WE LANDED THE CABLE; NOW WHAT?

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Abstract: How will submarine cable networks of the future look? Historically, submarine networks were cable landing station (CLS) to CLS configurations, common routes, common equipment vendors, backhaul circuits, and joint owner operated networks. The industry transitioned towards a point of presence (POP)-POP or data center (DC) to DC network consisting of multiple fibre pairs with individual fibre pair owners. Today, the norm is open cable systems allowing fibre pair owners to terminate at different physical locations, selecting their own SLTE, control upgrades, and circuit activation based on individuals' requirements. Hyper-scalers or cloud operators can consider different traffic termination locations (their own data centers) for their fibre pairs (or spectrum) while carrier or enterprise traffic have choices of existing network POPs or data centers. All owners will share a "near-shore" facility for deployment of PFE but not necessarily for termination of capacity. High bandwidth/capacity applications and hyper scalers will shape the future submarine cable networks routes and termination locations.
Future submarine cable networks will benefit from advances in technology while physical routing will continue to be regional configurations. New subsea routes will continue to be built within region based upon physical diversity requirements, bandwidth and population growth, latency improvements, and favorable regulatory climate; but then what? There are concerns of concentration in single data centers, existing POP locations, and hubs with these new routes. Are there limitations on routing of terrestrial segments to inland termination locations, are open interconnection services available for customer traffic, should multiple termination locations be considered or will multiple submarine cables to the same termination locations suffice? Data center interconnection, regional hubs, and multiple DC termination are a few available options; are there others? This paper will provide insight on options to consider and present a few more to stimulate the conversation.

1. INTRODUCTION

Advances in coherent optics, reconfigurable optical add-drop multiplexers (ROADMs), new fibre types, spectral shaping, spacial division multiplexing (SDM), C+L-Band, modulation formats, and power management are all being considered in the design of new submarine cable systems. These technological considerations along with the "open" cable concept allow for the implementation of new end-end network design options and associated architecture. Cable owners can now pursue alternatives to termination of capacity at conventional cable landing stations (CLS) at the beach and extend "wet" capacity further inland utilizing a combination of submerged fibres and terrestrial fibres.

New submarine cable systems reflect shifting change from capacity centric deployments to infrastructure centric. Submarine cable ownership by over the top (OTT) providers is accelerating and carrier's carrier entities with diminishing ownership by international carriers. The mix of ownership varies by region, but most new cable systems will have OTT involvement. These systems can now be considered infrastructure supporting extended networks for their owners or their customers. Most recent submarine cable

system deployments and associated ownership reflect a combination of individual end-end owners of this infrastructure. Ownership of a wet/dry fibre pair, multiple fibre pairs, or a portion of a fibre pair (spectrum) is now considered the level of entry for cable system owners or partners.

Owners agree upon a common cable landing location but may prefer different termination locations for their portion of the cable system. Under this scenario, each submarine cable owner (or collective owners) may consider terrestrial extension of fibre pair(s) or spectrum with placement of SLTE at an OTT data centre or city centre POP such as a multi-tenant data centre(s) (MTDC) or tele-house facility), concentration hubs, or combinations there of to form their own individual network configuration. No longer are cable systems required to stop at the beach. Another possible configuration is one/or more owners may prefer an offshore branching unit (BU) and route fibre(s) to a different landing location(s) from other fibre owners.

These configurations rely upon access to adequate terrestrial infrastructure, favourable in-country partners, and stable geopolitical climate to assure owners of an adequate return on their subsea cable investment. In certain configurations, an owner may need to consider acquisition of needed terrestrial infrastructure without participation of other owners. All these factors drive considerations for terrestrial network architectures/solutions including terrestrial fibres.

Also, to be considered are the benefits to be gained for SDN enabled architecture and open APIs. Consideration should be given to each owner having visibility (but limited control) of the common equipment to view current and historical network performance and consider automated provisioning by each owner. Finally, regulations play a key role depending on the geography.

2. TERMINATION LOCATIONS

What are the objectives to determine ideal termination locations? Some owners will need to provide connectivity between OTT DCs, others will need to provide maximum accessibility for their customers to other networks such as cloud service providers (CSPs), network service providers (NSP), and/or internet peering locations. Is having ready access for connection to other subsea cable systems a priority? Who are the customers and potential customers, and where are they located? Is providing the lowest latency route an objective? The answers to these questions will help to identify the most favourable termination location(s), requirements for in-country infrastructure and associated routing, and ultimately provide the most cost-effective network design to meet your objective(s). Choice of a termination location should consider elimination of backhaul cost for both cable/capacity owners and their customers, maximizing interconnection potential to customers and service providers, reduce circuit provisioning timeframes, and minimize ongoing operational expenditures.

Recently, a Submarine Cable Concentration Hub is being considered as a point of termination for new submarine cable systems. A Submarine Cable Concentration Hub is an open and carrier neutral facility where multiple submarine cables and inland providers of capacity or dark fibres terminate their respective networks. The facility is considered to be located in a near-shore environment with provision of space and power for housing submarine cable terminal equipment and meet me room (MMR) for interconnection to terrestrial networks. This offers the benefits to submarine cables terminating in the facility with a.) direct connectivity to each other for onward extension of capacity to other countries or

provide restoration services when needed, b.) access to terrestrial networks for onward extension of capacity to in-country OTT DCs, MTDCs, or customers, and, c.) access to inland networks for extension of capacity to another submarine cable terminating in another in-country Concentration Hub or CLS. In some cases, access to customers collocated in the same Concentration Hub may be available. Concentration Hubs are being considered as regional opportunities for future submarine cables in new landing locations.

PTC16 presented the benefits of consideration of MTDCs as a termination point for submarine cable systems. Since that time MONET, FASTER, NCP, ASC, SACS, Indigo, SMW-5, AEE-1, and Hawaiki have chosen to terminate one or more fiber pairs in one or more MTDCs in their design.

Most of the submarine systems currently in the design and or construction phase are also incorporating this concept in their deployment plans. While submarine cables with sole OTT ownership will continue to prioritize termination in their own DCs in deployment decisions, cable(s) with combined ownership (OTT, carriers, private, enterprise, and educational/research entities) must consider the needs of each party in the design process.

MTDC development has grown substantially over the last three years with multiple facilities now located in every major market in the world. MTDCs have historically served as points of interconnection for user connectivity to Internet Exchange (IX) points, various network service providers (NSP), and cloud service providers (CSP). Recently there has been an effort by some MTDC operators to offer cloud connectivity services between their own global DCs and third-party offerings for connectivity among competing DC facilities. MTDC development in new or emerging markets in some cases are being driven by new submarine cable projects. In most cases, these projects are being driven by cloud deployments in these new regions. The combination of the above service offerings and consideration for development in new and emerging markets present a compelling case for consideration for termination of submarine cables in MTDCs.

3. TERRESTRIAL ARCHITECTURE

The ability to extend submarine cable capacity inland has prompted construction of terrestrial route infrastructure such as conduit and fibre cables between city POPs and existing/new cable landing locations around the world. New submarine cable systems have also adopted the open cable system principal. Open in this context refers to the ability of each fibre pair or spectrum owner the freedom to provide, install, operate, and maintain their own SLTE. For the foreseeable future other land-based submarine cable system equipment such as Power Feed Equipment (PFE), Terminal Line Amplifiers (TLAs), wet plant monitoring, supervisory, control components, and in certain cases spectrum controller devices (i.e. ROADMs, , wave portal equipment) can be considered common equipment to all owners. The location, assignment and control of this common equipment would need to be agreed by all owners.

Any cable system utilizing subsea optical amplifiers will require a location for placement of PFE. The facility supporting the PFE can be a small purpose-built shelter located in near proximity to the cable landing location (within 15 Km is considered common practice). The facility should have access to dual commercial power feeds if feasible, provided with stand by generator(s), and have access to regional dark fibre providers. If required, this smaller facility may also accommodate other common equipment described above. Options include the following:

a) Architecture considering use of a MTDC or Concentration Hub as a full CLS: If available, an existing MTDC in near proximity to the cable landing location (within 15 Km), could be utilized as a full CLS supporting PFE, common equipment, and SLTE for all or some owners. Use of this facility would save capital and operations cost compared to constructing new facility and staffing the dedicated facility. Elimination of costly backhaul circuits would also be eliminated as the MTDC would offer access to available collocated customer ecosystems comprised of network services, cloud and content providers and other submarine cables in the same facility.
In the case of a Submarine Cable Concentration Hub, the same facility components and availability of NSPs should also be expected. Access to CSPs and other collocated customers may be limited which could vary by provider.

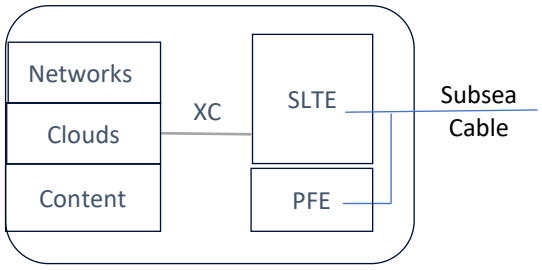

Figure 1: MTDC or Concentration Hub as Full CLS

b) PFE at the beach and SLTE at MTDC: Landing areas where there is no MTDC in local proximity, a submarine cable system can consider use of a smaller purpose-built facility (prefabricated or purchase/lease of local facility) in the coastal area for housing PFE and common equipment. Fibre pairs would need to be available at the coastal facility and continue inland to the selected termination location. Dual routes may be considered for route diversity. Depending on the distance between the two facilities optical amplifiers may be required. This configuration will require early discussion with the system supplier to assure optical performance specifications are addressed in the supply contract to satisfy the extended distance requirements for the design.

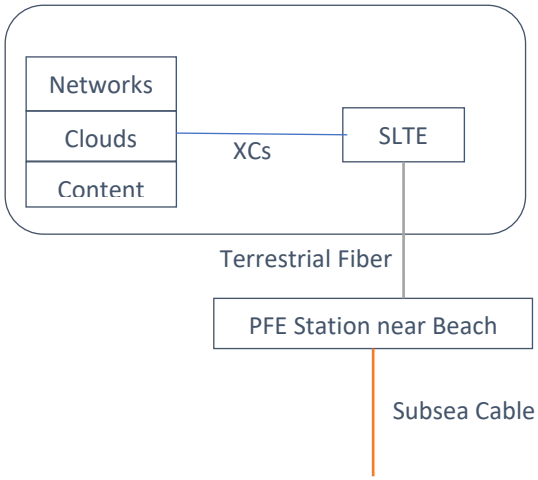

Figure 2: PFE at beach w/SLTE at MTDC

c) PFE at the beach and multiple inland termination locations:
This configuration will require close analysis of submerged optical amplifier spacing to eliminate potential costly placement of additional submerged amplifiers unique to any individual fibre pair(s). A common ROADM may be required near the shore terminating all submerged and terrestrial fibre pairs to eliminate additional submerged amplifiers. In this case, all owners would need to consider their specific inland termination location compared to each other during the system design process with the supplier.

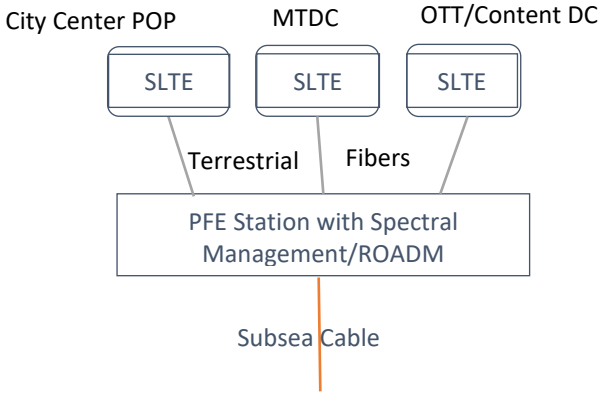

Figure 3: PFE at Beach with Multiple Inland Termination Locations

4. TERRESTRIAL FIBER

The segment of cable between the coastal landing location beach man hole (BMH) and an inland termination location is referred to as Front Haul. Front Haul can be considered the optical cable, the power cable connecting the PFE to the subsea cable, and the sea earth cable where the earth electrodes are located on the beach. The power cable and the earthing cable will be a relatively short segment between the PFE location and the BMH or beach joint. The fibre cable can be a much longer segment providing connectivity to the traffic termination location (SLTE) which may be much further inland. Terrestrial fibre type, route length, optical amplifier locations, fibre maintenance procedures, and history of performance of selected routes are just a few items to consider in the fibre selection process.

5. REGULATORY AUTHORITY

Cable systems involving multiple owners with landings in different countries (host country) require a reliable in-country landing party to address host country regulatory concerns. Each country has it own unique international cable landing requirements which address authority granted to place, operate, and maintain cable in their territorial seas. Intrinsically, cable system owners must select a company with an international landing license (normally an in-country provider) in each host country. Another option could be to establish a local entity and pursue an in-country international license on their own. While this quite often burdensome process may be possible in some countries, other countries do not have such an open market which could allow such consideration. In addition to regulatory issues, a reliable in-country landing party will also be able to provide support to environmental permitting efforts, engage discussion with local population, commercial fishing industry, and other concerns. Successful conclusion to the above items may only get the cable out of the water; still needed is the terrestrial extension to the local termination location. As mentioned earlier, this extension may be in multiple directions to multiple locations depending on the requirements of each cable owner. Quite often the international license granted to the landing party may not include inland extension of an individual owner's fiber/spectrum. This could require each cable system owner to seek other regulatory authority or license to extend his capacity further inland. In the case of physical ownership or construction of fibre infrastructure local licenses and permits may also be required for road opening permits, railroad crossings, etc. As such, long term lease of existing infrastructure (such as dark fibre, conduits, manholes, etc.) from a local licensed provider may be the preferred option for inland extension from the cable landing location. Early engagement with a legal representative with knowledge of country laws and regulations is strongly suggested very early in the project.

6. SUMMARY

Topics discussed in this paper; Termination Location, Terrestrial Architecture, Terrestrial Fibre, and Regulatory Authority represent a collective and fundamental concern which must be satisfactorily resolved for inland extension of a submarine cable. Each demands its own level of specific expertise for optimal consideration.