Project Code/Version No:
TCPEN01/1.0

Electricity Network Innovation Competition Full Submission Pro-forma

Section 1: Project Summary

1.1 Project Title: Offshore Cable Repair Vessel and Universal Joint

1.2 Funding Licensee: TC Ormonde OFTO Limited

1.3 Project Summary:

This project will seek to:

i) Convert an existing telecom-cable repair vessel so that it can also repair OFTO power cables which are much larger and heavier than telecom cables and usually require non-coiling storage. This cable vessel would immediately become available to all transmission owners through the Atlantic Cable Maintenance Agreement (ACMA). This would mean access to a vessel that is permanently on standby to undertake repairs at a price that is a small fraction of current offshore cable repair prices.

ii) Manufacture and test a new "universal" cable jointing system which will allow dissimilar sections of OFTO-type subsea cable to be jointed together.

iii) Train and qualify jointers to repair cables on board the repair vessel referred to in (i) above using the joint referred to in (ii) above.

It is envisaged that the project would have started by Q2 2015, with the project complete by Q2 2018 at the latest.

In order to ensure value for money for consumers, we have agreed a contractual structure with our project partner (GMSL) which ensures that they cannot profit unreasonably from the funding provided by electricity customers. This structure includes protections for consumers that would apply should it, for any reason, become impossible to use the vessel and joint through the ACMA.

1.4 Funding

1.4.1 NIC Funding Request (£k): £9,016k

1.4.2 Network Licensee Compulsory Contribution (£k): £1,033k

1.4.3 Network Licensee Extra Contribution (£k): nil

1.4.4 External Funding - excluding from NICs/LCNF (£k): nil

1.4.5 Total Project cost (£k): £10,329k

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Section 1: Project Summary continued

1.5 Cross industry ventures: If your Project is one part of a wider cross industry venture please complete the following section. A cross industry venture consists of two or more Projects which are interlinked with one Project requesting funding from the Electricity Network Innovation Competition (NIC) and the other Project(s) applying for funding from the Gas NIC and/or Low Carbon Networks (LCN) Fund.

1.5.1 Funding requested from the LCN Fund or Gas NIC (£k, please state which other competition):
The Project does not intend to request funding from the LCN Fund or Gas NIC.

1.5.2 Please confirm if the Electricity NIC Project could proceed in absence of funding being awarded for the LCN Fund or Gas NIC Project:

☐ **YES – the Project would proceed in the absence of funding for the interlinked Project**

☐ **NO – the Project would not proceed in the absence of funding for the interlinked Project**

1.6 List of Project Partners, External Funders and Project Supporters:

External Partners: Global Marine Systems Ltd (GMSL) will act as prime contractor for the vessel modification, joint development work and jointer provision. GMSL will work to a fixed price and will take certain commercial risks in relation to NIC funding. The repair services will be accessed through the Atlantic Cable Maintenance Agreement (ACMA).

[Paragraph redacted]

Project Supporters: in addition to other cable owners, the project is supported by public sector bodies with an interest in increasing marine renewables. A letter of Support from The Crown Estate is attached as Appendix 12

1.7 Timescale

1.7.1 Project Start Date: 1 Jan 2015	**1.7.2 Project End Date:** 31 July 2018

1.8 Project Manager Contact Details

1.8.1 Contact Name & Job Title: Sean Kelly Partner	**1.8.3 Contact Address:** c/o Transmission Investment 135 Cannon St London EC4N 5BP
1.8.2 Email & Telephone Number: Sean.kelly@transmissioninvestment.com (07767) 298 983	

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Section 2: Project Description

This section should be between 8 and 10 pages.

Project Context

The amount of renewable generation in general and offshore wind in particular is growing rapidly. National Grid's latest Future Energy Scenarios, issued in July 2014, show 3.9GW of offshore wind in service already, rising to as much as 31GW by 2030. Even in the scenario with the lowest offshore wind build the amount in service doubles by 2030.

Large offshore wind developments require high voltage (132kV and above) export cables. To date just under 30 such high voltage export cables have been installed, with each connecting an average of 150MW of offshore wind. The total length of wind farm HV export cable installed to date is 920km, but could reach almost 8,000km by 2030.

In contrast to onshore transmission systems, offshore transmission does not provide full redundancy. This means that even where an offshore wind farm is connected by multiple cables, the failure of any cable will reduce the amount of power that can be exported. Should this failure occur the wind farm owner will be exposed to the bulk of the financial loss resulting from being unable to export all of their potential output.

For windfarms that are connected by a single cable the situation any cable failure will mean that no power at all can be exported. Furthermore the loss of the single cable will deprive the wind turbines of the auxiliary power they need for the heaters, dehumifiers, oil circulation, etc needed to prevent equipment deterioration.

Wind farm designers have attempted to reduce the impact of prolonged offshore cable repairs by using multiple smaller-capacity cables, but this increases the cost of connecting wind farms substantially: for instance the use of two cables in place of a single double-capacity cable may increase the installed cost of cabling by 80%.

Technical Background – Cable Repairs

A cable repair requires that a section of cable (often several hundred metres in length) around the fault be cut out and a new length of cable, taken from a stockpile of spare cable kept onshore, be put in its place. "Joints" connect this new length of cable to the cable being repaired. These joints are substantial objects, typically 4m or more in length, and will also have been taken from a stockpile of spare parts kept onshore.

In more detail, the cable repair process involves the following steps:

i) A suitable vessel must be selected, chartered and mobilised. This vessel must be large enough to carry a length of spare cable and the repair equipment. High voltage export cables are larger than other cables (a typical cable might be 0.2m in diameter and cannot be bent in loops of less than 7m in diameter) and repair vessels and equipment must be sized accordingly. The vessel must also be large enough to provide a stable platform for repair activities in variable sea conditions.

ii) The specialist tools required for repair must be mobilised, as must general purpose tools (e.g. cranes) if they are not provided by the selected vessel. The specialist tools required will include equipment to store the spare cable being used, to unbury the cable from the seabed, to cut the damaged cable on the seabed, to recover each end of the cut cable to the repair vessel, to hold the cable in position while joints are made to connect it to the spare cable length, to make the joints, to lower the repaired cable to the seabed, and to monitor the lowering process. If the vessel is not designed for cable repairs then each of these tools will need to be separately hired and assembled on the vessel in question to a create what is, in effect, a vessel purpose-built for the repair. In some cases accommodation modules for the repair crew, and power supplies for their equipment, will also need to be hired and fitted to the repair vessel.

iii) The specialist staff required for the repair will need to be located and mobilised. The persons who assemble the joint ("jointers") are often particularly difficult to source, but operators will also be required for all of the other tools described above.

iv) Once mobilised, the repair vessel will then sail to the site where the spare cable is kept and take a suitable length on board. Cable joints will also be loaded from the spare parts stockpile.

v) The vessel will then sail to the repair site to start the repair. Once the cable has been uncovered and cut, the end containing the fault is taken onboard the vessel. The vessel then continues to pull up, test and discard cable until the location of the fault has been passed and dry, undamaged cable is found.

vi) A joint is then made between the cable pulled up from the seabed and the spare cable on board the vessel. This will require a number of days (typically 3-5) of continuous good weather.

vii) The vessel, depositing spare cable into the sea as it goes, now recovers the other cable end from the seabed and continues along it until dry undamaged cable is found. A joint is then made between the spare cable and the cable end that has just been recovered. At this point the vessel will have a U-shaped length of cable on board, which must be lowered onto the seabed.

viii) Finally the cable is then returned to service and reburied or otherwise protected.

At present, and for the foreseeable future, all offshore wind connections are designed and built by the wind farms themselves before being transferred to Offshore Transmission Owners (OFTOs). The stockpiles of spare cables and joints for undertaking repairs received by the OFTOs tend to vary considerably from wind farm to wind farm. On some wind farms ample spares are available, while on others the amount can be very limited. Technical differences between the cables used on different windfarms make it difficult to use surplus spares on one project to substitute for deficiencies elsewhere.

The Problems to be Addressed

This section describes the problems that the project is intended to resolve. These relate to the time required to undertake offshore cable repairs and the cost of these repairs, both of which are far higher than offshore: almost an order of magnitude worse for repair times, and many orders of magnitude worse for repair costs. In particular:

i) There are both delays and high costs associated with mobilising the vessel and the tools.

ii) There are frequently delays associated with obtaining jointers.

iii) On some projects the amount of spare cable is limited. Particular fault types and/or difficulties exactly locating the fault could mean that large amounts of spare cable would be required to undertake the repair. Where this exceeds the amount of spare cable that has been stockpiled the result is that new cable would need to be manufactured to undertake the repair, causing an extremely severe delay.

iv) Similarly a stockpile of joints may be exhausted if joints are damaged during assembly, or if multiple faults occur, or if joint parts become unusable due to age or storage conditions.

The sections below provide further information on these problems.

Obtaining a suitable repair vessel typically involves either finding a power cable laying vessel that is not already engaged in cable laying activities or using a "vessel of opportunity". (Note that "vessel" is used here to refer to either a self-propelled ship, or alternatively a barge in conjunction with several tugs).

At present the European offshore cable sector is very active: most if not all cable laying vessels will already have been chartered for construction work, a situation that is expected to continue for the foreseeable future. The combination of the active market and the "distressed purchaser" status of any OFTO seeking to charter a vessel means that the prices charged to the OFTO will be very high. In addition many power-cable laying vessels are configured only for cable installation and can require additional tools and/or deck layout modifications before they can undertake repairs. This increases their cost still further.

The alternative to chartering a power-cable laying vessel is to locate an unused general purpose vessel (a so-called "vessel of opportunity") that can be converted into a repair vessel. Some vessels of opportunity come with general purpose tools (e.g. cranes, remotely operated vehicles) and only need repair-specific tools to be added. At the other extreme are entirely bare barges to which crew, accommodation, power supplies, stores and cranes all need to be added to create what is – in effect – an entirely new vessel. Although shipyards can undertake such conversions remarkably quickly (only a few weeks), such speed has predictable consequences for price. Furthermore both types of vessel of opportunity require additional time for undertaking design, obtaining design approval, equipment rental and testing. And there is additional risk in using what is, in effect, a new cable repair vessel on its first mission.

After the repair is complete all equipment will be removed and the vessel of opportunity returned to its original configuration. In effect the OFTO will have to pay for the assembly of a new vessel just to undertake their one repair.

As part of their construction contracts, all wind farm projects purchase a stockpile of offshore cable repair joints, and those that are not used during the construction phase are transferred to the OFTO. These joints are purchased as part of the export cable supply contract and will be manufactured by the cable manufacturer. We have found that cable manufacturers generally wish to retain for themselves the business of making their own offshore cable joints; often declining to train or qualify third party jointers on their joints and not offering to work on joints made by third parties. This means that should a repair be required the OFTO will have to go to one supplier, with a high risk of delay should that supplier's jointers already be busy elsewhere.

As noted above, each wind farm separately procures export cable and repair joints. The repair joints that are supplied will be customised for the particular export cable in question, making it impossible to use spare cable or spare joints from one wind farm to repair a fault on another wind farm.

The effects described above mean that the typical time taken for offshore power cable repairs is very long with the average time being over 3 months. Costs are also extremely high (many millions of pounds). An extreme example of this would be two repairs to the Scotland-Northern Ireland ("Moyle") cable which according to the cable owners cost £27.9m (plus insurance) in 2011-12. A less extreme example would be a single repair to the Jersey-Guernsey cable which according to the cable owners cost £8m in 2012.

This affects consumers through:

i) Reduced generation at offshore wind farms due to prolonged outages, which increases the delivered cost of energy. In addition reduced wind output must be replaced by fossil-fired generation leading to higher carbon emissions

ii) Higher costs for OFTOs (insurance, risk, procurement of spares, etc) which leads to higher OFTO tariffs and ultimately higher energy prices for consumers.

iii) Suboptimal designs for wind farm connection (e.g. using multiple smaller cables to reduce the impact of prolonged offshore repairs). This leads to a higher cost of energy from offshore wind and ultimately higher energy prices for consumers.

The Method Proposed to Solve the Problems

The method proposed for addressing the problems set out above combines two elements: converting an existing telecom cable repair vessel so that it can handle power cable repairs, and developing a universal joint which can connect different types of cable and which is not dependent on the availability of jointers from the original equipment manufacturer.

The two elements are mutually beneficial: the joint will not accelerate repairs unless a suitable vessel is available, and the vessel will not accelerate repairs unless spares and jointers are available. By bringing the two elements together in a single project a very substantial acceleration can be achieved in the vast majority of OFTO cable repairs.
The project will go beyond trialling these methods, as it aims not just to demonstrate their feasibility but to make them available on highly attractive terms to all relevant network licensees. In addition the project will demonstrate an approach to offshore repairs that can subsequently be applied in other areas. For instance the concept could be extended to include shallow-water repairs (an estimated 25% of all OFTO repairs), or cable repairs at higher voltages such as the 220kV AC cables recently ordered by SHE Transmission.

The project would consist of:

i) Detailed design, implementation and testing of the modifications necessary to enable a telecommunications cable repair vessel to be equally capable of conducting subsea power cable repairs. Changes will include a new deck layout, installation of equipment to handle larger/heavier cables, installation of a carousel for storage of spare power cable, and improvements to station keeping. Although the modified vessel would not be able to operate in very shallow water, it is estimated that it would still be able to repair 75% of OFTO cable faults (see Section 3).

ii) Detailed design, manufacture and testing of universal repair joints capable of connecting dissimilar cable types. This will include: a mechanism for bonding conductors of different sizes, an insulation system that can interface between insulation layers with different dimensions, fibre-optic splices, a mechanical containment system to provide protection and to interface between different armouring systems, and bend restrictors to ensure that both cables' minimum bending radius requirements are respected during the repair process.

iii) Training and qualification of cable jointers for the new universal joint. A sufficient number of these jointers would be either permanently assigned to the cable repair vessel referred to in (i) above or available for mobilisation in less than the time taken for the fault to be located and for the vessel to mobilise and load cable and joints from stockpiled spares.

A key part of the project is that the vessel to be modified, the *Wave Sentinel*, already operates as a cable repair vessel and does so within a commercial structure that is much more attractive to cable owners than the ad hoc distress-purchase arrangements currently employed by offshore power cable owners. This commercial structure, called the Atlantic Cable Maintenance Agreement (ACMA), is described in more detail in the Solution section below, and will be available to any OFTO or other Licensee that joins ACMA.

The *Wave Sentinel* is one of three vessels currently within the ACMA commercial structure. At present all of these vessels are dedicated to the repair of telecom cables for the more than 60 companies that are ACMA members. The dominance of telecoms repair work in ACMA's portfolio is unlikely to change: our calculations suggest that even by 2030, with all OFTOs joining ACMA and the huge expected growth in OFTO cable lengths, 80-95% of ACMA's repair work would still be for telecom cables. This reflects the fact that the installed length of telecom cables is, and will remain, far greater than that of power cables.

Sharing a repair service with telecom cables is important because we do not expect OFTO cable faults to be sufficiently common to justify a repair vessel dedicated solely to OFTO cables until 2030 at the very earliest. Sharing a vessel with the telecom sector in this way will enormously reduce ongoing costs for network licensees, but – because telecom repairs are completed rapidly – it should not significantly delay power cable repairs.

Development Work to be Undertaken

The development work involves:

i) the modification of the *Wave Sentinel*, and the testing of the modified vessel.

ii) building a prototype universal joint and a small number of production joints, several of which will be used (along with lengths of spare cable provided by TCP-portfolio OFTOs or others) to assemble test articles which are then subjected to mechanical and electrical tests to prove their capability and reliability.

Project Description continued

In this section the roles of the various parties involved in the development will be explained, along with the proposed contractual arrangements for development work and the two-stage process adopted in order to minimise risk of cost overrun.

The prime contractor for the development work is to be Global Marine Systems Ltd (GMSL). GMSL is a British company that owns one of the world's largest fleet of cable ships, with their particular strength being in telecom cable repairs. Following discussions with other cable repair vessel owners, GMSL was selected as the prime contractor because:

i) They have agreed to the commercial conditions required by an OFTO using the NIC funding (e.g. they have accepted the risk of costs being disallowed by Ofgem, and have accepted that payment is conditional on the availability of funds in the project bank account). These arrangements are set out in Appendix 2, which sets out the Memorandum of Understanding between ourselves and GMSL.

ii) They operate (telecom) cable repair vessels under the ACMA, our preferred commercial arrangement.

iii) They operate the *Wave Sentinel*, the only British-based repair vessel under the ACMA.

iv) They have consistently expressed a high level of interest in the concept, and have assisted in its early development.

A large number of subcontractors will be engaged by GMSL. Of particular importance is the jointing subcontractor who will undertake the development of the universal joint. [Sentence redacted].

TCS will supervise the work being undertaken by GMSL in conjunction with technical specialists in the fields of cable repair vessel design and operation and cable and joint design and testing. [Sentence redacted]. Further information on the project management and governance arrangements is provided in Section 6.

As set out in the Memorandum of Understanding (Appendix 2), the development work will be undertaken in two stages:

i) Once funding is available, work will start on the detailed design of the vessel conversion and detailed specification of the joint itself and its test regime. This is to provide the information needed to invite competitive tenders for the work involved. Examples of work packages tendered would include the supply of various pieces of new equipment for the vessel, shipyard work to install this equipment, procurement of the parts needed to assemble the joints, and rental of a high voltage laboratory where the joints can be tested. This design and tendering work would be undertaken by GMSL and the jointing contractor at day rates, but subject to a cost cap of [redacted], as set out in the memorandum of understanding.

ii) Once these tenders have been received GMSL will prepare a fixed price offer for the main development work. The memorandum of understanding sets out a framework for the calculation of this fixed price from auditable subcontractor tenders and prevents GMSL from making excessive profits from the development process.

This two-stage process leading to a fixed-price contract with a single prime contractor largely eliminates the risk to consumers that the project could exhaust its NIC funding without completing the intended programme of work. If cost escalation does occur this will be apparent after only limited expenditure (c. 4-5% of the total budget). At this point the project can be reconsidered: potential options open to the applicant / Ofgem will include abandonment of the project, modification of the scope, selecting a new prime contractor or seeking additional funding sources.

The Solution that will be Enabled

We have identified the Atlantic Cable Maintenance Agreement (ACMA, acmarepair.com) as a particularly attractive commercial structure for power cable repairs, and have held discussions with its chairman to confirm that – subject to final approval by ACMA members when the detailed designs are available – the proposed Solution will be welcomed and all relevant network licensees will be able to join ACMA on essentially the same terms as telecom companies. Reasons for the selection of the ACMA structure include:

i) ACMA is a very well established non-profit co-operative cable repair organisation. Founded in 1965, it has been stable over an exceptionally long period. This stability increases confidence that ACMA will continue to be the most attractive option for power cable repairs (though, as set out below, arrangements are in place that will protect consumers should this prove not to be the case).

ii) ACMA is very large, covering 60+ cable systems with a total length of 140,000km. This scale is important because it means that ACMA can afford to fund the costs of a fleet of permanently mobilised cable repair vessels, even though the OFTO sector in isolation cannot.

iii) ACMA contracts for three cable repair vessels. Although only one of these would be converted to handle power cables, the number of vessels available, along with the short time required for telecom repairs, will greatly reduce the risk that a power cable repair will be delayed waiting for a telecom repair to complete.

iv) ACMA has highly standardised contractual terms, which ensures fair and equal treatment for all members. The Chairman of ACMA (see letter attached as Appendix 11) has, subject to final review by members, indicated support for this project and has confirmed that ACMA's terms would be applied unchanged to any power cable owner joining ACMA.

v) ACMA is run by cable owners, and allows the bulk purchasing power of a very large group of such owners to be deployed in negotiations with vessel owners.

vi) ACMA provides vessel owners with a low-risk multi-year revenue stream which allows them to price their services very attractively.

For the reasons set out above, a specialist cable repair vessel accessed through ACMA should undertake repairs much more cheaply than the vessels currently used. Our analysis suggests that using existing cable repair approaches it is not possible, even in best-case conditions, to reduce costs below around £[redacted]. Actual costs appear to be even higher with costs of £10-15m being noted on several projects. Despite these costs the response time with existing approaches is poor, with our analysis showing an average of 3-4 months.

ACMA members pay an annual standing charge which is calculated on a per-km basis, and would typically be [redacted] per OFTO – for instance it would be c. £[redacted]k for Transmission Capital Partners' OFTOs. Should a fault occur there would be no cost to mobilise the repair vessel (if is permanently mobilised) and the cost per day is c. £[redacted]k/day (£[redacted]k/day to hire the vessel plus £[redacted]k/day for fuel, converted from US Dollars using July 2014 exchange rates). The total time for the repair is expected to be [redacted] weeks, so the repair cost will be between £[redacted]m and £[redacted]m unless there are unusual circumstances like very bad weather.

As one of the vessels contracted by the ACMA the *Wave Sentinel* will be kept on permanent standby, ready to sail to start a repair within 24 hours. Even on occasions when dry-dock maintenance is required, the vessel will be able to sail in less than 5 days. Work on a power cable fault may be delayed if the vessel is already executing a telecom cable repair; our analysis shows that this could occur 30% of the time, but since telecom repairs are executed quickly (less than 2 weeks in most cases) the average waiting time would only be 2 days. Since there are three cable repair vessels in the ACMA, with two normally based in Europe, situations where multiple repairs become "queued up" are virtually unknown.

The *Wave Sentinel* is based at Portland in Dorset, which is within 2 days sailing of all British OFTOs and interconnectors. On occasion ACMA may temporarily relocate vessels to areas where numerous faults have occurred, and this has led to the *Wave Sentinel* being temporarily relocated to Bermuda on occasion. It cannot be ruled out that this might happen in the future, and should this happen the extra sailing time from Bermuda would add 10 days to the repair time, though repair times would remain much shorter than with current repair approaches. To date the extra the cost of the transit has not been charged when an ACMA member has recalled the vessel to Europe. At the project's initial stage the future treatment of such situations for power cable owners will be confirmed with ACMA.

It should be noted that it has not been assumed that the *Wave Sentinel* would be able to undertake the actual repair work any faster than currently used vessels (though it is hoped that with a vessel and crew specialising in cable repairs the process can be accelerated). Instead all of the acceleration is assumed to come from a reduction in the time spent waiting for the actual repair work to start due to delays obtaining the vessel, the tools or the jointers.

The proposed arrangements will provide transmission customers and end-consumers with benefits through:

i) Increased delivery of renewable energy from wind farms that would no longer suffer from prolonged cable outages. This increased power injection should lower wholesale power prices through increased real-time competition, and the increased availability of renewable energy will reduce the level of subsidies required to achieve a given target level of renewable power.

ii) Higher transmission availability will allow offshore wind power to be viable at a lower strike price.

iii) Higher transmission availability and lower cable repair costs will allow OFTOs to reduce their tender revenue streams when competing to acquire assets.

iv) In the longer term the availability of rapid cable repairs will allow offshore wind farm connection designs to change to lower-cost arrangements. For instance fewer-but-larger cables can be used if rapid repair is assured, and this allows capital costs to be reduced thanks to the strong economies of scale in cable manufacture and installation. This will further contribute to allowing offshore wind power to be viable at a lower strike price.

In order to ensure customer value for money we have arranged that GMSL will pay compensation if changes to the ACMA mean that the Wave Sentinel is no longer used by ACMA, or if ACMA membership is, for any reason, no longer possible or attractive for power cable owners. This is described further in Section 4.

Technical Description of the Project

Appendix 9 is a general arrangement drawing showing the existing design of the *Wave Sentinel*. Appendix 10 shows the proposed vessel modifications and (in red) the cable pathway for a power cable repair. Detailed drawings will be prepared at the initial stage of the project (as defined in Section 6) at which stage only £[redacted] will have been released to GMSL.

In order to validate the technical proposal made by GMSL for the conversion of the *Wave Sentinel*, we have commissioned RedPenguin to undertake a technical description and assessment of each individual modification proposed by GMSL and GMSL's budget (which is attached to the Memorandum of Understanding in Appendix 2).

RedPenguin is an SME which specialises in advising on and supervising offshore cable installation and repair work. Major projects that they have overseen include BritNed, the Western HVDC link and repairs to the NorNed cable. Several RedPenguin staff members have served previously on board the *Wave Sentinel* and are very familiar with the vessel.

RedPenguin have confirmed that, subject to the need for detailed design during the initial phase described above, the proposed vessel modification does not face any showstoppers. They have also confirmed that the budget assumed has been estimated to a sufficient level of accuracy given the level of risk margin provided.

For the full technical description of the vessel conversion please see the RedPenguin report which is attached as Appendix 3. In addition to confirming technical feasibility and validating the budget, RedPenguin has also identified the key risks and uncertainties in relation to the vessel conversion; in particular risks that need to be addressed at the initial stage of the project, prior to entry into a fixed-price contract. The measures that will be used to mitigate these risks are addressed in the risk register attached as Appendix 7.

We have commissioned Cable Consultants International (CCI) to confirm the feasibility of offshore universal joints and to report on the adequacy of the shortlisted joint development contractors and the budget for joint development. CCI is an SME advisory company made up of specialists formerly employed in the design and manufacture of cables, joints and other cable accessories.

CCI have confirmed that a universal joint is feasible, and have identified key design decisions that will need to be made in the selection of the jointing contractor and the subsequent initial phase of the project. They have also confirmed that the budget for joint development and testing is reasonable.

For the full description of the jointing technology and examination of the potential developers and the budget please see the CCI report which is attached as Appendix 4. In addition to confirming technical feasibility and validating the budget, CCI has also identified the key risks and uncertainties in relation to joint development; in particular risks that need to be addressed at the initial stage of the project, prior to entry into a fixed-price contract. The measures that will be used to mitigate these risks are addressed in the risk register attached as Appendix 7.

Tests & Trials

The project is to include the following tests and trials:

i) A short production run of joint parts are to be ordered, from which parts for three test articles are to be selected. Using lengths of spare cable to be provided by OFTOs managed by TCS and/or others 3 test joints are to be assembled and subjected to the full set of tests specified by Cigre (bending tests, pressure tests, high voltage tests).

ii) Following the upgrade work the vessel is to undergo sea trials to confirm that it meets the "DP2" classification (i.e. it is able to remain stationary above a patch of seabed even if a component in its propulsion or control systems fails).

iii) As a final test the vessel is to undertake a simulated repair involving recovering the ends of lengths of spare cable that have been placed on the seabed, making a joint between them and then lowering the joint and cable bight to the seabed. Note that this is to be a mechanical test only; the cable would not be energised.

Changes since ISP

Since the ISP we have worked with GMSL and potential jointing contractors to improve the quality and detail of the cost estimates. The final cost estimates are shown in Section 3 below.

We have then commissioned independent studies by industry experts (RedPenguin and CCI, see Appendices 3 and 4) to verify the detail of the technical proposals and cost estimates.

We have concluded a Memorandum of Understanding (see Appendix 2) with GMSL. As described above, this includes a number of features to ensure value for money for electricity consumers.

We have refined our cost benefit analysis, as shown below in Section 3.

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Section 3: Project Business Case

This section should be between 3 and 6 pages.

Project Cost Estimates

The project cost is broken down as follows:

GMSL – Initial phase fee	[redacted]	Design costs; prior to fixing price
GMSL – Vessel subcontractors	[redacted]	Checked by RedPenguin
GMSL – Jointing subcontractors	[redacted]	Checked by CCI; c. £[redacted] in initial phase
GMSL – Project management fees	[redacted]	From MoU
GMSL – Risk margin	[redacted]	Maximum allowed by MoU
GMSL – Profit margin	[redacted]	5% profit margin on subcontractors
GMSL subtotal	[redacted]	
Advisors to help monitor GMSL	[redacted]	E.g. Vessel and jointing specialists
Labour	[redacted]	At rate set out in charging statement
Travel & Expenses	[redacted]	Pass-through without margin
Contingency	[redacted]	General purpose contingency
Total	£10,329k	

The timing of this expenditure has yet to be subject to detailed analysis, however for the purposes of completing the Full NIC submission spreadsheet the table below shows the profile estimated for GMSL and the (more front loaded) assumption for the in-house and advisory costs

Year	**% GMSL cost**	**% other cost**	**Notes**
2014/15	2%	19%	Bid costs, MoU to contract, select joint subcontractor
2015/16	9%	33%	Initial phase + start of main phase
2016/17	69%	33%	Bulk of the main phase
2017/18	20%	15%	Tail of test campaign and closeout/reporting phase
2018/19	Nil	Nil	Contingency (programme slack) only

Data Sources for Benefit Calculations

Information sources for this analysis are as follows:

i) At present there are 920km of wind farm high voltage export cable in service in Britain. Subject to it being in water of a sufficient depth (see below) all of this cable could be repaired using the *Wave Sentinel* and the universal joint.

ii) The 2014 release of the Future Energy Scenarios by National Grid contains three scenarios that specify the future trajectory of offshore wind development:

Scenario	**Offshore wind today**	**Offshore wind 2020**	**Offshore wind 2030**
Gone Green	3.9 GW	11.7 GW	31.1 GW
Slow progression	3.9 GW	6.3 GW	24.3 GW
No progression	3.9 GW	4.3 GW	8.6 GW
It is noted that the project benefits table also contains an entry for 2050. As there are no reasonable predictions of offshore wind development beyond 2030, the results for 2030 have been assumed to continue until 2050.			

iii) The report "Cable Manufacturing Capability Study", released by the Crown Estate in 2012, draws on a questionnaire completed by project developers and National Grid's Offshore Development Information Statement to conclude that 34GW of offshore wind would require 8000km of cable (230km/GW). Some 20% of this is assumed to be 132-150kV AC cables of conventional design, where the universal joint could be used, the remainder being AC cables with a higher voltage or novel design, or DC cables. However subject to the final design for the vessel modifications, it should be possible to use the *Wave Sentinel* to repair any of these cables.

iv) For the calculation of the project's benefit, three scenarios for the amount of cable were developed. These are for the present day, 2020 and 2030 (2050 is assumed to be the same as 2030). National Grid's central "slow progression" generation scenario was selected: "gone green" was rejected to ensure results were conservative and "no progression" was unnecessary since assessing the payback period using the present day offshore wind fleet (i.e. assuming no additional generation at all) is even more conservative. Using the figure indicated above, the following is derived:

	Existing cable	New gen	New cable	Total cable 132-150kV (universal joint)	Total wind farm export cable (*Wave Sentinel*)
Today	920km	Nil	Nil	920km	920km
2020	920km	6.3-3.9 = 2.4GW	2.4*230 = 552km	920+0.2*552 =1030km	920+552 =1472km
2030	920km	24.3-3.9 = 20.4GW	20.4*230 = 4700km	920+0.2*4700 =1860km	920+4700 = 5620km

v) For further conservatism the figures above do not include other types of offshore transmission (interconnectors, island connections, "bootstraps"). On current trends these might be expected to add a further 50% to cable lengths.

vi) The probability of faults occurring on a cable is set at one-in-2000km.year, based on historical fault data published by Cigre (an international group of transmission owners, suppliers and consultants). This figure is based on a conservative interpretation of the statistics (i.e. the actual fault rate is likely to be higher). The fault rate is assumed to be equally split between external faults where the cable is hit by an external object (anchor, fishing gear, etc) and internal faults where the cable fails without any outside influences at the time of failure.

vii) Only faults occurring on cables that have been commissioned are considered. This is very conservative given that to date planned and unplanned jointing activities on not-yet-commissioned OFTO-type cables have been approximately four times more common than faults on commissioned cables.

viii) Based on an examination of a representative sample of existing OFTO cable routes, it has been estimated that 60% of OFTO-type cables will be at a depth greater than 10m and therefore accessible to the *Wave Sentinel*. This is conservative firstly because the *Wave Sentinel* has a draft of 6.3m and therefore can be used in waters shallower than 10m subject to the discretion of the vessel's Master, and secondly because as new wind farms are developed further offshore the proportion of their export cable in waters shallower than 10m can be expected to fall.

ix) The typical fault repair time (including waiting) using the current approach to repairs averages 3-4 months. A conservative average of 3 months is used in the analysis.

x) The reduction in cable repair time made possible by using the permanently-mobilised *Wave Sentinel* and not being reliant on the availability of jointers from the cable manufacturers is estimated to be 1.5 months. Given that the actual repair work itself (i.e. excluding waiting for vessel, equipment and people) takes as little as 12 days, this is a highly conservative estimate. This level of conservatism means that any delays due to fault location issues, previously scheduled telecom repairs or the vessel being temporarily based away from Portland are already fully modelled.

xi) There is assumed to be a 5% probability that sufficient spare cable or spare joints will not be available, requiring replacements to be manufactured. This could be due to a stockpile of spares that has diminished over time as repairs are undertaken and equipment has aged, or it could be due to a repair that requires an unusually large quantity of spares – for instance because the fault cannot be exactly located or because spares are damaged during the repair and need to be replaced. The delay beyond current repair-time norms that would result from such a situation of insufficient spares are estimated to range from 2 months (for joints) to 18 months (for cable), with a mean of 6 months.

xii) It is assumed that with current repair arrangements there will be a 20% probability that specialist jointers will be unavailable from the cable manufacturer within the assumed normal timescale. This is based on our knowledge of two projects in Britain that have experienced situations where the cable manufacturer was unable to provide jointers when required. The delay beyond current repair-time norms that would result from jointer unavailability is estimated to be 2 months.

xiii) The impact of a single cable failure on the generation output of an offshore wind farm is assumed to be an output reduction of 20GWhr per month. This is based on the impact of a prolonged outage at the Thanet offshore wind farm in Kent, as reported in the shareholder report of the project's owner. Thanet was selected as a conservative is example as it is connected by two cables: a failure on a project with only a single export cable will have a much greater impact.

xiv) The financial impact of this loss of generation described above is calculated using an offshore wind price of £140/MWhr presently and a target value of £100/MWhr in 2020 as targeted by the offshore wind industry.

xv) The carbon impact of this loss of renewable generation is calculated using a Carbon Conversion Factor of 0.43t/MWhr (430t/GWhr), as used by Ofgem in their impact assessment of GSR007. Note that this carbon benefit does not contribute an additional financial benefit since the value of carbon reduction is already included within the £100-140/MWhr electricity price paid to offshore wind.

xvi) With current practices the minimum cost of an offshore cable repair is £[redacted], but it is usually substantially higher with costs in the £10-15m range not unknown (see Section 2). £[redacted] has been selected as a typical repair cost with current practices.

xvii) Using the *Wave Sentinel* with ACMA the cost of a repair is expected to be £[redacted] (see

Section 2). Selecting the high end of this range for conservatism the cost saving that would result from the proposed method is £[redacted] per repair.

Analysis

The *Wave Sentinel* is assumed to be able to repair faults on 60% of the length of wind farm export cables (i.e. cable in more than 10m of water). However cables in shallow water are unlikely to be hit by anchors or fishing gear large enough to cause damage, since large vessels and trawlers will not operate in these areas. This is assumed to halve the fault rate in these areas, so that overall 75% of all faults will be accessible to the *Wave Sentinel*.

<u>Benefit from reducing outage durations</u>

The proposed solution will reduce cable repair outages in the following ways:

Firstly where there are 132-155kV wind farm export cables in sufficiently deep water the availability of the *Wave Sentinel* and the universal joint should reduce fault duration by an average 1.5 months. At a fault rate of one fault in 2000km.years with 75% of faults being accessible the outage reduction <u>per 1000km of cable</u> is:

(1000km/2000km.year) * 75% * (1.5 months) = 0.56 less outage-months in each year

Secondly the universal should joint will save a further 6 months in 5% of all faults (avoid running out of spares) and a further 2 months in 20% of faults (avoid delays waiting for jointers). Note that this applies to all faults, not just those accessible to the Wave Sentinel as the universal joint can be made on board any vessel. The benefit <u>per 1000km of cable</u> is:

(1000km/2000km.year) * (5% * 6 months + 20% * 2 months) =0.35 outage-months

Thirdly for other types of transmission cable (e.g. 220kV or HVDC) the *Wave Sentinel* may still be used to accelerate repairs, at least on the occasions where manufacturers' jointers are available without delay. In this case the acceleration is assumed to be reduced from 1.5 months to 1 month. Conservatively assuming that 75% of faults are at a sufficient depth for the Wave Sentinel, the benefit <u>per 1000km</u> from accelerated repair is:

(1000km/2000km.year) * 75% * (1 month) = 0.375 less outage-months in each year

Multiplying these by the cable lengths for today/2020/2030 gives the number of outage-months saved thanks to the project. Multiplying further by the 20GWhr of generation saved through every outage-month saved gives the benefit of the project in terms of offshore wind energy (that would otherwise have been un-exportable) released:

	Acceleration for 132-155kv repairs (mths pa)	**Avoid extra delays due to universal joint (mths pa)**	**Acceleration for non 132-155kV repairs (mths pa)**	**Total benefit (outage-months pa)**	**Total benefit in GWhr pa generation released**
Today	920/1000*0.56 =0.52	920/1000*0.35 =0.32	-	0.84	16.8 GWhr pa
2020	1030/1000*0.56 = 0.58	1030/1000*0.35 = 0.36	442/1000*0.38 = 0.17	1.11	22.1 GWhr pa

2030	1860/1000*0.62 = 1.05	1860/1000*0.35 = 0.65	3760/1000*0.375 = 1.41	3.10	62.1 GWhr pa

The figures for offshore wind energy released can in turn be converted in a direct CO_2 reduction (based on the increased output from offshore wind will displace fossil-fired generation) and a financial benefit:

	Direct CO_2 benefit from increased wind output	**Financial benefit from increased wind output**
Today	16.8GWhr pa * 430t/GWhr =7,220 t pa	16.8GWhr pa *£140/MWhr =£2.4m pa
2020	22.1GWhr pa * 430t/GWhr =9,510t pa	22.1GWhr pa *£100/MWhr = £2.2m pa
2030	62.1GWhr pa * 430t/GWhr =26,689 t pa	62.1GWhr pa *£100/MWhr = £6.2m pa

Benefit from reducing repair costs

With a saving of [redacted] per repair the saving per 1000km of cable is: [redacted]

Payback time

The financial benefit from increased offshore wind output and reduced repair costs is now compared to the cost of the proposed project is (£10.3m) to yield a payback period:

	Value of increased wind output	**Value of reduced repair cost**	**Total financial value**	**Payback period**
Today	£2.4m pa	[redacted]	[redacted]	2-3 years
2020	£2.2m pa	[redacted]	[redacted]	c. 2 years
2030	£6.2m pa	[redacted]	[redacted]	<1 year

Changes to design philosophy

In addition to the more immediate and easily quantifiable benefits that can be provided by shortening outages and reducing repair costs, these benefits are likely to trigger indirect benefits by changing the way that offshore wind farm export cables are designed.

At present British offshore wind farms are generally connected using multiple smaller-capacity export cables rather than the minimum number of large-capacity cables.

One of the driving factors behind this approach is the time taken to repair offshore cable faults and the consequently severe effect on wind farm economics should a fault occur. For wind farms which would only have a single cable if the number of cables were to be minimised, such consequences would be particularly severe.

There are substantial economies of scale in wind farm export cables – using half the number of double-sized cables might reduce cable costs by 40% and overall costs by 15-20% on a typical wind farm connection. This means that an approach based on multiple small cables will inevitably push up the capital cost associated with a wind farm connection. Ofgem has indicated that such costs are expected to reach as much as £15-20bn (see brochure

"Offshore Transmission: An Investor Perspective", prepared by KPMG for Ofgem). This means that even a small improvement in capital efficiency can yield a very substantial benefit; even a 5% benefit due to limited number of projects changing design would save as much as £1bn.

Conclusions

Despite an extremely conservative set of input assumptions, the proposed project shows an excellent payback period in terms of financial returns to the industry as a whole. Nevertheless development is not feasible without assistance from NIC funding due to the barriers described in Section 4.

The proposed project will facilitate delivery of the Carbon Plan by increasing the contribution of renewable generation (para 2.3 of Plan refers to 30% by 2020) through reduced outages. As noted above the contribution to reducing carbon emission is estimated to be over 34,000 tonnes of CO_2 pa by 2030. As explained in Section 4, in the absence of NIC funding (i.e. with only business-as-usual OFTO opex funding arrangements) this Solution would not be deployed at all and this renewable generation will continue to be lost.

Appendix 1 reproduces these results in a slightly different format, giving cumulative benefits (net of the project costs) for the years to 2020, 2030 and 2050 respectively.

The project will further facilitate renewable generation by making it possible to lower the cost of connecting offshore wind generation. This would come about through the use of fewer, larger, export cables with consequent economies-of-scale benefits. This will contribute to lowering the costs of new offshore wind projects, helping to reduce offshore wind costs from the current £140/MWhr to the target level of £100/MWhr deemed necessary for large-scale deployment of offshore wind in the 2020-30 period.

Environmental benefits will be delivered directly through reduced fossil-fired generation and hence reduced emissions. The reduced number of export cables will also have environmental benefits, as it will reduce impacts from cable installation work.

Other benefits include the development of a robust and cost-effective British supply chain for power cable repairs, and the learning created (see Section 5) which should encourage the introduction of similar arrangements for offshore maintenance services generally, and in particular should encourage similar arrangements for the repair of other offshore cable types (e.g. shallow-water cables).

Note that the project has no "Direct Benefits" as defined by paragraph 5.21 the governance document – i.e. no financial benefits that can be used to help fund the project. Such Direct Benefits would only arise if a cable fault could be guaranteed to occur at the relevant time. Given the relatively low probability of cable faults (1 in 2000km.years has been assumed) the applicant does not have a budget for cable repairs and relies instead on insurance products.

(a) Accelerates the development of a low carbon energy sector and/or delivers environmental benefits whilst having the potential to deliver net financial benefits to future and/or existing Customers.

Rapid availability of a repair vessel through ACMA, and availability of a universal joint, will provide environmental and low-carbon benefits through:

i) Directly reducing CO_2 emissions by expediting the repair of faults which reduce offshore wind output. The analysis set out in Section 3 quantifies this benefit and Appendix 1 shows the cumulative benefit over time.

ii) Accelerating the development of a low carbon energy source (offshore wind) by reducing its long-run levelised cost of energy (LCoE) and so allowing more generation to be delivered within the levy control framework. This reduction in LCoE will in turn come from:
   - Increasing the load factor of the wind generation by reducing the down-time that would otherwise be caused by prolonged fault repair times.
   - Reducing risk for investors in offshore wind through mitigating the consequences (in terms of lost income) of export cable failure.
   - Reducing offshore transmission tariffs through reducing the transmission capex. This will be achieved because with faster cable repairs it is easier to take advantage of cable economies of scale, i.e. use fewer high-capacity cables so as to reduce costs relative to current designs which use multiple lower-capacity cables.
   - Reducing offshore transmission tariffs through reduction of OFTO costs for repairs/insurance, and reduction of OFTO investor risk. The competitive system for appointing OFTOs ensures that these benefits will be passed through as reduced tariffs.

iii) Improving the availability and reducing the costs of interconnectors and "bootstraps" (offshore links between GB onshore substations) by permitting faster and cheaper offshore cable repairs. Even though these projects will remain reliant on their cable manufacturers to provide jointers, availability of a repair vessel on permanent standby will significantly accelerate repairs, and ACMA membership offers a four-fold reduction in repair costs. Since interconnectors and bootstraps facilitate the connection and integration of renewable generation, facilitating such links will facilitate the development of low-carbon energy.

The net financial benefits of the project are set out in Section 3. The payback period is extremely short: just 2-3 years even if not one further offshore wind farm is added and the repair vessel is never used for power cables other than wind farm export cables.

The competitive nature of the OFTO bidding regime and (in future) offshore wind Contracts for Difference (CfD) means that these benefits will be fed back to consumers through a reduced LCoE for offshore wind.

In relation to the specific parts of this question referred to in the guidance notes:

(Part i) ° The aspect of the Carbon Plan facilitated by this Solution is the increased contribution of renewable generation (para 2.3 of Plan refers to 30% by 2020).

° The roll-out of the Solution will facilitate this increase in renewable generation by reducing the length of time for which energy is lost due to cable failures preventing power from being sent to shore.
° As described below, in the absence of NIC funding (i.e. with only business-as-usual OFTO opex funding arrangements) this Solution would not be deployed at all and this renewable generation will continue to be lost.

(Part ii) The project will provide increased network capacity by reducing the amount of capacity lost to prolonged offshore cable faults. Note that this is the same increase referred to in Part i above and is not a separate benefit.

(Part iii) The project provides environmental benefits through the carbon savings resulting from the increasing wind output referred to in Part i, which will displace fossil-fired generation from the grid. By 2030 this would reach an estimated 80GWhr pa (see Section 3), which is equivalent to the output of a reasonably large (30-40MW) onshore wind farm being provided with zero environmental impact.

(Part iv) The Base Case Cost and Method Cost of undertaking an offshore cable repair are estimated to be £[redacted]/repair and less than £x[redacted]/repair respectively (see Section 3). Total cumulative financial benefits of the project are estimated to be £18m by 2020, £175m by 2030 and £625m by 2050. See Appendix 1 for more information.

(b) Provides value for money to electricity transmission Customers

This project has a Direct Impact (i.e. its deployment "will cause a measurable change in the operation of the Transmission System in a controllable way") which is:

i) Increased availability of OFTO assets within the Transmission System due to more rapid offshore cable repairs. Additionally the risk of particularly extreme outages, where repairs take 6-18 months, would be sharply reduced.

ii) Increased availability of other types of offshore cable within the Transmission System ("bootstraps", interconnectors, island links, etc) due to greater repair vessel availability, leading to reduced constraints on energy flows and increased renewable generation.

iii) Reduced cable repair costs (including a reduced need to manufacture replacement spare cables), and a sharply reduced risk of extremely high repair costs – occasions where single repairs can cost £10-20m. Both factors would ultimately lead to lower OFTO tender revenue streams and reduced financial risk for OFTOs.

iv) In the longer term, a shift to offshore wind connections with fewer (but larger) cables, giving lower capital costs.

The scale of the proposed project is appropriate as it is the minimum scale required to actually deliver a suitable repair vessel and a suitable universal joint design within in a suitable commercial arrangement. Even a modest reduction in funding would mean that the functionality of the solution would be greatly curtailed and the overall cost-effectiveness of the project would be reduced.

The high level of benefits and short payback period set out in (a) above and in Section 3 show that the proposed project is very attractive relative to the status quo. We have also taken care to structure our proposal so that it offers value for money relative to alternative approaches to implementing the same solution, and does not result in unreasonable profits for participants. This is done as follows:

i) Undertaking repairs through the ACMA means that OFTOs, other relevant transmission licensees, and ultimately consumers, stand to gain from its collective-buying power and its ability to offer long-term stable income streams to vessel owners.

ii) The applicant will not gain preferential access to the *Wave Sentinel* or the jointing technology through intellectual property rights (since the default IPR arrangements are to be used) or special commercial arrangements (since ACMA insists on standard terms with all of its members).

iii) The benefits of the project will be directly available to all Network Licensees without each needing to implement the concept separately on their own systems. All a licensee needs to do is to join ACMA, which requires only a modest annual charge. This, along with the very strong commercial incentives provided by a dramatic reduction in repair cost and time, will contribute to the concept's rapid roll-out among Licensees. In particular this means that all OFTO bidders will have access to the same ACMA services on the same terms, and so the competitive process used to appoint OFTOs will result in the benefits of the project being transferred to transmission customers: OFTO bidders cannot retain the benefits for themselves without becoming uncompetitive.

iv) We have structured the project so as to maximise the use of competitive bidding; we expect it to be used wherever possible to select the subcontractors who will manufacture and fit to the *Wave Sentinel* the new equipment required for power cable repairs.

v) The subcontractor who will undertake the development of the universal joint will similarly be selected through a competitive process that will allow us to judge alternative subcontractors based on their technical ability, their price to undertake the development work, and their price to provide jointing services and/or train others. Because of the specialist nature of this service we have commissioned an independent report (see Appendix 4) to confirm that multiple acceptable competing concepts do exist.

vi) The contract with the jointing subcontractor will be structured to comply with the default IPR arrangements. In addition the jointing subcontractor will either provide full training to GMSL staff so that power cable jointing will be undertaken as part of the ACMA services accessible to all, or they will provide jointing services (likely alongside GMSL staff) on a long-term call-off basis with man-hour rates set in advance at a reasonable level. These measures will prevent the jointing contractor from extracting unreasonable profits when the joint enters service.

vii) It was not feasible to select our prime contractor through a competitive process, as there are only two vessel owners serving ACMA (GMSL and Orange Marine), and of these two companies GMSL put forward a unique proposal. For this reason a system of fixed fees and margins is used, as set out in the memorandum of understanding (see Appendix 2) in order to prevent unreasonable profits.

viii) The GMSL profit margin allowed under the Memorandum of Understanding (see Section 3) is reasonable because of the risks taken by GMSL:

- Following the completion of the project's initial stage, GMSL will be undertaking the work at a fixed price. GMSL will accept the risk of cost overruns following acceptance of this offer, thus minimising risks for consumers and placing cost-overrun risks with the company best able to manage them.
- GMSL will take the risk that project funding is disallowed and "clawed back" by Ofgem.
- GMSL will compensate electricity consumers if the *Wave Sentinel* is not accepted as a future ACMA vessel, or if changes to ACMA rules cause membership to become unattractive to power cable owners. This is discussed further below.

ix) GMSL will not be able to charge ACMA more for the *Wave Sentinel* following its upgrade to undertake power cable repairs because the telecom-cable owners who predominate within ACMA will not accept higher fees solely to facilitate the entry into ACMA of a much smaller amount of power cable with correspondingly small contributions to meeting ACMA's total costs.

x) If at some future date the *Wave Sentinel* ceases to be contracted to ACMA (whether through GMSL seeing to extract an unreasonably high price, as noted above, or through a breakup or fundamental change in of ACMA – unlikely given the longevity and stability of this organisation, or through any other factor) GMSL must provide an equivalent arrangement or pay compensation. Provision of an equivalent arrangement is thought unlikely, and we assume that in most cases compensation would be paid. Compensation is to be at the rate of one seventh of the cost of the vessel conversion per year and will apply for seven years after the conversion is completed – i.e. for a length of time far in excess of the project's payback period. This ensures value for money even if the provision of the service is cut short. The existence of this compensation system gives GMSL a strong incentive to ensure that the vessel remains contracted to ACMA.

xi) The memorandum of understanding specifies that this compensation would be paid to the Applicant, who would then need to return it to NETSO who would use it to reduce transmission tariffs. It would be preferable to have a simpler approach where compensation is paid directly to NETSO, and the applicant would like to discuss the details of the compensation mechanism with Ofgem at the appropriate time.

xii) Both the Applicant (through its management company, Transmission Capital Services, TCS) and GMSL have considerable experience with the delivery of contractually and technically complex projects rapidly, efficiently and successfully. Indeed GMSL has already undertaken similar modifications to allow another of its vessels to handle power cables – though in this case the vessel was optimised for the laying of new cables rather than the repair of old cables. This experience reduces the risk that a value for money solution fails to emerge due to errors and omissions on the part of its management. More information on project management is provided in Section 6.

xiii) The progress of GMSL and their subcontractors will be monitored and, if necessary audited, by the applicant to ensure value for money at all stages of the project. To do this the applicant will use a combination of its in-house project management staff and external advisors in marine and cable technology; these external advisors would be SMEs. Should they be required, external audit and legal services are available from TCS's accountants and solicitors. Further information on external advisors is provided in Section 6.

xiv) The risk of cost overruns eroding customers' value-for-money is further reduced by structuring the project as a low cost initial phase where detailed design is undertaken and bids are solicited from subcontractors. The project can then be halted if expected costs have escalated. If it decided to go ahead the work would be undertaken by GMSL on a fixed price basis so that customer value-for-money is "locked in".

In the short term we expect that roughly half of the economic benefit will accrue to the transmission companies (OFTOs), primarily in the form of reduced repair/insurance costs, and half will accrue to the offshore wind farm owners in the form of increased income due to higher export-cable availability. If benefits to interconnectors are included the proportion may increase in favour of transmission owners, whilst if rapid repairs facilitate a reduction in wind farm export cable capex (by changing the design to one based on fewer higher-capacity cables) this may return the ratio back towards 50/50.

In the longer term, however, it is expected that all of these benefits will be passed through to consumers. The competitive system for appointing OFTOs forces OFTO-bidders to pass through any cost savings; otherwise they will be uncompetitive. Similarly competitive bidding for offshore wind contracts for difference, when it is introduced, will force generators to pass through their cost savings.

(c) Generates knowledge that can be shared amongst all relevant Network Licensees

The project generates knowledge in two forms, both of which will be shared amongst all relevant Network Licensees:

i) "Pure" knowledge that will be circulated through reports, peer reviews, etc, as set out in Section 5.

ii) More importantly, knowledge "embedded" in the products that will be delivered by the project: a power-cable repair vessel and a universal joint for the type of offshore cables used by OFTOs. As explained in Section 4(b) above, this "embedded" knowledge is available to all Network Licensees without each needing to implement the concepts separately on their own systems. All a relevant licensee needs to do is to join ACMA.

(d) Is innovative (ie not business as usual) and has an unproven business case where the innovation risk warrants a limited Development or Demonstration Project to demonstrate its effectiveness.

The project has two aspects – modification of a telecom repair ship so that it can repair power cables and development of a universal joint. Both aspects are innovative:

i) This will be the first time that a vessel operating within a telecom-oriented shared-cost cable repair "club" (of which there are 6 around the world: ACMA, MECMA, 2OCMA, SEAIOCMA, Yokohama & NAZ) has been upgraded to be equally capable of repairing power cables of the type used by OFTOs, a type which is particularly large and heavy and cannot be tightly coiled. While some clever design approaches have been developed for the conversion (see Appendix 10), the main innovative elements here relate to commercial structures rather than technology. As noted above, GMSL has already modified one of their telecom cable laying vessels in order to allow it to handle power cables – but the converted vessel was too expensive for ACMA and is better suited to laying new cable than repairing old cable. In contrast, the *Wave Sentinel* conversion will be designed to lead to a vessel optimised for cable repairs, and which will be equally comfortable repairing either power or telecom cables.

ii) This will be the first time that an offshore universal joint has been available for OFTO-type cables that is not the product of a cable manufacturer and is not restricted to use on that manufacturer's cables or with their jointers.

These measures have not been tried before because they necessitate expenditures on vessel modification and joint production ahead of need, i.e. ahead of a specific cable fault occurring. It is not possible to fund such work as part of business as usual as the cost is very large relative to OFTO opex budgets and OFTOs do not have the capital available to fund such large up-front development costs, this being one of the features of cost effective non-recourse project financing.

Additional barriers to applying these innovations without NIC funding include:

i) Although the cost benefit calculations show very short payback periods, these are dependent on the project being used by multiple GB licensees. However co-ordinated funding of these innovations by multiple network licensees from their business-as-usual sources is not feasible as these companies have different technical and business aims and are competitors. As a result previous attempts to arrange collective funding for shared cable repair arrangements have not been successful. However NIC funding combined with the access-for-anyone principles of ACMA allows the outcome of the project to be immediately applied at a large enough scale to generate a benefit which more than justifies the initial investment.

ii) Due to the "shared club" nature of organisations such as the Atlantic Cable Maintenance Agreement, where all parties access services according to the same fixed set of rates, it is inherently difficult to prevent others from also benefiting from the investment. This "free rider" vulnerability of the concept tends to prevent investment by any single party. In particular OFTO investors will be unwilling to invest in a concept that can immediately be applied by all of their competitors.

iii) Consumers and offshore wind generators (not OFTOs) stand to gain most of the benefit from these innovations, due to the higher generation outputs that are possible thanks to shorter cable repair times, and due to competition between OFTOs preventing them from capturing the benefits. If an OFTO were to fund the cost of the project from business-as-usual sources they would only be able to consider the limited proportion of the benefits that would accrue to them.

(e) Involvement of other partners and external funding.

The applicant has selected Global Marine Systems Ltd (GMSL) as prime contractor and supply-chain partner. GMSL is not able to contribute as an External Funder because, as explained in Section 4(b) above, ACMA's insistence on maintaining vessel costs at a level appropriate for a telecom-only repair vessel will prevent GMSL from profiting from the vessel conversion through charging higher fees for the use of the vessel. The applicant has employed reasonable endeavours to attract external funding, but has found that this effect similarly prevents other vessel owners from contributing, while other OFTOs are deterred by unavailability of funds and the "free rider" effects set out in Section 4(d) above.

Although GMSL is not an External Funder, they are an external accepter of key project risks – and without them undertaking this role the applicant would not have been able to bid for NIC funding. The key risks taken by GMSL are cost overrun risk (following the initial phase they will work at a fixed price), funding-clawback risk and the risk that the *Wave Sentinel* ceases to be contracted to ACMA at some point in the future.

GMSL is willing to take these risks because:

i) It receives a profit margin for its role as prime contractor.

ii) It is the entity best placed to manage these risks: it will run the implementation of the project on a day-to-day basis, and the price it charges will be the key factor determining whether the *Wave Sentinel* remains in ACMA.

iii) It has a corporate goal of becoming the largest independent player in the power cable repair industry – a role it already plays in the telecom-cable repair industry.

The system used to identify project partners was based on following principles:

i) To ensure value for money we prefer to use competitive tendering where possible (see Section 4(b) above). This leads to a preference for appointing the supply chain companies after funding has been secured, when there will be willingness among supply chain companies to invest the time and effort necessary to bid competitively.

ii) However the role of prime contractor needs to be filled prior to NIC bidding in order to show project readiness and because finding a contractor willing to take the risks discussed above is critical to the feasibility of the concept.

iii) Consideration was given to separating the role of prime contractor for the vessel conversion from the cable jointing contractor. However this approach was rejected because of increased complexity and because no jointing contractor was found that was willing to take the clawback risk. As a result the project was structured with the jointing contractor being added to the set of subcontractors under the prime contractor (GMSL). This had the additional advantage that the decision on which jointing company is selected is deferred until funding is in place: this improves the client's negotiating position and, as all potential jointing contractors are continuing to work on refining their concepts, it allows us to judge concept maturity based on the most up-to-date information.

GMSL was selected as the prime contractor as they are one of only two vessel owners contracted to ACMA; the other is Orange Marine with whom we also held discussions. GMSL was willing to accept the risks set out above, and they put forward an attractive proposal based on the conversion of the highly economic *Wave Sentinel* into a vessel that would be equally capable of repairing power and telecom cables (thanks to separate cable handling systems for each product) and would also be attractive to ACMA (thanks to the vessel's competitive cost).

The process used to select the concept for which we are seeking NIC funding started with a re-examination of the three concepts that were submitted for ISP approval in 2013. These concepts in turn originated from a larger pool of concepts that were either brought to our attention by third parties (e.g. suppliers and the wind farms that we serve), were the result of needs identified internally by our asset managers, or were in general circulation in the offshore-cable industry.

More specifically, the origin of the three project ideas put forward in 2013 were as follows:

i) The universal joint concept. This is in wide circulation within the industry, particularly because of the existence of a universal joint for submarine fibre optic telecom cables – a development which has been of huge benefit to that sector. Additionally our asset managers have direct experience of onshore universal joints, and have purchased onshore universal joints for our OFTOs.

ii) The modified telecom repair vessel concept. This concept was initially raised by ourselves with suppliers, who referred us to ACMA as a body that could provide the commercial framework necessary for the concept. The concept was then developed further with ACMA.

iii) The tyre-mat concept. This was brought to us by E.on, owner of one of the wind farms that we serve. E.on has been involved in the development of tyre mats for the protection of wind turbines from scour and believed that the concept could also be applied to the protection of export cables.

In 2013 all three projects were judged to be sufficiently attractive (in terms of cost-benefit case, technical risk and business case) to merit ISP submission. In the re-examination of these concepts for the 2014 NIC funding round it was concluded that:

i) The strength of the cost-benefit case was better for the universal joint and repair vessel concepts.

ii) Technical risk was judged to be higher for the tyre-mat concept, and the commercial structure / business case was less clear.

iii) There were found to be opportunities for synergy between the repair vessel concept and the universal joint concept. Without the universal joint, the value of a rapidly-available repair vessel would be degraded if it had to wait for the manufacturer's jointers. And similarly without a rapidly available repair vessel, the value of rapidly available spares is reduced.

iv) Further new concepts were sought, but none were judged to be sufficiently attractive.

As a result of this analysis, it was decided to combine the repair vessel and universal joint concepts, and to make an integrated vessel-and-joint concept our 2014 NIC submission.

(f) Relevance and timing

The move to a low carbon economy is bringing about a dramatic increase in the use of offshore power cables. There are three main factors that are driving this:

i) The increase in offshore renewable generation, at present mainly offshore wind although tidal and wave power sources are likely in the near future. British offshore generation has increased from near zero ten years ago, to 3.9GW now and to as much as 31.1GW in 2030 (source: National Grid's Future Electricity Scenarios).

ii) The increased use of and need for interconnection. This is driven in part by the need to diversify sources of generation over a wider area due to low-carbon sources either suffering from variable weather-dependent outputs (wind, solar, wave) or comprising very large single units that, in the event of a failure, will require immediate replacement (nuclear).

iii) The increased use of offshore cables between onshore substations (so called "bootstraps") to reinforce the GB grid. Examples currently under construction are the Hunterston-Kintyre and Hunterston-Deeside cables, while numerous additional projects are under development. These reinforcements are generally required because low carbon generation (and in particular onshore wind) tends to be located in remote areas far from demand centres.

iv) Remotely located onshore wind (and the emergent wave and tidal generation sources) is also expected to drive an increase in the number of cables to islands, with projects to the Isle of Lewis, Orkney and Shetland all under development.

This means that one of the key challenges associated with a move to a low carbon economy is the construction, maintenance and repair of an increasingly large and critical fleet of offshore cables. To date cable repair of offshore cables has been a particularly unsatisfactory area, characterised by very long waiting periods before the repair was undertaken and extremely high costs (see Section 2). This leads to:

i) Increased costs for repair and/or insurance.

ii) Reduced renewable energy output due to the length of time taken to repair offshore wind export cables, bootstraps, island connectors, etc.

iii) Increased capex due to designs using multiple low-capacity cables, a more expensive option than a small number of high-capacity cables, due to the threat of long repair times.

The project, therefore, is addressing an important issue associated with the move to a low carbon economy.

If the method proves successful it will be used by the applicant and its management company in order to reduce costs on our existing OFTOs and in order to allow us bid lower prices in future OFTO competitions. As previously noted we expect that the concept would rapidly be adopted by all existing OFTOs and all OFTO bidders.

Project Code/Version No:
TCPEN01/1.0

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Section 5: Knowledge dissemination

This section should be between 3 and 5 pages.

☐ Please cross the box if the Network Licensee does not intend to conform to the default IPR requirements.

Summary

A notable feature of this proposal is that it does not just create knowledge that needs to be absorbed by other network licensees in order for the benefits to customers to be realised. In addition to knowledge it creates fully functional products that will deliver dramatic reductions in repair cost and outage durations. This means that the benefits of the project will be directly available to all Network Licensees without each needing to implement the concepts separately on their own systems.

While there is no obligation on any network licensee to join ACMA the benefits of doing so are so dramatic in terms of the reductions in cost and time of cable repair (see Section 3) that we believe that all will do so. Although there is a modest standing charge, we have confirmed with our insurance broker that this will be more than offset by insurance savings. Because of these commercial benefits we expect ACMA membership to roll-out rapidly among network licensees with offshore cables.

All Network Licensees will be able to join ACMA on the same terms as the Applicant.

Results will be captured through reports and, once the work is complete, through marketing of the services of the vessel and the universal joint. Project reports would be made available to all GB network licensees, and we will seek to arrange "peer review" sessions with as many as possible of the GB network licensees who own offshore cable assets of the relevant type.

Knowledge Created

The knowledge created by the project will be contained within the design of the universal subsea joint and the modified repair vessel. Both designs will be validated by testing to give confidence that the vessel and joint are ready for service. Jointer training and qualification, which forms part of this project, will involve knowledge transfer from the joint designers to the jointers who will assemble the joint in the field.

Additional knowledge creation will be the establishment of a model for cable repairs which can be adapted to other repair scenarios, e.g. shallow water repairs (less than 10m), jointing of HVDC cables and jointing of >155kV AC cables.

Targeted Audiences / Customers

The first targeted audience will be other GB licensees, specifically:

i) Other OFTOs. At present all OFTOs use cables of the type that can be jointed using the universal joint, and all OFTOs face exposure to the cost of repairs and circuit availability, either directly or through insurance premiums. OFTOs managed by others are therefore likely to be alongside TCS's OFTOs in being among the first customers for the products of this project. The cost and time benefits of using the *Wave Sentinel* are so great that we would expect it to be used in all cases where the water depth is sufficiently great. It will be for each individual OFTO to decide whether to use the universal joint. In situations where there are ample numbers of the spare joints originally provided by the cable manufacturer available, and where the cable manufacturer can provide jointers without delay, many OFTOs may decide to use joints from their existing stockpiles rather than universal joints.

ii) "Onshore" (i.e. RIIO-regulated) TOs and DNOs. At present the offshore cables owned by "onshore" TOs/DNOs are limited to low power island feeders at 33kV and below (for whom smaller vessels may be suitable for repairs) and the short 132kV cables to the Isle of Wight. However by the time that this project is complete these will be joined by 220kV AC cables between Hunterston and Kintyre, and 600kV DC cables between Hunterston and Deeside, with many further projects under consideration. Although the universal joint is unlikely to be applicable to more than a handful of these projects, it should be feasible to use the *Wave Sentinel* for repairs on all the sufficiently-deep parts of these cables.

iii) Interconnector Owners. At present there are five interconnectors to Britain (from Northern Ireland, Republic of Ireland, France, Isle of Man and Netherlands). Although the universal joint will not be applicable to these projects – except maybe the Isle of Man – it should be feasible to use the *Wave Sentinel* for repairs on all the sufficiently-deep parts of these projects. In addition numerous further interconnectors are under development, with destinations including Belgium, France, Norway, Ireland and Denmark.

iv) Generators. Offshore wind farms contain an array of 33kV cables that take power from the turbines to the offshore substation. Although the impact of a failure of one of these cables will typically be an order of magnitude less severe than the failure of an export cable, repairs – often achieved by replacing an entire cable circuit between turbines – remain very expensive. Substantial cost savings should be achieved by using the *Wave Sentinel*.

ACMA has already started marketing to these potential users, via a series of conferences. To date these have been in London (hosted by one of ACMA's telecom members), in Belfast (hosted by the owners of the Moyle interconnector) and in Portland, on board the *Wave Sentinel* (hosted by GMSL). These conferences have highlighted the industry's unmet demand for a more rapid and economic approach to offshore cable repairs.

While traditional project reports will still be available, ACMA marketing through this and similar forums is expected to be a key mechanism for the wider dissemination of the new approach to cable repairs.

Another important target audience will be the developers of new offshore transmission projects, in particular projects for the connection of new offshore wind farms. It is understood that the time required for offshore cable repairs, and the resulting prolonged loss of transmission capacity without compensation, is a principle reason why wind farm connections in Britain tend to use multiple small-capacity cables. In contrast Denmark, for instance, connects its wind farms with a small number (often only one) of high-capacity cables. The installed cost of cables exhibits a very strong economy of scale effect (so doubling cable rating, for instance, can increase installed cost by as little as 20%), and as a result using a small number of larger-capacity cables can give a significant saving in capital costs. Educating the developers of new projects in relation to the reduced outage times possible through ACMA membership offers a way to unlock these savings, which are discussed further in Section 3.

Knowledge dissemination continued

Dissemination methods

Envisaged dissemination methods are:

i) Marketing by ACMA, as described above, and marketing by GMSL on behalf of ACMA. ACMA operates as a cost-sharing pool, so that the membership of power cable owners and the amount that they pay for repairs will drive a reduction in the costs for existing members. This gives a strong commercial incentive for the marketing of ACMA membership to additional companies.

ii) A final project report will be produced explaining the work undertaken and the lessons learned. The report will also make recommendations for the future extension of the project's key concepts, i.e. a vessel-sharing repair club and the cable-owner-led development of jointing accessories. The report will be sent to all GB network licensees with offshore cables and all owners/developers of GB offshore wind farms.

iii) Dissemination of the final report will also be assisted by a peer review conference. This will have invitees similar to the ACMA marketing conferences referred to above.

iv) A further route for the dissemination of the results will be through trade bodies such as Subsea Cables UK and the Offshore Wind Programme Board, the latter being particularly relevant in terms of influencing the developers of future offshore wind connections.

IPR arrangements

We expect to adhere to the default IPR arrangements.

The project has been structured in order to ensure that the parties involved cannot make an unreasonable profit from their involvement through use of IPR gained at customer expense. In particular:

i) The applicant will not gain any IPR from the project, nor will it gain any better pricing or any preferred access to the *Wave Sentinel* vessel or the universal joint. Indeed this is one of the features that comes from accessing the vessel through ACMA: ACMA has fixed rules on fees and access to vessels which have remained largely unchanged for decades and which will not be significantly changed simply because one of the vessels now has the ability to handle larger power cables. Other network licensees can therefore join ACMA and be assured of exactly the same deal as the Applicant. This means that the applicant cannot use the project to gain a competitive advantage over other OFTO bidders, and so the benefits of the project will not go to OFTO bidders but rather will be transferred to customers through lower OFTO bid prices.

ii) GMSL's allowed project management fees and profit margins are limited, as described in Section 4(b). GMSL will not gain any IPR from the project: while considerable design work will be done for the modification of the *Wave Sentinel*, this work is specific to this vessel and would not rise to any generic patentable conversion techniques that can be applied elsewhere.

iii) The jointing company, which is a subcontractor to GMSL, will be required to adhere to the default IPR requirements. As part of the process for selecting a jointing company bids will be solicited for offers that integrate joint development, provision of jointers on a long-term call-off basis and training of third party jointers. The winning bidder will be the company that provides the optimum mix of these three features. Requiring the jointing company to provide access to its IPR and to provide long-term support and/or training at pre-agreed reasonable prices will prevent them from making unjustified profits through restricting access to the universal joint.

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Section 6: Project Readiness

This section should be between 5 and 8 pages.

Requested level of protection require against cost over-runs (%):
Default arrangements should apply.

Requested level of protection against Direct Benefits that they wish to apply for (%):
Nil (there are no Direct Benefits – see Section 3 Conclusions)

Timely Project Startup & Project Organisation

A clear and simple project structure (see Appendix 5) has been chosen. This facilitates rapid decision making, promotes accountability, and accelerates project startup. The structure features a single ultimate authority (the TCS board), a single client project manager, and a single prime-contractor project manager.

Rapid mobilisation following a positive NIC decision is facilitated by the simple structure and the fact that personnel have already been selected for the various roles, as set out in Appendix 5.

Following announcement of NIC award the project would enter a preliminary phase which would be characterised by the following activities:

i) Conversion of the Memorandum of Understanding to a full contract.

ii) Agreement of any remaining issues with Ofgem (e.g. arrangements for GMSL to compensate consumers in the event that the *Wave Sentinel* ceases to be contracted to ACMA).

iii) Selection of the jointing contractor by the Applicant and GMSL, and negotiation of their contract terms with GMSL.

iv) Selection of any external advisors that will assist the Applicant in monitoring GMSL to ensure technical success and value for money.

This preliminary phase would be completed by mid-April 2015, i.e. the point at which funding cash would first be paid into the project bank account. The project will then enter its initial phase during which design work will be undertaken and GMSL will obtain quotations from its subcontractors. GMSL's costs during this phase are capped at a relatively low level (£[redacted]). At the end of the initial phase GMSL will make a fixed-price contract offer to the applicant, based on the pricing rules set out in the Memorandum of Understanding. (Timing differences, discussed later in this section, between the vessel conversion and the joint development work may mean that there will need to be separate fixed-price offers for each. We are still investigating this and our aim is to have only one fixed-price offer if this is possible).

If the offered fixed price is excessive then the applicant may chose to halt the project at this stage, or they may seek Ofgem's permission for additional funding, for a change in project scope, or for the selection of a new prime contractor.

If the offered fixed price is acceptable then the project will proceed to its main phase, where the bulk of the vessel conversion and joint development will be undertaken.

The proposed project organisation benefits from:

i) TCS's experience in managing technically and contractually complex projects in regulated businesses. Examples are the bid process for OFTOs, financing / licence grant / asset transfer for OFTOs, operation and maintenance of OFTOs, and the development of a new GB-France interconnector. TCS's proposed project manager (Mr. Sean Kelly) has experience with numerous large and complex projects in the offshore cable sector including the project director role in the development of several interconnector projects and the technical lead role in the bidding for and acquisition of several OFTO cables.

ii) GMSL's experience of similar projects, including the previous conversion of a telecom cable lay vessel to allow the handling of larger power cables. The simple project structure will allow it to make use of GMSL's internal project governance framework, which has been proven on projects such as this. GMSL's proposed project manager (Mr. Tom Manning) has considerable experience dealing with ACMA and cable repair clients generally. A project manager with experience of large vessel modification and refurbishment projects will be brought in as the project enters the initial phase.

iii) The use of external experts to provide independent specialist advice. [Sentences removed]

iv) The short distance between TCS's offices in the City of London and GMSL's headquarters in Chelmsford (30min by train).

Contractual Arrangements Already Agreed

A Memorandum of Understanding (MoU) has already been signed by TCS and GMSL. It is attached as Appendix 2.

The MoU confirms the key parts of the project including:

i) The budget.

ii) The offering by GMSL of a fixed price at the end of the initial phase, and the rules for ensuring that this fixed price does not include unreasonable level of profit.

iii) Acceptance of "clawback risk" (i.e. if Ofgem decides that funds have not been spent in accordance with the Project Direction).

iv) Compensation should the *Wave Sentinel* cease to be contracted to ACMA.

Robustness of Cost Estimates

Cost estimates for vessel conversion are based on a combination of inputs:

i) GMSL's general marine-equipment cost database, acquired from its ongoing operation of a worldwide fleet of cable vessels similar to the *Wave Sentinel*.

ii) GMSL's experience from previous vessel conversions, in particular conversion work on the *Sovereign* to enable it to lay power cables (though it is not optimised for cable repairs).

iii) Budget prices provided by manufacturers of particular items of new equipment that would be required on board the converted vessel.

iv) In the case of the single largest uncertainty in relation to costs – whether the *Wave Sentinel's* electrical switchboard could be modified to meet the standards required for vessel operating in proximity to platforms, or whether it would need to be replaced – GMSL arranged for technical specialists from the equipment's manufacturer to be flown to the vessel (which was outside the UK at the time) to undertake an inspection and provide a price estimate.

v) Additional inputs contributed by RedPenguin.

[Paragraph redacted]

Both cost estimates have been independently reviewed and verified as adequate. The vessel modification costs have been assessed by power cable installation and repair specialists RedPenguin (see Appendix 3) and the joint development costs have been assessed by cable and accessory specialists CCI (see Appendix 4). Both advisers confirmed that the estimates had the level of robustness that would be expected at this stage in the project.

Robustness of Benefit Estimates

The benefit estimates that are calculated in Section 3 are based on a set of conservatively estimated inputs, i.e. where there is a range of possible inputs we have deliberately tended towards the input that yields the poorest economic case for the project.

In addition a range of possible outcomes for the volume of offshore wind have been considered, with the low-end assumption being the volume of offshore wind and associated cable already in service and under construction (i.e. absolutely no additional offshore wind projects go ahead). Even in this extremely conservative case the project still shows a payback period of 2-3 years.

It should be noted that the project is not reliant on the take up of renewable energy in a particular "trial area" – on completion it can be immediately applied to all offshore wind connections in Britain, and it is economically viable even if no additional offshore wind is built.

Verification of Information in the Proposal

In order to verify the information in the proposal – and in particular to confirm the budget and the technical feasibility of the project – we have commissioned the independent verification reports attached as Appendix 3 (vessel modification) and Appendix 4 (universal joint).

In addition to confirming technical feasibility and verifying cost estimates these reports also identify certain key risk areas for examination and resolution at the initial (i.e. limited commitment) stage of the project. These risk areas are discussed further in Appendix 7 (risk register) and Appendix 8 (mitigation and contingency planning).

Minimising the probability of cost overruns

The probability of cost overruns is minimised through the following measures:

i) A robust, detailed budget as described above.

ii) Independent verification of the budget, as described above.

iii) Appropriate risk margins to deal with unexpected contingencies.

iv) Other than the initial phase, all work is to be undertaken at a fixed price.

v) The prime contractor is experienced in undertaking vessel modifications, which constitute the bulk of the expenditure.

vi) The prime contractor is to be supervised by an experienced project manager within TCS who will be assisted by external technical experts and (if necessary) legal and audit resources.

vii) The contingency plans set out in Appendix 8 provide identified mechanisms of dealing with certain contingent events that might otherwise cause cost overruns. The risks dealt with in this appendix have in turn been informed by the findings of RedPenguin and CCI in Appendix 3 and 4.

Project Plan

Appendix 6 shows the overall project plan. This is divided into:

i) A preliminary phase during which:
   - The project team (see Appendix 5) is established.
   - The contract with GMSL is finalised.
   - The jointing contractor is selected by the Applicant and GMSL.
   - The naval architects who will undertake the detailed design of the vessel modifications are selected.

   This phase is expected to last from November 2014 to April 2015.

ii) An initial phase during which:
   - Payments to the project bank account begin
   - The naval architect and GMSL's in house staff undertake the detailed design of the vessel modifications.
   - The design will receive "Class Approval" from a Classification Society (i.e. formal sign-off that the design meets international safety standards).
   - Specifications are developed for the equipment and services that will be purchased by GMSL to effect the conversion of the vessel.

- GMSL invites tenders from subcontractors for equipment and shipyard / installation services (in low-risk areas budget prices may be used in lieu of tendered prices).
- The jointing subcontractor will complete manufacturing drawings for the joint and its components and will undertake a similar process to GMSL in order to fix the prices of its parts suppliers and the HV test lab.
- The jointing subcontractor will identify sources for the joint components; orders may be placed for certain long-lead components where this is needed to avoid delaying the joint development process.
- Based on the price information generated from the sources listed above, GMSL will submit a fixed price offer to the applicant for the remaining stages of the project.
- The proposed joint design will be reviewed to ensure that it meets the needs of prospective users and their insurers.
- Overlapping with the development of the fixed price, the detailed designs would be submitted to ACMA members for review to demonstrate that the modifications will not compromise the *Wave Sentinel's* telecom-cable repair capability or lead to slow power cable repairs that will keep the vessel away from telecom-repair duty.
- A vote of ACMA members to confirm their agreement to the project will be held.

This phase is expected to last from April 2015 until the start of the main phase (which, as explained below may be at slightly different times for the vessel modification and joint development work).

iii) The main phase, which for the vessel modification work will involve:

- Placing contracts for major items of new equipment required.
- Placing a contract with a shipyard for the installation of this equipment and changes to the ship such as cutting plates to allow equipment to be lowered into interior compartments and replacing the plates subsequently. The changes required are summarised on the drawing attached as Appendix 10.
- [Item removed].
- Undertaking factory acceptance tests on new equipment and supervising its installation.
- Undertaking sea trials of the vessel to prove that its station-keeping abilities reach the standard required for vessels operating close to platforms.
- Undertaking a test where spare cable (provided by the applicant) is placed on the seabed, cut, recovered, jointed and laid back on the seabed. (Note that this is a purely mechanical test as it is not practical to test the cable electrically).

For the vessel modifications this phase is expected to start in June 2016. Shipyard work is expected to be in late 2016 and early 2017, with sea trials of the station-keeping system following in March 2017.

The sea trials of cable recovery, jointing and joint lowering are dependent on weather and vessel availability (i.e. the *Wave Sentinel* must not be required to undertake a telecom repair). Furthermore even though the test is purely mechanical (the cables are not energised) it would not take place until at least a substantial part of the joints' onshore test programme is complete as the intention is to use joint components re-claimed from the onshore tests. This means that the sea trials are unlikely to take place until late 2017 or even early 2018.

Once the vessel has been converted it should be possible for it to start to undertake repair work, even though the universal joint would not be fully tested and so the project as a whole would not yet be complete. The repair work would need to be undertaken using the joints provided by the cable manufacturer and the manufacturer's jointers.

iv) The main phase, which for the joint development work will involve:

- Assembly trials, to verify part fit and function
- Procurement and manufacture of parts for 8 joints (as noted above, some long-lead items may already have been purchased). Selection from this of parts for three joints that will be assembled as test articles.
- Assembly of the first test article with 15m lengths of different-type spare cable that will be provided by OFTOs (either TCS OFTOs or other OFTOs). The test article will then be subjected to a series of mechanical tests (pulling, bending, high pressure water) and then a series of electrical tests in a high voltage laboratory. Tests will be undertaken in line with the guidelines set out by Cigre.
- The second test article is then assembled, with (different) spare cable lengths and subjected to the same tests. Work on assembly of the second joint may need to start before the tests of the first joint are complete, but there will still be opportunities to apply any lessons learned in the assembly of the first joint to the second joint.
- When testing of the second test article is complete, the third test article is assembled and tested in the same way

This phase is expected to last from June 2016 until Q1 2018.

If other external factors are identified that could slow fault repairs and so reduce the benefit of the project for particular users (e.g. a need for environmental permits for fault repairs in sensitive areas) then these should be addressed by the relevant OFTOs at this time (e.g. by pre-arranging the necessary permits).

v) A closeout & reporting phase, during which:

- Test reports for the joint are compiled
- Supporting documentation for the joint is compiled and jointer training is delivered.
- The main project report is written.
- The project is described to relevant licensees through the "peer review" process, with this process providing an additional input for the final project report.

This phase is expected to last from late 2017 to Q1 2018, overlapping with the completion of the testing of the joint.

vi) The project completion date is July 2018, so a further 3-6 months remains as programme margin (slack).

Project Halting

In certain circumstances it may be necessary to pause or halt the project. The project structure already incorporates a formal "breakpoint" at which the project can be cleanly halted. This occurs at the point where GMSL submits a fixed price offer to the applicant and the applicant considers whether or not to accept the offer and proceed with the project. In principle the project might be halted here for a variety of reasons, though the expectation is that if the project is proceeding according to the scope set out in this application, and is within the budget set out in the memorandum of understanding (see Appendix 2) then it will be allowed to proceed.

The project has not been structured to allow clean cancellation following this point, and so there could be material cancellation charges from GMSL and its subcontractors if this is done solely because of the client has changed their approach concerning cable repairs.

Cancellation might also be considered in the event of exceptionally severe technical problems that GMSL is unable or unwilling to correct within the fixed price contract, or financial failure by GMSL.

Regardless of the exact nature of the extreme circumstances that might result in project cancellation, the structure of the project – where the board of TCS provides a single clear point for rapid and final decision making – will reduce risk relative to more complex multi-party project structures.

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Section 7: Regulatory issues

This section should be between 1 and 3 pages.

☐ Please cross the box if the Project may require any derogations, consents or changes to the regulatory arrangements.

There are no proposed derogations or other changes to current regulatory arrangements associated with this project either to undertake the work or as a contingency should the work fail.

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Section 8: Customer impacts

This section should be between 2 and 4 pages.

The project will have no impact on customers or customers' premises, other than the increase in transmission availability and reduction in outage times that is described in Section 3.

In particular the project requires no planned interruptions, and has no impact on customer contractual or charging arrangements.

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Section 9: Successful Delivery Reward Criteria

This section should be between 2 and 5 pages.

The applicant proposes a set of successful delivery reward criteria based on the following principles:

i) There should be a number of criteria, with the total reward amount being allocated to individual criteria ideally pro-rata to the level of expenditure associated with achieving the criterion in question.

ii) The criteria should be based on the achievement of concrete events which represent real milestones in project development, and should not be linked to the undertaking of a routine process.

iii) There should be target dates for the achievement of these milestones. This should be based on the project programme, but with additional time added to provide a margin. Additionally, while the importance of timely delivery is recognised, an element within the project should not be judged as unsuccessful due to delays caused by external factors beyond the control of the applicant and their contractors. (For instance this might include delays in scheduling the temporary removal of the *Wave Sentinel* from service while modifications are undertaken, or delays because all HV tests labs are busy).

Criteria 1

Complete Initial Phase

- GMSL completes the detailed design needed before seeking a fixed price
- GMSL completes fixed-price offer
- ACMA agreement
- Criteria to be met by September 2016 unless influenced by events beyond the control of the applicants or contractors.
- Since the purpose of the initial phase is to determine whether there are critical risks that would lead to project cancelation, and to do so while expenditure levels are only a few percent of the total budget, if new information is discovered that leads to project cancellation before the initial phase is complete, the success criteria should still be met.

Evidence:

- Fixed price offer made by GMSL as specified in MoU (see Appendix 2)
- ACMA approval

Criteria 2

Vessel Modification

- The modifications to the *Wave Sentinel* required for power cable repairs as listed in the Annex to the MoU (see Appendix 2) are to be completed.
- Criteria to be met by September 2017 unless influenced by events beyond the control of the applicants or contractors.

Evidence:

- Completion of DP2 sea trials following completion of vessel modifications. (But not

Successful Delivery Reward Criteria Continued

the jointing sea trial which is part of criteria 3 below).

Criteria 3

Universal Joint

- The HV testing of a universal joint test articles to Cigre standards.
- Sea trial of joint
- Criteria is to be met by June 2018 unless influenced by events beyond the control of the applicants or contractors.

Evidence:

- Test report issued by independent test witness.

Criteria 4

Project Close

- A project close report consolidating all of the lessons learned from the project and making proposals in respect of how to further develop the vessel and joint concepts.
- Criteria is to be met by July 2018 unless influenced by events beyond the control of the applicants or contractors.

Evidence:

- Project close-down report issued.

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Section 10: List of Appendices