HOW ABOUT TECHNICAL SKILLS WITHIN THE SUBMARINE INDUSTRY?

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Abstract: The submarine business is always described as a small industry with high expertise and challenging requirements. A limited number of turnkey suppliers exist and the learning curve for acquiring a credible technical background is long for any new player (vendor or operator). However on the one hand, some suppliers have delivered unreliable wet plants while some others have failed laboratory demonstrations or field trials. On the other hand, some operators became more sensitive to financial considerations and marketing, offering more managers than engineers to the industry.

This paper elaborates on both aspects - failures of suppliers and change in the operator's mind-set - which can both contribute to a fundamental change in the industry.

1 THE TWO SIDES OF THE SCENE

1.1 My system is running fine

In formal discussions, cable owners are always pleased with the submarine systems they are running and it is quite rare to hear owners reporting problems in operation & maintenance. The definition of a "successful system" can take multiple forms that are not exclusive:

- The cable routing/burial/armouring is such that a very limited of external traffic-impacting aggressions are experienced. Link availability is also dependent on dry equipment reliability and protection scheme(s).
- The wet plant is future proof. This can ease upgrades beyond the design capacity, especially with the 100 Gb/s technology. This implies profitability.
- The capacity can be efficiently managed by using intelligent wet/dry equipment that can adapt dynamically traffic profiles with no trouble, optimize the actual line channels utilization and minimize the bandwidth allocated for protection/restoration.

All these definitions have in common the only key parameter for cable owners: return on investment (ROI). The business case must allow them to manage capacity supply and demand by using their existing submarine cable assets in the most efficient way. Unfortunately, the world is not ideal and many systems may not be running so fine.

1.2 Maybe not so fine

From the above, a successful system assumes that it has no intrinsic problem and conforms to the quality requirements of the supply contract. In the real world, this assumption has proven to be disputable in the recent years and two concrete metrics can be defined to verify it:

- The number of wet plants suffering from repeater 980nm Laser Diode issues.
- The number of WDM retrofit programs.

The latter might not be deemed critical because exchanging boards in a rack is not technically difficult and does not affect the existence of the system itself. However any dry equipment that does not work per the specifications in the first place and requires complete replacement indicates an issue with quality/performance control.

The former is quite different since in the end, it can jeopardize the system performances and even commercial lifetime. That is, it can demolish the business plan of the cable owners and affect the financial resilience of the supplier in question.

2 THE TWO UNPLEASANT METRICS

2.1 980nm LD pump issues

The conventional industry metric for the reliability of the submerged equipment is the expected number of ship repairs over a 25 year system life, it was developed in the mid-1990s [1]. This excludes faults due to external aggression. In general, due to redundancy, the failure of one laser diode used within the repeaters does not require a ship repair. Based on reliability engineering, the number of expected failures during the system lifetime can be predicted and systems are designed to survive them.

However, it is evident that severe operational problems have developed with the 980nm pumps in the last 3-4 years. Numerous unexpected failures are now affecting many systems worldwide. For some systems, cable owners already know that all repeaters are at risk and are likely to be replaced. For some others, Weibull analysis [2] indicates that this is due to infant mortality hence failure rate is expected to decrease over time. In both cases it is lengthy and requires the highest expertise in many connected fields to establish the root cause. Four major findings can be reported:

- Failures can declare after many years of operation
- Root causes amongst systems are diverse
- Unreliable wet plants were delivered by different suppliers
- Accuracy of the supervisory system is crucial to identify pump degradations in time

The 980nm pumps failures experienced by cable owners have two main origins:

- Intrinsic. This reveals a design problem that often comes from packaging, more so than from laser manufacture itself [3]. This problem is generally dependent on operating or local environmental conditions. The fact is that no supplier produces this key element, and a very limited number of manufacturers exist.
- Extrinsic. This reveals a dependence with external factors that was not identified during design and qualification. Most of the time, these failures are due to weak protection against electrical aggressions.

Due to confidentiality clauses, no name of supplier or submarine cable can be reported in this paper. However, the number of laser diodes potentially at risk is telling: around 10,000[1]. Almost 10% of them have already failed and required more than 80 repeaters to be recovered. Tens of other repeaters are also eligible for replacement. No less than at least nine systems are affected; they entered service between 2000 and 2010. For some of the systems, repeater replacements may become more impacting than the cable repairs due to external aggressions (e.g. fishing, anchors) considered in the power

[1] Author's personal estimates

budgets. They may also represent a significant portion of the Operation & Maintenance cost (for reminder, a marine operation is ~600 kUSD on average, excluding the cost of refurbishment or new manufacture). Obviously the accuracy of predictions (how many abnormal pump failures should be faced during the 25-yrs lifetime) depends on i) understanding of the root cause of failures and ii) number of samples available. But when the single failure probability is significantly increased and exceeds the contractual values, the number of ship repairs can be impacted and the probability for multi failures in the same amplification unit is also increased. Consequently, regardless of other contractual obligations, meeting the individual equipment reliability is crucial.

2.2 Retrofit programs

Despite discussions on sparing levels [4], retrofit programs for dry equipment (SDH, WDM) or numerous software upgrades/fixes in the field have also been experienced on systems in recent years. They related to 10G and 40G products, OOK and PSK formats. For two established submarine vendors, these programs have concerned around 900 transponders each over the last two years. The cause of these retrofit programs is not unique but in most cases, proper burn-in testing during qualification, using prototypes which use the same components as the real product, would have alerted designers and prevented hardware failures on site with commercial products.

These reliability issues and subsequent deterioration of submarine vendor's image may also explain to some degree why the upgrade market is now almost completely dominated by relatively "new entrants" [5], even at 100G. This might cause a problem to the industry in the long term.

2.3 Consequences

When confronted with these recurring problems, anyone would look at reasons and lessons to learn for the future. So who to blame? There is an easy and contractual answer to that question: the willing buyer has bought, the willing seller has sold, and the responsibility of the product quality goes with the vendor, always. For example, when the 980nm pumps were introduced into the submarine repeaters at the end of the 1990's, most of the suppliers knew that the failure mechanisms were different from the 1480nm pumps and required improved reliability assessment techniques. The cable owners had no other choice than accepting this new technology in their systems. Also, and more fundamentally, the business of cable owners is to make capacity available for their customers, they do not design systems or require specific technologies or techniques. Suppliers are responsible for poor quality – and they pay for it most of the time – but this may be too simple an answer.

Besides monitoring periods, health checks, trouble-shooting regular actions, etc. repeater failures have many critical implications for cable owners that are not exclusive:

- Temporary loss of traffic during repeater replacements and unexpected use of restoration/protection resources
- Decrease of Q factor performances, regular transmission link re-optimization (e.g. gain control, wavelength reallocation) and sometimes re-design of these links
- Annihilation of system upgradeability
- Decrease of system lifetime

SLTE retrofit programs compromise the ability of cable owners to free up bandwidth on time for their customers and either cause delays (means penalties) or loss of business due to competing cables.

On the other hand, suppliers always suffer from repeaters/SLTE problems since they bear all costs associated with replacements through "amicable" settlements. Such financial exposure is obviously tragic and can ultimately lead suppliers in question to severe financial difficulties. More insidious is the underlying loss of confidence in suppliers, whoever they are, and the temptation for some cable owners to set requirements in contracts in anticipation of problems to come, instead of findings ways to avoid them before contract signature. One aspect of that loss of trust can materialize with more stringent requirements in bank guarantees, liquidated damages and other clauses of the Terms and Conditions, which cable owners do not want to exercise normally. This change in mindset is problematic in the medium term because sooner or later, Parties have to work together to bring projects to success. As in the economy and stock market, confidence is key and determines the type of the relationships desired.

3 THE TWO-SIDED SPECTRUM OF SKILLS

The submarine industry, which generates millions of profits and billions of communications, actually relies on a limited number of technical experts, whatever the field of expertise is. They belong to two categories: suppliers and cable owners.

3.1 The blue band

It is supplier's exclusive responsibility to design, manufacture, install and commission systems. It then becomes natural that most of technical experts belong to this category. However it is clear that some teams have either downsized or re-oriented priorities. This is visible in the field of qualification as discussed above, which is where the problem basically lies with the repeater failures and SLTE retrofit programs. Many suppliers have expanded subcontracts and sometimes critical components are not even double-sourced until issues appear. Developing new products (e.g. soft FEC, Digital Signal Processing chips, new generation OADM branching units) from the concept definition to the R&D phase and product validation, developing skills for personnel is long and represents a significant source of costs. This is especially true when some products did not really match their market applications but in practice eased technology emergence for "better" products (e.g. 40G coherent boards).

Unfortunately, outsourcing critical components/modules not only offers cost saving to system suppliers, it places them at the mercy of very few manufacturers. In the medium term, transfer of technology goes with transfer of skills. This transfer has been visible for some suppliers when the first 40G/100G coherent were demonstrated in the laboratories. Within a few years, the expertise necessary for designing submarine systems moved from 100% optoelectronics (direct detection systems) to almost 100% signal processing (coherent systems). The use of recirculating loops and so-called offline performance measurements has revealed gaps between capacity predictions and capacity that could reasonably expected during laboratory demonstrations. Some of them have failed, and these were a big first in an industry where technical excellence has always been a top-1 priority.

3.2 The red band

At the other side of the spectrum and for interfacing the suppliers, cable owner experts have also reduced. France Telecom may be one of the last operators having dedicated R&D forces for submarine and experts in all fields. Training them and understanding all multi-levels underlying implications of technology breakthroughs is also expensive in time and monies for

operators. Many of them do not want to take their share of the burden and either i) are not participating in submarine project as team leaders/experts or ii) simply copy/paste from other systems without any intention of improvement.

As a result, operators bring more managers than engineers to the industry, at a time when many representatives want to be tagged "expert of consortium X" for prestige. Suppliers may have observed this change since the marketing approach developed in the aggressive terrestrial market is now expanding to the submarine business. "Successful field trial", "best technology available", "incomparable reliability" are magical words used on PowerPoint presentations by many vendors, and statements are sometimes taken for granted by their audience. Unfortunately, this approach hides the subtleties of technologies and the complexity of products. It hides the fact that due to implementation, there is often a difference between a technology on paper and a commercial product. It may also leave the impression that no challenge can exist technically because slides are philosopher' stones for non technical people. This may explain why some operators now want to be the first to deploy brand new technologies on all their systems, whatever the real benefit could be, while they would have been reluctant to take any risk years ago, even if the understanding of the said technologies was more complete. In the end, the virtuous circle from constant challenging (operators) to innovation (suppliers) in a fair context is broken.

Looking at a complementary angle, some operators think that they can secure their interests on the commercial front only assuming that, whatever the problem is, in the end the terms and conditions apply, which is true. But i) there is no more technical anticipation and ii) without expertise, it is difficult to assess the degree of problems one encounters and set priorities. Bottom line, no case can be settled without proper technical resolution.

This dangerous erosion in skills is also visible during supplier selection. It is well known that many approaches can exist for evaluating offers. The predominant form is now based on a "smart" set of key parameters and a number of relative weightings which contribute to an overall score and ranking. No methodology is perfect but the critical drawback of this one, which consists in mixing technical and commercial/project-oriented considerations, is basic. No priority or non negotiable requirement exists anymore, and that this can cause an offer to be ranked first provided it is cheap and quick to implement, while it is technically questionable.

Note: between blue and red bands is normally the green band. This band is made of consultants who come from either of the two above categories, sometimes after retirement. Consultants can be freelancers or work for limited-size firms. They can offer services on strategy (e.g. predictions in bandwidth requirements, new emerging markets or areas) and/or technical expertise. This expertise was initially acquired in big companies with significant means at that time. It is then maintained via experience and continuous work with the operators and suppliers but is no longer "home-made".

4 CONCLUSION

Two types of catastrophic events occurring on submarine systems were highlighted and some background on technical skills was presented. Suppliers, including newcomers, have to seriously look at appropriate manufacturing processes and reliability analysis before releasing equipment, especially in view of new wet products currently developed (e.g. OADM

branching units). Operators have to remember that nothing comes for free and that any technical decision has long-term implications. Overall, if the technical connection between suppliers and operators is lost, no one can predict who is really at risk. These are both sides of the gun.

5 REFERENCES

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6 ACKNOWLEDGEMENTS

I would like to thank very much Mr. P.Booi from Verizon for his constructive review and all valuable comments made to improve the paper.