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Hydrolink



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# Shaping future robotised O&M in offshore wind

By Serena Langiano, Christian Verrecchia, Miguel Marques and João Formiga

Operations and maintenance (O&M) constitute a significant part of the total costs for offshore wind power, accounting for up to 30% of the total cost of energy with the current technologies[1]. Cost reduction comes through structured and innovative solutions. The ATLANTIS project, which includes ten partners from six different EU countries, aims at establishing a pioneer pilot infrastructure, capable of demonstrating key enabling robotic technologies for inspection and maintenance activities in offshore wind farms.

**Figure 1** | Windfloat Atlantic. Courtesy of the Windplus consortium.

## Introduction

The offshore wind energy projected market value for 2024 is around EUR 54B: it is one of the fastest growing green energy sources and expected to be one of the main energy sources in the near future as for the end of 2020[2], Europe is currently the leader of this market thanks to the high wind potential already exploited in the North Sea (almost 79% of the whole European installed capacity) distributed among: the UK (around 10.5GW), Germany (7.7GW), Netherlands (2.6GW), Belgium (2.3GW) and Denmark (1.7GW). Other European waters have been less exploited (the Irish Sea accounts for 12% of the offshore wind farms capacity, while the Baltic Sea and the Atlantic Ocean stand at 9% and less than 1% respectively[2]) mainly due the higher water depths and harsher environmental conditions. With the continuous development of floating technologies, future wind farms are expected to be installed farther from the shore. In 2020, in Europe the average water depth[2] of new installed wind parks was 36m, slightly higher than the previous year (34m). In this sense, the WindFloat Atlantic (WFA) shown in **Figure 1**, the largest floating windfarm fully operational in the world (25MW), represents a pioneer infrastructure for the floating wind sector. The WFA is located 20km off the coast of Viana do Castelo, in Portugal, where the water depth reaches 100m.

Offshore wind is an emerging sector facing economic pressures due to the uncertainties and high costs associated with O&M activities of the offshore assets, which significantly contribute to an increase of the Levelised Cost of Energy (LCoE) from - 56-76EUR/MWh for land-based wind parks to 99-175EUR/MWh for offshore windmills[3]. Safety is a fundamental concern for O&M activities, particularly when taking place at sea. Offshore operations must guarantee a high level of occupational safety by minimising the probability of workers being exposed to major hazards. ATLANTIS tackles this goal by replacing and/or supporting human operators with robotic assets.

## ATLANTIS' objectives and targets

The ATLANTIS project aims at fostering robotic assets in the offshore wind energy supply chain, by demonstrating their benefits in terms of improving the efficiency of O&M activities and reducing the costs associated with the same. The pioneer infrastructure to be deployed in Viana do Castelo will shorten the time-to-market of new technologies, creating new business opportunities for Small and Medium Enterprises (SMEs) and local communities.

The pilot will be made available free-of-charge for technology developers for demonstrating their own technologies and it will establish an international O&M network for the offshore wind energy sector to increase the adherence of robotic solutions for O&M activities by at least 25% by 2025. The decision support tools in the planning of support vessel operations will contribute to lower the O&M costs up to 15% by minimising fuel consumption and downtime. Robotic-based operations ensure regular and less invasive interventions, which will reduce the need for divers and expensive support vessels. This translates into cost savings of up to 50%.

ATLANTIS technologies allow more accurate and faster activities with consequent lower downtimes and loss of profitability. The development and integration of the ATLANTIS' approach into operating offshore wind farms could bring a general reduction of O&M costs up to 10% and consequently a LCoE reduction of around 2%. ATLANTIS will provide guidelines for a harmonised certification approach towards a common standard for robotic-based O&M activities that can be more reliable, safer and environmentally friendlier, reducing the exposure to risks and hazards for workers and the marine ecosystem.

ATLANTIS represents an optimal trade-off between economic competitiveness and decarbonisation of the energy sector providing an important step forward towards the achievement of the Paris Agreement targets: ATLANTIS will encourage the offshore wind energy to embody robots in the O&M value chain as a mean for minimising the externalities of offshore wind.

## The Atlantic Testing Platform for Maritime Robotics (Coastal and Offshore testbed)

The ATLANTIS project will demonstrate the concrete benefit that robotic technologies can bring to O&M activities performed in offshore wind farms. The Testing Platform (**Figure 2**) will be installed in the Atlantic Ocean, in the coast of Viana do Castelo in Portugal where the WindFloat Atlantic is located. This pilot will be demonstrated and operated by a strong collaboration between R&D institutes and industrial players, which will cooperate strictly with the aim of bringing together end-users' expectations and technology maturity level, facilitating the market roll-out of maritime robotic technologies through real-world demonstrations. The ATLANTIS project embraces all the value chain, grouping stakeholders from the maritime robotics and wind power industry, SMEs, R&D institutions and energy operators, bringing them together into a test centre.

The ATLANTIS philosophy foresees a long-term deployment and integration of robotic assets in offshore wind farms, to accomplish significant improvements in the LCoE, by the elimination or minimisation of supporting vessels for O&M tasks, as well as specialised workforce. A group of robots (underwater, surface and aerial) will be deployed to conduct less invasive, more frequent and effective O&M activities. These robots will perform the needed activities autonomously, by taking off from their base, travelling to the working spot and returning in autonomous mode. This autonomy strongly diverges from conventional strategies, which resort to divers or remotely-operated vehicles, where launch, recovery, and many times travelling to site still require great assistance from the operators.

The ATLANTIS Test Center is the core of the project, and it will be installed on the Portuguese coast to facilitate the roll-out of robotic-based O&M strategies through real-world demonstrations. The large pilot will include a Coastal Testbed and an Offshore Testbed, to host demonstrating campaigns in environments with increasing complexity and risks.

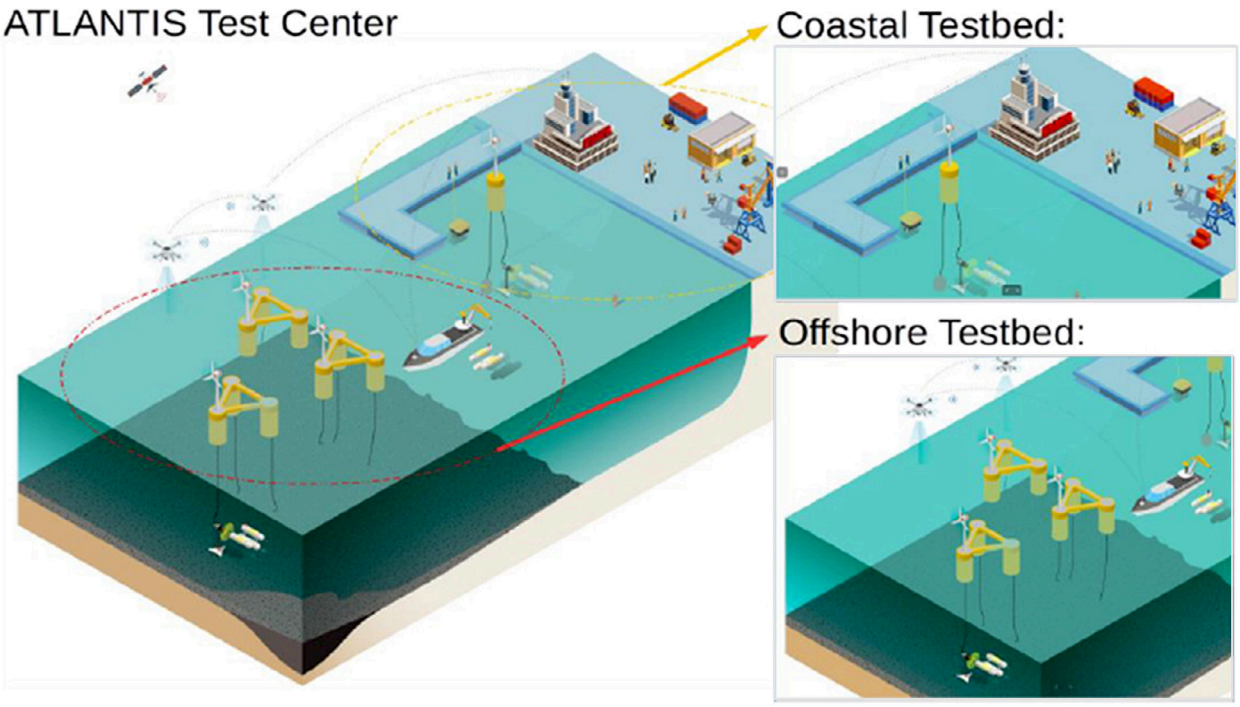


Figure 2 | The ATLANTIS Test Center formed by the Coastal and the Offshore Testbeds.

The **Coastal Testbed** will serve for technology developers to test and rehearse their robotic technologies in a de-risked environment, through cost-efficient, staged and rigorous testing campaigns in a near-real scenario. This testbed will be set-up in the harbour of Viana do Castelo and it will comprise a Shore Control Center (SCC) and a Floating Structure System (FSS). The FSS will be a semi-submersible platform anchored to the seabed through mooring lines. Both mooring lines and the structure will be inspected by the ATLANTIS robots to detect cracks and defects which represent one of the major concerns and which nowadays are spotted by divers via time-consuming work that includes the removal of marine growth from the welding seams. This task becomes notably important as offshore foundations are moving farther from the shore in deeper waters where stronger loads by waves and wind, and the impact of salt-water are present. The Coastal Testbed, besides being available for the robotic developers of the ATLANTIS consortium, will be at disposal of SMEs, R&D entities and academia that intend to test their own technologies. All experimentations inside the ATLANTIS Test Center will provide a common control framework where users can request, monitor and manage the validation or demonstration in a controlled replication scenario of harsh marine conditions and face the technical O&M challenges for both fixed and floating offshore wind turbines. After the close-to-shore testing phase, the robotic assets that have proved to be ready for the demonstration stage will be given the opportunity of testing and collecting performance data in a real-world environment, to enable the achievement of a higher technology maturity level.

The **Offshore Testbed** encompasses a commercial wind farm, the WFA, owned by the Windplus consortium (Ocean Winds: 85.2%, Repsol: 13.6% and Principle Power: 1.2%). The WFA, to date, is the largest floating offshore wind farm in operation, comprising three wind turbines supported by a floating structure based on WindFloat technology (Principe Power France-PPF patent). It provides unique wind, wave and weather conditions of the Atlantic waters to prove the reliability, feasibility and effectiveness of robotic solutions. The data gathered throughout the offshore test campaigns will be benchmarked against those related to standard strategies, thus allowing a direct comparison. The novelty of the ATLANTIS Test Center is the demonstration of complex offshore robot-based activities in a multi-domain environment that can be operated remotely or autonomously, encompassing but not limited to: survey of the foundations (underwater); survey of the mooring systems (underwater); survey of the biological growth (underwater and surface); survey of the export and array cables; survey of the turbines (aerial) and the floating structure (underwater and surface).

In terms of robots, the ATLANTIS project will make it possible to perform O&M activities by *Autonomous Surface Vehicles (ASVs), Unmanned Aerial Vehicles (UAVs), Autonomous Underwater Vehicles (AUVs)* fostering the ***vessel-less*** approach through experimental research. In addition to this, *Remotely Operated Vehicles (ROVs)* with advanced features for Non-Destructive Testing (NDT), cleaning of subsea assets for subsequent inspection of weldings and/or underwater light works for maintenance purposes will also be deployed.

Three communication modalities are foreseen in this operations context: an underwater acoustic modem; a local wireless communication system which will be used to communicate mission updates from the SCC to the robots and a main satellite-based link between the docking platform and the onshore SCC (see **Figure 3**).

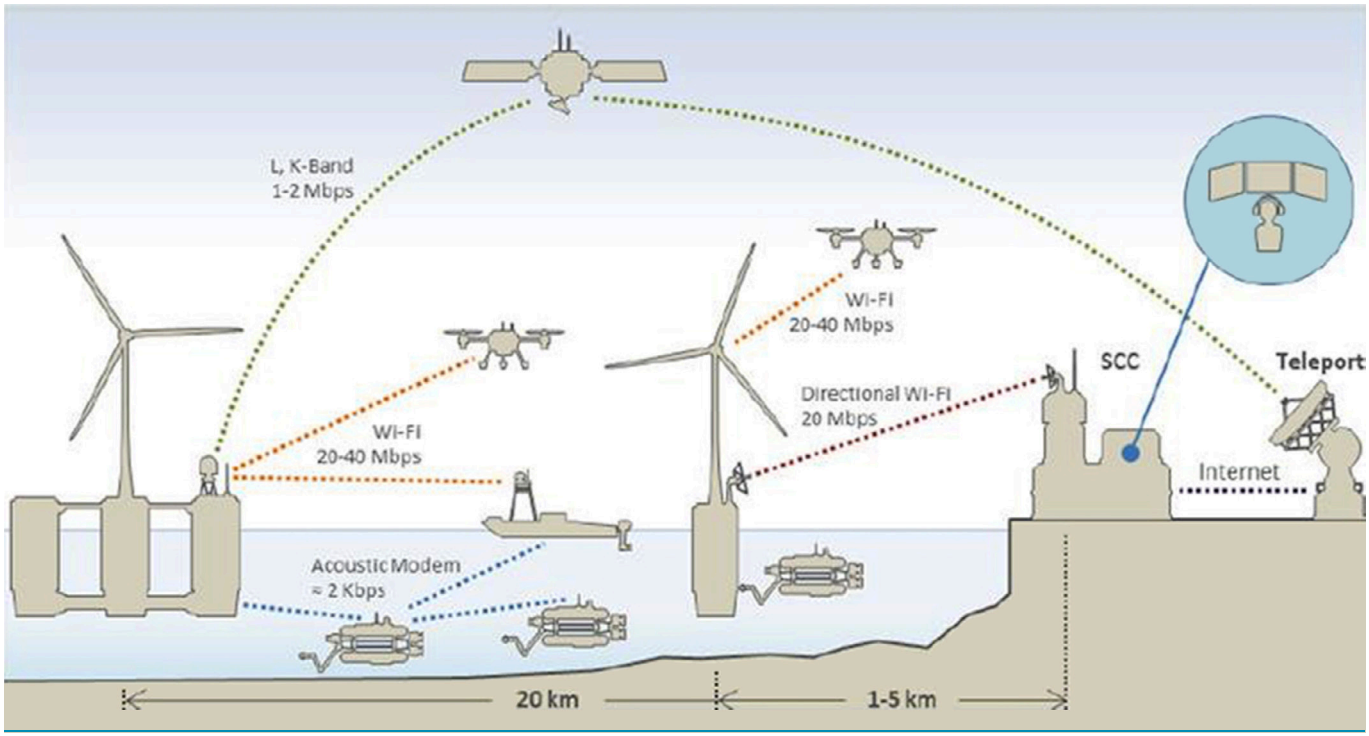


**Figure 3** | ATLANTIS Communication architecture.

## Scenario description

The ATLANTIS project established four showcases that it can leverage with the adoption of robots, which are representative of key areas of the O&M offshore wind value chain. Each showcase addresses sensitive topics of the different components of the offshore wind park.

The first showcase addresses the inspection and maintenance of the wind turbine. Currently, maintenance activities entail mainly visual inspection and remedial work when needed. Blades and tower, in ATLANTIS, will be inspected through UAV with advanced inspection capabilities, with the scope of identifying cracks, delamination, fatigue and extreme loading of blades, which are the major concerns for the offshore wind industry. O&M activities will be dedicated to the submerged structure, where marine growth cleaning is paramount to avoid over-loading effects as well as to allow NDT. Both cleaning and NDT will be performed by AUVs and ROVs properly customised.

The second showcase deals with the maintenance of both export and array cables that are exposed to tides and sediment flows, whose consequence is the movement of the cable. Waves and tides, vortexes, scour pits and storms can damage the cable protection system, exposing the cable to harsh conditions. ROVs and AUVs will be used within ATLANTIS to inspect the cable protection systems as well as to perform some interventions such as cleaning and/or rock removal. ATLANTIS aims at establishing a new methodology for cables inspection, by employing AUVs and ASVs with long endurance capabilities that will allow a constant and long-term inspection of the system.

The third showcase addresses the maintenance of the foundations and scour protection. The atmospheric, splash and submerged zone will be inspected via AUVs and ROVs with close-range navigation capabilities.

The fourth and last showcase aims at enhancing the planning of offshore activities through more accurate weather forecasts and multiple robotic-based operations. ATLANTIS' main objective is to establish vessel-less strategies by putting in place autonomous robotic operations supported by crewless vessels, such as ASVs, with the capability to transport, deploy and recover robotic assets in a real-environment. These assets will be demonstrated in this showcase. Moreover, within this use case optimised robotic-based operations will be performed in a multi-domain environment where robots will be (co)operating simultaneously.

Robotic-based operations will be complemented by two more solutions:

- A predictive maintenance supporting tool (developed by Teknologian tutkimuskeskus VTT Oy-VTT) which, by gathering and processing operational data, will be able to predict defects and fault in an early stage and
- A planning tool that will allow to schedule the activities considering environmental conditions at the scope of minimising costs and downtime (developed by ABB).

### What's in it for EDP

The EDP group, as indicated through the just recently launched strategic plan for the five-years period 2021-2025, aims to be a leading global player in offshore wind via its joint venture Ocean Winds. Currently 6.6GW of offshore wind capacity are envisioned through eleven different projects which are already in place (e.g. Windplus in Portugal and SeaMade in Belgium), under construction (Moray East in the UK) or under development (in France, the UK, the US, Poland and South Korea). Some of these projects have already been secured by Power Purchase Agreements (PPA) or Feed-in Tariff mechanisms. It is then remarkable that further investments in offshore wind energy go through a more affordable, reliable and durable technology that can compete with well-established energy assets, such as onshore wind or Photovoltaic (PV) parks, and that can be better positio-ned in the energy market without or via less-intensive incentive mechanisms.

In this sense, the ATLANTIS project is key to bringing offshore wind technologies several step forward by allowing a more secure and economically viable operation and management of these energy plants. EDP, which participates in the ATLANTIS project through its R&D centre EDP NEW, envisions to: i) expand the company's skills in the O&M sector of offshore wind by sharing knowledge and contributing to the development of solutions, ii) foster the development of novel solutions for autonomous O&M enabling important reductions of OPEX and thus lowering the LCoE, with the result of increasing the financial attractiveness and ultimately improving the industry's business case.

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Serena Langiano graduated in Electrical Engineering from University of Cassino in 2018. Her background is namely in renewable energy, electrical machines and electrical systems. She joined EDP NEW in 2020 to contribute to projects focused on offshore wind and ocean energy. At EDP NEW, she performs economic analysis (LCoE, NPV, IRR) for energy power plants and designs business models for O&M applications in the context of offshore wind. She also contributes to the verification and validation of design tools for ocean energy systems aiming at supporting plant planning, performing economic assessment and system performance evaluation.

**Christian Verrecchia**

Christian Verrecchia graduated in Electrical Engineering from University of Cassino in 2018. His background is in renewable energy, power electronics and smart grids. He joined EDP NEW in 2020 as researcher in projects related to renewable energy and smart grids. At EDP he works in numerical modelling for RES technologies, namely PV and offshore wind, developing software for the computation of the power output, LCoE and O&M costs. He also supports real-world demonstrations of smart grids, focusing on storage integration and operation. Before joining EDP, he worked as a power electronic designer for the Italian Railway Network manager, designing and prototyping power converters.

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Miguel Marques is the Head of Business Development at EDP NEW, whose main activities comprise the screening of new funding opportunities and the support of the development of R&D projects, namely in the areas of flexibility, hydro power, offshore wind and ocean energy. Before joining EDP NEW, Miguel worked in modelling and numerical software simulation of electrical power systems and as a field engineer in electrical grid maintenance in Portugal's main Distribution System Operator, EDP Distribuição. Miguel holds a master's degree in Electrical Engineering from the Lisbon Technical University, Portugal, with a major in Power Systems and minor in Telecommunications.

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