POP TO POP : REMOVING THE TERRESTRIAL SUBMARINE BORDER

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Abstract: The performance of POP to POP seamless system resides in a well designed and protected backhaul compatible with the submarine system to be extended. In this paper, we discuss the different protection schemes ensuring the high availability of submarine systems while moving transmission equipment from beach to city, the impact of mixing terrestrial and submarine links on optical system design as well as the requirements of the single management system for terrestrial and submarine equipment mixing.

1. INTRODUCTION

The terminations of submarine system are mostly located close to the seashore in the Cable Landing Station (CLS) where the Submarine Line Terminal Equipment (SLTE) is often collocated with the submarine cable Power Feed Equipment (PFE). As PFE and high voltage safety requires a protection which might not be permitted by a long terrestrial cable, this cable station is often connected to the submarine cable via few kilometers of a land cable. In this conventional configuration, connection to the operator's Point Of Presence (POP) located in urban areas is done through a terrestrial system which is fully independent of the submarine system.

This architecture has been recently more challenged with the important increase of capacity of submarine cables brought by ultra large repeaters bandwidth and reduction of channel spacing which could lead to hundreds of regeneration per fiber pair in the CLS to bridge the submarine system to the terrestrial system.

Integrated submarine and terrestrial systems with terminations located in the operator's POP will form a single system with single line terminal equipment. This hybrid system provides a reduced space requirement and power consumption in the terminal station, an improved latency even if regeneration delay is marginal in a submarine system.

From a system operation point of view, the hybrid system shall be operated with a single wet and dry equipment management system and shall permit quicker capacity provisioning and simplified maintenance procedures assuming the system is managed by a unified maintenance team.

2. INTEGRATION OF THE TERRESTRIAL LINK IN SUBMARINE SYSTEM DESIGN

The transmission path of a POP to POP system consists in 3 sub-segments, as depicted on figure 1, the wet plant linking beach manhole to beach manhole, the repeater less link connecting beach manhole to cable landing station and the terrestrial repeatered link connecting cable landing station to urban POP. The beach manhole consists in a buried container where the submarine cable is terminated

and jointed to a terrestrial cable. The cable station containing only high voltage equipment to power supply the submarine cable is usually located hundreds of meters from the beach manhole. The POP is located in an urban area and could be hundreds of kilometer far from the seashore.

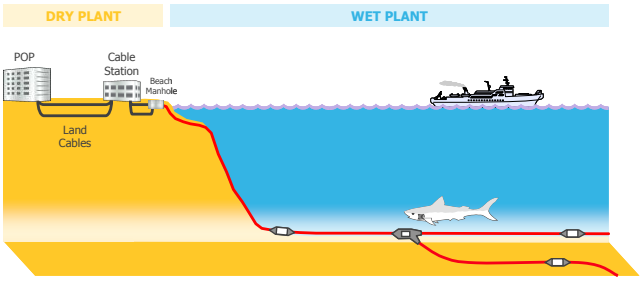

Figure 1 : Submarine System scheme

The design of integrated terrestrial and submarine system leads to revise the optical design of the submarine link with new constraints to ensure a submarine grade transmission performance from POP to POP, with the required aim to keep the high robustness and availability of the system.
While pure submarine system allows for optimization of the repeater spacing depending only on system length and design capacity, the design of hybrid system must take into account the predefined location of amplifier sites and the higher attenuation of terrestrial cable. Such constraints can lead to a design penalty which could decrease the submarine repeater spacing in the wet plant. Consequence may be even more important if terrestrial link is already installed and fiber type is not suitable with a submarine system.

3. TERRESTRIAL LINK PROTECTION

While submarine cable system are very well protected in deep sea and in shallow waters thanks to sound route engineering and cable protections, terrestrial cable is the Achilles' heel of POP to POP hybrid systems.
Different protection schemes must be considered depending on the system topology to protect the transmission path from seashore to POP including duplicated terrestrial cable routes and switching mechanisms to maintain a high level of availability.

Y node configuration

In Y node configuration, depicted on figure 2, cable station and POP can be distant by few hundred of kilometers that require amplifiers in order to maintain the optical budget.

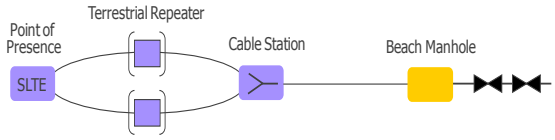

Figure 2 : Y Node Configuration

Protection is performed by switches located in the POP and in the cable station. For this protection scheme, over few hundred kilometers, the two paths can be fully different.

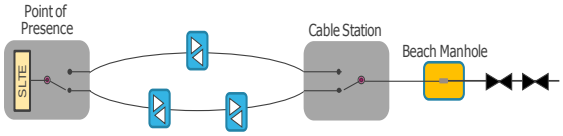

Figure 3 : Y Node protection scheme

V node configuration

In V node configuration, depicted on figure 4, POP is located in the cable station and the terrestrial links are repeater less as the path is usually short enough (i.e. shorter than a submarine repeater span).

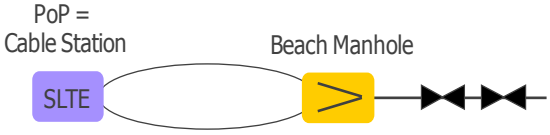

Figure 4 : V Node Configuration

If a cable cut occurs, transmission signal is rerouted on the second fiber. The protection mechanism shall rely on switches located in the POP and coupler located in the beach manhole as the manhole is not supposed to be an adequate place to install switching equipment due to environmental conditions. Such a protection configuration requires special protection protocol.

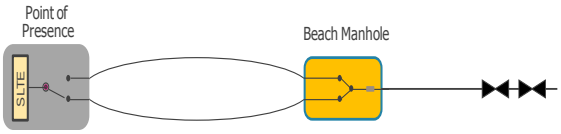

Figure 5 : V Node protection scheme

However it is worth noting that in this configuration the terrestrial section is usually not protected since the land cable route is often very short and installed in a well protected area.

X node configuration

The last configuration uses two duplicated terrestrial link between Beach Manhole, cable station and POP (figure 6).

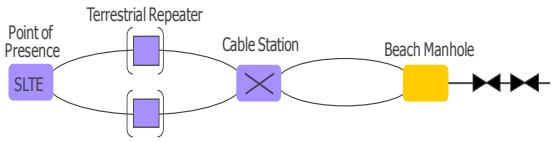

Figure 6 : X Node Configuration

To ensure robustness of the protection mechanism, in the three configurations presented above the switching is performed locally at hardware level. Various switching criteria are considered (e.g. loss of signal, hardware failure, defect indication). Moreover switching is unidirectional and there is no need of a dedicated communication protocol between network elements.

To keep the high availability of submarine systems, optical system design has to consider that the duplicated terrestrial link with protection can bring penalty on the global system, especially if we consider terrestrial cable repairs and environment variations on the cable and on the land repeaters. It is therefore necessary to pay attention to the equalization of different paths, or to provide a margin on the design of the system to compensate imbalanced terrestrial routes.

4. SINGLE MANAGEMENT SYSTEM FOR TERRESTRIAL AND SUBMARINE EQUIPMENT MIXING

The operation of a POP to POP system requires a single management system able to monitor and operate both submarine and terrestrial sections. The submarine management system (SMS) shall in particular seamlessly manage terrestrial repeaters.

The various protection schemes presented above shall be transparently managed. Switching is indeed performed at hardware level and the SMS shall provide real time knowledge of the protection status and of the active routes effectively taken by the traffic.

Moreover fault detection shall not be restricted to main routes. Spare routes shall be continuously monitored to enable proactive maintenance and ensure link robustness and high availability.

5. CONCLUSION

A submarine system design with an automatic end to end reconfiguration needs to provision margins for the global system to overcome terrestrial variation and to ensure the traffic recovery. A single management system along the hybrid transmission path leads to a more efficient system monitoring and maintenance.

6. REFERENCES

[1] T. Frisch & G. Raffin, City to city - Avoiding unnecessary complexity, SubOptic 2001 meeting (20-24 May 2001)

