Effective Subsea Cable Repairs

Cable showing shunt fault damage. 'Scrapes' from lateral movement on the seabed and oxidisation resulting from power short are clearly visible.

Cable Break

Despite all best measures to protect subsea network cables against damage, failures are sometimes unavoidable. Natural disasters such as earthquakes, and man-made pursuits such as fishing / trawling or anchor drag from shipping can all have catastrophic effects. Faults may occur at any time and at any position on the globe. In FLAG Telecom's case, this can occur in over 100,000 square kilometres of ocean, and in locations ranging from the beachhead on which the cable lands to water depths of more than 8,000 metres. This variation in potential fault location, alongside the logistical and engineering complexities associated with operating at sea, can make the process of effecting subsea cable repairs one of the most complex fault management tasks within telecommunications. FLAG is an expert at the rapid isolation and repair of subsea cable faults. This paper introduces the key procedures adopted by FLAG to perform submarine network repairs, and highlights just some of the capabilities that enable us to do this quickly and with minimal disruption to customer traffic.

Shunts, Crushes and Breaks

The most common subsea network faults encountered are shunt faults and cable crushes or breaks:

- Fibre-optic cables carry electrical current to power the optical amplifiers within the repeaters. The copper conductor, which surrounds the fibre-optic 'bundle', is insulated from the surrounding seawater. A leak may occur within the insulation layer, causing the electrical current to drain to earth through the water. This in turn can prevent full system power from reaching downstream equipment. Such leaks can be caused by erosion to the cable, for example due to cable movement over a hard rock area caused by water currents or seabed shift. In the majority of cases no immediate fibre damage is caused and if the system can be single / double-end fed with current of the opposite polarity from either end, the cable can continue in-service until a repair can be planned and executed
- Cable crushes or breaks can be caused by 'events' such as natural disasters or unplanned human intervention (e.g. ship anchor drags). A cable break is the most fundamental failure, cutting a cable into two separate lengths and ceasing operation

Locating and Repairing Faults

A standard process is applied to locate, retrieve and repair cable faults. A repair ship is dispatched to the fault area with a FLAG Marine Engineer on-board to manage activities. Electrodes are towed over the cable to detect the change in electrical field strength caused by a disruption to the normal current flow. Once located, the repair ship drags a grapnel cross the cable path at the point where the electrical field strength decreases to lift the cable end to the surface. Once recovered, optical and electrical tests are conducted towards shore. The retrieved end is placed on a buoy before recovery and test are completed on the other cut end. After clearing both ends, a new piece of cable is spliced into the system, which is then re-laid back towards the buoy. The two ends are then re-

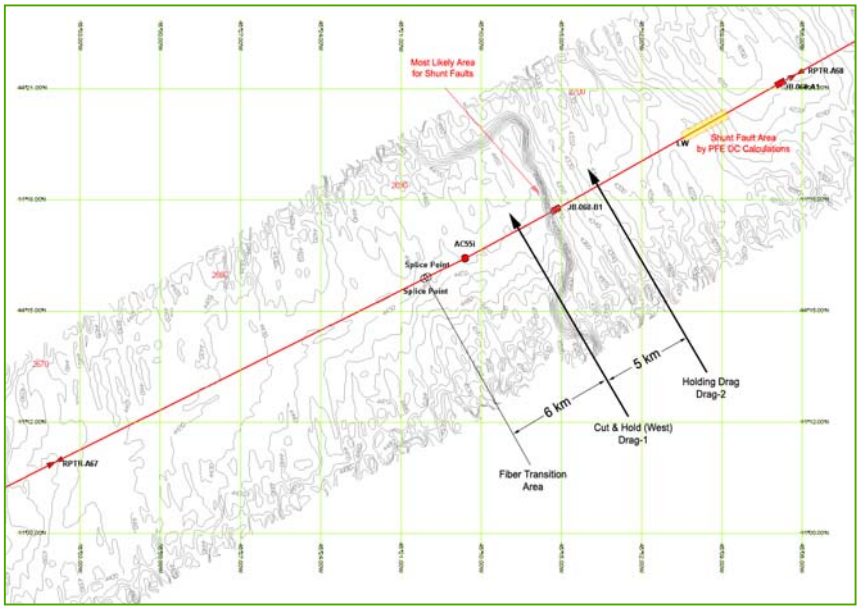
On-site fault inspection by a diver

spliced and tested on-board, before being lowered to the bottom and released with an acoustic release hook.

FLAG Telecom Cable Repairs

FLAG can point to a range of features and capabilities than enable us to ensure rapid cable repairs:

- The FLAG Marine team has over 100 years combined experience in cable route planning, installation and maintenance. This team is on 24-hour callout and is available to fly out immediately to join any one of 12 cable ships that are pre-positioned globally to repair the FLAG submarine cable in the event of a fault
- FLAG plans cable routes in fine detail, and insists on unusually detailed notation of the geographic positioning of the actual laid route. This as-built information is transferred to cable Route Position Lists (RPL), which are specially modified for fault-finding. As a result of these stringent documentation procedures, FLAG has consistently been able to locate cable faults with better than 99.8% accuracy
- FLAG designs a Method of Procedure (MOP) for every fault type and individual repair. This provides a full specification of the expected fault location and exactly how we want it repaired. The MOP also provides a definition of tests to be performed and includes charting information produced with FLAG's GIS system. This level of detailed preparation and instruction to the marine service provider is not seen with all cable maintenance authorities

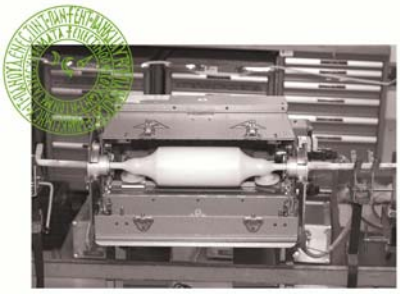


Route & Survey Chart included within a typical FLAG repair MOP. This example pinpointed the precise location of a fault and provided 'cable drag' instructions to the repair ship

Buoy 'cutaway' during a cable fault repair

- When a shunt fault occurs, electrolysis will rapidly eat away the copper and steel components of the cable if the proper current balance within the system is not carefully maintained. Within days or even hours, hydrogen gas can degrade the fibres at the shunt point and seriously impair or stop traffic flow. As another part of the MOP, FLAG provides instructions on maintaining proper powering conditions so that service can be maintained until a full repair is completed
- FLAG uses the very latest in optical test equipment (Coherent Optical Time Domain Reflectometers) alongside highly sophisticated software algorithms that simulate electrical line potentials under resistive shunt conditions. Tools such as these, in combination with detailed commissioning records, frequently enable FLAG to be the first provider to repair faults in situations where multiple provider faults occur
- As the maintenance authority for the FLAG Telecom subsea network, we are directly and solely responsible for ongoing management of Marine Maintenance Agreements (MMA) that facilitate and cover the storage of spare cables, repeaters and other replacement parts, the coverage areas of repair ships, and maintenance costs

The result of these features is that FLAG is often the quickest in the business to get to the site of a fault, the quickest to isolate and locate faulty cable, the quickest to repair faults, and the quickest to get our customer traffic flowing again on the original, primary route. We believe our sub-10 day average cable-repair time is well below industry benchmarks. Whilst this statistic is important and our rapid-repair capability is critical, the most important fact is that the large majority of cable faults do not stop our traffic flows. The following case study provides a useful, real-life illustration of our strength in this area.



Spliced fibre mold undergoing examination via x-ray

2003 Algerian Earthquake

In May 2003, an earthquake centered on Algeria caused severe damage extending over thousands of kilometers. The earthquake was a major disaster in both human and economic terms. All subsea cable networks in the Mediterranean basin encountered serious disruption. FLAG Telecom's job was to make sure that this was not also a major disaster in telecommunications terms. This was particularly important to FLAG as a primary carrier of traffic to, from and via the Middle East.

FLAG was the first Maintenance Authority to respond, and one of the first to restore full service in this instance. The Algerian earthquake is a live example of our ability to rapidly pinpoint the location of cable faults and to dispatch the repair vessel. Other examples include the Pacific earthquake experienced off the coast of Taiwan in December 2003, where again FLAG was one of the quickest to locate, repair and restore the fault. Throughout the Algerian earthquake repairs, FLAG was able to restore all circuits against which customers had ordered protection despite outages. Furthermore, and based upon an understanding of the severity of the natural disaster, FLAG contacted all customers who had purchased unprotected circuits and was able to offer short term restoration solutions. FLAG's efforts were widely welcomed by our customers, and were made possible through our on-net restoration capabilities via Italy and via the USA/Pacific, our dedicated customer commitment and through our effective response processes to network events and faults.