Innovate UK

Results of Competition: **Demonstrator for RAI in Extreme and Challenging Environments – Phase 1**

Competition Code: **1706_EE_CRD_RFHEDP**

Total available funding is £6m

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
INNVOTEK LTD	In-service X-ray radiography of offshore wind blades (RADBLAD)	£219,281	£153,497
COMPUTERISED INFORMATION TECHNOLOGY LIMITED		£111,387	£77,971
London South Bank University		£148,999	£148,999

Project description - provided by applicants
The first phase of the project will demonstrate the feasibility of using agile mobile wall-climbing robots, portable radiography equipment and artificial intelligence (AI) technologies to perform asset management of off-shore wind farms located in extreme and challenging environments. Gaining access to off-shore wind turbine blades is difficult and expensive e.g. with large cranes on ships or climbing with rope/platform systems. Because of the difficulty of deploying large systems off-shore, a modular approach is required to easily transport lightweight systems to test sites and assemble them quickly. A modular wall climbing robot, assembled on site, will carry the radiography deployment system up the wind tower. Two arms will extend on either side of a blade positioned in a 90 degree configuration so that the source and detector are on either side of the blade. An intelligent positioning system will keep the two aligned and normal to each other as the complex aerodynamic shape of the blade is inspected along the width of the blade. The climbing robot will then move a small distance up the tower and repeat coverage of the blade width. Allowing a full length of the blade, with inspection starting from the tip of the blade up to the blade root. An intelligent control positioning system will be required since the blade shape and curvature will be different in each horizontal plane and the source/detector will need to adapt to the shape for optimum imaging. To cope with blade in-plane and out-of-plane vibrations, the X-ray source and detector will be kept stationary with respect to a blade by designing passive compliance into the deployment arm. Embedded intelligence will carry out automated defect detection and classification and enable autonomous decision making for further inspection and intervention.

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
ROVCO LIMITED OFFSHORE RENEWABLE ENERGY	Advancing Underwater Vision for 3D (AUV3D)	£165,836 £22,952	£116,085 £22,952

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 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. Ultimately, live 3D enables accurate navigation for fully autonomous underwater vehicles reducing manpower and increasing efficiency yet further. 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.

The key objective of the AUV3D project is to prototype and demonstrate the feasibility of a high-quality underwater, intelligent, stereo camera system. This system will enable innovative, real-time processing of underwater 3D from ROV video survey. To do this we will exploit recent advances in both camera technology and embedded GPU computing, and together these technologies enable Artificial Intelligence to be used to accurately to assess underwater 3D scenes.

By demonstrating the feasibility of 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 has the potential 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
BLADEBUG LIMITED OFFSHORE RENEWABLE ENERGY	Enabling technology for robotic inspection and maintenance of offshore wind turbine blades	£68,582 £10,550	£48,007 £10,550

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, inspects etc. can wear away the surface of the blade's leading edge, a phenomenon known as leading edge erosion. This, in turn, alters the aerodynamic shape of the blade, affecting the efficiency AND potentially exposing the blade to further and more serious damage, thereby reducing the life of the blade. Whilst the mechanisms that cause leading edge erosion are not yet fully understood, it can be said that at some point, ALL wind turbine blades will suffer from some form or degree of leading edge erosion during their life, which will need to be addressed. Maintaining blades in the offshore wind sector is an expensive and dangerous job. Typically, highly skilled rope access technicians have to scale down the blades to carry out leading edge repairs. This project aims to take the first steps of developing a robotic device to carry out a number of these detailed inspections and repetitive repairs on the leading edges of blades, freeing up the time of the skilled rope access technicians, enabling them to perform specialist repairs or upgrades to blades only they can do. This would enable more blades to be inspected and treated, maximising the electrical output of the turbines that in turn benefit the owner with increased revenues, maximise the CO2 savings that everybody benefit from and increasing the security of electrical supply for the end users.

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
INNOVATIVE TECHNOLOGY AND SCIENCE LIMITED Brunel University London	Autonomous, robotic and AI enabled biofouling monitoring, cleaning and management systerm for offshore wind turbine monopile foundations - RoBFMS	£349,669 £148,585	£244,768 £148,585

Project description - provided by applicants
Offshore wind is an attractive option for operators, primarily due to higher yields and less resistance from onshore homeowners and stakeholders. Within the UK the exploitable resource is especially attractive, at 6200TWhpa, ~18 times present UK electricity consumption and hence could provide all of the UK's electricity requirement with minimal emission and visual impacts. More than 5GW of installed capacity has been achieved in UK waters, enabled by government subsidies. The major barrier to further exploitation is that the levelized cost of electricity (LCOE) from offshore wind is Â£140/MWhr. 2-3 times higher than other key renewable sources: onshore wind, solar and nuclear (a large non-renewable but low emission source). The high LCOE is caused by the severe environment which results in high operational, reliability and maintenance (O&M) costs. Seabed turbine foundations (largely monopile structures) O&M accounts for at least than 25% of all life cycle O&M costs, mostly caused by marine biofouling amounts to 10% of the LCOE. Even with the deployment of state of the art fouling prevention technology, the fouling thickness deposited on foundations grows continuously, eventually causing stress induced corrosion and crack defects. Fouling remediation treatment consists of deploying cleaning tools such as brushes and power jets by divers (which is dangerous) or ROVs with annual costs ~ Â£30k/MW. The project will develop a fouling management system consisting of a mobile survey robot leading a cleaning robot team that will eliminate be need for divers and ROVs. The team will be placed on the turbine structure at sea level and will journey down below sea level to the work place. The lead robot will travel autonomously over the entire subsea monopile surface, imaging the fouling and measuring its thickness in real time at every location where it occurs. Simultaneously the leader will instruct one or more cleaning robots to every fouled location and remove the fouling with an innovative guided power ultrasound technique. On returning to the sea surface the team 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 Â£7/MW (5%) reduction in LCOE. This is a significant contribution to the overall LCOE reduction required to make offshore wind competitive with other energy sources and thus reap the full environmental advantages of offshore wind.

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
NATIONAL NUCLEAR LABORATORY LIMITED	Closed Loop Variable Buoyancy Lifting System for In-Pond Nuclear Retrievals	£31,185	£15,593
ROVTECH SOLUTIONS LIMITED		£125,750	£88,025
Project description - provided by applicants			
The in-pond harsh environment closed loop variable buoyancy lifting device relies on the Archimedes principle. Archimedes principle states that a body partially or completely immersed in a fluid is buoyed up by a force equal to the weight of the fluid displaced by the body. By changing the volume of displaced fluid, the device creates a variable lifting force. The novel application is to use a closed loop in which the inflation air is stored under pressure in a receiver. This compressed air inflates the variable displacement to provide lift. To submerge the air is transferred back into the receiver via a compressor and a series of control valves. The small observation class ROV systems currently being operated on the Sellafield site will be able to manoeuvre the suspended load. This can be most clearly demonstrated how historically during the era of canal transportation a horse could easily pull a fully laden 100 ton barge along a canal.			

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
LIVING MAP LIMITED	Living Map's Precision Positioning System (PPS)	£84,206	£58,944

Project description - provided by applicants

Living Map is a fast growing UK SME with R&D capability in the field of spatial orientation, digital mapping and sensor systems. The company has developed and commercialised a proprietary world-class digital mapping software \[Cartoengine\] and is now developing a highly robust precision positioning system (PPS) as an enabling technology for next generation human and machine navigation.

Using a combination of sensor fusion and machine learning, Living Map's novel PPS module will facilitate more accurate way-finding and mobility tracking throughout indoor and outdoor, multilevel and underground environments. The platform will be unique and innovative in that it is:

* hyper-accurate in terms of position, orientation and directional movement
* can operate independently of infrastructure or signals
* fully portable and highly resilient to the conditions i.e. designed to work seamlessly in extreme or hostile environments
* agnostic to the operating platform as it has an adaptive operational mode for both high and low end mobile devices

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
SAFEGUARD NAUTICA LTD REYGAR LIMITED	Micro Autonomous Surface Vessel (Micro-ASV) for inland waterway surveying	£65,512 £70,032	£45,858 £49,022
Project description - provided by applicants			
Safeguard Nautica Ltd and Reygar Ltd have formed a collaborative partnership to develop a hydrographic survey mission planning and control system for an Autonomous Surface Vessel (ASV), specifically aimed at operation on challenging inland waterway environments, (such as streams, rivers, lakes, ponds and estuaries). The concept draws upon the partners existing experience in developing dynamic positioning systems, but addresses unique challenges associated with high-energy, turbid and shallow waterways, often in GPS denied environments and without clear line of sight to the vessel. One of the main aims of the project is to enable survey campaigns to be readily planned and executed under automated control under the watch of an operative, improving accuracy and reducing skill levels required to navigate remotely; but at a target price which can disrupt the market for manually operated remote controlled boats. This demonstrator could prove the concept for use in many other unmanned marine platforms; in particular in offshore renewable energy installations at tidal worksites, and offshore decommissioning of fixed structures.			

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AUTONOMOUS DEVICES LIMITED WOOD GROUP UK LIMITED	Offshore Infrastructure Robotic Inspection System (OSIRIS)	£62,187 £38,858	£43,531 £19,429
Project description - provided by applicants			
OSIRIS is a highly innovative robotic solution for the inspection and maintenance of offshore structures, including wind turbines and oil rigs. It alleviates the risks imposed on workers, who typically carry out these tasks manually under hazardous conditions, and provides a step change in the capabilities currently provided by drones in this application. The project combines in-depth requirements capture with lab-based technology validation. It is delivered by Autonomous Devices, a Small to Medium Enterprise (SME) that has traditionally developed innovative robotic solutions for Defence and Security, and Wood Group, a major provider of products and services to the Oil and Gas, Power Generation, Clean Energy, Chemical, Petrochemical and Manufacturing sectors. Although our innovation targets the Offshore Energy sector, 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
NEPTEC UK LIMITED University of Oxford	Orbital Situational Awareness using Infrared Cameras	£185,685 £59,264	£129,980 £59,264

Project description - provided by applicants

The key objective of this project will be to conduct a feasibility study into the development of algorithms that will be able to generate positional information in all 6 degrees of freedom from data generated by the Neptec UK (NUK) space qualified IR Camera.

NUK will use their Space IR Camera and Simulator in order to demonstrate the technology being developed by NUK and Oxford University Active Vision Group. We also plan a basic hardware demonstration to test the feasibility of the technology.

The innovation in this study resides in the identification and tracking of non-cooperative targets by a cost-effective, low mass, volume and power solution.

The main markets for this technology will be Orbital Debris Removal and Satellite Servicing which are two key activities that will play a major role in making the skies safe by removing orbiting debris from space and the future maintenance of satellites. Both of these activities require a high degree of Robotics Artificial Intelligence (RAI) in order to autonomously control the movement of a chase vehicle up to a target satellite/debris and guide a grappling device to accurately capture the satellite/debris.

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
AUTONOMOUS SURFACE VEHICLES LIMITED University of Exeter	Autonomous Robotic Intervention System For Extreme Maritime Environments (ARISE)	£226,087 £104,868	£135,652 £104,868
Project description - provided by applicants			
The Autonomous Robotic Intervention System For Extreme Maritime Environments will apply artificial intelligence to result in safer and more efficient operation, maintenance and inspection of offshore assets. In the UK and globally, offshore assets require an increasing amount of interventions. Many 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. This joint feasibility project between ASV and the University of Exeter brings together leading industrial and R&D expertise to develop an innovative intervention system that jointly employs work class ROV's and Autonomous Surface Vessels (ASV) for inspection and intervention in hazardous offshore environments in order to make a step change to unmanned marine operations. 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 safer and more efficient.			

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
MYRTLE SOFTWARE LIMITED	AI Object Detection Hardware for Space and Polar Region Exploration	£89,004	£62,303
Project description - provided by applicants			
Artificial Intelligence, or AI, algorithms are becoming ever more powerful - improving speech recognition, providing driving assistance and even recommending movies and music. To take these algorithms into environments where conditions are extreme, and both power and human intervention are limited, requires that they run as power efficient robust hardware. This project will produce electronic hardware that realizes a cutting-edge object detection AI system. These electronics will be capable of coping with extremes of heat and large fluctuations of power and radiation. Our project is explicitly supported by end users in the fields of space and polar region exploration: some of the most challenging and hazardous environments on and beyond earth.			

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AIRBUS DEFENCE AND SPACE LIMITED TISICS LIMITED	Robotic In-Space Manufacturing Demo	£189,967 £47,610	£94,984 £33,327
Project description - provided by applicants			
In the next decade, both government and commercial entities will increasingly rely on robotic in-space assembly, manufacturing and servicing for the setup and maintenance of future space assets for civil and commercial missions. Intelsat published an analysis (AIAA Sep 2014) that calculated that on-orbit servicing could save commercial telecomunications companies alone $28M per year per spacecraft. While fields of autonomy, robotics, and space engineering are all making progress, true representative in-space manufacturing and assembly as an end-to-end process has not been widely demonstrated, despite the UK having a strong knowledge base in all these three areas. This project will assess the feasibility of combining the Lightweight Advanced Robotic Arm Demonstrator (LARAD) technologies, including its metallic-composite structure, to robotically demonstrate the construction of representative space structures in a laboratory environment. The Phase-2 demonstration will be a major stepping stone in providing our end-user with the means to fly an actual in-space manufacturing spacecraft in the early 2020's. Both phase-1 and phase-2 of this demonstrator will enhance the UK's momentum in the robotic, autonomous and space technology sectors.			

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INNOVATIVE TECHNOLOGY AND SCIENCE LIMITED	Robotic digital X-ray scanning system for deep water flexible riser inspection (RobotX)	£239,948	£167,964
Brunel University London		£79,653	£79,653
COMPUTERISED INFORMATION TECHNOLOGY LIMITED		£104,270	£72,989
London South Bank University		£69,569	£69,569

Project description - provided by applicants
New challenges are present for offshore oil and gas operators to provide adequate integrity assurance of their assets as the production facilities are reaching for the deep-water areas. Challenging conditions arise from more corrosive environments, higher pressures and temperatures. In deep water and hostile environments, where loading is high and complex and often design methods are pushed to the limit of current industry capability and experience, the riser systems have received an increased focus, more than ever in the light of several operational incidents (like the Deepwater Horizon accident in the Gulf of Mexico). These accidents have caused operators and regulators to question and update codes of practice. Flexible risers pipes are by nature complicated in design with many varying material types, corresponding to challenges in the inspection and integrity evaluation. The inspection techniques currently available in the market consist of only irregular diver or Remotely Operated Vehicle (ROV) inspections and are able to inspect only the near side layers for wire disruptions, with the far side layers remaining uninspected. The RobotX project will investigate the feasibility of a robotic digital x-ray scanning system that will address the needs and challenges of deep water flexible risers inspection. The robot and digital radiography equipment would have to withstand harsh environmental conditions i.e. high pressure (100bar). The system will perform a see--through quick scan as it crawls and process the data using innovative image processing methods and categorise them using machine learning. If defects are detected the robotic system will be able to turn around the riser and perform a more thorough scan. The defect will be correctly identified, using images taken at several angles. These innovations will allow not just to detect and locate the defects, but also classify them according to an existing historical database and automatically decide on bespoke scans for assessing the severity and needs for future intervention.

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ARCHANGEL IMAGING LTD.	HyRIZON for Maritime Protection	£94,148	£65,904
Project description - provided by applicants			
We are developing hyperspectral machine vision payloads for unmanned systems. Not only will we be abel to see the invisible; we will be able to tell what it is made from and detect interesting objects automatically in remote areas.			

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SONARDYNE INTERNATIONAL LIMITED	AutoMINDER – Autonomous MarIne Navigation in Denied EnviRonments	£203,642	£101,821
GUIDANCE MARINE LIMITED		£219,194	£131,516
Project description - provided by applicants			
Fault tolerant, high availability navigation systems used in the oil and gas industry today can already be considered automated. However, there are always at least two people on watch on typical mobile offshore drilling unit (MODU) as the Dynamic Positioning systems still rely on human intervention to take action when automatic fault detection and decision making are defeated. Automatic station keeping of a MODU is currently limited to benign environments where the operation of other vessels within 500m is either forbidden or highly regulated. The project will address these limitations by delivering a step change in the level of automated positioning possible. The technology developed and demonstrated will enable a vessel to behave in a safe and predictable manner beyond the point at which existing systems revert to human control. This will include safe, predictable positioning in the event of a sensor failure (such as the denial of GNSS), and enhanced positioning to enable moving in a challenging and complex environment.			

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
ARCHANGEL IMAGING LTD.	Watch Chain for pipeline and border monitoring	£98,098	£68,669
Project description - provided by applicants			
We will develop remote monitoring equipment for infrastructure security.			

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
STS Defence TWI LIMITED	CLAIMS++ (Coolant Leak Artificially Intelligent Monitoring System)	£218,555 £93,418	£131,133 £93,418

Project description - provided by applicants

Nuclear plants are valuable, high capital costs assets with longer operating lifetimes delivering reliable base electricity load to the grid. It is recognised by nuclear operators, national regulatory bodies, and organisations such as the IAEA, that in order to maintain optimal safety and economic viability, application of advanced Surveillance, Diagnostics and Prognostic (SDP) technologies will be required, particularly as plant lifetimes extend to 80 years and beyond. STS Nuclear in conjunction with TWI Ltd will develop a high temperature, high pressure test rig to complete leak propagation experiments and utilise previously developed sensing techniques to develop AI algorithms providing a material healthiness score in real time representative conditions. The aim of development is to produce a technology to inform operators about potential leak sites, and ultimately provide the characterisation of these sites including, location, size, rate of leak and time at risk, informing safety systems and operations.

CLAIMS++ (Coolant Leak Artificially Intelligent Monitoring System) is a development of a TRL3 technology focused on detecting, localising and classifying small leaks in the Reactor Coolant Pressure Boundary of pressurised water rectors (PWRs). This is timely for the market, given the increased recognition that intelligent monitoring systems can add significant benefits to reactor plants, being high-value, long term ROI assets for their operators and investors.

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