Subsea Cable Repairs using Habitat Technology

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Agenda

• Introduction to the habitat cable repair system
• Previous projects
• Overview of offshore operations
• Fault location methods
• Training, development and testing
• Future applications

Paper being presented at CIGRE Paris 2018
Introduction to the Habitat
Cable Repair System
Introduction to the Habitat

- Innovative repair capsule for repairing cables subsea in-situ.
- Designed originally for the Moyle Interconnector.
- Low cost solution.
- No mechanical risk to the cable.
- Minimal seabed excavation.
- Minimal environmental impact.
- Designed by ESB International.
- Patent published.
Problem Hypothesis

Infrequent faults on submarine cables due to
- electrical faults,
- seabed movements, trawler action, ship anchors,
- faults introduced during original installation,
- faults introduced during other repairs.

The impact of faults are
- lost energy revenues,
- unavailability of supply,
- reputational damage,
- insurance costs,
- costs of contingent liability.

Conventional repair methods (on-deck) have a number of limitations

- **Downtime** due to
  - non-availability of cable repair vessel,
  - vessel operation restricted by weather,
  - fault localisation can be hit & miss,
  - trenching work takes time,
  - logistics of spare cable takes time,

- **Environmental impact** due to
  - Trenching of up to 400 metres

- **Costs** due to
  - project duration
  - trenching work
  - spare cable, including omega loops

- Propensity to cause **other faults** due to
  - Stress on cable while hoisted onto ship

- **Operating restrictions** of vessel
  - in very shallow waters
  - close to offshore wind turbines
Solution Hypothesis

A fundamental advancement in undersea cable repair
- focused on rapid resolution, to reduce
  - **Downtime** to 1/5th of conventional repair method
  - **Costs** to 40% of conventional repair method
- and also reducing
  - environmental impact by 97%,
  - volume & logistics of cable spares to almost negligible levels,
- whilst being capable of operating
  - in shallow waters, close to offshore wind turbines & in weather conditions that would restrict conventional repair vessels.

The basis of the Solution is
- a hardware device applied to the cable **in situ** on the seabed,
  - enabling jointing by experienced cable jointers, trained as divers,
  - connected to a control room on the surface,
- the entire operation being planned & executed within a sophisticated project that entails the application of;
  - engineering expertise, skilled personnel, training & accreditation, process & procedures, and hardware.
Previous Projects...
The Moyle Interconnector is a 500MW DC Subsea Interconnector between N.I & Scotland. Previous faults on the cables were repaired using conventional methods. ESB International appointed to develop and design a cable repair technique to be utilized to effect a repair in situ on the sea floor.

Significant Milestones were achieved:

• Significant advancements made in Fault Finding.
• New Method of Subsea Cable Repair.
Moyle Interconnector
Aran Islands

- 40km of 3 core EPR 20kV AC subsea cables linking 3 islands off the west coast of Ireland to the mainland electricity grid.
- Fault occurred in 2016 resulting in 2 islands losing power.
- Repair carried out during the winter in the North Atlantic.
- Exact fault was located on the seabed and cable was repaired in-situ.
Aran Islands
• Mobile diesel generators provided temporary supply.
• Combifloat J.U.B used as dive platform.
• All equipment was transported out to the island and assembled there.
• 97 dives were required to complete the repair.
• Fault was 2 km from the shore, 20 km from the mainland.
• Repair campaign carried out in poor North Atlantic weather conditions.
• Repair joints were tested at 3.5 times operating voltage.
• Cost efficient solution!
Overview of offshore operations
Habitat Repair Considerations…

- Dive platform – Anchor barge, J.U.B or DP.
- Offshore dive system – Air, T.U.P or Sat.
- Cable excavation system.
- Equipment to pinpoint the fault location.
- Diver friendly subsea joints.
- Diver friendly jointing system.
- Method of testing/ commissioning.
Repair Platform

Moyle Cable Repair 2014

Aran Cable Repair 2016
Subsea Habitat Repair System
Fault Location Methods
A needle in a hay stack…….

- A pin hole in a cable buried beneath the seabed…….

- Innovative fault location methods:
  - HF Tone injection methods
  - Multichannel hydrophones
  - Fibre optic DTS
  - Fibre optic DVS
Innovative Fault Finding DVS

Localization of Event

- $t_1 + t_2$, equal to the cable length in time
- $\Delta t = t_2 - t_1$, calculated from correlation between the two fringe patterns
- $\Delta t$ is then converted to the distance, hence the position of the Event.
Innovative Fault Finding DTS

- Connect DTS to identify temperature change.

- Change in temperature is detected by changes in Refractive Index of Fibre.

- Inject current into cable to create heat at fault location
Fault Finding Offshore Repair Spread
Training, development and testing
Training Centre!
Diver Training
Repair Design, Proof of Concept
Applicable Standards

• Habitat designed, built and tested to ASME Sec VIII Division 2.
• Habitat Nitrogen Purge/Drying System designed to BCGA C.O.P 4.
• Previous cable repair and testing in accordance with IEC 60502, CGRE 496, IEC 60230, IEC 60229.
• ESBI Process Safety Review conducted for each project.
• Dedicated ESBI H&S & PM resource allocated for each project.
• IMCA D023 dive spread used for previous repairs.
Future Applications....
Increasing Insurance Claims

INSURANCE MARKET CABLE CLAIMS 2008-2015

Source: GCube
Future Applications

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<th>Potential benefits</th>
<th>Uses</th>
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<td>• Minimises the amount of deburial.</td>
<td>• Inter-array Offshore Wind Park Cables.</td>
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<td>• High operational efficacy.</td>
<td>• Umbilical repairs.</td>
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<td>• No mechanical risk to the cable.</td>
<td>• Voltage range LV to 132kV Wet design AC.</td>
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<td>• Especially beneficial at landfalls which tend to be shallow but heavily rock placed.</td>
<td>• DC return conductors for Interconnectors.</td>
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<td>• Commercially and environmentally efficient</td>
<td>• Developments underway to fix subsea fibre optic cables.</td>
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<td>• Testing of long subsea cables!</td>
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