



The Atlantic
Testing Platform for
Maritime Robotics

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1. Introduction

This document was created as a guide for potential users of the ATLANTIS Test Centre in Viana do Castelo. Moreover, it can be used as material for preparing training sessions if needed. The main part of the deliverable is a set of presentations describing the location of the test site, the environmental conditions, and the available infrastructure, as well as specific use cases related to the experimental trials, conducted, by the partners, at the site. The presentations are summarised in the sections below and attached in the Appendix.

2. ATLANTIS Test Centre

The ATLANTIS test center is a proving ground for marine robots and related technological solutions. Installed in Viana do Castelo, the ATLANTIS Test Centre, it is composed of two test sites, the Coastal Testbed and the Offshore Testbed, as well as a Shore Control Centre.

The Coastal Testbed is located within the harbor of Viana do Castelo, in close proximity of the local sailing club. It is easily accessible by car or train, and as it is a public space, there are no restrictions in terms of access. It is composed by a decommissioned floating offshore structure, that replicates the challenges presented in floating offshore wind farms. Due to its proximity to the sailing club, the Coastal Testbed has access to all infrastructures required for easy deployment of robotic technologies. These include energy supply (directly on the structure or provided by power banks and generators, if needed), support vessels, large access roads for the transport of equipment, crane, internet access, toilets and a sheltered room (room of the control center).

The Offshore Testbed is composed by a real wind farm, the WindFloat Atlantic Wind park, located up to 20 kilometers from the coast of Viana do Castelo. It is composed by three floating wind turbines, and access is possible through the use of a support vessel at the disposal of the Test Centre users. During testing operations, users have access to 4G and a satellite link. Access to the testing area is restricted and subject to regulations defined by the owners of the wind park.

The Shore Control Centre (SCC) provides full communication with the robotic platforms on both testbeds; direct line of sight communication with the vehicles operating in the Coastal testbed, and with the vehicles on the Offshore testbed vehicles operating in the Offshore Testbed. The SCC is a private space, that allows easy monitoring of operations, with all of its infrastructures compatible with ROS (Robot Operating System), allowing easy transfer of data and remote monitoring of the operations.

For users performing tests in the ATLANTIS Test Centre, the process starts with coordinating with us the deployment and storage of the equipment to be used during the tests. Once the equipment is transported to (and stored in) the Test Centre, deployment will be dependent on the type and weight of the equipment. Easily transported equipment can be deployed manually, while for heavier and bulkier equipment support from the sailing club is required for deployment. Once the equipment is deployed, if *in loco* water support is required, a support vessel is deployed with the team member supporting the operation. Once the test is completed, the recovery process of the equipment occurs in a similar manner as the deployment. Manually for lighter and smaller equipment, and with support from the sailing club for heavier and bulkier equipment. Once back on shore, if further tests are required, the process is repeated. If the testing is concluded, arrangements need to be made for the transport of the equipment back to the origin point.



While one of the aims of the ATLANTIS Test Centre is the de-risking of the technologies, performing work in a floating structure or offshore can pose some danger to human operators. Even though the Test Centre presents an ideal location to perform training programs and gather experience on the use of robotic technologies, risks still exist. As a result, there are a set of safety regulations in place for users of the Test Centre. These include the use of protective gear (life jacket and helmet) when on a vessel or on the floating structure, close inspection of the equipment to be used before deployment and the report of any potential hazards detected.

In addition to the safety regulations imposed by the ATLANTIS Test Centre, there are permission pertaining tests in the harbor and at sea that are required by external entities. These include the approval for all tests in the areas involving aerial vehicles by the Captaincy of Viana do Castelo and by the AAN (National Aeronautical Authority), registration of support vessels with DGRM (Directorate-General for Natural Resources, Safety and Maritime Services), and both Sea Survival Training and OEUK certificates for those going offshore. Depending on the tests to be performed, particularly offshore, additional training certificates might be required from the users.

To apply to test technologies in the ATLANTIS Test Centre, potential users are required to email atlantis.testcentre@inesctec.pt, indicating their interest and providing information on the test to be performed. The minimum information on the tests required includes the type of technologies to be tested, their intended application, which testbed would be used (testing on the Offshore testbed requires previous testing in the Coastal testbed), any supporting infrastructures required for the tests, the size of the team present at the Test Centre and the expected time-frame for the operations.

All data collected by ATLANTIS, either during the application or during the testing activities is subject to GPRD guidelines. This means that no personal information will be collected and all data collected during testing will be confidential and secure.

3. Use cases

3.1. INESC TEC

The INESC TEC team was involved the development of technologies that can be applied to 3 different scenarios: i) inspection of the floating structure, ii) support of operations with crewless vessels and iii) inspection of blades and tower. The technological developments related to these scenarios were centered on two different type of vehicles: an Autonomous Surface Vehicle (ASV), Nautilus, for the first two scenarios and an Unmanned Aerial Vehicle (UAV), RAVEN, for the last one. These developments involved the design of new sensor payloads to be integrated in the vehicles, as well as new navigation algorithms.

The development of Nautilus involved the design of a new mechanical structure and reconfirmation of the sensor payload and actuators. The objective was the development of a vehicle with increased robustness and stability. This will not only contribute to increased reliability in offshore environments, with its harsh conditions, but allow the ASV to pull tow vehicles transporting other robotic platforms.

For the scenario of inspection of the towers and blades, the developments were geared towards NDT inspection of the offshore infrastructures as well as achieving fully autonomous deployment and recovery of the vehicle. This was achieved through careful consideration of the sensor payload to be used by the RAVEN UAV, considering both the needs of inspection activities and the autonomous deployment of the vehicle. The payload consists of a 3D LiDAR, a visual camera and a thermographic camera. For the



autonomous deployment, a small landing platform was designed and constructed to allow autonomous landing and take-off. This included the design of a marker that allows the UAV to detect the position of the platform.

During the trial performed in the ATLANTIS Test Centre, in July 2022, the INESC TEC team was able to successfully demonstrate the autonomous take-off and landing of the RAVEN UAV into the landing platform, both when the platform was attached to a fixed structure and when it was being pulled by the Nautilus ASV. Additionally, the inspection of the floating structure was also successfully validated.

The Nautilus ASV was deployed through the use of the crane present in the facilities of the Coastal Testbed of the ATLANTIS Test Centre. The vehicle was transported to the crane using a boat trailer. From there it was attached to the crane carabiners through fixation points specifically implemented for the deployment. Once in the water, a support vessel was used to release the carabiners. The vehicle can then be either tele operated from shore or from the support vessel, or it can perform an autonomous operating, whilst being monitored with a support vessel (with a kill switch).

The deployment of the landing platform for the UAV can be performed in the same manner as the ASV, or through water access ramps, as the platform has wheels. Once attached, either to fixed structures or to the ASV, the UAV takes-off manually from shore and is operated until it is positioned directly above the landing platform. From there it starts its landing operation autonomously. Once the UAV has safely landed, if the platform is attached to a fixed location, the drone takes off autonomously. If the landing platform is attached to the ASV, this one moves towards a different position, while carrying the UAV in the landing platform, with the AUV taking off autonomously upon arrival of the pre-determined goal point.

During the operations of the vehicles a ground station provides the RTK base information through WiFi to the vehicles in operation. The operations and data collected can be monitored and controlled through a mission controller deployed on shore. All of the telemetry data is shared from the robots with both the mission controller and the ATLANTIS SCC.

3.2. UdG

In the ATLANTIS project the UdG team has been developing technologies in two different directions: a) the permanent deployment of autonomous underwater vehicles for continuous monitoring of the wind farms and b) the autonomous IMR operations on the Windfloat structure, including cathodic protection testing with a contact probe, cleaning with a rotating brush, and laser scanning of anodes. Development of the first technology involved a complete design of a docking station for the Sparus II AUV as well as new control algorithms for autonomous docking. Development of the second technology included a new, dual-manipulator payload design for the Girona 1000 I-AUV, as well as implementation of control algorithms allowing for fully autonomous IMR operations.

The permanent deployment test was composed of a few parts: undocking of the Sparus II AUV, autonomous survey of the seabed, and autonomous docking manoeuvre. To monitor the operation of the robot during the test, it is connected to the control panel through a cabled buoy, floating on the surface and equipped with a WiFi antenna. This wireless connection is used only as a safety measure due to ongoing evaluation of the system reliability and performance and in the final solution it would be removed.



The IMR tests with the Girona 1000 I-AUV were focused on fully autonomous cathodic protection measurements with a contact probe. Each operation includes multiple stages: submerge action; identification of the location of the structure; approach to the surface of the structure and docking with a permanent magnet gripper, installed on one of the manipulators; unfolding of the second manipulator; touching multiple points on the surface of the structure, with a probe; folding the probing manipulator; undocking and surfacing.

During the trials performed in the ATLANTIS Test Centre in November 2022, the UdG team was able to successfully complete the permanent deployment tests, but failed to perform the IMR tests for various reasons explained below and in the related presentation.

The docking station was installed in the seabed, in the part of the port assigned to the ATLANTIS Test Centre, with the help of a crane and a group of divers. It was supported by wooden planks due to large amounts of sediment. The vehicle was deployed to the water from a floating pier of the sailing club, which is easily achieved by a single person, thanks to the design of the Sparus II AUV trolley and the low weight of the robot. The robot was then teleoperated in the surface, to the surroundings of the docking station. The autonomous docking algorithm was used to dock the robot, undock, and perform a survey of the bottom using a forward-looking sonar. Multiple sequences were completed successfully.

The IMR tests planned to perform using the Girona 1000 I-AUV were not possible to conduct. The main reason was the fact that the floating structure, being part of the ATLANTIS Test Centre, was not installed deep enough and its surface was covered with marine growth. This has pushed the UdG team to use an alternative structure, a test rig built for the trials in the CIRS test tank. The robot has successfully performed autonomous CP measurements in the lab environment, using this structure. However, two problems hindered the testing of the developed algorithms in the ATLANTIS Test Centre. The first problem was the difficulty in installing the test rig in the site. The location chosen for the installation was a pier which is constructed from concrete blocks with big holes, reducing the water resistance and allowing it to pass. When the test rig, which is a curved panel, was installed on the wall of the pier underwater, the forces exerted by the water have broken the lines and parts of the structure in a few hours. Therefore, the panel was not fixed and moving with the water, which has made it infeasible for performing any manipulation tests. The second problem was the very high turbidity of water in the site, which rendered impossible the testing of the laser scanning technology developed for anode inspection (see photos in the presentation). It is an important factor to consider if any vision based system is to be tested in the site.

3.3.IQUA Robotics

The main focus of Iqua in the ATLANTIS project is the development of algorithms for autonomous inspection of submerged sections of Windfloat structures. For this task, Iqua has chosen the Girona 1000 AUV, as it provides very stable roll and pitch DoFs, large and flexible payload area and connectivity, high processing power and accurate localization using GPS, DVL and INS. Iqua has also developed a payload specifically for this task which includes a multibeam sonar, two optical cameras and a pan/tilt device. The multibeam sonar and one of the optical cameras can be tilted using the pan/tilt device. The autonomous exploration algorithm developed at Iqua for the autonomous inspection of submerged structures is divided in two main stages: assessment and inspection. In the assessment stage, the robot navigates around the structure at a moderate distance, gathering occupancy information for path



planning and obstacle avoidance. In the inspection stage, the robot performs a trajectory much closer to the structure, gathering not only occupancy information, but also optical data for the inspection of the asset. At all times, a path planner ensures the robot trajectories are safe. Prior to the testing in the ATLANTIS Test Centre in Portugal, Iqua tested the algorithm in two scenarios near Girona, a natural islet and a breakwater structure, with excellent results.

In the tests performed in the ATLANTIS Test Centre in November 2022, the Girona 1000 control station computers and the operators were located inside the provided containers. While a battery powered Wi-Fi antenna was used as an intermediate connection point between the control station and the robot. Deployment of the AUV was realized using the crane available in the operational area. In addition to the robot, a small cabled buoy was deployed to maintain communication when the robot is underwater. Several successful runs of the algorithm were performed in the ATLANTIS Test Centre, with the robot circumnavigating the floating structure from a close distance. However, the poor visibility during the test days impeded obtaining optical data of sufficient quality to perform a 3D reconstruction of the site. During the experiments in the ATLANTIS Test Centre, two payload configurations were tested. One of them with the tilting device sweeping the multibeam to scan vertically (forward), and the other sweeping the multibeam to scan horizontally (mainly sideways).

In the presentation, details are given regarding the integration with the SCC in the ATLANTIS Test Centre, developed in close coordination with the SPACEAPPS team. Mainly, the developments focused on transmitting telemetry from the vehicle to the web APP, mission integration and programming through the SCC and receiving basic commands from the web APP to the Girona 1000 AUV. Finally, the presentation concludes with a section describing problems and observations regarding the operation in the Test Centre.

3.4.RINA

The focus of Rina in the ATLANTIS project is the identification of new methodologies for O&M activities using robots, within the emerging set of technologies and to develop potential options that may be able to respond to industry's challenges.

This goal will be achieved through the development of methodologies and through the progressive increase of know-how acquired through testing campaigns carried out using robotic technologies (UAV, ROV, ASV) already available on the market.

Another crucial factor is the development of Risk assessment. Risk assessment and risk management of the structure will be also driven by data collected by the robots: therefore, the most relevant parameters to be monitored with/without robots will be early identified to constantly monitor the safety and the risk of the structure.

During the tests performed in the ATLANTIS Coastal Testbed in November 2022, Rina has performed following activities:

UAV

- **Equipment:** DJI MATRICE M 210 RTK V.2
- **Main Objectives** Calibration and Data collection Floating Structure capture of images and data.



- **Planned Activity:** Inspection to verify the condition, construction, and integrity of the structure through thermographic and visual analysis.
- **Executed Activity:** Operational checks: (test of optics and thermographic sensors, wind resistance and stability during flight operations, electromagnetic fields interference). Test of Control signal (long distance ~7-8 km). Capture of details (components data of installed wind turbine is acquired). Verification of semi submersible structure (visual analysis)

ASV

- **Equipment:** Flytech model D16C-500 with sonar chirp plus deeper
- **Main Objectives** Calibration and Data collection: state of the seabed capture of images and data.
- **Planned Activity:** Analysis of the seabed of the area surrounding the floating structure conducted with the help of a drone that mounts a sonar chirp + and telescopic system with 360° camera. This sonar with a continuous flow of frequencies from bottom to top will allow the reading of the seabed and in association with bathymetric surveys allow to monitor the interference of the structure with the coastline. With the captured images it will be possible to monitor the development of benthic flora and fauna developed around the system to evaluate the possible impact/effect of the structure in the coastal environment.
- **Executed Activity:** Considering the adverse weather conditions and the poor visibility the activity has been limited to the use of the sonar for depth characterization.

ROV

- **Equipment:** FIFISH V6 EXPERT M20
- **Main Objectives** Calibration and Data collection Floating Structure (submerged section) capture of images and data.
- **Planned Activity:** The purpose of the activity is to determine the state of the art of the structure especially the erosive state to which the material is subjected.
- **Executed Activity:** Operational checks: (resistance and stability during operations). Capture of details (components data, mooring line). Verification of semi submersible structure (visual analysis). Considering the adverse weather conditions and the poor visibility the activity has been limited

The presentation provided by Rina is related to the use of drones in the coastal testbed. The objective is to provide useful information to possible users of this platform who intend to test drones or components of drones (sensors) in inspection operations.

Listed below the main topics analyzed for UAV inspection:

1. Briefing: preliminary checks to be carried out before to start the mission
 - Verification of insurance documentation of vehicles and pilot certificates
 - Weather forecast monitoring before and during the mission
 - Notify to Remote Surveillance Unit Start/End of the Inspection Works
 - Briefing Pre-flight With other Team Members
 - Check Installation Micro Sd Card
 - Check Battery Installation (Check Full Charge)
 - Check The Planned Route
 - Flight Mode Switch (On Desired Position)



- Preflight-check: Before departure UAV shall be tested and checked according to supplier's guidelines
 - Control of Possible External Interference
 - Home Point Check (Take-off Point)
2. Identification of operational area within the Coastal Test Center (Take-off Area)
 3. Characterization of floating structure
 4. Communications & SCC (*)

(*) Possibility to monitor all the mission with some parameters: state of vehicle, position, battery status, etc) to be evaluated and implemented in SCC.

Some videos and pictures are available to plan the activity (see pos.2&3).

3.5.ECA

ECA Team was present in the ATLANTIS Test Centre Coastal Testbed during one week from 7th to 11th of November for testing the ruggedized version of the Roving Bat (A remote controlled Hybrid ROV). The Roving Bat is involved into 2 different scenarios of the project: inspection of the floating structures and inspection of cable protection systems. For these trials the Roving Bat was equipped with 3 full HD TV cameras, a rotating sonar, a 7-axis manipulator fitted with a cleaning brush and a cathodic potential measurement probe and - as a payload - the MARESyE 3D camera designed by INESC TEC.

These tests were the first sea trials of the Roving Bat and were mainly focused on navigation of the vehicle and its attachment on the floating structure. The purpose was to demonstrate the functionalities of the new technologies deployed and the future ability to operate in offshore conditions.

Both scenarios were tested with the inspection of the floating structure and of the mooring chains that keep it in position (replacing the cables protection system)

Firstly, we have demonstrated the functionality of the newly designed 8KW power converters installed on the Roving Bat and a dedicated umbilical cable. Some pictures and video were recorded by divers thus showing the Roving Bat in its real environment.

On the other hand, due to the slope and the lack of depth of the floating structure, there were difficulties in performing its landing on it. Some attempts were done but only attachment on the walls of the quay was performed. Some technical problems also made these operations even more difficult.

The manipulator, the cleaning brush and the CP probe were functional but not operational because the Roving Bat could not be placed correctly on a vertical structure (the arm must be operated while the Roving Bat is still)

Regarding the integration and the calibration the MARESyE camera, the results were successful and we have performed realistic 3D images using some predefined object immersed near the ROV. This camera may be used on the structures of windfarm for 3D object reconstitution on the field during maintenance operations.

During the week we also have finalized the communication link between the Roving Bat system and the SCC in order to allow the remote reception of images and the future interoperability from the shore.



These trials were also the opportunity to train our pilot for the future offshore trials. The Roving Bat was deployed by the mean of the crane present in the facilities of the Coastal Testbed of the ATLANTIS Test Centre. The launching and the recovery using the latch lock system installed on the ROV was successfully used and can be extended to its future use on a support vessel for the offshore deployments.

The Roving Bat was operated by a pilot by the mean of a control unit installed on a 20 feet container together with the power supply unit. A generator was used to delivered the necessary power for both 400Vac and 230Vac electrical supplies. The winch was installed outside. No particular problem to report for this installation except the management of the umbilical cable that was a little bit tricky. For these operations the umbilical cable needs to be supervised by an operator during all the navigation phases to avoid entraping on the different floating structures present on the site. This monitoring is easy du to the fact of the umbilical cable is floating and visible even during bad meteorological conditions.

During all the trials HD videos and sonar images were recorded on a PC, but due to the water turbidity the cameras need to be close to the structure to take exploiting images. Only the sonar could be used for the navigation of the ROV. Automatic navigation like auto heading and auto depth functionalities are essentials to help the pilot to reach the floating structure from the launching point. As an axis of improvement we noted that a multibeam imaging sonar (Like *Oculus* from BluePrint or *Gemini* from Tritech model) would help during the approaching phase and the landing on the floating structure. The capabilities of Gigabit Ethernet transmission will allow the use of these sonars in real time.

4. Supporting technologies

4.1.SCC (SpaceApps)

In order to supervise the operations performed in the ATLANTIS context, Space Applications Services is in charge of the development of the Supervisory Control Centre, SCC, and of the integration between the robots involved and the SCC using the C++ interoperability library provided. The objective of the control centre is to monitor data coming from robots and to send commands to robots. Data coming from the robots are shown on the User interface of the SCC in real time and the operators can also navigate in the history of the data based on time constraints. Numerical data, Booleans, images, odometry, GPS and joint states of URDF models from all the robots can be received and visualized directly on the SCC.

An automated mission planning module is also integrated to the SCC to allow the operators to define missions by defining robots capabilities and assigning robots to geographical targets with associated actions to perform individually on each targets such as clean, inspect or asses.

Operators have the abilities to send direct commands to the robots connected to the SCC. Numerical commands, switches, target points and follow paths actions are handled. The operators can also set constraints to every commands in order to allow the commanding of the action only if the constraints are met. Robots can also be operated using the automated mission planning module that will output a coordinated list of actions for each robot involved in a mission. The operators can check and validate the mission plan before deploying it on the robots directly from the SCC. The control centre will then allow the operators to monitor and follow the execution of the mission plan on each robot simultaneously on the same view.



To provide a better user experience the SCC was designed to be accessible on any web browser being connected to the ALTANTIS secured network. It can be accessible on laptops, tablets or even smartphones. The user also has the possibility to fully customize the view of the user interface to split it in different components and share it to other devices connected to SCC network.

4.2. Buoy sensor system (VTT)

VTT uses the ATLANTIS pilot site, and the Coastal Testbed in particular, for developing predictive maintenance analytics for offshore wind O&M needs. The Coastal Testbed is virtualized to bring together data from different sources: weather data, motions of the testbed structure, robot-based inspection data etc. VTT O&M module uses this data for predictive maintenance analytics and then provides analytics output to the SCC. A central part of the virtualization is a digital twin model of the Coastal Testbed floating structure that processes the motion data for the O&M module.

The Coastal Testbed was instrumented with three accelerometers, a motion sensor and two cameras to detect motions of the floating structure. Weather data was gathered with a wave buoy and an anemometer (wind sensor). Measurements are sampled simultaneously with the separate data acquisition modules connected to a local PC for data storage and measurement management. Wave buoy data and onsite video stream are synchronized with the rest of the data based on offline comparisons with data responses and time values.

Applied sampling frequency depends on the measurements, and at maximum, it will be about 100 Hz. The sampling is set to fulfill the requirements for promoting virtualization of the Coastal Testbed and structural O&M analytics requirements. The motion data is used as input to the digital twin seakeeping model that then provides (wave) loadings to the digital twin structural model. These together are used to provide short-term predictions for operations (e.g. motion limits) and long-term forecast for structural integrity.

The goals and first observations are reported in the training documentation (presentation).



5. Appendix – presentations

5.1. ATLANTIS Test Centre

atlantis The Atlantic Testing Platform for Maritime Robotics

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WP 4
ATLANTIS Testing Centre

INESC TEC
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atlantis The Atlantic Testing Platform for Maritime Robotics

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Summary

1. Overview of the pilot infrastructure
2. Logistics
3. The coastal testbed
4. Safety procedures
5. Data sharing
6. Communications & SCC
7. Legal procedures
8. How to apply

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29/01/2020

1. Overview of the pilot infrastructure

- The ATLANTIS test center is a **proving ground** for marine **robots** and related technological solutions.
- Located in the city of Viana do Castelo, north of Portugal.
 - 60 km from Porto Airport (PT)
 - 73 km from Vigo Airport (ES)

ATLANTIS Test Center

Coastal Testbed

Offshore Testbed

- Two sites:
 - (a) Coastal testbed, inside the harbor
 - (b) Offshore testbed, 20km from coast

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29/01/2020

Coastal Testbed: Overview

- Located inside the harbor, in a protected area - next to the local sailing club
 - Since the location is public, no access restrictions apply to this test site.
- Easily accessible by car or train
- Complete infrastructure for enabling easy deployment

City of Viana do Castelo

Coastal Testbed

Offshore Testbed

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Coastal Testbed: Facilities

- The Viana sailing club covers most needs in terms of logistics:
 - Electric supply (although power banks and generators are available)
 - Support vessels
 - Large indoor road for easy vehicle/vessel deployment
 - Crane
 - Internet access
 - Wi-Fi
 - Sheltered room (control center)

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Coastal Testbed: Test area Bathymetry

Depth (m)

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Coastal Testbed: Buoy location

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Offshore Testbed: Overview

- Test center users have access to a **windfarm** located 20 km offshore
- A **support vessel** is the users disposal
- A **4G connection and satellite link** is available
- Subject to **access restrictions and strict regulations**



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Communications & Shore Control Center (SCC)

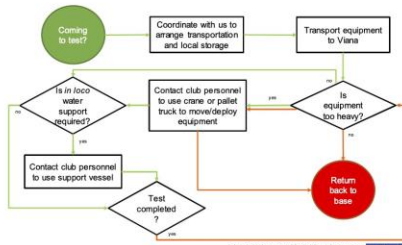
- Full communications infrastructure at the users disposal
 - Direct line of sight communication between the floating structure mounted access point (which the vehicles can connect to transfer data to operators) and SCC room.
 - Offshore test center access point connects (which the vehicles operating offshore can connect to) via 4G or satellite link (charges due).
- Internet access across the test sites.
- ROS compatible communications middleware provided, enabling easy monitoring using the available systems.
- The SCC is a private space where users can monitor & supervise their operations.



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Deployment Logistics



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Safety Procedures

- Working offshore or even in a harbor is **tough and can be dangerous**
- ATLANTIS test center is the correct location to perform **official training programmes and gather experience** about the equipment
- Nevertheless, to **decrease the risk of an accident or injury**:
 - Wear **protective gear** – helmets and swimming vests are provided.
 - **Report hazards** to identify problems and implement correction measures.
 - **Inspect tools and equipment**: perform predeployment tests to make sure your equipment is working correctly
 - Promote a **safety culture**



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Data Sharing

- GDPR compliance required
- Information about experiments taking place in the test centre are **confidential**
- No personal data shall be collected
- Any data collected through the communications middleware (in case it is used) will be kept in a secure local server with access restrictions – users may control what sensor data is logged.



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Legal Procedures

- Testing in the Test Centre requires a set of **permissions and certifications**
- All tests involving UAVs (both Coastal and Offshore) require:
 - Approval from the Captaincy of Viana do Castelo
 - Registration in the AAN of the platform, pilot and details of the flight
- Support vessels need to be registered with DGRM for the duration of the testing
- All personnel going Offshore is required to (as minimum):
 - Have completed the Sea Survival training
 - Present medical aptitude certification (OEUK)
- Depending on the activities being performed offshore, additional training might be required



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How to Apply

- To apply to use the ATLANTIS Test Centre send an email to atlantis.testcentre@inesctec.pt, detailing:
 - Technology to be tested, validated or demonstrated
 - Intended application of the technology
 - Which Testbed(s) is the test directed towards
 - Supporting infrastructures required (support vessel, divers, etc.)
 - Size of the team present at the Test Centre
 - Timeframe within you expect the testing to be performed



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5.2. Use cases: INESC TEC

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WP 4
ATLANTIS Testing Centre training: Use cases

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Summary

1. Introduction (description of use case)
2. Deployment of assets
3. Operations
4. Communications & SCC
5. Problems and observations

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1. Introduction

- The INESC TEC team was involved in **3 different scenarios**. The validation of several robotic platforms was supported by the infrastructure available in the Coastal Testbed.

ATLS Scenario 2 & 7: Inspection of DURIUS

- Case 1 - NAUTILUS ASV (a vessel with 3.0x1.4x1.5 m and 130 Kg of weight).
- Inspection of transition piece (NDT activity supported by visual and 3D information).

NAUTILUS ASV

NAUTILUS operating on the test area

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1. Introduction

ATLS Scenario 1: Aerial inspections of DURIUS

- Case 2 - RAVEN UAV (a drone with a wingspan of 1.6 m and 22 Kg of weight).
- Inspection of DURIUS (NDT activity supported by visual and 3D information).
- Autonomous operations (landing the UAV in a floating platform with area of 2x2m).

RAVEN UAV

RAVEN inspecting DURIUS

RAVEN landed on NEST

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2. Deployment of assets

Case 1: Deployment of NAUTILUS ASV

- Push the ASV to the crane area using the boat trailer;
- The crane available at the test site can lower an ASV;
- Use a support vessel to detach the carabiners.

Note: the support area #1 is an open zone, without obstacles and with a good visibility to the Test Area.

The recovery of NAUTILUS is made through the same method.

NAUTILUS boat trailer

NAUTILUS deployment with crane

Support vessel to detach the carabiners

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2. Deployment of assets

Case 2: Deployment of Floating Landing Platforms

There are 2 options available to deploy floating structures (like NEST):

- Use the crane available at the site (similar to case 1).
- Use an access ramp to slide the landing platform to the water (if the floating structure has wheels).

The NEST was secured by ropes or trailed to NAUTILUS.

The recovery of NEST is made through the same method.

Access Ramp

Crane

NEST in the Test Area

NEST trailed to NAUTILUS ASV

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2. Deployment of assets

Case 2: Takeoff and landing of RAVEN UAV on shore

The takeoff and landing of RAVEN UAV was performed in the Support area #1.

Note: the support area #1 is an open zone without obstacles and with a good visibility to the Test Area.

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3. Operations

Case 1: Inspection of DURIOUS with NAUTILUS ASV



NAUTILUS ASV
(<https://youtu.be/124lanOnml8>)



NAUTILUS operating near DURIOUS
(<https://youtu.be/8884uA-cDc>)

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3. Operations

Case 2: Inspection of DURIOUS and autonomous landing of RAVEN UAV in NEST floating platform



Autonomous landing of RAVEN on NEST trailed to NAUTILUS
(<https://youtu.be/8pUfmgZT9w>)



RAVEN inspecting DURIOUS
(<https://youtu.be/7586qYRFXc>)

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3. Operations

Mission Monitoring:

- Support vessel can be used to monitor the mission along Test Area. Best solution for moving around and close to the DURIOUS structure, and all of the Test Area. The use of life jacket is mandatory.
- The red areas present high visibility location for different perspectives of the Test Area and of DURIOUS structure.
- DURIOUS structure can be used as a monitor station. All safety procedures should be followed (e.g. helmet and life jacket).



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4. Communications & SCC

The vehicles were connected to SCC through a portable Mission Controller and over Wi-fi. A ground station provides the RTK base signal to the vehicles, also through Wi-fi. The Mission Controller is located at Support area #1, and Ground Station is located near the Test Area. The telemetry of the vehicles was transmitted simultaneously to the SCC of the ATLS Test Centre.



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5. Problems and observations

- When a large vessel passes near the Test Area, it creates waves that may interfere with the vehicles being validated at the surface.
- The Test Area is windier in the afternoon that may compromise UAV operations.
- There are a significant number of seagulls near the Test Area that approach UAVs in flight.
- Supporting vessels are available on the Coastal TestBed.
- On the winter, an halocline can appear around 3m of depth. SONAR measurements can be noisy.
- The lighting conditions changes throughout the day requiring to adjust the camera parameters.
- The Ground Station was deployed close to the Testing Area to avoid satellite occlusions caused by the surrounding buildings.

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5.3. Use cases: UdG

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UdG
Pere Ridao

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Agenda

1. Introduction (description of use case)
2. Deployment of assets
3. Operations
4. Communications & SCC
5. Problems and observations

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1. Introduction (description of use case)

The UdG team has developed **two different scenarios** to be validated in the ATLANTIS Test Centre. These scenarios involved each a different robotic platform and some additional infrastructure.

Scenario 1: Autonomous docking of Sparus II AUV

In this scenario the UdG team has used the Sparus II AUV (IQUA Robotics) and a docking station built specifically for it, to demonstrate autonomous docking, based on acoustic localization, as well as seabed mapping, using a forward looking sonar.

Docking station design and final assembly.

Sparus II AUV
60 kg

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1. Introduction (description of use case)

Scenario 2: Autonomous cathodic protection testing using Girona 1000 I-AUV

In this scenario the UdG team has used the Girona 1000 I-AUV, to perform autonomous cathodic protection testing using its two manipulators - one used as a docking device and second one as the main probing manipulator. Unfortunately, it was not possible to complete the trials in the ATLANTIS Testing Centre, although a test rig used successfully in the UdG test tank was installed in a pier.

Fully equipped Girona 1000 I-AUV.

Test rig used in the UdG test tank.

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2. Deployment of assets

Scenario 1: Deployment of docking station

The first step in performing the autonomous docking in the ATLANTIS Test Centre was the deployment of the Sparus II AUV docking station, with a help of a team of divers.

The crane available at the site was used to lower the docking station to the water.

The crane available at the site was used to lower the docking station to the water. Then it was transported to the deployment site using balloons and a RIB.

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2. Deployment of assets

Scenario 1: Deployment of docking station

Docking station on the sea bottom.

Due to large amount of sediments the feet of the docking station were supported with wood planks.

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2. Deployment of assets

Scenario 1: Deployment of Sparus II AUV

Deployment of the AUV was simple thanks to its trolley that is designed to allow releasing the robot into the water, as long as there is direct access to the water surface.

The robot was released to the water from the floating pier.

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2. Deployment of assets

Scenario 2: Deployment of Girona 1000 I-AUV

Deployment of the AUV was realised using the crane available in the operational area. It was supervised from a RIB. Apart from the robot a small cabled buoy was deployed.



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2. Deployment of assets

Scenario 2: Deployment of the test rig

The UDg team has decided to bring a test rig, used in the test tank for the demonstration of manipulation tasks, to the ATLANTIS Test Centre. It was deployed to the water in the same manner as the docking station. The panel was then attached to the wall of a pier.



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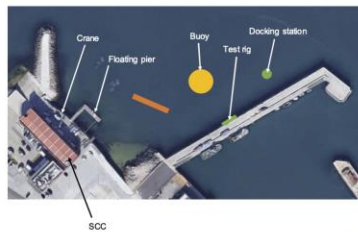


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2. Deployment of assets

Site map



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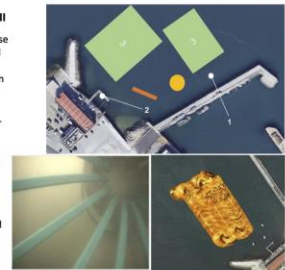
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3. Operations

Scenario 1: Autonomous docking of Sparus II

The docking station was installed in the site, close to the end of the concrete pier (1). The Sparus II AUV was deployed from a floating pier of the sailing club (2), using its trolley and single person operable release system. The robot was teleoperated in the surface to the test site, to reach close the docking station deployment site. Sparus II AUV performed multiple autonomous docking, undocking and seabed surveys in the area (3). The docking algorithm was able to deal with elevated navigation errors, occurring due to rapid changes in salinity (mixing of water of the ocean and the river). The robot could operate successfully in the highly turbid water because it was relying completely on acoustic sensors and the camera system was only used for recording the mission.



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3. Operations

Scenario 2: Autonomous cathodic protection testing using Girona 1000 I-AUV

The test rig was installed on the wall of the concrete pier (1). The robot was deployed using the sailing club crane (2) and teleoperated close to the test rig. The autonomous IJR testing was not possible to perform because the panel was not fixed to the wall properly. The high forces exerted by the water in the pier area, caused by the water flowing through the holes in the pier, caused damages to the panel, as well as broke the ropes holding the panel. It has to be remarked that it was never designed to be installed in this location. Moreover, the secondary goal – laser scanning of anodes – was also not possible to achieve, due to very high turbidity of water in the area. This turbidity is caused by large amounts of sediments in the seabed as well as mixing of the sea water and the water from the river.



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4. Communications & SCC

- Vehicle to SCC communication realised through a network of Ubiquity Bullet devices:
 - Both vehicles equipped with an onboard antenna and a cabled buoy with a second antenna on the buoy (see map, point 1).
 - A middle point Bullet station deployed in the pier (see map, point 2).
 - The final antenna installed in the window of the SCC room (see map, point 3).
 - Communications passing from vehicles, through the pier antenna to the SCC room antenna.
- SCC developments:
 - Transmitting telemetry from both vehicles simultaneously to the web APP.
 - Receiving basic commands from the web APP to the AUV.



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5. Problems and observations

- Sparus II AUV docking was successfully completed using an inverted USBL configuration (USBL installed in the vehicle and acoustic transponder installed in the docking station).
- Seabed mapping with the forward-looking sonar was completed but the data was hard to process.
- Large changes of sound velocity were detected (around 30 m/s between the surface and the bottom).
- It seems that at around 3 m depth there is a halocline related to the mixing of sweet water from the river and salty water from the ocean.
- Dual arm based non-destructive testing with Girona 1000 I-AUV:
 - Buoy was not prepared for working.
 - The test rig was not stable enough in order to work (detached from the pier).
- Laser scanning:
 - Water turbidity too high for this technology:
 - Not possible to calibrate laser at required distances.
 - Not possible to obtain measurements with the current mounting place of the laser scanner.
- Setting up communication links between the robots and the SCC room requires planning and hardware to attach the modems/antennas.

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5.4. Use cases: IQUA Robotics

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WP 4
ATLANTIS Coastal Testbed training: Use cases

Iqua Robotics

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Agenda

1. Introduction (description of use case)
2. Deployment of assets
3. Operations
4. Communications & SCC
5. Problems and observations

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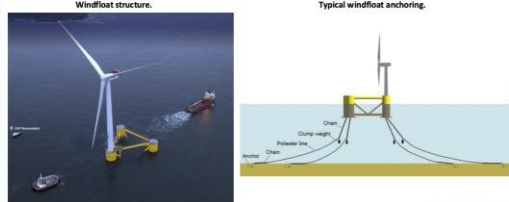
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1. Introduction (description of use case)

Problem description:
The main focus of Iqua in the ATLANTIS project is the development of algorithms for autonomous inspection of submerged section of windfloat structures.


Windfloat structure. **Typical windfloat anchoring.**



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1. Introduction (description of use case)

Robot platform:
For the ATLANTIS project, Iqua uses the Girona 1000 AUV.

Girona 1000 AUV.



- Very stable roll and pitch DoFs.
- Large and flexible payload area and connectivity.
- High processing power.
- Accurate localization using GPS, DVL and INS.

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1. Introduction (description of use case)

Iqua payload proposal:
The payload developed by Iqua includes a multibeam sonar, two optical cameras and a pan/tilt device. The multibeam sonar and one of the optical cameras can be tilted using the pan/tilt device.


Girona 1000 payload developed by Iqua.



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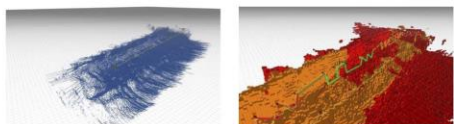
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1. Introduction (description of use case)

Iqua algorithm proposal:
The autonomous exploration is divided in two main stages:




Stage 1: Assessment **Stage 2: Inspection**

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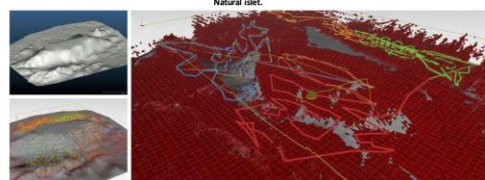
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1. Introduction (description of use case)

Prior tests:
Prior to the testing in the ATLANTIS Coastal Testbed in Portugal, Iqua tested the algorithm in two scenarios near Girona.


Natural islet.



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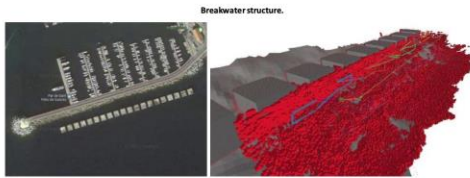
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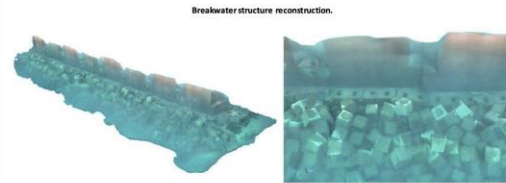
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1. Introduction (description of use case)

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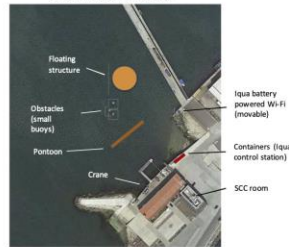
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2. Deployment of assets

ATLANTIS Coastal Testbed map.



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2. Deployment of assets

Control station location and communications setup:

The Girona 1000 control station computers were located inside the provided containers. A battery powered Wi-Fi antenna was used as an intermediate connection point between the control station and the robot.



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2. Deployment of assets

Deployment of Girona 1000 AUV:

Deployment of the AUV was realised using the crane available in the operational area. In addition to the robot, a small cabled buoy was deployed to maintain communication when the robot is underwater.



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3. Operations

Autonomous exploration of the floating structure:

The dual-step autonomous exploration of the floating structure consisted in performing a full turn around the structure at a moderate distance (assessment stage)...



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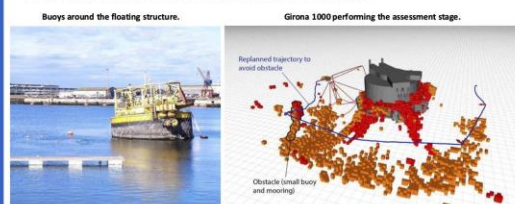
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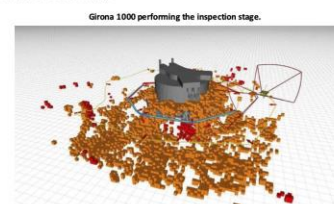
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3. Operations

Autonomous exploration of the floating structure:

...and then a close inspection of the structure, gathering optical images and higher resolution occupancy data (inspection stage).



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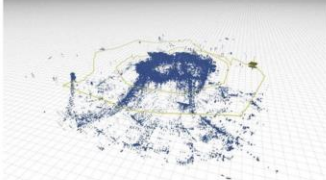
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3. Operations 17

Autonomous exploration of the floating structure:
...and then a close inspection of the structure, gathering optical images and higher resolution occupancy data (inspection stage).

Occupancy data gathered during both stages.




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3. Operations 18

Autonomous exploration of the floating structure:
...and then a close inspection of the structure, gathering optical images and higher resolution occupancy data (inspection stage).

Visibility at 1 meter from the floating structure.




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3. Operations 19

Payload alternative configuration:
A second configuration was tested, with the multibeam scanning horizontally instead of vertically. In this configuration, only the side camera was used. The goal was to avoid stopping at each waypoint. However, less occupancy data is gathered when using this configuration.

Multibeam 90 degrees right configuration. Multibeam 45 degrees front/left configuration.

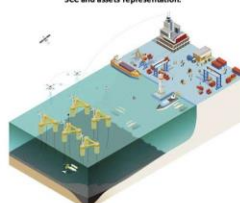


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4. Communications & SCC 20

SCC integration:
The SCC (Supervisory Control Centre) sends commands to (and receives data from) the different assets in the infrastructure.

SCC and assets representation.



- Vehicle to SCC communication realised through a network of Ubiquiti Bullet devices and a 4G dongle.
- The acoustic modem bandwidth was taken into consideration: the bandwidth was severely restricted to simulate what will happen when the modem is used.
- SCC developments:
 - Transmitting telemetry from the vehicle to the web APP.
 - Mission integration and programming through the SCC.
 - Receiving basic commands from the web APP to the Girona 1000 AUV.

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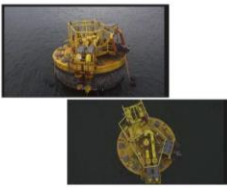











5. Problems and observations 21

- The vehicle was able to navigate autonomously, and at close range of the structure, while simultaneously building and maintaining an occupancy map, and using it to feed the path planning algorithm to avoid unexpected obstacles such as small buoys that were present on the site.
- The poor visibility during the period made it impossible to capture optical images of sufficient quality to perform a reconstruction of the submerged part of the structure.
- In the Coastal Testbed, water current did not cause control issues to Girona 1000.
- The battery powered Wi-Fi antenna proved very useful in providing connectivity with the robot in the different Coastal Testbed areas.
- The floating structure was not static. Due to the wind and the tide, several meters of movement can be expected. In some cases, the movement was enough to cause the plan generated in the assessment part to become invalid for the inspection part. The algorithm should be more robust against wind/float movement.
- The lack of direct visibility from the main SCC room and the floating structure area led to the decision of installing the Girona 1000 control station in the provided containers. The containers did not have wired internet connection. This meant that the integration with the SCC had to be done through a 4G dongle, which had a tendency to fail periodically.
- While the inspection of the floating structure of the Coastal Testbed is representative of the industry needs, the fact that the floating structure is only submerged 3 meters makes it difficult to test truly 3D inspection strategies.

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5.5. Use cases: RINA

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<p>Agenda</p> <ol style="list-style-type: none"> 1. Introduction (description of use case) 2. Deployment of assets 3. Operations 4. Communications & SCC 5. Problems and observations  <p>WWW.ATLANTIS-H2020.EU</p> <p>This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 871571</p> <p>29/01/2020</p>	<p>1. Introduction</p> <p>Rina Services team has planned one scenario for ATLANTIS Test Centre. This scenario involves Unmanned Aerial Vehicle (UAV) for Floating Structure Inspection</p> <p>Scenario 1: Asset Inspection (Floating Structure - Above Sea Level)</p> <p>In this scenario has been planned an inspection of Floating Structure (above sea level section) using a drone that supports 4K optics and thermographic sensors to verify the condition, construction, and integrity of the structure through thermographic and visual analysis. The Main Objective is calibration and Data collection of Floating Structure</p>   <p>WWW.ATLANTIS-H2020.EU</p> <p>This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 871571</p> <p>29/01/2020</p>
<p>2. Deployment of assets</p>    <p>Unmanned Aerial Vehicle (UAV) can start the inspection from operational area identified.</p> <p>No specific Requirements shall be complied. No lifting equipment are required</p> <p>Pilot will operate from this operational area for all duration</p>  <p>WWW.ATLANTIS-H2020.EU</p> <p>This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 871571</p> <p>29/01/2020</p>	<p>3. Operations</p> <p><u>Before to start:</u> Verification of insurance documentation of vehicles and pilot certificates</p> <ul style="list-style-type: none"> • Weather forecast monitoring before and during the mission • Notify to Remote Surveillance Unit Start/End of the Inspection Works • Breafing Pre-flight With other Team Members • Check Installation Micro Sd Card • Check Battery Installation (Check Full Charge) • Check The Planned Route • Flight Mode Switch (On Desired Position) • Preflight check: Before departure UAV shall be tested and checked according to supplier's guidelines • Control of Possible External Interference • Home Point Check (Take-off Point)  <p>WWW.ATLANTIS-H2020.EU</p> <p>This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 871571</p> <p>29/01/2020</p>
<p>3. Operations</p> <p><u>Operation (*) (**):</u></p> <ul style="list-style-type: none"> • Flight testing and compliance of safety and control systems: Functional test before and during the mission • Test of optics and thermographic sensors • Wind resistance and stability during flight operations • Electromagnetic fields interference • Test of Control signal (long distance ~7.8 km) • Capture of details (components data of installed structure are acquired) • Verification of semi submergible structure (visual analysis) <p>(*) Check weather condition during activity (**) Check battery and signal level during activity</p>  <p>WWW.ATLANTIS-H2020.EU</p> <p>This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 871571</p> <p>29/01/2020</p>	<p>3. Operations</p> <p>Operation: Video 18389</p>     <p>WWW.ATLANTIS-H2020.EU</p> <p>This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 871571</p> <p>29/01/2020</p>



4. Communications & SCC

- The communication provide the ability to monitor all the mission (state of vehicle, position, battery status, etc).
- For autonomous Drone, even if the vehicle has its level of autonomy, the Portuguese Law requires that the vehicle must be in line of sight with the operator.

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5. Problems and observations

- Interference during inspection due to the presence of gulls.
- Installation of ultrasonic bollards can be a solution



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5.6. Use cases: ECA

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WP 4
ATLANTIS Testing Centre training: Use cases

ECA
Fabrice CALDERONI

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Agenda

1. Introduction (description of use case)
2. Deployment of equipment
3. Operations
4. Communications & SCC
5. Problems and observations

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1. Introduction

During these trials ECA is involved into the scenario 1 : inspection of the floating structure and NDT measurements. These tests were the first sea trials of the Roving Bat and were mainly focused on navigation of the vehicle and its attachment on the floating structure. The purpose was to demonstrate the functionalities of the new technologies deployed and the future ability to operate in offshore conditions. For these trials the Roving Bat was equipped with 3 full HD TV cameras, a rotating sonar, a 7-axis manipulator fitted with a cleaning brush and a CP probe and – as a payload - the MAREEye 3D camera designed by Insectec.

Roving Bat MK3 before trials and during coastal trials


1000V / 8kW embedded power converter

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2. Deployment of the system


Launching and recovery of the Roving Bat

The Roving Bat was deployed by the mean of the crane present in the facilities of the Coastal Testbed of the ATLANTIS Test Centre. The launching and the recovery uses a latch lock system installed on both ROV and umbilical cable.

The crane available at the site was used to lower the Roving Bat on the water.

Launching and the recovery using the latch lock system





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2. Deployment of the system

Launching and recovery of the Roving Bat

During these operations the umbilical cable needs to be monitored to avoid entrapping on the different floating structures present on the site. Fortunately the umbilical cable is floating and visible even during bad meteorological conditions. The sonar installed on the ROV is used to pilot to the floating structure

Navigation phase of the Roving Bat from the launching point to the floating structure


Sonar screen used during the navigation phase




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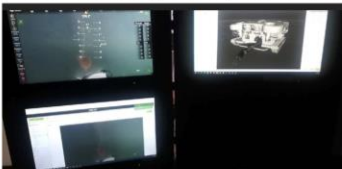
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3. Inspection of the floating structure

Inspection of the floating structure

During all the trials the HD videos and sonar images were recorded on a PC, but due to the water turbidity the cameras need to be close to the structure to take significant images


Main view of the control screen used by the pilot. Real time 3D position of the 7 manipulator



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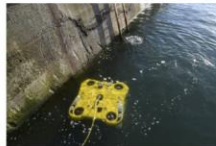
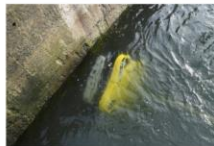
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4. Roving Bat landing operation


Due to the slope and lack of depth of the floating structure, only attachment on the walls of the quay was performed. Once stuck on the structure inspection, deployment of the manipulator and NDT measurement are possible.

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5. Inspection of the floating structure


Televsual inspection : Some pictures extracted from the videos of the Full HD inspection camera (showing the important amount of concrete on the floating structure during trials)



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5. Inspection of the floating structure

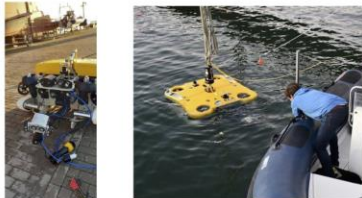
Cleaning and NDT
Deployment of the manipulator equipped with the CP Probe and a soft brush. These operations suppose that the anode to measure are in correct condition and not covered by a big amount of concrete



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6. Test of the 3D camera

The integration and the calibration the MAREsye camera with the were performed using some predefines object immersed near the ROV. This camera will be used on the structures of windfarm for 3D object reconstitution on the field during maintenance operations



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6. Communications & SCC

During the week we also have finalized the communication link between the Roving Bat system and the SCC in order to allow the remote reception of images and the future interoperability from the shore.



- 1- Floating structure
- 2- Roving Bat
- 3- Umbilical cable
- 4- 20 ft Container for Control unit/ pilot
- 5- Wifi transmission from CCU to SCC
- 6- SCC
- 7- crane for launching and recovery

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7. Success and fails

- Integration and the calibration the MAREsye camera were successfully performed and tested using some predefines object immersed near the ROV
- Finalization of the communication link between the Roving Bat system and the SCC in order to allow the remote reception of images
- The manipulator, the cleaning brush and the CP probe were functional but not operational because the Roving Bat could not be placed correctly on a vertical structure
- Correct working of all the power system and correct behavior of the umbilical cable
- 2 main breakdown during these trials :
 - Lack of the crawlers control
 - Lack of one vertical thruster control

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7. Problems and observations

- Poor visibility due to the water turbidity
- Bad weather at the beginning of the week
- Large tides making some times launching and recovery more difficult
- Management of the umbilical cable not easy due to the different floating structures present on the site
- Use of a generator to delivered the necessary power for both 400Vac and 230Vac electrical supplies was correct
- Good support by Insectec teams and the personnel of the site

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5.7. Supporting technologies: SCC (SpaceApps)

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WP 4 SUPERVISORY CONTROL CENTER

Space Application Services
Lilian DURAND,
Shashank GOVINDARAJ

AGENDA

- SCC Installation
- Interoperability
- Robots monitoring
- Robots commanding
- Automated mission planning
- Onsite integration
- Offshore integration

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SCC INSTALLATION

- The SCC was installed on-site at Viana Do Costello.
- External access provided using a VPN.

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INTEROPERABILITY

- Robots are integrated to the SCC using a CPP interoperability library.
- The interop can be used to monitor and command robots.
- Compatible with aerial, ground and marine vehicles.
- Secure DDS data exchange.

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MONITORING

- Robot status, Live and historical data
- Telemetries : Odometry, Numerical, imagery, GPS, video, joint states

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MONITORING

- 3D visualization
- Odometry on local map
- URDF compatible
- Robot joint states

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COMMANDING

- Action goals and targets
- Move commands
- Swtich commands
- Numerical targets
- Follow path commands

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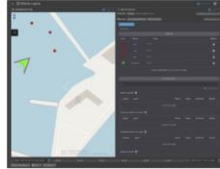
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MISSION PLANNING

- Multi-robots mission configuration
- GIS based view
- Interactive map
- Task planning automation
- Path planning automation
- Coordinated mission plans
- Time based synchronization



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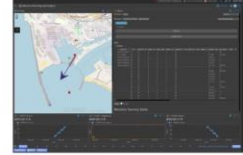
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MISSION PLANNING

- Synchronized deployment on robots
- Mission plan execution monitoring
- Combined with robot monitoring views



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ONSITE INTEGRATION

- Robots were integrated onsite with the SCC.
- Drones, AUVs, ROVs integrated



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OFFSHORE INTEGRATION

- Robots connection to the SCC through VPN
- SCC accessible through VPN
- Robot monitoring from the SCC onsite



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5.8. Supporting technologies: Buoy sensor system (VTT)

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WP4
ATLANTIS testing centre training: use cases

VTT

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Samuli Eskola
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Summary

1. Introduction (description of use case)
2. Coastal Testbed instrumentation
3. Operations – Overview of excitation & response
4. Virtualization of the Coastal Testbed
5. O&M module for predictive maintenance
6. Problems and observations

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1. INTRODUCTION

Virtualization of the Coastal Testbed for predictive maintenance analytics

OVERVIEW OF COASTAL TESTBED DATA SOURCES

A is processed parameter information (vibration, inclination, stresses etc.)

B is robot sensor data (pictures, videos, location, etc.)

C is textual information (state detection, operation limits, inspection work order requests, etc.)

D is mission and historical data from SCC database (DB).

COASTAL TESTBED

Structure instrumentation: External data, O&M module routines, API Client

Robot inspection: Robots data, SCC DB, API server, API Client

This training material focuses on external data, virtualization and O&M module.

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2. COASTAL TESTBED INSTRUMENTATION

Overview of external data instrumentation
CTB seen from above

Wave buoy

Y dir

Z downwards (right hand rule)

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2. COASTAL TESTBED INSTRUMENTATION

MEASUREMENTS 1/3

Measurement	Location	Name	Unit	Fs [Hz]	Other
Vibration acc * 3	CTB outer circle	1_acc_X, Y, Z	g	200	sensor range +/- 1.5 g
Vibration acc * 3	CTB outer circle	2_acc_X, Y, Z	g	200	sensor range +/- 4 g
Vibration acc * 3	CTB outer circle	3_acc_X, Y, Z	g	200	sensor range +/- 12 g
Vibration acc * 3	CTB inner circle	SBG_ACCEL_X, Y, Z	m/s ²	100	
Velocity	CTB inner circle	SBG_GPS_VEL_DOWN	m/s	10	
Inclination * 3	CTB inner circle	SBG_PITCH, ROLL, YAW	Deg	10	
Inclination velocity * 3	CTB inner circle	SBG_ROT_X, Y, Z	Deg/s	10	

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2. COASTAL TESTBED INSTRUMENTATION

MEASUREMENTS 2/3

Measurement	Location	Name	Unit	Fs [Hz]	Other
Motion * 3	CTB inner circle	SBG_SHIPMOTION_HEAVE, SURGE, SWAY	m	10	
Motion velocity * 3	CTB inner circle	SBG_SHIPMOTION_VEL_X, Y, Z	m/s	10	
Yaw angle	CTB inner circle	SBG_TRUE_HEADING_GPS	Deg	10	
Wind direction	CTB outer circle	wind_direction	Deg	10	360/0 degrees points North
Wind frequency	CTB outer circle	wind_freq	Hz	10	
wind_speed	CTB outer circle	wind_speed_mps	m/s	10	
Wave buoy movement	At sea about 2 m from CTB	Wave_buoy_heave_north, west	cm	1.28	Oven anchor to the sea bottom

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2. COASTAL TESTBED INSTRUMENTATION

MEASUREMENTS 3/3

Web video stream for wave and status monitoring

Single set of wave excitation by a passing boat

wave set at the wave buoy and the CTB

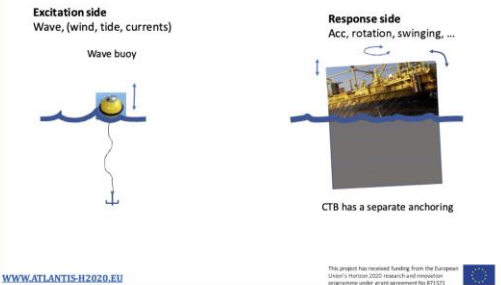
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3. OPERATIONS - OVERVIEW OF EXCITATION & RESPONSE

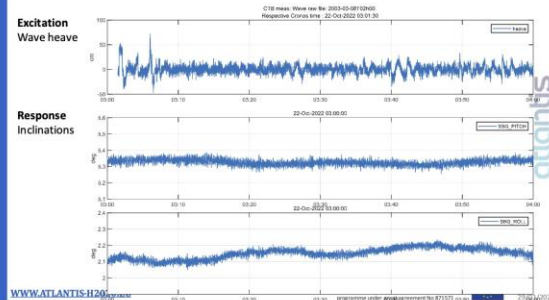


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3. OPERATIONS - OVERVIEW OF EXCITATION & RESPONSE

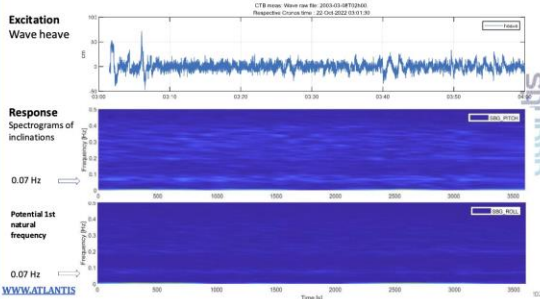


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3. OPERATIONS - OVERVIEW OF EXCITATION & RESPONSE



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4. VIRTUALIZATION OF THE COASTAL TESTBED

Fluid-Structure Interaction simulation (DT)

Two objectives

- Short and long term predictions for loads and stresses in structure (3 hours → life time)
- Operative criteria/limits for wind turbine

Tools such as

- Ansys AQWA → Ansys Mechanical
- Ansys FLUENT, OpenFOAM → Ansys Mechanical

Are used for both frequency and time domain solutions

The diagram shows a physical structure with 'Loads' being applied, which is then modeled in a 'FEA' (Finite Element Analysis) simulation.

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5. O&M MODULE FOR PREDICTIVE MAINTENANCE

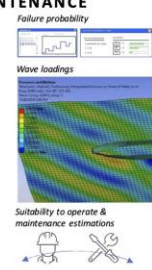
Coastal test bed (CTB) – VTT measurement, modelling and analytics

Objectives:

- Stochastics loading analytics for deterministic decision making → e.g. deployment of robots for inspections
- Simulation model development for wave loading estimations → e.g. critical loadings and movements & operation criteria

Utilization for Coastal Testbed related demonstrations:

- Operation limits for the maintenance (e.g. state of motions at different locations of the test bed).



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6. PROBLEMS AND OBSERVATIONS

- The wave conditions at the Coastal Testbed are calm -> the floating structure motions are small
- Power outages and other interruptions in power supply resulted in breaks in data measurements. Batteries and automatic turn on in measurements proved very useful
- As the Testbed is in a harbour, remote connection to measurements is easy to arrange
- Various support from the local hosts were asked multiple times, and got with rapid response 😊

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