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Needed versus Helpful in Submarine Network Supervisory

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In response to insatiable capacity needs, the traffic capacity of submarine systems has increased greatly over time, in part due to the development of higher-bandwidth amplifiers, in part thanks to better terminal technology â€" coherent detection and multi-level/dimensional transmission formats. Branching units have also become more sophisticated, with reconfigurable wavelength routing an objective in many systems. Commercially there have also been changes, notably the upgrading of existing systems with third-party equipment and more recently the purchase of line plant separately from the terminal equipment.

How do these affect the supervisory requirements? And which supervisory approach is best positioned to accommodate such new requirements?

Different Supervisory Schemes

The passive supervisory schemes, loop-back and Coherent Optical Time Domain Reflectometry (COTDR), have some similarities, both essentially measuring only optical loss. COTDR, however offers the possibility of measuring the position of a loss change, while the loop-back scheme can only locate it to being between two amplifiers. Both require lengthy averaging for a measurement, which isn't generally a problem, but does make it difficult to determine precisely when a change occurred. The focus on loss means that pump health can only be assessed when the pump output has dropped to the point where the amplifier output has degraded significantly.

The command-response scheme provides a much more rapid measurement and can report on pump currents before the amplifier output is affected (enabling preventive maintenance); it can also provide a range of other useful data. It can locate a fault or loss change to the nearest amplifier, but cannot provide higher precision. Hence, repeaters are now available that also include the coupling needed for COTDR. The command-response supervisory scheme also offers the possibility of changing the operating parameters or configuration of submerged equipment.

Pump Performance Monitoring

Growth in optical bandwidth has required significant increases in the output power of pump lasers. Moves to composite amplifiers (such as C + L or EDFA + Distributed Raman Amplifier) are likely to continue this trend, with each new system needing more power than the previous one.

With higher powers and shorter development cycles, it seems prudent to be concerned about the reliability of pumps, even if the track record of reputable suppliers has so far been good. Havir a scheme that makes it possible to monitor pump performance â€“ e.g., drive current, output power, and temperature â€“ means that unexpected aging will be detected at an early stage.

Open Systems

A second factor making more comprehensive monitoring desirable is the recent interest in "open" systems. With submerged equipment and terminal equipment coming from different suppliers, there is the obvious potential for difficulties if system performance degrades. Does the problem arise because of the terminal degradation or is it due to submerged equipment?

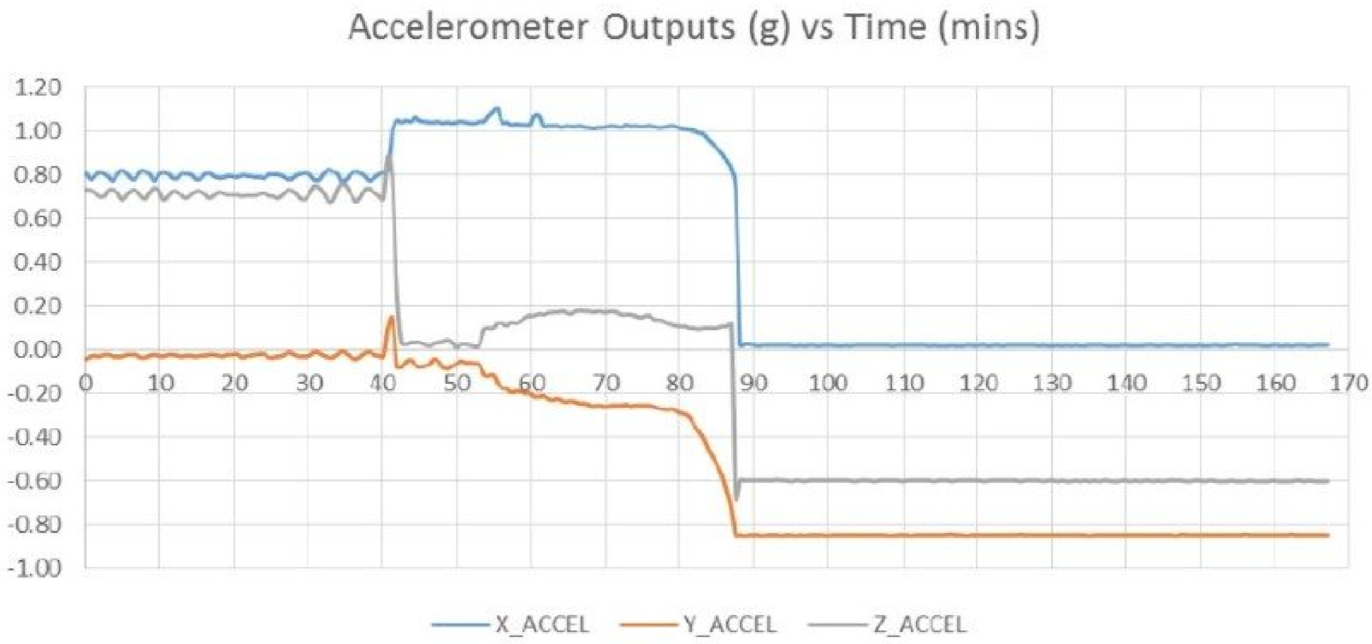
With good data on light levels, pump currents, and other submerged parameters, it becomes much easier to decide. Without such data, there is the potential for wasting time and effort debatin whether the terminal or the submerged line is the source of the problem.

Extra Information for Free

A further factor is the belief that while certain information may not be necessary, it may be helpful. An example is the accelerometers Xtera put in its prototype repeater, which were intended for use only during sea-trials. Customers said that the information they provide would be helpful; it was suggested that having them in the repeater would both enable monitoring of the arrival of th repeater on the seabed and encourage the marine installer to ensure a gentle landing!

While we can't say if such encouragement would work, the accelerometers have revealed a significant difference between the time at which the repeater actually arrives on the seabed and the predicted time. They also make it possible to deduce the degree of twisting during deployment.

Figure 1 illustrates the information the accelerometers make available. In the example, one can deduce from the Y and Z values that the final inclination is twisted axially by about 55 degrees. Such information otherwise would be apparent only by sending a remotely operated vehicle (ROV) to inspect the deployed submerged equipment and take photographs.



Submarine operators expressed interest in information from accelerometers installed in a prototype repeater.

Remote Control of Submerged Plant

The ability to provide remote control of submerged units, however, is probably even more valuable than the monitoring benefits so far described.

For example, branching units often provide power switching. In the first designs, the power switching relays were controlled by the current flowing through the branching unit. This approach aimed for design simplicity, but it created complexities in powering up and reconfiguring. It was not easy for people who rarely did this to ensure that the current flow was as required; it typically took a long time due to the required coordination between all the branching stations. Under fault conditions, a branching unit might change its power configuration, and for a non-expert it takes some time to work out what has happened by analyzing all the power-feed data.

Using the supervisory to switch the relays and to report the branching unit power configuration removes many of these issues. Powering up and reconfiguring can be further simplified via additional features the branching unit developer may provide that ensure that power glitches don't affect the unit's configuration and that "hot switching" doesn't damage the relay contacts.

Further useful branching unit features that require commands are the control of switchable ROADM units and the ability to lock the grounding of a branching unit leg for safety while a repair is carried out. In this latter case, no configuration commands are permitted until the code used to lock the branching unit is resent.

Gain tilt from cumulative repairs is a concern for long-term system operation. Some suppliers address this by providing adjustable tilt equalizer units; others provide amplifiers with controllable t
In either case, the ability to control submerged units is the key.

There are other ways that tomorrow's wider bandwidth amplifiers can benefit from remote control. Such amplifiers typically have multiple pumps with more complex algorithms driving them â€“ amplifiers that combine distributed Raman and EDF with separately controlled pumps, for example. While the control scheme can be left to make adjustments autonomously, some users are concerned that this approach can mask aging effects. These users prefer to make adjustments manually.

There is also concern that any fixed control scheme will not necessarily be optimal for all modes of operation. For example, there are cable systems that operate at reduced line current as a wa of reducing the output power to accommodate changes from direct detection to coherent detection at a higher line rate. The ability to control the power output of different fiber pairs independently, however, is something that can only be done with remote control.

Given that different pairs may well be owned by different operators and thus be upgraded in varying ways and at different times, it seems clear that independent power control is very worthwhil

Command-Response Supervisory

A supervisory system based on a command-response scheme, versus one purely based on loop-back, is best positioned to provide the benefits described here. It can measure useful parameters such as temperature, acceleration, etc., while adding almost nothing to the complexity of a repeater. And in the case of open systems, the clarity that such information brings could help resolve the question of where performance problems have originated.

But perhaps more significant is the use of commands to control submerged equipment. Traffic routing in a branching unit is really only possible if there is some form of remote control. The abili to control the behavior of individual fibers is also worthwhile, where they may be carrying different line-rates and signal formats, as upgrades may occur at different times or use different transmission formats.

Submarine systems are becoming more sophisticated, as are the commercial models for operating them. For this process to continue, they need a supervisory scheme that produces clear information and allows flexible control.

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