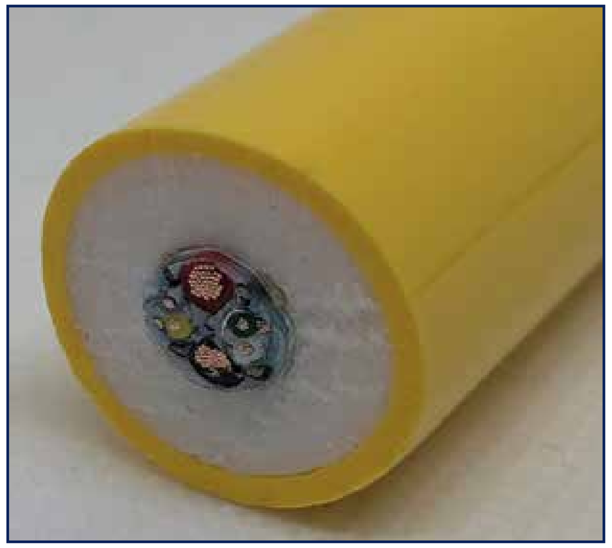
PURPOSE-BUILT ROBOTIC CABLE FOR UNDERWATER ARCHAEOLOGY

Focusing on design and production of purpose-built cables for marine robotics, NOVACAVI has developed a special slightly floating tether to be connected with a Tether Management System (TMS) used for deep-sea archaeology activities.

NOVACAVI was asked to develop a 3000m depth rated water blocked buoyant mini-ROV cable to exchange data and supply power during accurate observation and intervention in deep archaeological sites with new robotic underwater vehicles.

With engineering expertise, comprehensive knowledge of materials and a high degree of manufacturing, NOVACAVI developed and provided its 6GAX168.



Buoyant mini-ROV cable

C_KORE QUEENS AWARD

C-Kore Systems Limited from Escrick, York have been honoured with a Queen's Award for Enterprise for the second time in 3 years. Following their award for Innovation in 2019, they have now been recognised for their contribution to International Trade.

Now in its 55th year, the Queen's Award for Enterprise is the most prestigious business award in the UK recognising outstanding achievement, with Her Majesty The Queen personally approving all winners. This year C-Kore is one of only 122 companies across the UK who are to receive an award for their contribution to International Trade.

Tim Overfield, Managing Director, commented "Having had a tremendous 2019, winning both the Queen's Award for Enterprise for Innovation and Subsea UK's Innovation and Technology Award, news spread globally on how our innovative products are changing the industry practice on how subsea testing is conducted.

This resulted in an increase in international trade of over 600%. With C-Kore's automated technology it is no longer necessary to use traditional error-prone manual measurement techniques."

CABLES

IKM ROVS ON AURORA

Nexans Norway and IKM Subsea have signed an agreement for ROV services on CLV Nexans Skagerrak, CLV Nexans Aurora and 3rd party vessel support.

The contract value including options is NOK 200 million and duration term is firm for 3 years + 2 yearly options.

Since 2012, IKM Subsea have supplied a Merlin WR200 Work class ROV's onboard on the *C/S Nexans Skagerrak*. For the new contract, IKM Subsea's remote operation platform and capacity is a vital part of the service offering. IKM Subsea have, since 2017, operated ROV's remotely from onshore 24/7-365 and gained vast experience on this offering.

IKM Subsea Singapore are currently setting up their own Onshore Control Centre in order to also supply onshore control services in Asia and Oceania.

IKM ROVS ON AURORA

NordLink partners TenneT, Statnett and KfW have now taken over the high-voltage direct current (HVDC) transmission system between Norway and Germany.

NordLink- the "green cable" for exchanging German wind energy with Norwegian hydropower- is a system of two optimally complementary systems.

NordLink is now in the operation phase. The Norwegian and the German energy markets can nopw
achieve supply security and stable energy prices while increasing the share of renewables in the energy mix.

IKM ROV on the Aurora

CABLE VULNERABILITY

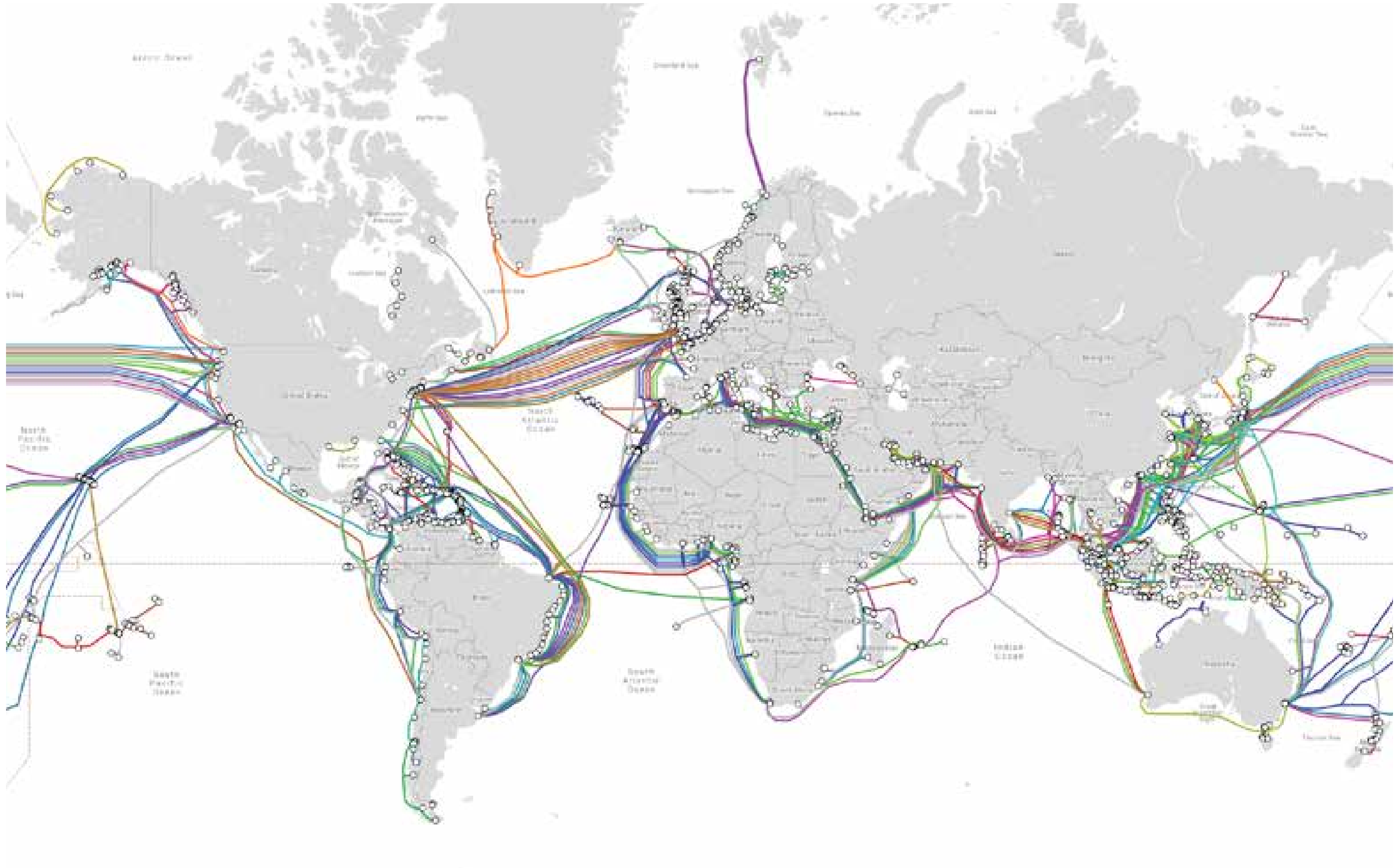
As part of the Defence Review, the UK government plans has announced that it will commission a new Multi-Role Ocean Surveillance Ship which, it claims, will protect the integrity of the UK's Maritime Zones and undersea Critical National Infrastructure.

At one time, *'critical national infrastructure'* could have referred to oil and gas pipelines. Today it is an euphemism for underwater telecommunications cables. Similar sentiments about needing to protect communications cables have been expressed by governments worldwide.

As the pandemic looks like changing the way internet services are consumed,especially when working remotely away from the central office, the world is becoming increasingly reliant on communications technology. Over the past few decades, high speed communication has driven globalisation with financial transactions worth over $10 trillion each day being conducted online.

In the not too distant past, companies needed to install physical computing infrastructure onsite. With the rise of cloud computing and high capacity, low latency connections, however, it is often more convenient or economic to use storage and processing facilities located anywhere in the world.

Pete Sandeman of defence analysts NavyLookout provided information for this article. www.navylookout.com



While the US is still the main consumer, between 2004 and 2019, it went from handling half of all internet traffic to just under a quarter.

SUBSEA CABLES

At present, estimates state that up to 97%-99% of all internet and voice traffic around the world pass through a network of subsea cables. To date, more than 1.2 million kilometres of submarine cables have been laid in the oceans of the world, some that run for over 20 000km.

A typical modern subsea cable is made up of up to 200 ultralow-loss fibres, each able to transmit 400Gb of data per second in both directions.

Cables with capacities of 250TB/s are now being used, roughly equivalent to simultaneously streaming 3.3 million 4K-resolution videos or serving 1.7 million small businesses using typical cloud services.

For most of its length, such cables are around the same circumference as a garden hose, although sections closer to shore have thicker sheathing, buried in trenches cut below the seabed or even have mating laid over them for protection.

Some nations are reliant on just one or two cables while some routes have multiple cables. There are at least 19 TransAtlantic cables that connect Europe to the US, offering a measure of redundancy.

DISRUPTION

Cable connectivity disruption could have an immediate effect on the economy, potentially crippling the banking system and halting commerce.

Every year, 150 to 200 subsea cable faults occur. Fishing (especially trawl nets) and shipping (anchor dragging in bad weather) activities

REDS UNDER THE SEABED

According to an analysis editorial by ***Navy Lookout***, cutting submarine cables is a deniable activity that would suit a power operating in the 'grey zone' below the threshold for full-scale war. This kind of attack is low risk and, for a relatively modest investment, could potentially achieve enormous impact.

Intelligence suggests that Russia, amongst other countries, are investing in sophisticated naval assets that could be employed to cut specific cables in a targeted and covert way. Submersibles with arms that can manipulate objects on the sea bed can place taps, cut cables or leave devices that could cut cables upon command in the future.

Many countries have an oceanographic presence but these establishments remain separate from the defence sector. In other countries, however, they are more allied.

The research ship ***Yantar***, for example, is officially classed as Auxiliary General Oceanographic Research (AGOR), with underwater rescue capability. She is tasked by the GUGI (Main Directorate Deep-Sea Research) which is an arm of the Russian Defence Ministry although separate from the Navy.

Yantar has been seen operating close to seabed cables on several occasions by open-source intelligence analysts and is doubtless tracked much more closely by professional naval intelligence. It is not inconceivable that vessels such as these have been engaged in information gathering, charting the location and vulnerabilities of cables and other undersea energy infrastructure should they wish to interfere with them in the future.

The US also maintains a secretive underwater network of sensors (Formerly SOSUS, now known as the Integrated Undersea Surveillance System (IUSS)) used to track submarine activity.

IUSS is increasingly mobile and less reliant on fixed infrastructure but it does still exist and adversaries remain interested in the location of the sensor arrays and supporting cables.

As part of its attempts to dominate the Arctic, Russia is known to be laying its own network of arrays under the ice called HARMONY. Incredibly, the system is believed to be powered by a series of small submarine-portable nuclear reactors laid on the seabed.

The construction of such a complicated system is only possible because GUGI operates the largest fleet of covert manned submersibles in the world.

This fleet includes six nuclear-powered mini-submarines; 2 x Paltus (730t) 3, x Kashalot (1,580 t) and Losharik (2,100t). Supporting them are two large 'mother' submarines that can covertly convey their deep-diving babies over long ranges.

Although the construction of HARMONY may be the initial task, this transporter submarine capability means the Russians can potentially interfere with submarine cables unseen anywhere in the world's oceans.

CABLE INTERFERENCE

Cable-interference is a well-established wartime tactic. Perhaps the most famous example was *Operation Ivy Bells* where the US Navy used nuclear attack submarines fitted with lockout chambers to lay cable tapping devices on the Soviet cables that linked the Russian naval base at Petropavlovsk to its Vladivostok headquarters.

The devices recorded conversations on magnetic tapes that were recovered and replaced by regular submarine operations.

SUBSEA CABLES

In February, SubCom completed testing of the Dunant submarine cable. Dunant is the first long-haul subsea cable to feature a 12 (rather than six or eight in past generations) fibre pair space-division multiplexing (SDM) design, which will enable it to deliver record-breaking capacity of 250 terabits per second (Tbps) across the Atlantic Ocean.

It is the second in a series of cable systems that Google has contracted with SubCom

Previous cable technologies relied on a dedicated set of pump lasers to amplify each fibre pair The new SDM technology allows pump lasers and associated optical components to be shared among multiple fibre pairs. This ‘pump sharing’ technology enables more fibres within the cable while also providing higher system availability.

Last year, Google SubCom announced the Grace Hopper cable with 16 fibre pairs (32 fibres).

are responsible for nearly two-thirds of all faults. Piracy also occasionally occurs.

INTERNET

A working principle of the web is that it is part of the network and if one part is destroyed, signals are automatically re-routed via other parts of the system. If a main cable or even multiple cables are severed the sheer amount of traffic and the, very limited spare bandwidth could cause the system to slow down large parts of the web.

One of the legacies of the pandemic is that there is likely to be an greater reliance upon online connectivity. Many organisations are considering abandoning or downsizing their offices as employees demand to work remotely at least part-time or with only occasional in-person meetings.

WAKE UP CALL

In 2017, Rishi Sunak,now the UK Chancellor of the Exchequer but then in the 'think tank', published a landmark document outlining the threat to undersea cables in a UK.

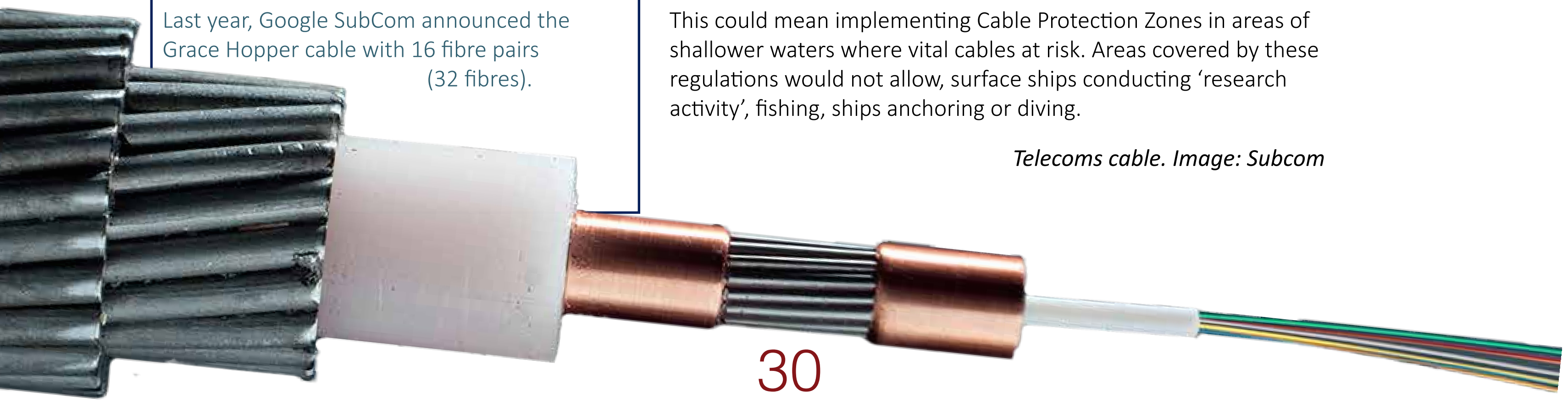
It named Russia as the primary agency for both developing the capabilities and having the potential motivation to interfere with submarine cables. If the UK was not to be caught sleepwalking into connectivity issues, the government would have to take steps to secure the lines.

PROTECTION

Protecting cables that stretch for thousands of miles across the deep ocean floor is extremely challenging and potentially expensive but there are three main ways in which security could be improved.

Legal and regulatory. There is limited protection for submarine cables in international law and this could be addressed with a new International treaty with punitive sanctions against any nation proven to have interfered with cables.

This could mean implementing Cable Protection Zones in areas of shallower waters where vital cables at risk. Areas covered by these regulations would not allow, surface ships conducting ‘research activity’, fishing, ships anchoring or diving.



Telecoms cable. Image: Subcom

Even assuming all nations would be willing to accept a new treaty,the primary difficulty would be to ensure round the clock enforcement.

Capacity and redundancy. Key data traffic routes could be backed up by redundant extra ‘dark’ cables, ideally not marked on charts and buried as much as possible.

There is already some redundancy in the system as accidental cable breaks occur frequently but there is limited financial incentive to invest large numbers of new cables, capable of providing the level of resilience required if a concerted attack cut multiple connections.

Building this additional resilience would likely require government funding in partnership with cable companies.

Surveillance and deterrence. It is possible to fit the cables with sensors that can detect the sonar frequencies used by submersibles intent on interference and alert authorities ashore. It may also be possible to use fibre optic cables themselves as sensors.

Small or unusual movements in the cable caused by interference may be detectable by analysing the transmission of light through the cable. There are already research programmes underway to investigate using undersea cables to measure distant seismic activity.

In recent years, the number and capability or unmanned underwater vehicles has grown and the costs have fallen. These could be used to affordably patrol sections of cable.

According to ***Navy Lookout,*** another maturing solution could be Persistent Autonomous Underwater Vehicles (PAUV). These use very little power and are can operate independently for several months are.

The deployment of patrol UUVs and the inspection and rapid repair of submarine cables could be a task for the new Ocean Surveillance/ Research Vessels. This activity cannot be undertaken by the UK alone and would require co-operation with other nations willing to invest significantly in cable security.

Further improvements in anti-submarine and underwater warfare capability for the RN and across NATO is needed. Small steps such as the new RVs and the procurement of the Manta XLUUV technology demonstrator are moves in the right direction but there is much more to be done to secure the backbone of global communications.

THE CHALLENGES OF SUBSEA ELECTRICAL TESTING

C-Kore units deployed on an Umbilical Termination Assembly (UTA)

CHALLENGES OF SUBSEA ELECTRICAL TESTING

How do you fault find an electrical system hundreds of meters below sea level, containing an extensive network of cables and equipment spread out over an area the size of London?

This is a question that subsea engineers in the oil and gas industry wrestle with daily all over the world. C-Kore Systems, a UK company specialised in subsea testing equipment, is helping subsea engineers solve this very problem.

Subsea electrical networks are essential for the production of oil and gas from subsea wells. They are used to open and close subsea process valves and read-back vital instrumentation on pressures, temperatures and flow rates.

The current trend for these systems to become increasingly complex means that if something goes wrong the challenge of locating the fault becomes increasingly difficult.

When the topside Line Insulation Monitor (LIM) starts to warn that the insulation resistance (IR) of the system is dropping, engineers must plan how to find the source of the low IR. One option is to try and test from topside.

Think of this as the old-fashioned string of Christmas tree lights; replacing one bulb at a time until the rest of the string lights up. Start unplugging the subsea equipment and see if the low IR issue goes away or stays.

However, unplugging equipment subsea is not as quick and easy as it sounds. After securing the appropriate vessel with the correct equipment on-board and having all permits in place, either a diver or ROV goes subsea to start the unplugging process.

Before unplugging, the equipment must be isolated to avoid short circuits, then turned back on once disconnected to see if the LIM's readings have improved. If the readings are unchanged, the process is repeated at another location until unplugging the equipment has a positive effect on the IR of the system.

A time-consuming process, that involves repeatedly powering on and off the system, and waiting on permit approval before each test. There is also no guarantee faults further on down the line are identified if testing is stopped once the first fault is found. Repeated intervention also creates its own risk of introducing additional IR problems into the system.

Another option is to test directly into equipment subsea using a down-line (a very long extension cable) connected to testing equipment located on the back deck of a vessel. The subsea system is isolated, the down-line is deployed, an ROV or diver disconnects the subsea equipment and then plugs the down-line into the circuit.

Testing is performed by a technician on the deck of the vessel. This has the advantage of connecting directly to a segment of subsea infrastructure and not having to test through all the connections from the topside location.

The downline, however, will affect the test readings. A faulty down-line will give faulty results and even a healthy downline will have a detrimental im-pact on TDR (Time Domain Reflectometry) readings. Deploying down-lines in deep waters is a time consuming, expensive and high-risk process.

Furthermore, weather conditions will affect the readings of the topside testing equipment. Trying to get reliable IR readings in damp North Sea conditions can be very difficult. Finally, topside test equipment requires specialised personnel to operate, and results are dependent on the correct operation.

Range of C-Kore tools including their Cable Monitor, Subsea TDR and Sensor Monitor

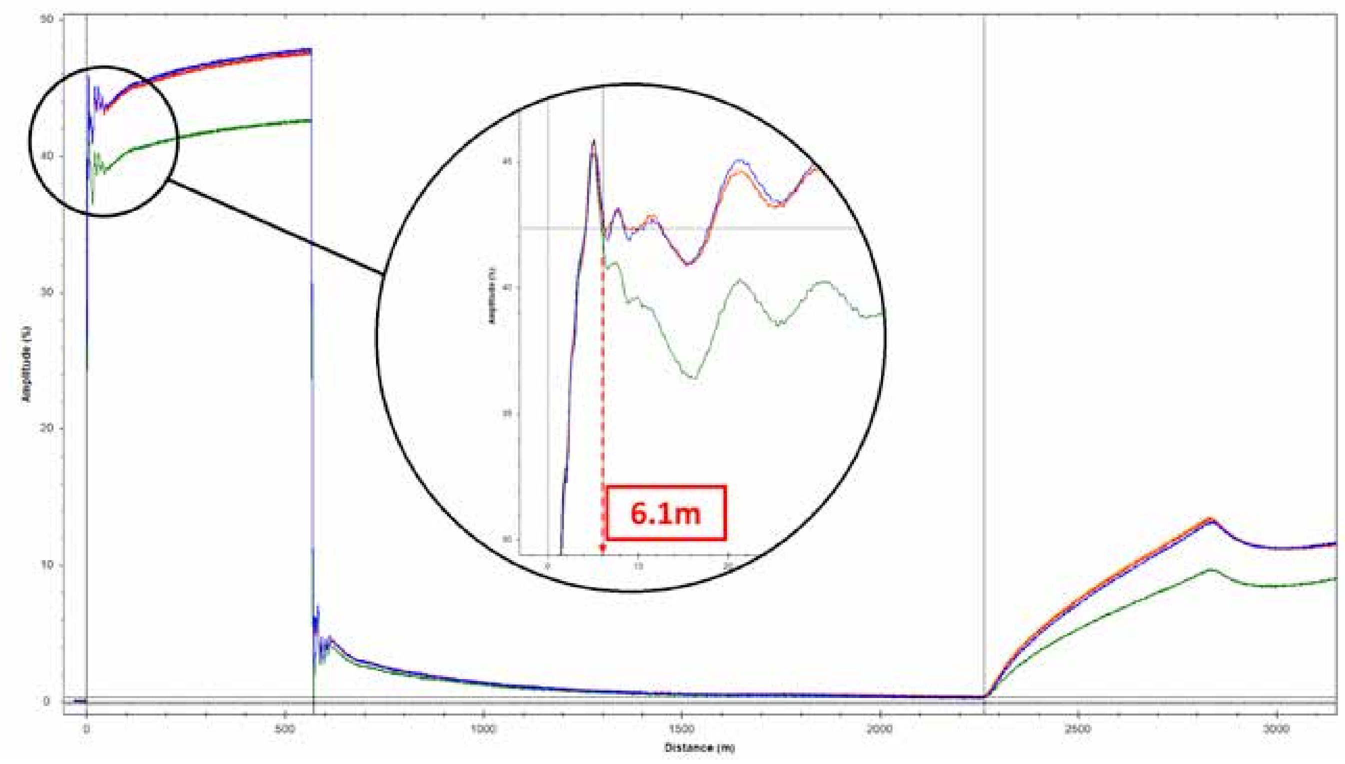


Fig 1 Fault located in subsea UTA

C-Kore Systems has developed a better way to perform subsea testing using a small hand-held testing unit with a wet-mate connector. The C-Kore unit plugs directly into the subsea infrastructure and can be operated by either diver or ROV.

The results displayed and data-logged give the condition of the subsea equipment and are not affected by down-lines or weather conditions.

The units are automated and programmed ahead of time to run the required tests, so no specialised personnel are needed offshore, and therefore the results are not influenced by human interaction.

In fact, the same test program can be downloaded onto the units years later. When plugged into the same equipment subsea, the new results can be directly compared to the earlier results to give a clear indication of any degradation that may have occurred.

Optimising subsea testing campaigns also involves looking at what is important during the operation, such as minimising the number of makes/breaks in the subsea system, minimising the vessel time on-site, or perhaps minimising the vessel movement throughout the field.

All of these factors need to be considered to ensure a quick and efficient work scope is planned.

A subsea field operator came to C-Kore Systems with a typical question: how to best find the source of the low IR that was plaguing their field. They wanted to minimize the makes/breaks of the system and execute as quick a campaign as possible.

C-Kore offered two different testing units to help with the fault-finding campaign. The C-Kore Cable Monitor measures insulation resistance and continuity of electrical lines and can identify which lines contain low IR.

The Subsea TDR unit localises where on the line a fault is, working much like a sonar, but firing an electrical pulse down the cable and "listening" for the electrical echo. By knowing the time it takes for the echo to come back, the distance to the anomaly can be accurately determined.

The combination of both tools allows not only the faulty line to be identified, but the precise fault location along the line's length to be determined.

By reviewing the field's layout in preparation for the mobilisation, C-Kore's engineers were able to advise on the appropriate testing philosophy and tools to achieve the customer's goals.

Going to a central location in the field and using the Cable Monitor to test the IR of the different legs of the field, the customer was able to quickly eliminate equipment that still had acceptable IR, and identify sectors with problems.

By taking both genders of Cable Monitor tools, one break enabled the customer to test the IR on both sides of the break, increasing visibility with fewer disconnections.

This method of testing quickly indicated that an umbilical and an Electrical Flying Lead (EFL) were both sources of low IR. The EFL could be changed out, but the umbilical posed a bigger question.

Was it possible to recover the end of the umbilical and re-terminate, or would the entire umbilical need to be replaced? The C-Kore Subsea TDR unit answered this question.

Figure 1 (overleaf) shows the result of the C-Kore software overlaying the responses from a known healthy conductor pair in a 2.25km long umbilical with one with a low IR fault. When the C-Kore software is used to zoom in on a feature at the near end of the trace a clear divergence between the faulty and healthy cores is seen at 6.1m, correlating precisely with where a field installable connection has been made in the Umbilical Termination Assembly (UTA).

With knowledge of the precise location of this fault, the customer was able to re-terminate the UTA, bringing their subsea field back to good working order with an offshore campaign that was completed quickly and efficiently with the help of C-Kore.

UXO SURVEY TECHNOLOGY

At a recent meeting of the Hydrographic Society in Scotland/ NOSP looking at ***The Next Steps in UXO Survey Technology & Techniques***, Chris Almond from PanGeo Subsea recently looked at 3D acoustic surveys to mitigate the target visualisation

The first stage of any survey focusses on conducting a desktop study. This collates a variety of information sources, such as known maps of munitions dumps, pipelines, wrecks and other seabed data that has been collected over the years from a variety of sources such side scan sonar, multibeam sonar echo sounders etc..

Armed with this information and the proposed route of the cable to be laid, the operator can commission a geophysical survey. Perhaps the most common tool used is a magnetometer which is towed across the planned area to produce a magnetic anomaly map highlighting ferrous metals on the seabed.

"A wind farm development could highlight targets revealing everything from debris to munitions and cable/pipelines depending on the location" said Almond. ROVs are then sent to carry out visual investigation. In 24 hours, they can look at around 5-10 targets, with more than 90% of targets found not to be UXOs.

A typical identification campaign could last 3 to 6 months and look at thousands of targets. This has prompted companies to use complementary tools to reduce the number of false positives."

PanGeo has developed a 3-D sub bottom imaging tool that produces a continuous high-resolution 3-D volume acoustic image in real-time with a subsea resolution of 5cm.

"The PanGeo Sub-Bottom Imager (SBI) measures acoustic impedance or more importantly, the boundary between different impedances that represents a surface or buried structure. It detects everything from ferrous pipelines and cables to nonferrous bodies such as boulders or concrete mattresses

When coupled with a magnetic UXO survey , the data can be combined to reduce the number of targets.

"It is particularly good at finding the shape and dimensions of the target," said Almond."The accuracy is also dependent on the speed of the survey and the natural distribution of the targets

"With reference to a magnetic anomaly map, it is possible to overlay the three-dimensional acoustic shape map to eliminate targets. It can mean the difference between looking at a munition or a clump of wire.

"One reason that some magnetic data produces false positives is that there was perhaps metal there once, but it has long since corroded away yet some sort of ferrous presence remains. It will still produce a magnetic response although the original metal body has disintegrated.

By acquiring the acoustic data, you are able to confirm that there is no acoustic anomaly associated with the magnetic anomaly, confirming a false positive reading in the magnetic data. Should an acoustic anomaly be present, by comparing the shape and dimensions to known munitions the overall magnetic target listing which requires visualisation can be reduced by a significant volume, driving down the time spent on site and as a consequence, the cost.

"In the Second World War some munitions had aluminium casings. These cannot be detected by magnetometers but can be detected by acoustic systems assuming the exterior is not corroded, said Almond. The presence of non-ferrous munitions is a small but growing issue however these acoustic surveys can and previously have located LMB mines within the sub-seabed.

PanGeo's Sub-Bottom Imager

PanGeo's Sub-Bottom Imager on a ROV