GLOBAL TRENDS IN SUBMARINE CABLE SYSTEM FAULTS 2019 UPDATE

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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 cable system supplier organizations. The paper analyzes and presents historical cable fault data to assist with designing and improving new cable routes advancing cable protection of undersea systems, enhancing cable system reliability, and planning and budgeting of cable spares and a maintenance program. Data from three independent suppliers are used in the analysis to obtain results with statistical significance. This analysis highlights recent system faults and provides a continuation of previous studies which were presented in 2016, 2010, 2007, 2004, 2001, and 1997. Global trends are reported with a focus on data from the last three (3) years. Observations with respect to fault causes, water depth and regional differences are described.

1. FAULT DATA SOURCES AND METHODOLOGY

The reliability of submarine cable networks continues to be largely influenced by cable breaks caused by external aggression. Route planning with a focus on cable protection is crucial to ensuring un-interrupted service of undersea communication. Understanding these cable break events and the resulting faults are the underlying reasons for this fault study so that new routes can be designed with the knowledge of the historical fault record.

Collected data on cable faults from three submarine cable marine operators have been used to provide an industry update on cable fault statistics. While none of the three companies claim to have data on all faults that have occurred, the comparison between the three datasets is nevertheless illuminating and indicative of the primary fault causes. The paper also references an annual report issued on behalf of the International Cable Protection Committee (ICPC) [1][2] that provides statistics on repairs and vessel mobilization time to initiate repairs, shown by country. This dataset is believed to be the most representative of fault data which shows that there are over 200 faults per year on average and the number is growing as more kilometers (km) of cable are installed. While the data from the three author companies do not record 200 faults/year, the data shown as a percent of total are indicative of the whole dataset within our margin of error.

We again note that the industry continues to place great focus on cable routing, burial, armoring, cable awareness, and Automatic Identification System (AIS) programs to improve protection and reduce fault rates.

In addition, many new systems have been installed in the last three (3) years since we last reported. These new systems are often subject to higher risk until nautical charts are updated and mariners become aware of their locations.

As in previous reports, this 2019 analysis is based on SubCom's, Alcatel Submarine

Networks', and Global Marine Systems Ltd.'s individual databases.

In general, the three databases compare well over the three-year focus period from 2016 to 2018. Fault data have been separated into three general categories: External Aggression, Manufacturing, and Other. As in the paper presented three years ago, in instances where faults could not be allocated, these data points were assigned to a fourth special category of "Unknown" and are not included in the statistics.

Within the External Aggression category, data were further subdivided into Fishing, Anchors, Abrasion, Geological, and Others. Faults where a sub-category or cause could not be determined or was not recorded (Unknown) were not included in the statistics. We believe that the overall conclusions within the study are unaffected by these allocations.

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 km per year', calculated as the sum of the 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 meters(m) (shallow water) and cable in greater than 1000m (deep water).

2. ABSOLUTE FAULT ANALYSIS

Faults are grouped into three major categories, including External Aggression, System Manufacturing, and Other (i.e. that do not fit the first two) and are compared by data source: SubCom, ASN, and GMSL. The overall fault trend corresponds well with previous studies [3] [4] [5] [6] [7] [8] [9] [10] [11] as shown in Figure 1, where External Aggression faults continue to represent the dominant category. There are only slight differences (within 5%) between the data sources despite many non-overlapping faults. External Aggression faults range between 87% and 92%, whereas Manufacturing-related failures are in the range of 5% to 12%, and Other range between 0% and 2%, depending on which database is considered.

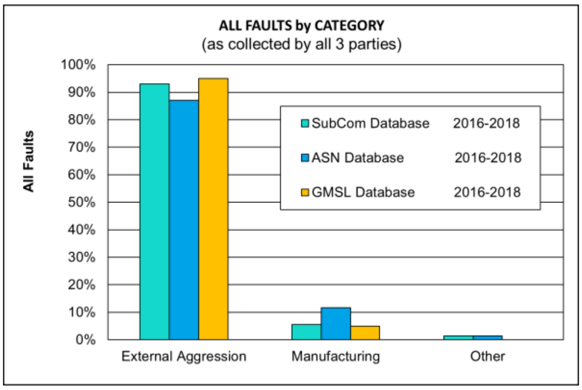

Figure 1: Overall Causes of Fiber Optic Cable Failure

The variation of fault data among the 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 both human activity (anchors and fishing) and natural causes (geological and abrasion). These are also presented by data source.

For External Aggression faults recorded by the three companies, eight out of ten (80%) are attributable to human activity, either from fishing or from anchor (i.e. dropping, dragging, etc.). This percentage is a slight increase from previous years showing 74% (2007-2009) and 72% (2010-2015), respectively.

We note a higher percent of fishing faults in the GMSL data. As is often the case, some of the faults attributed to fishing may have been caused by anchors (or vice versa). This is particularly true if AIS data is not available for a vessel or a region. We are more confident that the cause of the fault is reasonably accurate when the particular vessel involved is identified. When a vessel has not been identified, the fault cause is determined by a judgement based on available circumstantial findings such as cable damage, water depths, burial depths, fishing intensity, and anchorage proximity. The identification and categorization of faults is not infallible.

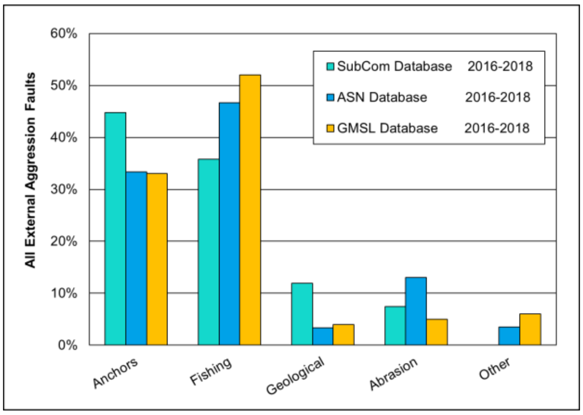

Figure 2a: External Aggression Faults for all Water Depths

The SubCom data show higher geological faults likely due to the bias of the number of repairs performed in areas where there are known turbidity currents. [9] The higher percent of abrasion faults reported by ASN may be due to the number of deep-water repairs they have completed.

Figure 2b shows the comparison with previous reporting periods. The SubCom data show an increasing trend in the percent of fishing faults from 31% to 41% from the 2007-2009 period to the current period, 2016-2018. Anchor faults range between 40% and 45%. Geological faults continue to show a slightly higher percentage attributed to earthquakes and turbidity slides.

Natural causes include such faults as earth movement and chafe/abrasion. Abrasion failures, remaining less than 10% in the 2016-2018 period, have averaged about 10% over the three data sets. For expediency, the rest of the data analysis is conducted using various combinations of the three data sources, as we have established equivalency among the three databases.

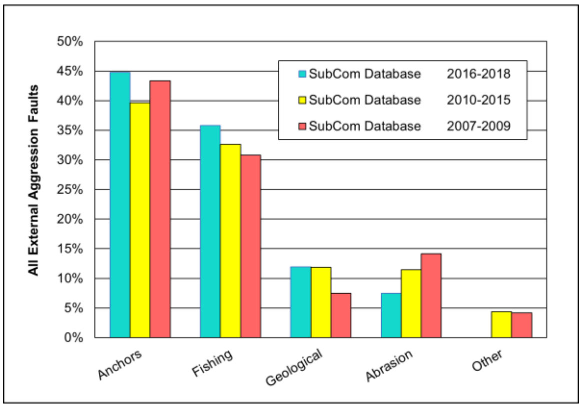

Figure 2b: Comparison of Faults by Category (all water depths) from 2007 to 2018

All External Aggression faults as a function of water depth are presented in Figure 3a and compare SubCom and GMSL datasets.

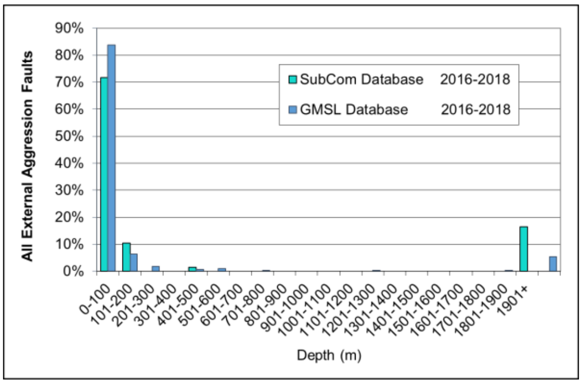

Figure 3a: Depth Distribution (m) of all External Aggression Faults

Most of the External Aggression faults occur in water depths of 100m or less. This water depth range is where between 71% and 83% of faults occur. Approximately 5% to 10% of faults are recorded in the 100 to 200-m water depth bin. A few faults show up in the 400 to 700-m depth ranges. Just under 20% of external aggression faults occur at depths greater than 1000m.

Figure 3b shows that faults vs. depth is quite consistent over all reporting periods. The SubCom data show small increases in deep-water faults from 10% to 16% over the three reporting periods.

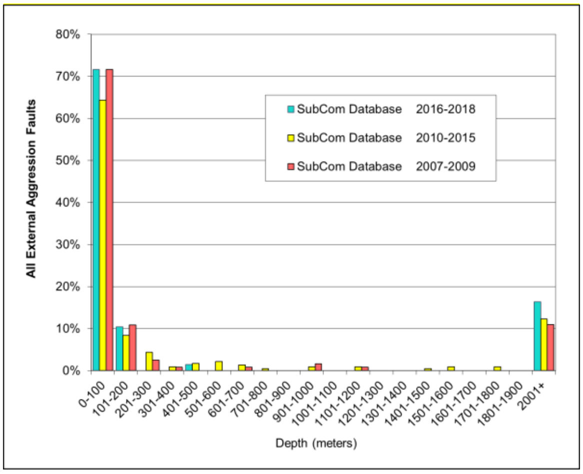

Figure 3b: Depth Distribution of all External Aggression Faults Comparing (3) Time Periods

Figure 4a focuses on fishing faults alone with respect to water depth and compares the data from the three company databases. Similar to all external aggression faults, fishing faults are correlated with depth. All of the companies' data generally agree and show more faults recorded in shallow water (80% to 88% shown by SubCom and GMSL). The ASN data show a trend within the 100 to 200-m depth range likely due to a bias of their area of maintenance operations.

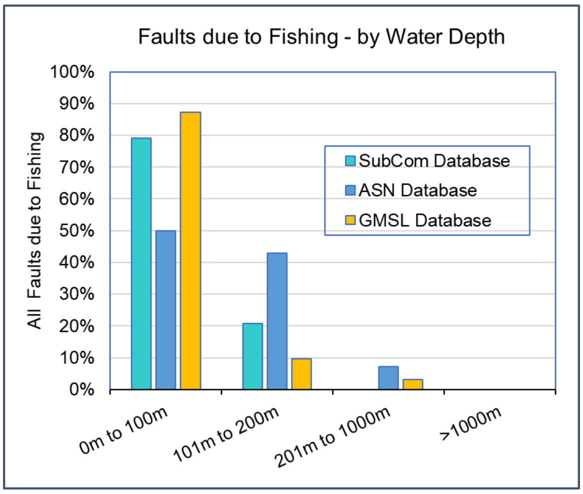

Figure 4a: Water Depth Distribution (m) of Fishing Faults

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

Figures 4b and 4c present Anchor faults and Combined Fishing & Anchor faults, respectively. Figure 4b shows some anchor activity beyond what is considered normal anchor deployment (i.e. < 100m).

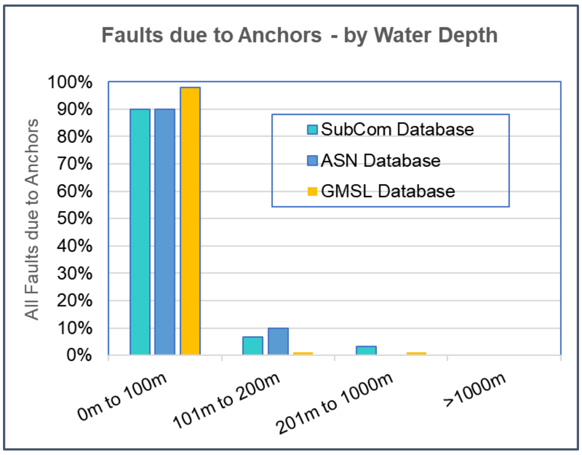

Figure 4b: Water Depth Distribution (m) of Anchor Faults

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

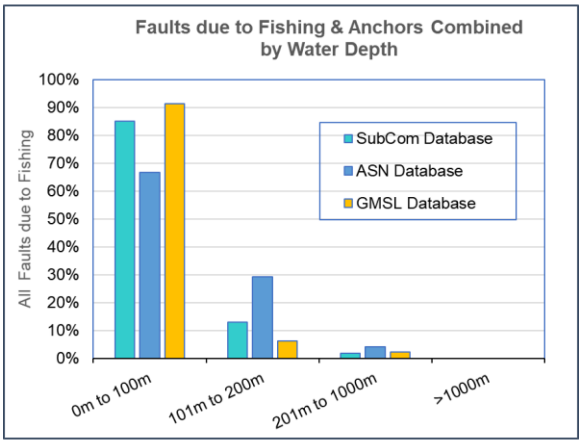

Figure 4c: Water Depth Distribution (m) of Fishing & Anchor Faults

As expected anchor faults are most prevalent shallower than 100m while fishing faults can extend much deeper. This is reflected in the plots when comparing Figures 4a, 4b, 4c.

3. LENGTH NORMALIZED DATA

Fault occurrences normalized by cable length deployed around the world and by year provide a very useful metric for easily predicting fault rates on new routes based simply on cable length.

This reference unit is only useful in a global sense, since it could be misleading if one uses it locally where fishing, and/or geological trends are significantly different.

Length-normalized fault rates per year (from 2010 on), in shallow and deep waters, are presented in Figure 5. The fault rate has been decreasing overall, and steadily declining over the last several years. Note that 2018 is incomplete since some known 2018 faults have not been characterized and entered into the SubCom database.

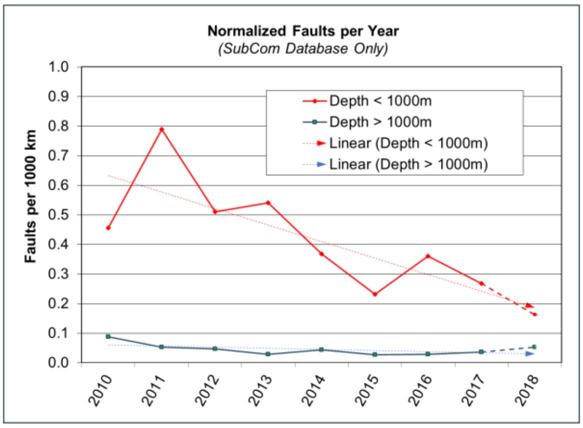

Figure 5: Length-Normalized Overall Fault Rates for Depths < 1000m and Depths > 1000m

The rates indicate about 0.04 faults per year per 1000 km in deep water (> 1000m). For shallow water (< 1000m), there is a trend of declining rates of faults over the last eight years with the last three years averaging 0.26 faults per year per 1000 km as compared with 0.40 (eight-year average).

The rest of the data analysis concentrates on fault trends in shallow water.

Annual fault rates for all External Aggression causes are presented in Figure 6.* The average rate of 0.27 faults per year per 1000 km remains in decline over the last eight years with the shallow water rate reaching an average of about 0.18 faults per year per 1000 km in the last three years.

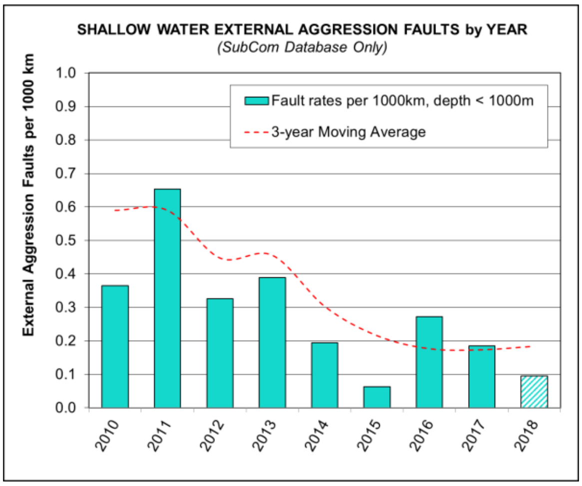

Figure 6: Length-Normalized External Aggression Faults in less than 1000-m Water Depth

Figure 7 presents fishing faults only. Over the last eight years, the average has decreased from about 0.11 to about 0.06 faults per year per 1000 km for the last three years.

It is 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 8 shows the absolute number of deep-water faults per year. This average rate is less than 1 fault per year over the last

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* *Absolute fault rates shown in Figures 6 through 9 are lower than in Figure 5 due—in part—to the fact that "unknown" faults (those not attributed to external aggression) were not included. The trend over time is the relevant metric.*

eight years with no faults recorded in the last two years.

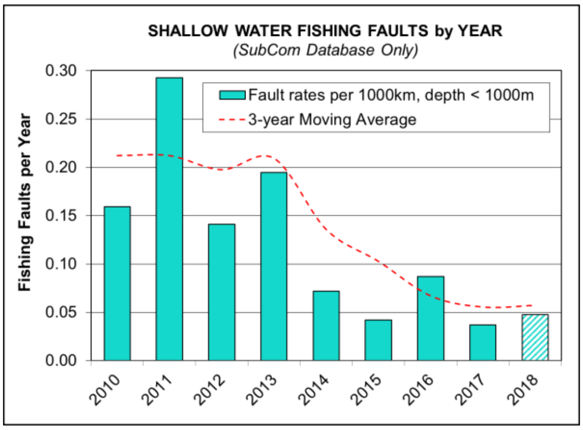

Figure 7: Length-Normalized Fishing Faults in less than 1000-m Water Depth

The second largest category of external aggression faults, in less than 1000-m water depth, is that of anchor faults. Figure 9 shows an average of about 0.12 per year per 1000 km over the last eight years and about 0.10 in the last three years.

These anchor 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.

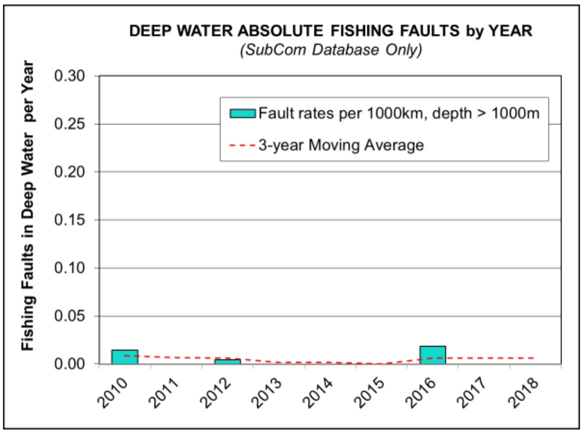

Figure 8: Absolute Fishing Faults in greater than 1000-m Water Depth

This year, we are including a snapshot of All External Aggression Faults based on three oceans: Atlantic, North Pacific, and South Pacific for the 2016 to 2018 period. Interestingly, the North Pacific had a higher percentage of Anchor faults as compared to the Atlantic. Whereas, the Atlantic had a higher percentage of Fishing faults.

In the South Pacific, only Abrasion faults were recorded in this time period (hence the 100% bar in that category).

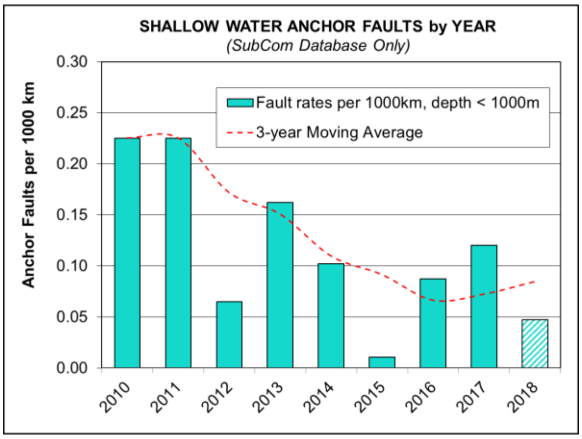

Figure 9: Length-Normalized Anchor Faults in less than 1000-m Water Depth

As mentioned earlier, these statistics show how global data could be somewhat misleading if applied to regional locations where anchoring, fishing, and/or geological trends are significantly different.

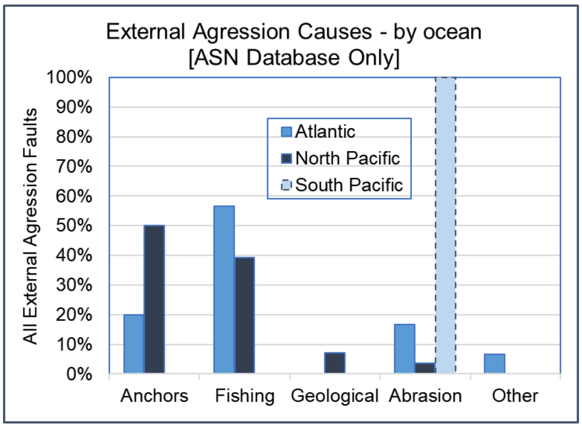

Figure 10: Comparison of External Aggression based on Atlantic, N. Pacific, and S. Pacific Ocean Regions for 2016-2018

4. CONCLUSION

Global analysis of undersea system fault data from the last three (3) years shows trends that are both consistent among the major suppliers' databases and a continuing trend of decreasing faults as seen in the analyses done for previous years.

Normalized fault rates, for the length of cable deployed, show annual external aggression fault trends continue to be extremely low.

Most faults continue to occur in less than a 200-m water depth. External aggression remains the primary cause of faults (87% to 92%), and fishing faults constitute the majority of those (~49%) followed by anchoring (~35%). Where both fishing and anchoring are prevalent, there is correlation with higher percent of faults in 0 to 100-m water depth. Fishing faults occur out to 1000-m water depth; deep water (> 1000m) fishing faults continue to be rare.

Continued uncontrolled anchoring, fishing pressure, greater use of the seabed, and geological events pose the primary risks to cables. We believe 3-m burial on new systems where warranted and when seabed allows for it, is improving protection in shallow water.

Natural hazards such as typhoon induced turbidity slides continue cause a slight rise in deep water geological faults. Although there is continued exposure of older cables, new systems avoid these deep canyons and are less prone to turbidity slides.

These conclusions provide global trends. Regional and local rates vary significantly.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

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