# Bilateral UK and US offshore wind R&D programme
# Expression of Interest

## Project Proposal Summaries

**17th April 2020**

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| Proposal number & title | 46463: Floating wind innovative assembly: design and cost estimate for US coasts |
| Summary | The project is focused on demonstrating the suitability of the **Starfloat(tm) floating offshore wind platform** for deployment at deep water locations off the east and west coast of the United States. The Starfloat(tm) 'multifloat-spar' has been the subject of a **technical feasibility study funded by Innovate UK under Energy Catalyst Early Stage Round 4 in 2017** and was further validated through conducting integrated wind and wave tests on a **1:36th scale working model** at the Cantabria Coastal and Ocean Basin **under EU MaRINET2 funding support in 2018** to take the device to Technology Readiness Level 4 (NYSERDA TRL Calculator). The key innovation is the combination of spar technology with multifloat semi-submersible technology to give a highly stable platform that can be configured to support the future generation XXL horizontal axis wind turbines while maintaining more compact dimensions than alternative technologies.<br>Starfloat(tm) is a **modular platform geometry** that has been developed for series production using any port facilities with quayside space and a load-out jetty. The key innovation that allows construction to be carried out without the need for very deep-water ports or specialist construction docks or slipways is t**he use of a dedicated Assembly and Deployment Barge (ADB)**.<br>The assembly and outfit of Starfloat(tm) units make use of a semi-submersible ADB onto which the unit is skidded from a load-out quay. The ADB allows the alongside outfit of units where the turbine tower, turbine nacelle and blades are added using shoreside cranes as used in onshore wind farm assembly. This has a significant impact on **reducing total CAPEX**. Once the Starfloat(tm) wind turbine unit is fully assembled and pre-commissioned (by connecting to the onshore grid) the ADB is towed out into deeper water or directly to the wind farm site where the ADB is docked down and the Starfloat unit is floated off and hooked up to its pre-laid moorings and power export umbilical. The ADB, therefore, obviates the need for offshore construction and heavy lift operations.<br>The ADB has special geometry to accommodate a 'multifloat-spar' unit and the feasibility study will cover the outline design and costing of the ADB for inclusion in an overall deep-water wind farm economics model. **The feasibility study will seek to demonstrate the attractive Levelized Cost of Electricity (LCOE)** that can be achieved with Starfloat(tm) using the ADB assembly and deployment process for exploiting US wind farms.<br>The feasibility study involves **six work packages.**<br>• WP1: ADB Concept Design for US operation, including:<br>• WP2: Build a strategy for Starfloat units at US coastal facilities,<br>• WP3: Anchoring solutions for US deep water wind sites<br>• WP4: Cost modelling and economic analysis<br>• WP5: Project management and reporting<br>• WP6: Dissemination and outreach |
| UK lead | RINA CONSULTING LTD<br>Adam Crocker<br>+44 1372 367 350<br>adam.crocker@rina.org |
| UK partners | OceanFlow |
| US partners – in discussion/confirmed | The University of Massachusetts Amherst |
| US partners – desired | A US **business** partner with strong vessel design expertise |
| NYSERDA application | Not applicable – will apply to NOWRDC solicitation July 2020 |

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| Proposal number & title | 47523: IMS Load Reduction Mooring System |
| Summary | The Intelligent Mooring System (IMS) aims to meet the current mooring challenges for floating wind structures and to deliver substantial LCOE reductions for floating offshore wind generation. It is an industry project led by Intelligent Moorings Limited in collaboration with the University of Exeter. The IMS has a unique approach to mooring damping, a flexible braided pressure based active control with no mechanical moving parts. This working principle incorporates flow and pressure control in operation to enhance platform stability during different operational modes. The technology has been developed under successful Innovate UK projects 101970 & 103889 and is covered by patents GB2501926 and GB2537031.<br><br>In addition to excellent load reduction performance, it can be tuned dynamically in operation in response to wind and wave conditions, as well as allowing multiple pre-configured responses to loading thresholds. Offshore structures which would accrue greatest benefits from IMS are large high-cost platforms used in Floating Offshore Wind which need high survivability and optimal station keeping. The shape and steepness of the load-extension curve is variable in operation to adjust to the prevailing metocean conditions. This allows a much wider range of response characteristics than would otherwise be available. The controllable nature of the resistance and stroke length in reaction to platform feedback and requirements such as accurate position keeping, tidal range compensation or attitude efficiency for energy harvesting devices are unique mooring capabilities and highly desirable for end users. |
| UK lead | INTELLIGENT MOORINGS LIMITED<br>David Newsam<br>+44 7738148807<br>dnewsam@intelligentmoorings.com |
| UK partners | University of Exeter |
| US partners – in discussion/confirmed | PCCI Inc (in discussion) |
| US partners – desired | A US developer. The developer partner would not necessarily need to be funded but support the development with end-user input, loads, operation requirements etc. Note however Innovate UK funding requires that a US partner be funded as part of an application to NOWRDC for IMS to qualify. |
| NYSERDA application | Not applicable – will apply to NOWRDC solicitation July 2020 |

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| Proposal number & title | 48384: Windflow Architect USA |
| Summary | UK-based Zenotech has been working wind energy sectors for 7 years, and has been involved as lead and partner in several Innovate UK projects in wind energy (131204 "SWEPT", 102236 "SWEPT2" and 133143 "Windfarm Architect") in which our aerospace-based technology was modified and applied to the modelling of wind turbine wakes in large arrays. During the SWEPT2 project, power company SSE asked for a blind test wherein our a-priori wind farm model for Greater Gabbard was compared with real SCADA from the operational farm. The independently assessed results were accurate to 2%. This work has been presented at the Wind Europe 2019 conference. One of our Asian customers has described Zenotech software as "the only software capable of accurately modelling a large-scale wind farm with 1000+ turbines."<br><br>Zenotech has been working with US-based company Aero Design Labs for three years on the development of advanced aerodynamic components for the civil aerospace parts aftermarket, and has been working with Chinese partner CEPC on wind energy technology commercialisation projects since 2018, with support from DIT, BEIS, RTC North and Innovate UK.<br><br>Our objective in creating "Windflow Architect USA" is to become the default provider of advanced, high-fidelity on-demand wind farm aerodynamic modelling capability to support the NYSERDA technology requirement. We expect this to be done in partnership via the newly created supply chain consortium, using the Innovate UK programme to customise and prove the technology for the local market. We propose to use the EOI phase to further refine our plans with appropriate US-based partners from the newly formed NYSERDA supply chain partners with Executive Director Carrie Hitt.<br><br>Windflow Architect USA will produce a new online wind farm simulation service based on the integration of Zenotech products ZCFD and EPIC with customisation for the local market. Unlike our existing deployment model (where fluid dynamics experts set up and run the software for each new project) the online service will integrate analysis components with default settings to automate the process and allow for rapid, scalable application by wind energy specialists - who may not be experts in the configuration of high performance computing (HPC) resources and the definition of numerical parameters for computational fluid dynamics (CFD) software. The service will be of use in each stage of the wind farm resource assessment, design and operation and support value-added services from partner organisations in the USA. Innovation will focus on characteristics of the NYSERDA wind farms in the competition call document that have specifically not been requested by other customers, requiring specific modification to the software and workflows to integrate data sources. Implementation of these and leverage of the Zenotech AI technology base for process streamlining and data exploitation. |
| UK lead | ZENOTECH LTD<br>David Standingford<br>+44 7870 628 916<br>admin@zenotech.com |
| UK partners | none |
| US partners – in discussion/confirmed | none |
| US partners – desired | • Wind farm operators or Tier-1 service providers to wind farm operators.<br>• From a technical perspective, Zenotech would complement the work done at NREL. |

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| Proposal number & title | 48384: Windflow Architect USA |
| | • Might partner with Amazon AWS to deliver the software service. |
| NYSERDA application | Not applicable – will apply to NOWRDC solicitation July 2020 |

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| Proposal number & title | 48473: Maintenance and in-situ repair of composite wind turbine blades and the development of high efficiency heat management for turbine (gearbox) components |
| Summary | The project has two main work streams/work-packages which are centred around improving the maintenance scheduling and operation of remote windfarms. Graphene Composites, and other partners, are proposing to work with Ørsted at the NYSERDA application stage. The two proposed work-streams are:<br><br>**Work Stream 1 – Blade Leading Edge Repair/Reinforcement**. The development of a repair patch for the leading edge of carbon-fibre reinforced composite wind turbine blades which is more resistant to the significant wear associated with the operation of the leading edge of the blade. The repair patch will be capable of in-situ application and provide several years of maintenance free operation, extending the operational lifespan of the installation. The first part of the work-package is the development of the multi-layer composite patch/ribbon system itself; and secondly, as this needs to be applied by a single operator during maintenance programmes (probably through rope access teams), a suitable applicator system will be developed during the process, with material selection being a key element in this design process. The main UK partners in the work-package are Graphene Composites Ltd (Lead applicant) along with Ocean Coatings Ltd and the Offshore Renewable Energy CATAPULT.<br><br>The innovation in this system results from the use of a liquid plus additive system which can be applied along the full length of the leading edge of a wind turbine blade during routine maintenance. The structure of the repair is designed to give extremely high adhesive properties for application with a softer, energy absorbing core, topped with an extremely abrasion resistant topcoat. The use of vibration dampening materials, such as polymeric aerogels, will add a high degree of vibration dampening, a technology which may be applicable to the original design phase of the blades.<br>The work-package proposes to select suitable carrier materials (epoxy resins and PU rubbers) based on properties such as abrasion resistance and adhesion, impact resistive additives such as graphene, carbon nanotubes and aerogel particles and/or tapes, and then develop an optimal structure for a repair patch. The suitability will be assessed through application testing, re-formulation and retesting.<br><br>**Work Stream 2 – Thermal Efficiency/Lubrication improvement in Drivetrain**. The development of an additive package for the lubrication and heat dissipation within the gearbox, mechanical transfer components, and electronic switchgear of the wind turbine installation. UK partners for this section are Graphene Composites Ltd and the Centre for Process Innovation. The addition of 2D materials (such as hexagonal boron nitride for example) at low weight percentages (<1%) to liquids such as solvents (including water) and hydrocarbon based oils, dramatically increases the thermal conductivity of the liquid system while not affecting other properties such as the viscosity and electrical conductivity (retains dielectric properties). Keeping the viscosity change to a minimum allows current specified pumps, for example, to be used. The 2D structure of the additive has been shown to decrease viscosity often allowing for a smaller pump to be used for the same heat dissipation.<br><br>The innovative element of this section lies in the particle deployment within the dispersion which retains non- agglomerated particles (as single 2D plates) which ensures there is no drop-out of particles within flow 'dead spots' in the system, which can cause other maintenance issues, and high thermal transfer |

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| Proposal number & title | 48473: Maintenance and in-situ repair of composite wind turbine blades and the development of high efficiency heat management for turbine (gearbox) components |
| | efficiency which results from a lack of large chain surfactant molecules required for stabilisation. selected surface treatment of the particles allows for integration of the particles between long chain hydrocarbon molecules with the ability to covalently bond with sister on these molecules increasing stability.<br><br>The work-package seeks to assess the chemistry of the current Lubrication packages and develop a suitable surface modification protocols to give maximum stability, then iterative testing to give the optimal loading to maximise heat flow. A final assessment within a mechanical and electrical system will be required. |
| UK lead | GRAPHENE COMPOSITES LIMITED<br>Stephen Devine<br>+44 7764 228 349<br>steve.devine@graphenecomposites.com |
| UK partners | Centre for Process Engineering, Offshore Renewable Energy Catapult, Ocean Coatings |
| US partners – in discussion/confirmed | Ørsted Inc (in discussion) |
| US partners – desired | Other US developers |
| NYSERDA application | Not applicable – will apply to NOWRDC solicitation July 2020 |

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| Proposal number & title | 48719: Cost Effective Methods of Installing Offshore Wind Infrastructure, Including Mooring Systems, Energy Buffering Systems and Other Subsea Elements |
| Summary | Aubin, with technical support from the University of Aberdeen (National Decommissioning Centre), plan to reduce the costs and time of installing offshore windfarms, developing methods to deploy mooring systems and other subsea infrastructure.<br><br>Aubin, a UK-based chemical and materials manufacturer, have developed and patented pumpable variable buoyancy technology (Deepbuoy) based on non-compressible liquids which can be deployed to 3000m. In recent years, this led to the development of a demonstrator model of an underwater lifting system (ULS), as part of a Knowledge Transfer Partnership graded as "Outstanding" by Innovate UK, taking the technology to approximately TRL5 with deployment of the ULS in a 5 metre pool. Aubin have utilised pumpable buoyancy in trials offshore to approximately 30 metres depth and have validated pressure rating of material using hyperbaric chambers to pressures equivalent to greater than 3000 meters depth.<br><br>Aubin's project, with the support of the National Decommissioning Centre's simulation and engineering capabilities, will aim to demonstrate liquid buoyancy and the underwater lifting system as technologies working in shallow, median and deep water wind farm installations, with a main focus being on the challenge of floating wind farm anchors and mooring systems. This should enable the subsequent deployment of the product in an operational environment to progress the technology to TRL 7.<br><br>Simulations, with associated cost/time/benefit analysis will be conducted on a variety of weather/surface conditions and will be done in comparison to conventional installation methods as well as other new lifting methods (e.g. air-based/syntactic buoyancy with variable ballast); the recent Hywind Scotland project may be used as a case study for some methods of mooring, as will future proposed wind farm deployments. This will be easily transferred to other subsea lifting challenges (both in offshore wind and other offshore industries).<br><br>Ultimately, the level of control in the installation of subsea infrastructure can be increased, along with a reduction in the dependence of heavy lift vessels, enabling a wider supply of vessels (lower cost/less specialist) during anchorage/mooring installation. This in combination with the increase in potential weather windows for installation (due to lifting systems not being impacted by surface conditions) enables deployment of more efficient field arrays, with precise anchor and infrastructure placement subsea; an added advantages to this include a reduction in material requirements (less tonnes of mooring lines) in large fields, avoiding damage to sensitive environments/structures subsea, increased efficiency of arrangements for future maintenance and, ultimately, providing options for reversing the process in future decommissioning. Some comparison in technical capabilities can be run *versus* other new technologies on the market to understand both competitive advantage and potential complimentary usages (please see Ecosse IP and Subsea Deployment Systems for potentially complimentary technologies with some overlapping applications). At this stage, Aubin are signed up to the Online Partnering Platform and ready to develop partners with US-based organisations. |
| UK lead | AUBIN LIMITED<br>Callum Scullion |

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| Proposal number & title | 48719: Cost Effective Methods of Installing Offshore Wind Infrastructure, Including Mooring Systems, Energy Buffering Systems and Other Subsea Elements |
| | +44 1358 747 163<br>callum.scullion@aubingroup.com |
| UK partners | National Decommissioning Centre, University of Aberdeen (advisory) |
| US partners – in discussion/confirmed | Oceanetics (TBC) |
| US partners – desired | Partners with US renewables, engineering and with subsea capability |
| NYSERDA application | Not applicable – will apply to NOWRDC solicitation July 2020 |

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| Proposal number & title | 49155: The Stinger Keel Concept: a deep-water floating wind turbine foundation design |
| Summary | The Stinger Keel Concept is a novel, patent registered deep draft foundation structure design for floating offshore wind turbines developed by Floating Energy Systems Ltd (FESL). It builds upon the results of FESL's previous Drop Keel Concept Research completed in 2019 with the support of Innovate UK (Application Number 20599). The deep draft, or spar, foundation approach offers benefits in motion response compared with shallower draft semi-submersible designs.<br><br>The innovation of the Stinger Keel addresses a longstanding problem facing spar structure development for floating offshore wind turbines: how to assemble and launch a foundation structure at a quayside construction facility in approximately 12m water depth when the operational draft of the structure is around 90m.<br><br>To date, floating wind turbine spars have been developed in Norwegian fjords using floating cranes which presents a significant geographic constraint and cost in chartered craneage.<br><br>FESL's solution is to elevate the foundation keel during assembly and transportation and, after towing out to location, deploy the keel to its operating depth. Other concepts in development follow a similar approach but use wire or chain as the means of suspending the keel from the topside floating unit. FESL's patented concepts use steel tubular frames to maintain a rigid connection between keel and floating unit to ensure a more robust assembly for the unit's planned 25-year lifespan. Steel tubulars also provide a fully rigid connection that maintain a single body motion response to wave and wind loading without concerns for a double pendulum effect arising from a cable suspended solution.<br><br>The original Drop Keel concept vertically deploys a multi-unit ballast keel using a multi hydraulic jack system. The Stinger Keel simplifies this approach with a single swing arm that rotates from horizontal elevation in transit to a vertical position under the gravity load of pumped ballast water. The process is reversible, and the swing arm returns to the horizontal by de-ballasting the pumped water.<br><br>Computer and wave tank model simulations during the research project in 2019 established the Drop Keel's promising motion characteristics but the ballast keel system design and means of deployment were too complex for ease of construction. The LCOE analysis also identified a lack of commercial appeal. The research project concluded that the keel deployment should be simplified, avoid reliance on a mechanical system, improve the deployed keel latching system and achieve a deeper deployment depth. FESL began design of the Stinger Keel Concept in parallel with the 2019 research work and adopted all these features. The resulting design achieves 44% reduction in structural steel weight and 50% reduction in solid ballast weight. The current Stinger Keel layout consists of only two prefabricated steel components that can be launched and assembled in 10m water depth using the same onshore craneage currently available for fixed bottom wind turbine foundation structure assembly and loadout.<br><br>FESL confirm a US partner in 2H Offshore, with whom FESL have been developing the current floating wind concept since May 2019. 2H Offshore are part of the Acteon group and specialise in the development of riser and |

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| Proposal number & title | 49155: The Stinger Keel Concept: a deep-water floating wind turbine foundation design |
| | mooring systems for offshore floating units. Since July 2019, FESL have established a working relationship with 2H Offshore's Houston office who developed initial analysis and CAD modelling of the Stinger Keel concept. 2H Offshore with its sister company Intermoor have applied for NYSERDA funding to develop a standardised mooring system design for spar-based floating offshore wind foundations. This will meet the needs specific to spar foundation designs independently of current research elsewhere into semi-submersible mooring designs.<br><br>FESL also propose to partner with (i) Strathclyde University (UK research institute) to perform scale model wave tank test simulations of the Stinger Keel to verify the findings of 2H Offshore's analysis results (ii) Tadek Offshore (UK naval architecture consultancy) to assess design, ballast and stability for the launch, assembly and transit conditions of the Stinger Keel (iii) SCDX Ltd (UK structural engineering consultancy) to develop an innovative pressurised floating unit hull design that reduces steel structural weight by adapting a similar design approach used for mid-water arch riser support structures in offshore oil and gas (iv) AgileTek (UK power cable analysis consultancy) to ensure compatibility between the interconnected floating foundation and riser export cable dynamic motions (v) DNVGL to provide certification authority support on the path towards eventual Approval in Principle (vi) Subsea Innovation Ltd to support the development and costing of a full scale fabrication and delivery plan to the point of handover to the offshore installation contractor.<br><br>FESL's shall project manage and co-ordinate output from the various project partners and compile a design package that (i) demonstrates no major hurdles for development to the next TRL (ii) allows a wind turbine vendor to assess the compatibility of the Stinger Keel's motion characteristics with the performance envelope of its specific wind turbine design. |
| UK lead | CPDSYS LIMITED<br>Gary Ross<br>+44 7826 435 361<br>gary.ross@floatingenergysystems.com |
| UK partners | University of Strathclyde, Tadek Ltd, Agiletek Engineering Ltd, Subsea Innovations Ltd, SCDX Ltd |
| US partners – in discussion/confirmed | Intermoor/2H Offshore |
| US partners – desired | Marine fabrication contractor |
| NYSERDA application | Intermoor/2H Offshore submitted a proposal to NYSERDA in December 2019 |

| Proposal number & title | 49222: INTEGRATI ORE |
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| Summary | During the bidding stage of Offshore Renewable Energy (ORE) Capital Projects, the large overhead cost to model scenarios and the lack of cost predictability creates uncertainty, challenging developer and investor confidence. This constraint can result in declining margins making it a difficult market for local content to compete and higher associated costs having knock-on effects to the Levelised Cost of Electricity (LCOE). This flawed model can be seen in use across Capital Projects in many industries.<br><br>Research carried out over 30+ years in the US by the Construction Industry Institute, showed that 98% of mega-projects experience cost overruns of 80%, 70% of all projects are not completed within 10% of budgeted cost or schedule, and over 40% of project expenditure is wasted due to non-value added transactional costs throughout the supply chain. The construction industry is not delivering financially (0.5% net profit in 2018), it is not attracting enough investment and it is suffering negative productivity growth. There is now an opportunity to protect the nascent US ORE industry from suffering a similar fate.<br><br>Xodus Group, an industry-leading energy consulting company, have partnered with Aberdeen-based start-up, eCERTO, to bring its INTEGRATI™ platform technology to the ORE industry with the aim of optimising financial performance, reducing commercial risk, enhancing local US content, and accelerating the growth of the US ORE industry.<br><br>INTEGRATI™ is a cloud-based end-to-end digital technology designed by eCERTO to optimise the financial performance of Capital Projects and Decommissioning, originally within the Oil and Gas industry. INTEGRATI™ ORE is conceived to be deployed from the early stages of the ORE project lifecycle where there is the greatest potential to create and capture value. Streamlining the entire procurement process, ORE Developers will use INTEGRATI™ ORE to define contracting strategies and engage their contractors during sourcing. Both parties will then use it to control their financial performance during execution in order to maximise the value realised in the project.<br><br>INTEGRATI™ ORE aims to accelerate the maturation of the US supply chain by lowering commercial risk for both suppliers and developers across the lifecycle of capital projects. It does this by harnessing business intelligence to power dynamic pricing models which ensures cost optimisation for customers and target margin protection for suppliers. The process of implementing INTEGRATI™ ORE requires engagement with suppliers and developers to ensure the interests of both can be reflected within the commercial models, increasing the utilisation of US assets and favouring local content. INTEGRATI™ ORE will particularly benefit small companies as it will help create visibility whilst also protecting their target margins. It will also reduce the commercial risk for the larger suppliers looking to invest within the nascent ORE industry, allowing them to pivot into a new industry with reduced risk, promoting new investment and knowledge transfer opportunities to up-skill the developing local ORE work force.<br><br>On completion, the desired output of the NOWRDC project will be a clear demonstration of INTEGRATI™ ORE as an end-to-end eCommerce Platform that optimises the financial performance of ORE Capital Projects within the US. This will include an in-depth feasibility study consisting of both primary and secondary research which will map current US ORE market commercial practices and demonstrate market pull. Support from Innovate UK will bring |

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| Proposal number & title | 49222: INTEGRATI ORE |
| | INTEGRATI™ ORE from TRL 5 to TRL 7 and one step closer to creating a cloud-based digital ecosystem that will integrate the operating model of ORE developers and suppliers across business functions, streamlining the procurement process.<br><br>Xodus and eCERTO are currently actively seeking a US partner to progress this project. We will be dialling into the NOWRDC hosted Webinar on the 23rd March and will continue to monitor alternative events which we can attend in response to the IPF delay. In addition to this, a member of our team will be based in Boston from April onwards should anyone like to reach out and have a conversation with them. |
| UK lead | XODUS GROUP LIMITED<br>David Porteous<br>+44 7711211515<br>david.porteous@xodusgroup.com |
| UK partners | eCERTO Energy |
| US partners – in discussion/confirmed | none |
| US partners – desired | Developers or key players within the US supply chain.<br>Ultimately, it is their data and projects we are seeking access to in order to contextualise and test our methodology and technology |
| NYSERDA application | Not applicable – will apply to NOWRDC solicitation July 2020 |

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| Proposal number & title | 49243: MONitoring of Undersea Mooring chains using acoustic Emission for floating wiNd Turbines (MONUMENT) |
| Summary | This project aims to develop and demonstrate a methodology for monitoring the condition of floating wind mooring chains in real-time and to provide automated assessment. This will be achieved through lab-based demonstration on real mooring chains in a representative environment under typical loadings conditions.<br><br>MONUMENT will develop an Acoustic Emission (AE) methodology for monitoring mooring chain condition. AE is the release of an ultrasonic strain wave when damage occurs. By monitoring AE activity and intensity, an assessment of the chain can be made. Assessment will be performed autonomously through the adaptation and development of an Artificial Intelligence (AI)-based algorithm, which will expedite data interpretation and present an easy-to-interpret read-out.<br><br>The goals of this project will be achieved by defining and outlining a detailed methodology specification, which will be driven by industry requirements and in-service constraints. A series of tests will be conducted to grow damage artificially in full-scale chain links and chain sections under representative loading conditions. During these tests, different AE approaches will be trialled to maximise the probability of damage detection and reduce false alarm. Algorithms will be developed to cluster damage AE from background AE sources automatically. This will reduce the amount of data handling required. AI-based algorithms will be developed that will automatically assess the condition based on the damage AE signals that have been supplied to it. This will streamline the data processing, time and human intervention required, demonstrating real-time mooring chain monitoring for floating wind applications.<br><br>This project is led by Modus Seabed Intervention Ltd., who currently provide inspection and asset management services to several offshore operators internationally. They are well positioned to provide direction and specification for the technology development, as well as to exploit and commercialise the project outcomes. Modus have partnered with FLICQ, who are at the cutting edge of algorithm development and analytics for real-time asset monitoring. FLICQ have successfully developed and implemented Internet-of-Things-based sensing solutions: these provide data to their interpretation algorithms, which autonomously deliver assessment of asset condition to their customers. They will provide their expertise in AI algorithm development to streamline the AE data analysis autonomously. TWI Ltd. are the third partner, a world-leading research and technology organisation specialising in non-destructive assessment. TWI will conduct AE experimentation on full-size chain lengths in their bespoke mooring chain test facility and conduct initial AE data analysis. The University of Bedfordshire completes the consortium, with strong expertise in data analysis, big-data management and algorithm development. The University of Bedfordshire will develop algorithms to differentiate AE damage signals from noise autonomously at their Renewable Energy Innovation Centre.<br><br>MONUMENT will address customer needs by developing a cost-effective, reliable methodology that provides suitable feedback for future mooring designs and has streamlined post-processing software. These needs are widely recognised in the industry, as global floating wind capacity is set to increase dramatically over the next decade and, as such, the number of mooring |

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| Proposal number & title | 49243: MONitoring of Undersea Mooring chains using acoustic Emission for floating wiNd Turbines (MONUMENT) |
| | systems deployed will increase. All these mooring systems will require technologies that can ensure asset integrity.<br><br>Inspection technologies used in the Oil and Gas (O&G) industry are not suitable for use in the floating wind industry due to the different associated costs and risk profiles. Ensuring the asset integrity of floating wind moorings in vital to maximising economical value. Hence, there is a business opportunity to develop a technology to monitor mooring chains during their operation.<br><br>Mooring systems are critical to floating wind turbine operation. However, experience in the O&G industry has demonstrated that mooring chains require frequent inspection to ensure their integrity. This has mostly been conducted using Non-Destructive Test (NDT) methods, which typically check chain condition visually and dimensionally. This costly, time-consuming and high-risk process provides limited information on chain condition and cannot be conducted successfully at low depths. As result, failures can still occur, which can result in loss of asset.<br><br>The industry need for mooring chain monitoring and the forecasted increase in global floating wind capacity demonstrates a significant business growth opportunity for all partners involved. Additionally, there are secondary exploitation avenues for the technology for monitoring mooring chains in the O&G sector and for floating other subsea structures and systems in the floating wind sector. There are currently no technologies that have the potential of MONUMENT. On project completion, this potential will be realised, creating opportunity for subsequent development and commercialisation. |
| UK lead | MODUS SEABED INTERVENTION Ltd<br>Mark Short<br>+44 1325 387 480<br>ms@modus-ltd.com |
| UK partners | TWI, University of Bedfordshire Beds, FLICQ UK |
| US partners – in discussion/confirmed | none |
| US partners – desired | • A mooring manufacturer: who would be able to supply information on mooring device design and operation for floating wind turbines<br>• A prospective floating wind operator/owner who could act as an end-user supplying steering on the operation of a mooring monitoring device<br>• A company with expertise of deploying mooring devices for floating structures which could supply knowledge and expertise on mooring deployment and recovery. |
| NYSERDA application | Not applicable – will apply to NOWRDC solicitation July 2020 |

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| Proposal number & title | 49770: Visual AI analytics of subsea structures during construction, operation or maintenance to enable efficient prognostics |
| Summary | Rovco has developed an advanced 3D data collection system that allows state-of-the-art video footage to be captured and analysed in real time. We have demonstrated a baseline ability to recognise objects in typical, low visibility subsea footage using Machine Learning. In this project, we will be conducting critical investigation and research to gain new knowledge and skills in applying advanced machine learning methods to the subsea inspection of offshore wind farm assets. The data collected over time will feed into the core technology, which will enable prognostic approaches to maintenance. These techniques will be applied to a wider range of components to extract the more nuanced data necessary to support a maintenance programme in line with NOWRDC aspirations for offshore wind digitization through advanced analytics.<br><br>The project will lead to a system able to autonomously provide a holistic view of the site and its assets and using component-level data enable O&M decisions to be made remotely and to predict optimal maintenance schedules. This will facilitate better O&M planning, yielding more cost-effective maintenance as well as reducing risk and $CO_2$ emission in the offshore environment. By increasing the amount of data being collected and applying machine learning algorithms, predictive models can be developed. This is an innovative technique which has the capability to eradicate the current practice of physical inspections which may only identify problems after serious progression. We will work with project partners to access assets during appropriate stages of their lifecycle.<br><br>Delivery of data to the operator will be through Rovco's proprietary web technology. Innovative data handling and processing techniques will combine with the development of novel presentation methods. Rovco has vast prior experience of storing, manipulating and presenting data for the Global Offshore Wind Industry. By combining this with the output of new machine learning techniques developed in this project, we will create an integrated system that can collect, analyse, and interpret a broad range of data.<br><br>The application of machine learning to discover the state of subsea components is a key innovation operation required for further autonomy in wind farm maintenance. Rovco is one of the few companies worldwide with the experience and skills necessary to realistically push the technological boundary in this area.<br><br>The outcomes targeted by this project are well defined and independent. For stage 2 it will fit well into a larger project where measurement or monitoring of an infrastructure is necessary. |
| UK lead | ROVCO LIMITED<br>Helen Murray<br>+44 117 230 0001<br>helen.murray@rovco.com |
| UK partners | none |
| US partners | none |
| US partners – desired | Looking to collaborate with US Partners who are currently constructing or operating offshore wind farms and are interested in the use of intelligent technology for installation and in predictive maintenance programmes. |
| NYSERDA application | Not applicable – will apply to NOWRDC solicitation July 2020 |

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| Proposal number & title | 50035: Offshore Component Condition Monitoring via Machine Learning Enabled Smart Sensors and Low-bandwidth Data Transmission |
| Summary | Operations and Maintenance in Offshore Wind is currently based on old protocols generated in the maritime sector, where routine, scheduled maintenance is carried out periodically. Industry insight has indicated a strong desire to transition to a predictive maintenance framework, based on accurate condition monitoring of individual components within an offshore wind asset. A key reason for this need is the prohibitive cost that offshore maintenance commands. Currently, 20-30% of the overall expenditure for an offshore wind farm is based on Operations and Maintenance, and as the number of offshore wind farms increases and becomes even more remote, the resources (human expertise, CTV's and SOV's) will become more limited, and costs could, therefore, increase further.<br><br>In the field, the current state-of-the-art for condition monitoring of mechanical systems involves sensors in place to measure vibration and acoustic emissions. A key challenge in this area is the cost of communications when transmitting data back from the wind farm to the control centre. FLICQ has developed a suite of smart sensors (SmartEdge) which combine AI-algorithms on wireless, power-efficient sensors. This smart sensor technology collects, processes and analyses asset data directly on the sensor enabling gigabytes of asset data to be turned into bytes of meaningful information prior to transmission over the air to the wind farm owner or operator. This results in minimising the amount of data transferred back onshore to the cloud or to legacy systems.<br><br>To carry out this data analysis, FLICQ's SmartEdge technology uses machine learning algorithms to pre-process this data prior to transmission. By accurately modelling how asset condition is changing, predictive models can be used to plan the best intervention time based on risk, anticipated downtime, and projected revenue loss.<br><br>This project aims to demonstrate the potential of FLICQ smart systems to support the development of predictive maintenance strategies in the offshore wind sector through a practical application and product development at Levenmouth offshore demonstration turbine, owned by ORE Catapult. While FLICQ sensor technologies have been employed in a range of other sectors, the technology is yet to be implemented in the challenging offshore wind environment. The innovative technology proposed by FLICQ uses intuitive machine learning algorithms embedded on the sensor where the data is collected. This means that the data connection required for transmission to onshore control centres can be ultra-low bandwidth, as the technology enables low amounts of data to be transmitted. This pre-processing also enables the sensor to be power-efficient and have a long battery life in the field. The success FLICQ have experienced in other markets represents an opportunity to disrupt maintenance strategies in offshore wind using FLICQ's SmartEdge sensor technology.<br><br>FLICQ, who are leading the application with ORE Catapult as partners are looking to add a US partner at the next stage. Discussions with DNV GL are ongoing and they have expressed their support for the project, and to incorporate the additional data streams into the Wind Gemini digital twin system and service. |
| UK lead | FLICQ UK LTD<br>Jean-Remy Lannelongue<br>+31 621 477 457 |

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| Proposal number & title | 50035: Offshore Component Condition Monitoring via Machine Learning Enabled Smart Sensors and Low-bandwidth Data Transmission |
| | remy.lannelongue@flicg.com |
| UK partners | Offshore Renewable Energy Catapult (plus DNV GL - TBC) |
| US partners – in discussion/confirmed | none |
| US partners – desired | • A wind farm owner/operator<br>• Wind turbine drivetrain OEMs<br>• An insurance company offering insurance for the sector |
| NYSERDA application | Not applicable – will apply to NOWRDC solicitation July 2020 |