Results of Competition: Demonstrator for Robotics and AI in Extreme and Challenging Environments: Phase 2

Competition Code: 1807_CRD_ROBDEM_WAVE2

Total available funding is £6 million

Note: These proposals have succeeded in the assessment stage of this competition. All are subject to grant offer and conditions being met.

Participant organisation names	Project title	Proposed project costs	Proposed project grant
INNOVATIVE TECHNOLOGY AND SCIENCE LIMITED	Autonomous, robotic and AI enabled biofouling monitoring, cleaning and management system for offshore wind turbine monopile foundations (RobFMS)	£699,642	£468,760
Brunel University London		£239,384	£239,384
THE EUROPEAN MARINE ENERGY CENTRE LIMITED		£53,537	£53,537

Note: you can see all Innovate UK-funded projects here: https://www.gov.uk/government/publications/innovate-uk-funded-projects
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Project description - provided by applicants
Offshore wind is proving very attractive for operators, especially due to the higher yields and less resistance from onshore homeowners and stakeholders. It is predicted that it could provide all the UK's electricity requirement, with minimal emission and visual impacts. However, there exist a major barrier to further exploitation due to the high levelised cost of electricity (LCOE) from offshore wind (£140/MWhr), which is 2-3 times higher than other key renewable sources (onshore wind and solar) and nuclear (a large non-renewable, but low emission source). The high LCOE is caused by the severe environmental conditions, which results in high operational, reliability and maintenance (O&M) costs, with the seabed turbine foundations (largely monopiles) accounting for over 25% of all lifecycle O&M costs, often caused by marine biofouling. Current methods of fouling prevention (dangerous: diver-deployed cleaning tools such as brushes and power jets) or ROVs (high annual costs ~ £30k/MW) are proving very costly and ineffective -- creating the need for an innovative solution to tackle this problem. The project will develop a fouling management system consisting of a mobile survey and cleaning robot that will eliminate the need for divers and ROVs. The robot will be placed on the turbine structure at sea level and will journey down below sea level to the work place. The robot will travel autonomously over the entire subsea monopile surface, imaging the fouling in real time. It will simultaneously activate its cleaning function at every fouled location and remove the fouling with an innovative guided power ultrasound technique. On returning to the sea surface the robot would simply be transported to the next turbine scheduled for treatment, and the cycle repeated. Overall O&M costs will be reduced by at least 50% compared with present diver/ROV techniques. This would mean a £7/MW (5%) reduction in LCOE.

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INNVOTEK LTD	In-service X-ray radiography of offshore wind blades (RADBLAD)	£139,002	£97,301
COMPUTERISED INFORMATION TECHNOLOGY LIMITED		£198,534	£133,018
FORTH ENGINEERING (CUMBRIA) LIMITED		£273,483	£185,968
London South Bank University		£209,999	£209,999
OFFSHORE RENEWABLE ENERGY CATAPULT		£80,781	£80,781
RENEWABLE ADVICE LTD		£97,934	£64,636

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Project description - provided by applicants
UK policy targets 15% green power generation by 2020 and 57% reduction of CO2 emissions by 2030\. This has led to a significant growth in installed wind power capacity within the last decade (especially in offshore wind power in the UK) to 18.9 GW in the UK and 539 GW globally. The UK market has multiplied 10-fold, supplying 5.4% of the UK's electricity consumption in 2016\. Turbine blades are subjected to gusting wind loads, driving the accumulation of fatigue damage in the blade structures, leading to failures. Around 3,800 blade failures a year are attributed to poor maintenance. Preventative inspection every 3-4 months and maintenance every 6 months is necessary, costing between £70,000 and £700,000 each. Accidents and fatalities are also quite prevalent: 2,265 accidents to June 2018, with fatalities accounting for 6% and injuries 7%. This phase 2 further develops RADBLAD, a first-of-its-kind magnetically-adhering wall-climbing robot, with manipulator arm that deploys the x-ray system around a blade. An end effector holds the source and detector against the blade, so they move with the blade in the presence of 3-D blade vibrations. A crucial and novel extension of RADBLAD lies in the use of a radiographic system for inspection and in providing an integrated solution that offers high-quality, efficient inspection method, which is human safe. Unlike radiography, RADBLAD does not require costly, time-consuming onshore dismantling of blades and transportation to workshop, inspection in x-ray bays and return and reassembly, taking around 10-days during which revenue is lost due to generating downtime. Contact methods, e.g. ultrasound volume inspection, are less effective on multi-layered composite structures, and more difficult to perform on-site. RADBLAD is also faster and cheaper than onshore inspection (not counting loss of revenue due to turbine downtime). To successfully achieve this, the project consortium features the relevant expertise, including robotic development and manufacture, radiography development, and AI algorithm software development. Our initial target market is the offshore wind turbine operation and maintenance market, with wind farm asset operators the target users. This project represents a clear technological innovation for the UK offshore wind generation industry, and major growth opportunity for the SME supply chain consortium.

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
ROVCO LIMITED	Advancing Underwater Vision for 3D Phase 2 (AUV3D-P2)	£947,525	£663,268
OFFSHORE RENEWABLE ENERGY CATAPULT		£339,841	£339,841
SCOTTISHPOWER RENEWABLE ENERGY LIMITED		£0	£0

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Project description - provided by applicants
Safe and efficient construction, operation and decommissioning of subsea assets is critically important to UK and worldwide energy production. This is particularly true for offshore renewable energy where cost efficiencies are necessary to deliver clean power that is cost competitive with other low carbon systems and at an affordable scale. From construction to decommissioning, underwater survey provides the data to monitor condition, predict asset life and ensure the environment is protected. We aim to deliver a step change in efficiency and safety by delivering live, dense, 3D point cloud data from small, Remotely Operated Underwater Vehicles. This will enable smaller vessels to be used with fewer crew, no divers, and removing the need to put people at risk. Compared to traditional visual survey, 3D data allows accurate measurement and repeatable, reliable metrics for asset condition monitoring and automatic monitoring from autonomous underwater vehicles (AUVs). Ultimately, live 3D enables accurate navigation for fully autonomous inspection AUVs reducing manpower and increasing efficiency yet further. Currently, AUVs do not possess the detailed mapping and localisation required for visual inspection work. Quality 3D visual data is also a prerequisite to applying artificial intelligence and deep learning solutions to 3D images thereby enabling greater autonomy and reliably repeatable measurements. AUV3D Phase 2 continues from the successful phase-1 project, which saw Rovco develop and demonstrate technical feasibility of live underwater 3D reconstruction from vision. This took place in the Offshore Renewable Energy Catapult's Blyth test facilities, where a dry dock with test targets was used to test and evaluate the system. For phase-2, the goal is to extend and improve on this both in terms of the underpinning technology and with more representative testing both in test tank and at sea. The prototype developed in Phase-1 enables innovative real-time underwater 3D survey from video, and for phase-2 we extend this into a more complete solution, considering integration with additional sensors and the delivery of live survey data to shore. By demonstrating the software and hardware necessary to produce live 3D data from cameras in the challenging and extreme subsea environment we enable the development of a complete vision based underwater Robotic Artificial Intelligence (RAI) survey solution. This is vital to create small, capable, intelligent autonomous vehicles and allow more efficient survey with fewer people in harm's way.

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
MYRTLE SOFTWARE LIMITED	LEO Satellite Based AI Demonstrator	£802,225	£561,558

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Project description - provided by applicants
Satellites typically have limited computing power, in part because they are solar powered and because their rigorous testing schedules and inaccessible operating location demands reliable, time proven technology, often several generations behind current state of the art devices we are familiar with. Our project aims to automatically produce a deep learning, object detection algorithm, which will be compressed and optimised to run on a space-grade FPGA device qualified to work in space on a satellite. The object detection algorithm will use synthetic aperture radar (SAR) and hyper-spectral image data as input sources and it will be trained using existing archives of satellite SAR and image data. The final deep learning system will be tested by Thales Alenia Space, a prime space contractor for ESA, at their satellite facility in Bristol UK. Satellites periodically transmit large volumes of collected data to earth based receiving stations for processing and distribution. This cyclic process restricts how much data can be collected during an orbit and requires significant bandwidth to transmit and receive data during the downlink window. By enabling the satellite with on-board object detection, it will identify and respond in real-time to observed events and then be selective about which data to source and keep for later downloads. These are fundamental problems with current satellite technology. It is relatively easy to attach high resolution scanners and radars to satellites, but much harder to store and transmit the volumes of data that can be gathered during one or more orbits. By finding ways to put smart AI algorithms into the limited, on-board compute devices of satellites we will make more efficient use of their capabilities and in-turn enable satellites and other space vehicles to undertake autonomous activities, when out of communication or too distant from Earth. This project is highly innovative because it will automate the design and creation of an object detection algorithm on a minimally configured, space-grade FPGA. If space technology is to reliably exploit AI algorithms this capability will be essential. There are no AI processors currently designed for space use. Although this project is developing an AI solution for a satellite platform, our solution is equally applicable to other space applications on deep space vehicles or on planetary rovers. It would require a different deep learning algorithm, which would need to be re-trained for the specific task, but the same space-grade FPGAs could be used.

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
ARCHANGEL IMAGING LTD.	WatchChainR	£388,953	£252,819
GMV INNOVATING SOLUTIONS LIMITED		£293,900	£117,560

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Project description - provided by applicants
'WatchChainR' builds on the successful Innovate UK funded Robotics & Artificial Intelligence Phase 1 WatchChain project. In this next demonstration phase Archangel Imaging will integrate world leading AI machine vision with GMV UK's unmanned rover vehicle, producing a robot that is designed to reduce risk to humans by undertaking monotonous and repetitive tasks in extreme and challenging environments. WatchChainR will operate remotely and independently using a powerful AI decision making system which has the designed-in intelligence to report only what it needs to; the system is able to save operators both time and money by filtering the mundane from the exceptional with human intervention only needed on an exceptions basis. This Innovate UK funded project is run by Archangel Imaging and GMV UK. Both companies are based at the Harwell Innovation Campus in Oxfordshire, a world leading centre for science and engineering innovation.

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AUTONOMOUS SURFACE VEHICLES LIMITED	Autonomous Robotic Intervention System For Extreme Maritime Environments (ARISE) Stage 2	£710,170	£355,085
BP P.L.C.		£38,793	£0
University of Exeter		£249,041	£249,041

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Project description - provided by applicants
ASV, BP and the University of Exeter will develop a new technology which offers high potential cost reduction for subsea inspection of global assets. The combination of an ASV, ROV and artificial intelligence, will enable safer and more efficient operation, maintenance and inspection of offshore assets. In the UK and globally, offshore assets require an increasing amount of intervention. Oil and gas platforms come to the end of their life and must be carefully monitored, whilst offshore wind installations must be efficiently operated and maintained. The offshore environment is harsh and hazardous with high levels of health and safety incidents reported every year, despite stringent safety procedures. The project will explore, address and test specific industrial use applications in the offshore wind and offshore oil and gas sectors, aiming to make operations much safer, cheaper and more efficient.

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
AUTONOMOUS DEVICES LIMITED	Offshore Infrastructure Robotic Inspection System (OSIRIS) Demonstrator	£392,470	£274,729
OFFSHORE RENEWABLE ENERGY CATAPULT		£30,340	£30,340
TWI LIMITED		£139,775	£139,775
WOOD GROUP UK LIMITED		£19,970	£9,985

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Project description - provided by applicants
OSIRIS is a highly innovative robotic solution for the detailed inspection of offshore wind turbine blades. It alleviates the risks imposed on workers, who typically carry out this task manually under hazardous conditions. OSIRIS combines the best features of drones and climbing robots, without their notable limitations. Drones offer flexible stand-off inspection, but their utility is limited by an inability to achieve secure contact with structures, ruling out contact-based Non-Destructive Testing (NDT) techniques capable of resolving sub-surface damage. Climbing robots offer constant contact with the target structure, but access to turbine blades requires placement and retrieval by a human, obviating the risk alleviation benefits. OSIRIS operates as both a drone and a climbing robot, with an ability to transition between the two modes, and therefore offers the benefits of each without the inherent limitations. OSIRIS can operate in close proximity to a turbine blade to obtain high definition stand-off imagery, attach and transition to climbing mode for contact based NDT, and then detach and return to drone mode. This 21-month demonstrator project brings together robotics specialist Autonomous Devices with end user Wood (a major provider of products and services to the oil and gas, power generation, clean energy, chemical, petrochemical and manufacturing sectors), materials and NDT expert The Welding Institute, and the Offshore Renewable Energy Catapult (as a demonstration partner providing access to an experimental 7MW offshore turbine at Levenmouth). Although our innovation targets the offshore wind turbine blade inspection application, there is real potential to read the technology across to adjacent markets. The global nature of all anticipated markets means that OSIRIS has high export potential.

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
BLADEBUG LIMITED	Demonstrator for robotic inspection and maintenance of offshore wind turbine blades	£674,249	£471,974
OFFSHORE RENEWABLE ENERGY CATAPULT		£275,850	£275,850

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Project description - provided by applicants
Offshore wind turbines operate in harsh and extreme environments such as the North Sea. As blades continue getting larger, their tip speeds can exceed 100m/s. At these speeds, any particulates in the air such as rain, dust, salt, insects, etc. can wear away the surface of a blade's leading edge, a phenomenon known as "leading edge erosion" (LEE). This, in turn, alters the blade's aerodynamic shape, affecting its efficiency and potentially exposing the blade to further and more serious damage, thereby reducing its working life. Whilst the extent and nature of contributing factors to LEE are not yet fully understood, it can be said that at some point in their lifespan, all wind turbine blades will suffer from some form or degree of LEE which will need to be addressed. Maintaining blades in the offshore wind sector is an expensive and dangerous job where, typically, highly skilled rope access technicians are required to scale down the blades to carry out leading edge repairs. Having successfully proven the concept in Phase 1 of the Innovate UK funding round, in this project, BladeBug Limited will continue its work with the Offshore Renewable Energy Catapult to develop, build and test a complete, walking robotic system designed specifically to carry out a number of these detailed inspections and repetitive repairs on the leading edges of wind turbine blades. The ability to perform these tasks remotely will free up time of skilled rope access technicians to undertake specialist repairs or upgrades to blades that only they can do. More blades could then be inspected and treated in the same time frames, maximising the electrical output of the turbines and, as a result, increasing revenues to turbine owners as well as the environmental benefit to everyone in CO2 savings.

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SAFEGUARD NAUTICA LTD	Unmanned Surface Vessels for Rapid Environmental Assessment in challenging inland waterways and tidal environments	£475,159	£332,611
CORE BLUE LIMITED		£217,610	£152,327
OFFSHORE RENEWABLE ENERGY CATAPULT		£68,512	£68,512
REYGAR LIMITED		£157,398	£110,179

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Project description - provided by applicants
The use of small, affordable Unmanned Surface Vessels (USVs) as remote sensing platforms for environmental surveys promises significant gains when compared to established techniques for charting shallow-water environments. High current velocities, unpredictable flow directions, turbidity and navigational hazards or obstructions can create a difficult operational environment for sensor platforms; and often a hazardous environment for surveyors. Safeguard Nautica has developed the micro-Rapid Environmental Assessment Vessel (mREAV) - a readily portable USV with an embedded dynamic positioning control system, mission planning system and redundant propulsion configuration with the intent of providing extended capabilities for hydrology and prospective users for whom waterborne site investigation in riverine, estuary and inland coastal environments is essential to their day-job. Phase 1 of the Demonstrator for Robotics & Artificial Intelligence (RAI) in Extreme & Challenging Environments, enabled the consortium to integrate the main mission planning and embedded control systems into the mREAV USV. The Phase 2 follow-on project will build upon this initial progress by delivering extensive testing of two fully integrated unmanned surface systems on real-world campaigns within a variety of still water, riverine, estuary and open-water environments using a range of hydro-acoustic, photogrammetry and user-defined sensor payloads. Close consultation with background partners from the user-community will ensure validated development feedback to optimise the platform iteratively during the two-year project. During Phase 1, consultation with the user community has revealed the value proposition and technical solution offered by mREAV for dynamic inland environments could have significant further applicability within high-energy wave and tidal work sites. In Phase 2, alongside continued development and testing of mREAV, a larger open-water variant with shared sub-systems will also be developed to operate in coastal / inshore environments. The REAV will complete two environmental survey campaigns at a UK tidal test site, providing a validated cost-reduction initiative for monitoring surveys aimed at the cost sensitive tidal energy sector, and other marine renewable energy applications within inshore waters. By operating the mREAV and REAV USVs together; the Phase 2 test plan will also demonstrate the extended capability of operating both USVs to provide relay / range extension through collaborative working at a special demonstration test in South West England. Collectively, the spread of operational testing delivered continuously during the project will provide continued development feedback, design improvement and validated demonstration of productivity improvements and reduced survey acquisition costs, in close cooperation with end-users.