can use the data as input. Later on, data collected from the site (from physical assets) can be benchmarked to the virtual data and predictions for maintenance can be formed.

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:

Within this work package the first task (T3.1) is ongoing and two tasks were started (T3.2, T3.3). The milestone M3.1 "*Floating system structure designed and internationa*l contract launched" was achieved and the tender was published in October 2021.

Description of the main role of partners:

Currently, tasks T3.1 "*Design and Fabrication of the Floating Structure System*", led by INESC TEC, and T3.3 "IT systems & Shore control centre", led by SPACEAPPS, are ongoing.

INESC: One of the objectives of task T3.1 is to design the floating structure that will be installed at Viana do Castelo. In order to get a preliminary design a list of functional, structural and scenario-based requirements was detailed in a draft version of D3.1. This draft received preliminary contributions from all partners according to their own experience and expectations, as they will need to be able to test the technologies being developed in WP2 at the Testbed, in the context of the identified scenarios. Although the showcases were actually identified in WP1, in WP3 our

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work focused in integrating the showcases in the Testbed design in order to enable real demonstrations of concrete scenarios focused on the user needs related to their IMR activities. The identification of such showcases would only be of value to the project if they were considered in the Testbed design phase. Several talks were held with industry partners in order to identify and list the general requirements for the Testbed, to understand their needs and benefit from their experience in the sector. This experience does not only apply to the establishment of the physical Testbed itself, but also how to handle all the different entities that need to be approached to actually be allowed to create it. INESC TEC considered all requirements, contributions from partners and installation site foreseeable limitations to produce a candidate design for the marine structures that enabled all operations envisaged in the WP2 scenarios to take place. Candidate designs were discussed in project meetings and a final specification was achieved. All partners, specially the ones deploying robotic assets in the Testbed, contributed with their expertise to the establishment of a final candidate design that accounts for all typical challenges found in real offshore infrastructures, while also considering the specific characteristics of each asset to be able to assess its performance in the context of IMR operations. A naval engineering office was contacted to evaluate the produced candidate design of the envisaged marine structures to be built and deployed in the Testbed. This office considered not only all of the requirements within the ATLANTIS consortium, but also the most relevant and applicable marine industry standards (including safety). Their work focused in studying the intact stability of the structures, in assessing the optimal positioning of each structure within the Lima river basin and validating the preliminary technical specification provided by INESC TEC. INESC TEC already defined with local and regional authorities the exact location on the Lima River where the Coastal Testbed will be physically deployed. The installation of this Testbed will enable cost effective operations and the technical validation of major showcases/scenarios defined in D2.1 while, at the same time, cause a minimum impact to environment and industrial activities (e.g., fisheries). The INESC TEC team attended multiple meetings with key entities at Viana do Castelo. First, talks were held with the City Hall to integrate the ATLANTIS Testbed in a technologic park focused in innovation and technology development. This investment in the area was highly regarded, as it has the potential of improving its social and economic background. Second, the Port Captaincy was consulted to better understand which location would be better suited to this type of application considering the testbed dimensions and depth requirements, while minimizing the impact to their own operations. Given the river dimensions and growth of the volume of the business of the Port, a large amount of time was spent to have a better understanding of the ideal solution.

INESC TEC travelled to Viana do Castelo with the purpose of getting to know the surroundings better. As part of the site evaluation process, INESC TEC performed a bathymetric survey of the selected Testbed area location with an autonomous surface vessel. By acquiring valuable sonar data, seafloor characteristics were fully detailed, constituting important information to be included in the contract specification to assist in the installation of the structures and shared among the ATLANTIS consortium to ensure adequate technology readiness.

The international call for the construction of the structures that will be installed on the Coastal Testbed was published in October 2021. The technical documents relative to this call were prepared and included in the submission documentation. Regarding the international call and technical specification, INESC TEC received valuable input from RINA Consulting, which used its extensive experience in offshore engineering to review and propose amendments to the contract

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specification, in line with the best practices in the industry and also regulatory assessment performed in Task 7.2. Currently, we are carefully analysing the tenderers proposals.

Task T3.3, which is concerned with the installation of a Shore Control Center (SCC) to monitor the operations in both Testbeds, was also started during this year. INESC TEC travelled to Viana do Castelo with the purpose of choosing the most promising places for the installation of the SCC. Multiple sites were identified and an agreement was made to rent an office nearby the Coastal Testbed. More specifically, the SCC will contain IT Infrastructure and furniture that enable continuous monitoring of IMR operations by trained operators and technicians.

SPACEAPPS: has done the selection of the IT equipment necessary for the pilot including the equipment meant for the SCC, the coastal testbed and the offshore testbed. The provision of the equipment will be done in collaboration with INESC. SPACEAPPS have also procured and commissioned the satellite communication system including the satellite dish and modem. Two server instances have been launched on SPACEAPPS IT infrastructure, one for hosting the data gateway and one for hosting the SCC backed. The two instances will be used for remote testing and validation.

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:

During the reporting period, the D4.2 "*Press releases about the Decision-making 2*" was delivered. This press release on the ATLANTIS consortium has been distributed to the offshore industry media. The coverage of the press release 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 TestCentre.

Description of the main role of 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

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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.

Currently, the task T4.2 "Data mining & Predictive maintenance (VTT)", led by VTT, is ongoing. The focus of the task T4.2 is to develop tools for windmill operation and maintenance (O&M) analytics. In the project, the main interest has been outside the windmill turbine internal power transmission line, but following the ATLANTIS project case definitions and scenarios for WFA. In addition, ATLANTIS Test Center to be constructed and implemented in Viana do Castelo will potentially be used as a testbed for targeted analytic developments and special measurement setups. The selection of the targeted objectives for the O&M analytic development in T4.2 is ongoing. At this point, the specific scenario that is being targeted includes a subsurface robotic visual inspection data that could be used for automatic organic growth identification which is crucial to plan the cleaning activities. An additional scenario is also being considered: the aerial drone inspection through visual or IR inspection data, e.g., for turbine rotor blade and frame wear and delamination fractures analytics based on data pattern recognition. Work is being made to identify the parameters that characterize what is critical and where, how to identify abnormal from normal feature: structural erosion, cracks, pits, scour, wear, pits, algae, scallops, etc. All the development in T4.2 will be based on data provided by under the project umbrella. At the moment, the selection of data sets is ongoing, and data have been requested from the operational and test site owners (Windplus). The data itself will enable the stepwise progress towards the objectives, and it can be from different sources and naturally used based on its content and possibilities. If the Costal Testbed will be instrumented (e.g. including acceleration, inclination, structural loadings or stresses on critical point(s), plus containing environmental data e.g. wind, individual waves, temperature etc.), it can be used for further O&M measurements and classification analytics to support e.g. for the development of stochastic environmental factor analytics. Output of this could be used to study load profiles based on operation and environmental measurements, estimate accumulated damage sum progress based on these load profiles, extrapolate loading on critical points based on indirect measurements etc.

It has been agreed, that in the first phase the analytics will be concentrating on the marine growth, which will, if not prevented/removed early enough, cause extra loading (static and dynamic) due to weight and increased flow resistance, increase the rate of corrosion on structures and impairing visual inspection capability to observe the true condition/quality of critical surfaces. Here, identified critical points are e.g. mooring cables, welding seams and cathodic protection. Information from critical points will be collected as labelled inspection video data samples containing both inspection video data and relevant metadata to categorize the data samples. Originating from the O&M development needs, data samples are planned to contain marine growth state varieties and progress over time and affecting other factors. In the first place, the divers collect the data manually (see Figure XX lower part). Data is forwarded for the O&M development module where the data is analyzed and further processed e.g. through visual pattern recognition based routines. Developed routines for data and metadata will be validated and uploaded for further use into O&M analytics module, which is connected into constructed Atlantis data and communication platform. If relevant, the existing data can be also used as a

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source for virtual data e.g. for linear or non-linear interpolation of missing data, and extrapolation of future data.

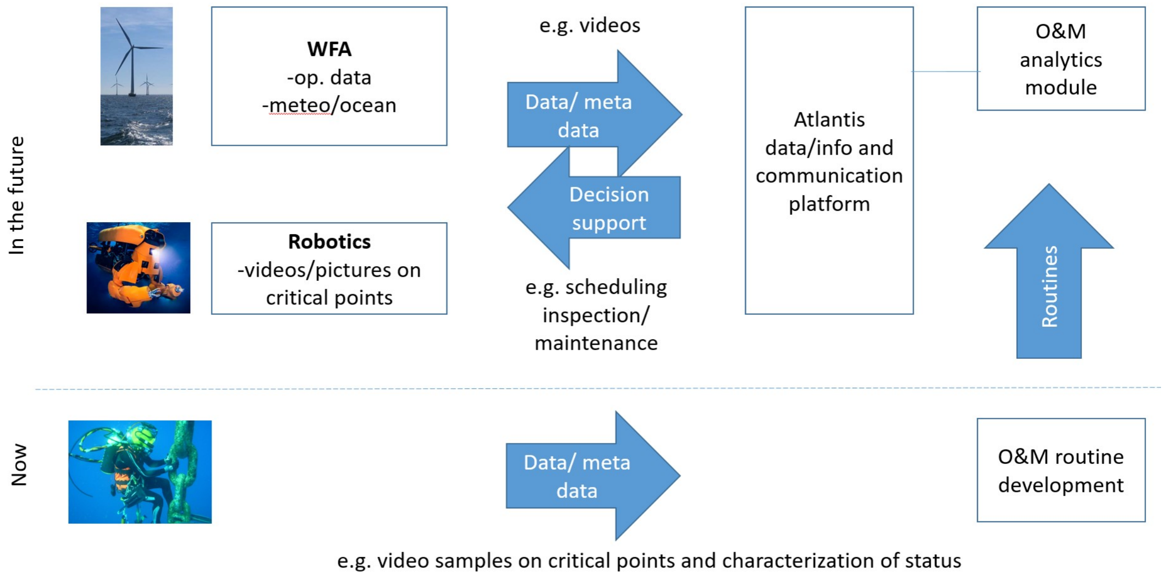

Figure 2-1 - Inspection data development schema.

2.4. 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 in the European offshore wind industry and, more specifically, on 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:

During the reporting period, of the two ongoing tasks, one was completed, and a new task was started. Two deliverables were produced as outcomes of this work package, D6.4 and D6.2.

The D6.4 "Assessment of Business Cases for the ATLANTIS stakeholders: financial and strategic considerations for the major stakeholders" was delivered on the 31st of July 2021, while the D6.2 "Offshore wind O&M Supply chain needs and opportunities" was delivered on the 14 of December of 2021.

Description of the main role of partners:

Task 6.4 "*Business Cases for the different stakeholders*" was completed in the reporting period. RINA-C participated to Task 6.4 activities also to connect these task outcomes to T7.1 and T7.2 activities. 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

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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 stakeholders, 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 cases 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 as 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.

The first ongoing 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 most pressing challenges of the industry.

The task T6.2 "*Integration of solution 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 spent in the 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,

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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 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 farm, 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 about costs (for logistic, manpower, equipment) was carried out and it led to the creation of an "internal database" used alongside with 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.

Task T6.5 "*Integration in the Industry Ecosystem & Stakeholder engagement*" was officially started in the reporting period. 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 stakeholders ecosystem that is being built on Viana do Castelo focused on offshore renewable energy and marine robotics.

2.5. 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. The communication strategy will be developed for exploiting the outcomes of the project during and beyond the project lifetime.

WP7 progress and achievements:

WP7 Impact analysis, dissemination, communication and exploitation consists of four tasks. During the reporting period of this second publishable report, i.e. M13-M24, all tasks are ongoing. Moreover, two deliverables were produced, D7.5 "First Exploitation strategy report" and D7.8 "ATLANTIS IPR Manual", and delivered on the 30th of June 2021 and 30th of August 2021, respectively.

Description of the main role of partners:

The task T7.1 "Social, economic and environmental impact analysis" is ongoing.

RINA-C is leading tasks T7.1 (Social, economic and environmental impact analysis) and T7.2 ("Exploitation strategy and IPR management"). Both tasks 7.1 and 7.2 started in June (M06) based on inputs from the work that was done in WP1 (T1.1 and T1.2), i.e. specification of showcases and the assessment of IMR activities. In T7.1, regulatory aspects analysed in WP1 have been analysed in order to understand how much these take into account also environmental aspects (thus if special permitting for environmental constraints are required), while in parallel a preliminary O&M cost reduction analysis/estimation has been performed (to be corroborated by demonstration data and data to be collected from off-shore operator). Regulatory aspects has

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been also analysed by RINA-C to support EDP in WP3 for the specifics to be included in the "Contract Specifications of Floating and Monopile Structures".

Generally speaking, regarding social acceptability of ATLANTIS innovations, RINA-C highlights that there are no major "general audience" objections to the use of drones as O&M operators, particularly for underwater ones, if their usage is adequately signalled and regulated. There is more an aspect of acceptability of business stakeholders/Offshore O&M operators, which come from a quite "innovation conservative" sector (particularly for companies more active in offshore O&G than offshore RES). Nevertheless it is clear that big names of offshore energy (e.g.SAIPEM, EQUINOR, TOTAL etc.) are looking more and more to drones for O&M and inspection. The industrial stakeholders acceptability should be studied via stakeholders surveys and workshops that the consortium hopes to organize in the second phase of the project in a "Physical way" otherwise digital events and web surveys will be organized.

The task T7.2 "Exploitation and IPR management" is ongoing.

Considering that no physical/in-presence exploitation workshops could be organized, in T7.2 a BFMULO analysis has been first performed by RINA-C with the collaboration of all project partners during summer 2020 period in order to identify and characterize project Preliminary Key Exploitable Results (PKERs) and partners intentions in their exploitation beyond the project end. A relevant number of PKERs has been identified even if many of them are quite "vertical" to specific partners. After this first phase a more detailed analysis and selection of PKERs has been realized also looking at potential synergies among them. This preparatory activity brought to the organization of an Exploitation Strategy Seminar organized with the support of Horizon Result Booster (HRB) in May 2021 where ATLANTIS partners had the chance to interrogate themselves more in detail about their project beyond strategy and the exploitation strategy not only of the different PKERs, but also of their participation as partner. An interaction about how to valorise demonstration campaign and facilities after project end has been encouraged as well among key partners (INESC TEC, EDP, PP). In May 2021, a two days Exploitation Strategy Seminar (ESS - arrived at the end of a monthly supporting activity conducted by RINA-C and INESC TEC with HRB experts) has been organized where all partners had the chance to get more acquainted to exploitation and discuss about PKERs potential exploitation strategies. The results of the ESS were crucial to realize D7.5 and subsequent D7.8.

Task T7.3 ("*Dissemination and communication activities*" is lead by VTT) - After the first dissemination and communication strategy was provided in 2020 (including target groups, target group specific key messages, dissemination channels and dissemination targets), this task has focused on producing videos of the showcase scenarios developed in WP1 and WP2, available events and publishing the results achieved so far. The first two scenario videos have been released and promoted on the project social media channels (ATLANTIS H2020 Project LinkedIn and Twitter accounts) and the work on the following scenario videos as well as an update on the Test Center video has been started. The social media channels have also been used to inform stakeholder groups of published articles (4 scientific journal articles, 1 professional journal article and 3 online media articles) and press releases (1 press release from ABB). The project website provides links to these where possible. Public deliverables are also provided through the website. Despite Covid restrictions, both remote and face-to-face events have been held and participated in. The full list of events for 2021 is provided in Section 3.3. The list of publications is given below.

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No deliverables were due during the second year of the project for T7.3 as the project duration was extended 6 months and some of the deliverables were delayed to fit the new schedule. Meetings include general WP7 meetings covering T7.3 topical issues and meetings with video producer(s).

Table Erro! Utilize o separador Base para aplicar Heading 1 ao texto que pretende que apareça aqui.**-2 - Publications and articles in 2021 - - Publications and articles in 2021**

Title	Contributing partners	State
Advancing Autonomous Surface Vehicles: a 3D Perception System for the Recognition and Assessment of Docking-Based Structures	INESC TEC	Published journal article
SENSE - The Autonomous Vessel for Multi-domain Inspection and Maintenance	INESC TEC	Published journal article
Underwater 3D scanner model using a biaxial MEMS mirror UdG	UdG, IQUA	Published journal article
Docking of Non-Holonomic AUVs in Presence of Ocean Currents: A Comparative Survey	UdG	Published journal article
ATLANTIS: Shaping future robotised O&M in Offshore Wind	EDP CNET	Published professional journal article
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
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-transformation		Online media article
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
Generation Future focus Towards sustainable success	ABB	Magazine

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.

2.6. WP8

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.

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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 M13 to M024 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, one deliverable was submitted, D8.6 “Second Quality plan, risk and peer review”, on the 30th of June 2021.

Description of the main role of partners:

Task 8.1 (“*Project management*" is led by INESC TEC) - This task 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. During this reporting period (M13-M24), the project coordinator requested 2 technical and 2 financial statements from partners in order to assess the overall status as well as, to measure the impact of COVID19 in this action.

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 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 8.2 (“*Quality assurance*” UdG). 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.

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Task 8.3 ("*Technical management*" VTT). VTT as Technical Manager, supervises the workflow in the different work packages and monitors risks. The effective risk management requires an informed understanding of the work conducted in each work package. The whole Consortium is in regular contact via email or virtual meeting 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. Ethical issues (e.g., misuse of research findings) were addressed between PMT and PCB, and the requirements were decomposed in several risks and included in deliverable D8.6, which was shared with the Consortium.

2.7. WP9

During the reporting period of this second publishable report, all deliverables were submitted in due time namely, D9.3 ("*H - Requirement No. 3"*) in 30th of June of 2021.

Ethics requirements (WP9) aims to address ethical issues related to protection of human beings, animal protection and environmental protection, data protection, privacy, compliance with national or international law and malevolent use of research results. The reports elaborated in this work package were shared among partners.

3. Project Progress Report

3.1. Deliverables and Milestones

WP2

Table 3-1 - Deliverables and Milestones submitted in WP2 -1 - Deliverables and Milestones submitted in WP2

No	Title	Description	Lead Benef.	Date Day & Month	Status
D2.3	Technologies to increase the robot awareness	A demonstration video.	INESC	*30, March, 2021* *On time*	**Submitted**

WP3

Table 3-4 - Deliverables and Milestones submitted in WP3 - Deliverables and Milestones submitted in WP3

No	Title	Description	Lead Benef.	Date Day & Month	Status
M3.1	Floating system structure designed and international contract launched	An international contract with conditions and terms specified	INESC TEC	*30, September, 2021* *Delayed*	**Achieved**

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WP4

Table 3-5 - Deliverables and Milestones submitted in WP4 - Deliverables and Milestones submitted in WP4

No	Title	Description	Lead Benef.	Date Day & Month	Status
D4.2	Press releases about the Decision-making 2	A document containing the 2nd press release about the operations planning tool for IMR robotics.	ABB	*28 , February, 2021* *On time*	**Submitted**

WP6

Table 3-4 - Deliverables and Milestones submitted in WP6

No	Title	Description	Lead Benef.	Date Day & Month	Status
D6.2	Offshore wind O&M Supply chain needs and opportunities	A report detailing strategies with the aim of integrating the solutions produced by ATLANTIS in the offshore wind supply chain.	EDP	*30, November, 2021* *Delayed 14 days*	**Submitted**
D6.4	Assessment of Business Cases for the ATLANTIS stakeholders: financial and strategic considerations for the major stakeholders	A report details the 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 is to point out the benefits that ATLANTIS could bring to the identified stakeholders, compared to the traditional inspection procedures.	EDP	*31, July, 2021* *On time*	**Submitted**

WP7

Table 3-6 - Deliverables and Milestones submitted in WP7 - Deliverables and Milestones submitted in WP7

No	Title	Description	Lead Benef.	Date Day & Month	Status
D7.5	First Exploitation strategy report	A document describing the exploitation strategy per each Key Exploitable Result (KER)identified in the project from the preliminary list presented in the Grant	RINA-C	*30, June, 2021* *On time*	**Submitted**

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		Agreement and refined after the exploitation strategy seminar realized in May 2021			
D7.8	IPR Manual	A document presenting guidelines to proper protect from an IPR point of view the KERs identified in D7.5 and a patent analysis per each of the KERs	RINA-C	*31, August, 2021* *On time*	**Submitted**

WP8 & WP9

Table Erro! Utilize o separador Base para aplicar Heading 1 ao texto que pretende que apareça aqui.**-7 - Deliverables and Milestones submitted in WP8 and WP9 - - Deliverables and Milestones submitted in WP8 and WP9**

No	Title	Description	Lead Benef.	Date Day & Month	Status
D8.6	Second Quality plan, risk and peer review	An updated report describing the KPIs to evaluate the impact of the project in a variety of fields.	UdG	*30, June, 2021* *On time*	**Submitted**
D9.3	H - No. 2	The procedures and criteria that will be used to identify/recruit research participants in the workshop must be included in D7.3, as part of Task 7.2. The informed consent procedures that will be implemented for the participation of humans in the workshops must be included in D7.3, as part of Task 7.2	INESC TEC	*30, June, 2021* *On time*	**Submitted**
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 update of the list of critical risks.	INESC TEC	*29, December, 2021* *On time*	**Submitted**

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3.2. Project Meetings

WP2

Table Erro! Utilize o separador Base para aplicar Heading 1 ao texto que pretende que apareça aqui.**-7 - List of meetings of WP2 during the reporting period -7 - List of meetings of WP2 during the reporting period**

Date	Place	Meeting	Comments
29-01-2021	Online	Adaptation of Robotic Platforms for O&M activities & IT systems for the Platform	Slides: ATLS_Technical/ATLS_WP2/WP meetings/WP2_ATLANTIS_29thJanuary_Meeting.pdf
19-02-2021	Online	Adaptation of Robotic Platforms for O&M activities & IT systems for the Platform	Slides: ATLS_Technical/ATLS_WP2/WP meetings/WP2_ATLANTIS_19thFebruary_Meeting.pdf
09-04-2021	Online	Adaptation of Robotic Platforms for O&M activities & IT systems for the Platform	Slides: ATLS_Technical/ATLS_WP2/WP meetings/WP2_ATLANTIS_9thApril_Meeting.pdf
07-05-2021	Online	Adaptation of Robotic Platforms for O&M activities & IT systems for the Platform	Slides: ATLS_Technical/ATLS_WP2/WP meetings/WP2_ATLANTIS_7thMay_Meeting.pdf
26-05-2021	Online	ATLANTIS O&M Workshop	Slides: ATLS_Technical/ATLS_WP2/WP meetings/ATLANTIS-Scenarios-4-WindPlus-Workshop.pdf
04-06-2021	Online	Adaptation of Robotic Platforms for O&M activities & IT systems for the Platform	Slides: ATLS_Technical/ATLS_WP2/WP meetings/WP2_ATLANTIS_4thJune_Meeting.pdf
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_PlatformInterfaces.pdf
20-09-2021	Online	Workshop: Interfaces for interoperability	Slides: ATLS_Technical/ATLS_WP2/WP_meetings/WP2_ATLANTIS_INTEROP_WORKSHOP_20th_September.pdf
01-10-2021	Online	Adaptation of Robotic Platforms for O&M activities & IT systems for the Platform	Slides: 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

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WP3

Table Erro! Utilize o separador Base para aplicar Heading 1 ao texto que pretende que apareça aqui.**-8 - List of meetings of WP3 during the reporting period - - List of meetings of WP3 during the reporting period**

Date	Place	Meeting	Comments
12-02-2021	Virtual	Testbed Technical Specification	
19-02-2021	Virtual	Testbed Technical Specification	
12-03-2021	Virtual	Testbed Technical Specification	
26-03-2021	Virtual	Testbed Technical Specification	
16-04-2021	Virtual	Project Coordination	WP status
14-12-2020	Virtual	Contract Specification	
03-05-2021	Virtual	Contract Specification	
25-03-2021	Virtual	Contract Specification	
02-06-2021	Viana do Castelo	Campaign for data collection	
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	

WP4

Table Erro! Utilize o separador Base para aplicar Heading 1 ao texto que pretende que apareça aqui.**-9 - List of meetings of WP4 during the reporting period - - List of meetings of WP4 during the reporting period**

Date	Place	Meeting	Comments
15-01-2021	Online	Planning meeting for 2nd year	T4.2 Plan for Y2
05-02-2021	Online	Task 4.2 O&M analytics	T4.2 Presentation and data related wishes for Task 4.2 O&M analytics
26-02-2021	Online	Conduction of potential challenges and O&M use cases (stochastic environmental factor analytics and organic growth and blade crack detection)	Presented in the PCB meeting
05-03-2021	Online	Task 4.2 O&M analytics	Template for blade inspection by drones presented during a weekly meeting. Sent to EDP.
26-05-2021	Online	Atlantis Offshore Wind O&M Workshop (EDP, INESTEC, PPI, Ocean Winds, ECA,UdG,ABB, VTT)	Presentation on Data analysis challenges
06-10-2011	Online	Marine growth data Workshop	Formulation of inspection data collection procedure related to marine growth

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29-10-2021	online	Progress presentation (VTT) 4.2 for Atlantis stakeholders.	
26-11-2021	online	Progress reporting 4.1 for Atlantis (ABB) stakeholders.	

WP6

Table Erro! Utilize o separador Base para aplicar Heading 1 ao texto que pretende que apareça aqui.**-10 - List of meetings of WP6 during the reporting period - - List of meetings of WP6 during the reporting period**

Date	Place	Meeting	Comments
11-06-2021	virtual	T6.4 Progress meeting between EDP NEW and RINA	
02-07-2021	virtual	T6.4 Progress meeting with all partners	

WP7

Table Erro! Utilize o separador Base para aplicar Heading 1 ao texto que pretende que apareça aqui.**-11 - List of meetings of WP7 during the reporting period - - List of meetings of WP7 during the reporting period**

Date	Place	Meeting	Comments
07-01-2021	virtual	Discussion of the approach to the scenario videos	
13-01-2021	virtual	Discussion about ATLANTIS scenario video production with company FLIK	With FLIK Oy
15-01-2021	virtual	Scenario 2 video planning	
21-01-2021	virtual	Scenario 1 video planning	
03-02-2021	virtual	Discussion about ATLANTIS scenario video production with Stereoscape	With Stereoscaupe oy
09-02-2021	virtual	Discussion about ATLANTIS scenario video production with company Miltton	With MILTTON Oy
11-02-2021	virtual	Scenario videos quotation details discussion	With BubbleCS
12-02-2021	virtual	Progress meeting	
23-02-2021	virtual	Scenario videos quotation details discussion	With BubbleCS
11-03-2021	virtual	Scenario 1 video progress meeting	With BubbleCS
11-03-2021	virtual	Scenario 1 video progress report	
18-03-2021	virtual	Scenario 1 video discussion	
19-03-2021	virtual	Scenario 1 video progress meeting	With BubbleCS
23-03-2021	virtual	Meeting to discuss potential external dissemination	
26-03-2021	virtual	Progress meeting	
29-03-2021	virtual	Meeting with external dissemination company	With Pressing Company
09-04-2021	virtual	Progress meeting	
07-05-2021	virtual	Progress meeting	
26-05-2021	virtual	Scenario 2 video meeting	With BubbleCS
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

WP8

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Table Erro! Utilize o separador Base para aplicar Heading 1 ao texto que pretende que apareça aqui.**-12 - List of meetings of WP8 during the reporting period - - List of meetings of WP8 during the reporting period**

Date	Place	Meeting	Comments
08-01-2021	Virtual meeting	WP8 meeting	
22-01-2021	Virtual meeting	General Assembly meeting	
28-01-2021	Virtual meeting	WP8 meeting	
21-02-2021	Virtual meeting	WP8 meeting	
26-02-2021	Virtual meeting	Coordination meeting (PCB)	
12-03-2021	Virtual meeting	WP8 meeting	
26-03-2021	Virtual meeting	WP8 meeting	
09-04-2021	Virtual meeting	WP8 meeting	
14-04-2021	Virtual meeting	Work Package Leaders and Coordination meeting (PCB)	Risk mitigation plan
16-04-2021	Virtual meeting	WP8 meeting	
07-05-2021	Virtual meeting	WP8 meeting	
10-05-2021	Virtual meeting	General Assembly meeting	Approval of the risk mitigation plan
21-05-2021	Virtual meeting	WP8 meeting	
04-06-2021	Virtual meeting	WP8 meeting	
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)	

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

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

Table Erro! Utilize o separador Base para aplicar Heading 1 ao texto que pretende que apareça aqui.**-13 - Major events summary- - Major events summary**

Type	Title	Date	Description	Partner
Workshop	European Academy of Wind Energy, PhD seminar		PhD seminar	PPP
Webinars	Windpower Data and Digital Innovation Forum	17 Feb 21	Windpower Data and Digital Innovation Forum	EDP CNET
Conference	Belgian Offshore Days	17 Mar 21	Belgian Offshore Days	SPACEAPPS

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Conference	Jornada sobre drones en el sector naval y offshore	12 May 21	IQUA presents the project to Naval Cluster of Cádiz area (Spain) in the Conference on drones in the naval and offshore sector	IQUA ROBOTICS
Webinars	Sprint Robotics Focus on clean energy: The impact of Robotics in I&M	26 May 21	Presentation of ATLANTIS in the Sprint Robotics Focus on clean energy seminar	PPP INESC TEC
Conference	EXCELLENCE IN WIND TURBINE LIFE-CYCLE MANAGEMENT	14 Jun 21	Presentation of ATLANTIS in the EXCELLENCE IN WIND TURBINE LIFE-CYCLE MANAGEMENT conference	EDP CNET
Conference	EMRA2021	07 Jul 21	Presentation of ATLANTIS in the EMRA2021 conference	INESC TEC
Conference	Floating Wind Solutions	28 Jun 21	Presentation of ATLANTIS in the Floating Wind Solutions Conference; Exhibition	PPP
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

3.4. 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.

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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.

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

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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 help 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.

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

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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 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

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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.

3.5. Deviations from the work plan and their Impact into the project

There are no major deviations from Annex 1 to be reported for the time period of M13 to M24 however, the COVID-19 pandemic situation imposed unexpected challenges and changes in some tasks, which can be summarized as below.

The Project Coordinator is tracking the evolution of the COVID-19 situation in close collaboration with partners involved in activities, mainly through bi-weekly meetings. Right after the first restrictive measures were adopted by some European countries, the Project Coordinator and the Technical Manager assessed the impact of the COVID-19 outbreak in the activities planned within ATLANTIS.

The risk of COVID-19 to ATLANTIS was identified for each work package according to the procedure described in the "*Second Quality plan, risk and peer review*" manual. Risk levels were specified according to the importance of partner for each work package, its ability to carry on the work plan and deliver results in time and quality.

Table 3-14 -Risk of COVID-19 to ATLANTIS -Risk of COVID-19 to ATLANTIS

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Activity in this WP is:
compromised (**red**)
severely affected (**orange**)
small impact (**yellow**)
no impact (**green**)

Time period	COVID-19 Pandemic risks	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8
M12-M15	production units stopped, supply chain disruptions	green	orange	yellow	orange	orange	green	yellow	green
M16-M18	supply chain disruption	green	yellow	yellow	yellow	yellow	green	yellow	green
M19-M21	supply chain disruption	green	yellow	yellow	yellow	yellow	green	yellow	green
M21-M24	supply chain disruption	green	orange	yellow	yellow	yellow	green	yellow	green
Nowadays	supply chain disruption	green	orange	yellow	yellow	yellow	green	yellow	green

Mostly, the impact of COVID-19 epidemic situation in this action can be summarized by :

- Reduced networking activities due to travel restrictions.
- Supply chain disruption.
- Overpriced of raw materials (for WP3).

Minor deviations in WP3:

Regarding WP3, milestone 3.1 was delayed one month as modifications to the contract specification were required to satisfy the requirements identified within ATLANTIS. These delays were mainly due to factors external to the project consortium, such as discussions with local authorities, external entities and the COVID19. In order to establish the Coastal Testbed, local authorities such as the City Council of Viana do Castelo, the local Port Captaincy (Viana do Castelo Port Captaincy) and the company administrating the local Port (APDL) needed to agree with the establishment of the ATLANTIS Testbed in their area of influence (Viana do Castelo harbor) and provide the required permits to do so in agreement with the portuguese law. The COVID-19 delayed all the process of discussing with each entity due to the constraints imposed by the pandemic and the containment measures imposed by the government. A final specification for the Testbed took longer to obtain than initially expected since the designs are dependent on the chosen location for the installation of the Testbed, and this decision making process is completely external and outside of the influence of the ATLANTIS consortium. The start of the Task 3.2 (installation of the structures in the Testbed) was also delayed as a consequence of the call for tender also being delayed. In addition to what was proposed in the project proposal, the ATLANTIS consortium considered that having two types of structures, a floating one and a monopile, would

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increase value of the initiative by improving the representativeness of the O&M scenarios which are accounted in the Testbed. However, since raw materials have suffered such a great increase in cost since the start of 2021 (as an example, steel increased 340% since August 2020), the financial impact and feasibility of such decision is currently being evaluated. According to an industry survey, the gross estimate of the manufacturing cost involving steel in January 2021 was 4000€/tone of steel. Our final design specification for the floating structure includes around 70 tones of steel, which totals a cost of 284k€, while the specification of the monopile includes around 17 tones, which total 79k€. Analyzing the increase in cost of a tone of steel from January onwards, which is 155% as of July 2021, we estimate a current manufacturing cost of 440k€ for the floating structure and 107k€ for the monopile. Since we were only notified about the final Testbed location in May, and this location has higher depth, this would imply an extra 8 tones in steel, increasing cost of the monopile on a extra 16k€. Thus, the total manufacturing cost of the structures increased from 353k€ (which were considered in the project proposal) to 563k€. This price disparity forced us to drop the monopile structure from the contract specification. Nevertheless, the tender notice was published and the proposals are currently being evaluated.

Minor deviations in WP7:

The T7.3 *"Dissemination and Communication activities"*: the large majority of events, conferences, workshops were postponed or cancel due to travel restrictions. The website of the project is online and the dissemination is being done through social media platforms such as, LinkedIn. However, as both the use of digital technology in remote events has become more common and usual and as vaccinations have progressed, ATLANTIS was able to participate in most planned events with limited cancellations. However, the plans needed to be adjusted on a regular basis and planning of events was on a shorter notice than traditionally. RINA-C was planning to organize a physical Exploitation Strategy Seminar to collect exploitation intentions and present relevance of exploitation activities (particularly in a "close to market/demonstration" project as ATLANTIS is) during a "face-to-face" meeting. Due to COVID-19 unfortunately RINA-C organized such "Exploitation intention collection" only via mail and thanks to a specific "Introduction" section during a digital project meeting. This made T7.2 activities a little bit longer and more complicated, nevertheless D7.5 has been delivered on time. In order to overcome such barriers RINA-C organized at this purpose an Exploitation Strategy Seminar with HORIZON RESULT BOOSTER support and this enabled RINA-C to submit on time both D7.5 and D7.8. Nevertheless for future Exploitation Strategy workshop, physical presence would be preferable.

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