Protecting submarine cables for enhanced connectivity

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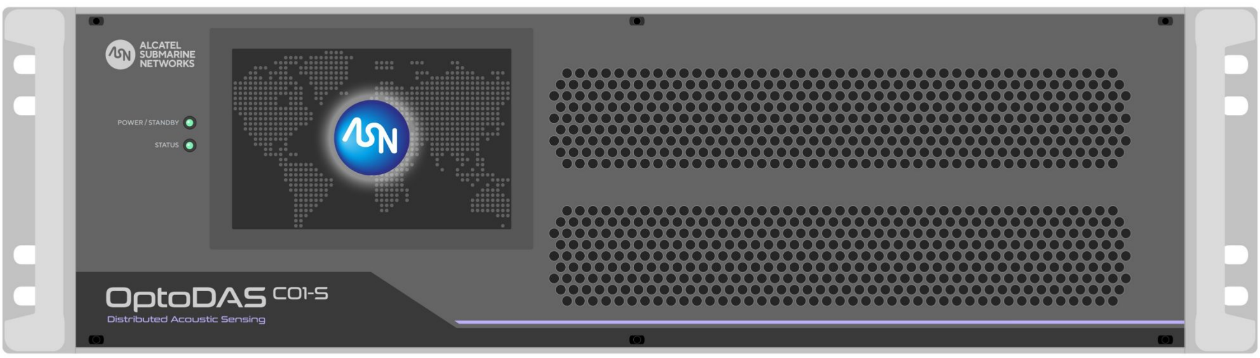
Morten Eriksrud, at ASN Norway AS, looks to the protection of the global network of submarine cables and other critical subsea infrastructure

Optical communication technology is the key technology to making internet connectivity available all over the world. Fibre-optic cables, distributing data with the speed of light, connect continents, countries, and islands together by creating a global telecommunication network. These cables are installed subsea and are placed on the seafloor (in deep water areas) or trenched in the seabed (in shallow water areas). This global network of submarine cables contains more than 400 active cable links covering nearly 1.4 million kilometres (over three times the distance from Earth to Moon). More than 95% of the global internet traffic runs through these submarine cables. Submarine cables can carry far more data at far less cost than satellites and the increasing digitalization of our societies will further increase the number of submarine cables.

Online data traffic is nearly impossible without functioning submarine cables

The growing dependencies on the internet in multiple areas make societies more vulnerable to submarine cable failures. On average, there are over a hundred breaks of submarine cables every year. Unintentional damage from fishing vessels and ships dragging anchors accounts for more than two-thirds of all cable faults. Environmental factors like earthquakes also contribute to damage.

In the context of the war in Ukraine and growing international tensions, the security and resilience of submarine data cables are receiving growing attention (1). Together with subsea high-voltage DC power cables (for the transport of green energy) and subsea pipelines (for the transport of oil and gas), the submarine cables (for the transport of information) are considered critical subsea infrastructure and need to be protected against deliberate attacks. Advanced surveillance capabilities will be required to improve the resilience of this subsea infrastructure.



Using Distributed Acoustic Sensing (DAS) to detect disturbances

One attractive technology for monitoring this critical subsea infrastructure is Distributed Acoustic Sensing (DAS) utilizing an optical fibre in a submarine cable as a distributed sensing element located on the seabed capable of detecting disturbances in the water and on the seabed. This sensor capability is achieved by launching light from an OptoDAS interrogator, located on the land side of the cable, into the optical fibre and detecting the characteristics of the light reflected along the optical fibre from the inherent light scattering process in the glass material of the optical fibre.

By analysing the light reflected from the optical fibre, the interrogator is able to monitor changes in the time delay of the propagating light (ie changes in the speed of light) along the optical fibre. If the light's travel time changes at a certain location, the interrogator reproduces the sound or vibration of the event at that location – be that a surface vessel, fishing equipment on the seabed or any other activity in the water or on the seafloor.

Using DAS as a tool in seismic tomography and ocean dynamics

DAS is extremely sensitive and even the tiniest time delays can be measured, making it possible to detect any activity creating relative movements of the seafloor down to the picostrain range with the ASN OptoDAS interrogator. ASN is using a different interrogation technique than competitors, giving a greater range in terms of signal to noise – up to more than 150 km from the interrogator can be monitored.

The beauty of DAS monitoring is that the sensing element is a standard optical fibre used in telecom cables. If a DAS interrogator can access a fibre in a submarine cable, it can convert the cable to a continuous array of sensors. One example is to track vessels crossing the area of installed submarine cables [(2)]. Another example is to track fishing gears in the vicinity of a submarine cable [(3)]. Gears hitting the seafloor up to more than 2 km away from the cable are visible with the OptoDAS interrogator. Scientists have also demonstrated that OptoDAS can record vocalizing baleen whales along 120 km of an arctic submarine cable [(4)]. It is also scientific interest to apply DAS as a tool in seismic tomography and ocean dynamics [(5)]. Earthquake monitoring with submarine cables have been reported by several scientific groups [(6)].

Real-time monitoring of any threats to submarine telecommunication cables require access to one single fibre in the cable. OptoDAS will then be able to monitor activity nearby the cable up to more than 100 km from the cable landing point where the cables reach land. This is normally the most vulnerable area with respect to interference from fishing and anchor drop activities but is also worth defending from other types of attack to disrupt the submarine cable.

Developing an optical amplifier for better DAS signals

The current OptoDAS technology limits monitoring to a cable distance of 100- 150 km from the cable landing point or to the first telecom repeater (since the DAS signal is not transmitted through a standard telecom repeater). However, many submarine telecommunication cable links are several thousand km long (with repeaters every 60-70 km) and many high-voltage power cables are longer than 200-300 km which currently is the maximum length to be fully DAS monitored from both ends. Subsea oil and gas pipelines can also be several hundred km long. How can we extend the monitoring range of OptoDAS to more than 1000 km?

The answer is to do the same as has been done in the optical telecommunication systems – to develop an optical amplifier (called an optical repeater) to be inserted at about every 70 km along the cable link. The optical repeater will have to be modified to handle DAS signals instead of data communication signals. Then a simple submarine cable with DAS repeaters can be installed to monitor any subsea infrastructure. Early warning of unidentified threats can be used to initiate other surveillance systems – for instance, underwater drone activity.

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