GLOBAL TRENDS IN SUBMARINE CABLE SYSTEM FAULTS

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Abstract: This paper is written on behalf of the Submarine Cable Improvement Group (SCIG). Fault data from undersea systems continues to be collected by several organizations. The SCIG attempts to analyze and present the data in order to provide a basis for improving the cable protection and overall undersea telecom network reliability. This analysis highlights recent system faults with focus on data from the last six (6) years and provides a continuation of previous global trend studies which were presented in 2010, 2007, 2004, 2001, and 1997.

1. FAULT DATA SOURCES AND METHODOLOGY

While the industry has continued to place great focus on cable routing, burial, armoring, cable awareness, and Automatic Identification System (AIS) programs to improve protection and reduce fault rates, there continues to be about 150 to 200 faults per year globally. In addition, many new systems have been installed in the last six (6) years since we last reported; these are often subject to higher risk until charts are updated and seabed users become aware of their location. Furthermore, there is a greater use of the seabed with renewables and oil and gas and mineral extraction. Natural hazards such as typhoon induced turbidity slides\(^1\) (Taiwan) and Earthquakes (Japan March 2011) continue to cause cable faults.

The density of network cables on the ocean bottom has made cable protection and network planning crucial to the uninterrupted service of undersea communication. Understanding these events and the resulting faults underlies the purpose of many fault studies.

The task of collecting fault data and maintaining fault databases continues to be carried out by several members of the SCIG and others within the submarine cable industry. As in previous reports, this year’s analysis is based on TE SubCom’s database, that of Alcatel-Lucent Submarine Networks, and that of Global Marine Systems Ltd.

In general, the three databases compare well. This study focuses primarily on the last six (6) years, but bridges the data back to previous studies published by some of the same authors. In some cases, yearly data is presented. In others, comparison to previous years is made to bring out potentially significant differences.

Specifically, the focus is on trends over the last six years from 2010 to 2015, inclusive, and, in some cases, on comparable data from 2004 to 2006 and 2007 to 2009. Other studies on the time to commence repairs in national...
jurisdictions have been critical to aid our understanding of where improvements are needed in permitting processes\[2\][3] (The referenced studies are complementary to this analysis).

Fault data have been separated into three general categories: External Aggression, Manufacturing, and Other. Within the External Aggression category, data was subdivided between Fishing, Anchors, Abrasion, Geological, and Others. Faults where a category or cause could not be determined or was not recorded (Unknown) were not included in the statistics.

It is worth noting, as reported in 2010, that great efforts continue by numerous maintenance organizations around the world to correctly assign or reassign many Fishing or Other/Unknown faults to the Anchors category. In these cases, vessels unknowingly deployed their anchors while under way, and dragged them across undersea cable systems causing the faults, or may have anchored over cable systems in error, having not consulted or ignored updated navigation charts.

These findings by the maintenance organizations are due to the continued—and increasing—use of their investments, along with others, in readily available technology (Automatic Identification System [AIS]) that allowed a better and more accurate tracking of vessels with respect to undersea system locations.

However, as it is with most field data collection efforts, some interpretation is required. In instances where faults could not be binned, these were assigned the special category of “Unknown”; and are not included in the statistics. We believe that the overall conclusions within the study are not affected by these interpretations.

As in previous reporting, the data are presented in two sections. First, the total number of faults throughout the world, as reported in the three (3) databases, is presented from an absolute (percentage) point of view. Second, the data is normalized using the total number of systems and their associated lengths. Length-normalized fault rates are presented in units of ‘faults per 1000 kilometers per year’, calculated as the sum of number of faults divided by the total length of cable known to the respective organizations. The data is further separated into two depth ranges – cable in less than 1000-meter water depth (shallow water) and cable in greater than 1000-meter water depth (deep water).

2. ABSOLUTE FAULT ANALYSIS

Faults are grouped in three major categories where External Aggression, System Manufacturing, and Other (such as corrosion and a few faults that did not fit the other two categories) are separated. These are also presented by data source (TE SubCom, A-L SN, & GMSL). The overall trend corresponds well with previous studies \[3\][4][5][6][7][8] as shown in Figure 1, where External Aggression faults continue to represent the dominant category.

![Figure 1. Overall Causes of Fiber Optic Cable Failure](image-url)
They range between 90% and 95.4%, whereas Manufacturing-related failures are in the range of 4% to 6%, and Other/Unknown range between 0% and 3.5%, depending on which database is considered. The variation between companies is small and well within our ability to categorize faults. We also note that no one company has a complete set of all faults.

External Aggression faults are further separated into sub-categories in Figure 2a, which include either human activity or natural aggression. These are also presented by data source.

Faults attributed to human activity, such as fishing and anchors are clustered from about 67% to 72% of the External Aggression faults recorded by the three companies. Seven out of ten External Aggression faults continue to be attributable to human activity, either from fishing or from dropping and/or dragging anchors.

Undersea cable maintenance organizations in selected regions are now able to better bin the failures with AIS technology and therefore assign numerous faults which would have been attributed to Fishing in the past into the Anchors category. The higher abrasion fault rate in the ASN data may be attributed to shore-end surf zone abrasion—a factor that should not be ignored when planning and protecting cable landings.

Despite this, the overall fault rate due to human activity (mostly fishing and anchors) remains in the 75% range. Figure 2b shows the distribution of these faults by depth. There is a slight increase from six (6) years ago showing a downward trend from 82% (2004-2006) to 74% (2007-2009) to 72% (2010-2015).

Geological faults show a slightly higher percentage attributed to earthquakes and turbidly slides. Here we compare the five combined categories for three periods, before and after the use of AIS.

Nonetheless, Fishing remains the major cause of human activity faults, making up about 39% of all External Aggression, down from 43% and 66% in the SubOptic 2010 report and the SubOptic 2007 report, respectively.

Natural Aggression includes such faults as earth movement and chafe/abrasion. Abrasion failures, remaining less than 10%, have averaged about 6% over the
Emerging Subsea Networks

three data sets. Again, Geological failures are slightly higher and could possibly be attributed to greater turbidity currents and earthquakes reported throughout the globe. Furthermore, no Crushing faults were reported.

For expediency, the rest of the data analysis is conducted using one data source, as we have established equivalency between the three databases.

All External Aggression faults with respect to depth are presented in Figure 3a.

![Figure 3a. Depth Distribution (m) of all External Aggression Faults](image)

The majority of the faults still occur in water depths of 300 meters or less where over 75% of faults occur. Only about 20% of faults occur at depths greater than 1000 meters. The data are quite similar to 2007 to 2009 but different from that of 2004 to 2006.

The number of External Aggression faults in less than 100-m water depth, where new cable has been more deeply buried in the last six years, has declined slightly to 54% (was 70% in the 2007 to 2009 period. Figure 3b compares the three periods: 2004 to 2006, 2007 to 2009, and 2010 to 2015. The difference is clearly shown between the three time curves between 100 and 700-m water depths. Deep-water (greater than 1000 meters) External Aggression faults are still around 15% to 20%.

![Figure 3b. Depth Distribution of all External Aggression Faults Comparing (3) Time Periods](image)

Figure 4a focuses on fishing faults with respect to water depth. Similar to all external aggression faults, fishing faults are correlated with depth for depths less than 1000 meters. The trend has remained consistent over the last two analysis periods.

![Figure 4a. Water Depth Distribution (m) of Fishing Faults](image)

However, the latest period (2010-2015) shows a slight decline in the 100 to 200-meter range, due to the deeper burial (3 meters) of new systems. Fishing faults in
The 300-800m range have increased slightly. This may be explained by fishing activity moving into deeper water—as fishing sources have depleted inshore in many areas.

The fishing faults deeper than 1500m water depth are attributed to fish aggregating devices (FADs); trawl and trap fishing occurs at than less than 1500m water depth.

Figures 4b and 4c present Anchor faults and Human Activity faults (Fishing & Anchors), respectively. Figure 4b shows some anchor activity beyond what is considered normal anchor deployment.

It is possible that these anchor faults were actually due to stow net anchors related to fishing activity.

3. LENGTH NORMALIZED DATA

The purpose of plotting and analyzing historical fault data is to attempt to focus improved protection measures or routing in order to reduce the overall number of faults, through studying individual faults, group of faults and trends. A useful standard unit is obtained from further analysis of the data, when one normalizes the fault rate per year by the length of undersea cables deployed around the world. Such standard/reference unit, normally called Faults per 1000 kilometers per year, is then obtained by dividing the number of faults by the total length of cables deployed.

Length-normalized fault rates per year, in shallow and deep waters, are presented in Figure 5 over the last decade and a half. The rate has been decreasing overall, and steadily declining over the last several years.

The rates indicate about 0.05 faults per year per 1000 kilometers for deep water, and less than 0.13 faults per year per 1000 kilometers for shallow water, over the last six years.

The rest of the data analysis concentrates on faults in shallow water, i.e. less than 1000 meters. Annual fault rates for all External Aggression causes are presented in Figure 6. The average rate over the last 10 years remains at a steady 0.1 faults per year per 1000 kilometers.
The years 2010 and 2011 saw rates almost double the average at approximately 0.2 faults. We note that the rate over the last 4 years shows an average of about 0.07 faults per year per 1000 kilometers.

Figure 6. Length-Normalized External Aggression Faults in less than 1000-m Water Depth

Figure 7 presents fishing faults only. Over the last decade, the average has increased from about 0.05 to about 0.08 faults per year per 1000 kilometers. This continues to be an extremely low rate.

It is even slightly lower than usual as some historically counted Fishing faults are now properly binned as anchor faults. As we reported in 2010, the overall low rate is certainly due to systematic cable burial and cable awareness throughout the world.

Figure 7. Length-Normalized Fishing Faults in less than 1000-m Water Depth

Figure 8 shows the absolute number of deep-water faults (deeper than 1000 meters) per year. This rate is about 1 fault per year (had been about 2 previously) over the last decade with no fishing faults reported the last three years.

The second largest category of external aggression faults, in less than 1000-meter water depth, is that of anchor faults. Figure 9 shows an average of about 0.023 (down slightly from 0.025) faults per year per 1000 kilometers over the last decade.

Figure 8. Absolute Fishing Faults in greater than 1000-m Water Depth

These faults are mainly concentrated within busy harbors and ship traffic areas.
which are hard to patrol and protect. We believe that the decrease in anchor faults is due to better awareness through AIS monitoring and notifications aimed at commercial vessels.

Figure 9. Length-Normalized Anchor Faults in less than 1000-m Water Depth

4. CONCLUSION

Global analysis of undersea system fault data from the last six (6) years shows trends that are both consistent with other major suppliers’ databases and show a continuation of improvements seen in the analyses done for previous years.

External aggression remains the primary cause of faults (90 to 95%), and fishing faults constitute the majority of those (over 40%). However, deep water (>1000-meter) fishing faults continue to be rare. Anchors while ship-under-way are now a slightly greater percentage, as they are better-identified (25 to 30%) and due possibly to more cables installed in shallow water regions.

Most faults continue to occur in less than a 300-meter water depth. We believe 3-meter burial on new systems is improving protection in shallow water. In this reporting period, 2010 to 2015, 74% and 80% of faults were in water depths less than 200 and 500 meters, respectively. Deepwater geological faults showed a slight rise due to the continued exposure of cables to typhoon and earthquake induced turbidity slides.

These conclusions provide global trends. Regional and local rates vary significantly. Normalized fault rates, for the length of cable deployed, show annual external aggression fault trends continue to be extremely low.

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6. REFERENCES