ADDRESSING THE THIN ROUTE MARKET

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Abstract: This paper proposes a new model in the design and implementation of submarine telecommunications cable systems that addresses the **thin route market**; typically characterized as underserved islands with relatively low populations and low capacity demands.

Over the past 15 years, the submarine telecommunications industry has realized unprecedented increases in bandwidth capability from 10, to 40, to 100Gbps per wavelength in new systems and upgrades. This has enabled the industry to match or exceed the explosive demand growth for bandwidth. Unfortunately this focus on increased capacity has fostered a second digital divide; a divide between countries that require huge amounts of digital bandwidth and have the means to pay, from those countries that have more modest needs of ≤10 Gbps, a much more limited budget, and typically rely on satellite connectivity; the **thin route market.**

The current supplier model for the industry is derived from processes, procedures, and purchaser-supplier relations focused on the delivery of large systems serving major markets. This legacy supplier model is geared to the needs of large capacity users with access to financial resources. The legacy model is not well suited to delivering economic solutions required to serve **the thin route market.** We examine this legacy supplier model and re-cast it with a focus on reducing overall system cost by re-engineering the conventional model of system design and implementation.

This study first investigates and estimates the **thin route market**. It then proposes existing technology solutions that address this market via implementation of lower capacity, single or low wavelength systems, coupled with lower cost implementation methodologies, equipment, and marine operations. The study also examines the benefits and risks associated with these recommendations and the resulting changes to the purchaser–supplier relationship. Finally, the study concludes with derived recommendations to the customers and industry that benefit by addressing the **thin route market**.

1 INTRODUCTION

Over the past 15 years, the submarine telecommunications industry has realized unprecedented increases in bandwidth capability from 10, to 40, to 100 Gbps per wavelength in new systems and upgrades, and more to come. This has enabled the industry to match or exceed the explosive demand growth for bandwidth. Unfortunately this focus on increased capacity has fostered a digital divide; a divide between countries that require huge amount of digital bandwidth and have the means to pay for those systems, from countries that have more modest capacity needs of ≤ 10 Gbps and a more limited budget, and currently typically rely on satellite connectivity; the **thin route market**.

2 THE THIN ROUTE MARKET CHARACTERIZATION

2.1 Market Characterization

In 2009 and 2010, the authors were involved in a project to bring a submarine cable to Pohnpei, Federated States of Micronesia, and Majuro and Ebeye, Marshall Islands. Out of this experience grew an understanding of the needs and obstacles involved in serving small island communities with submarine cable. Prior to this project, these islands were completely dependent upon satellite services, and because of the attendant high costs, usage of broadband was extremely limited. Total bandwidth per island was in the low tens of megabits, being shared by a population of 20,000 or more. In addition, services such as VoIP and teleconferencing were all but impossible due to the low bandwidth and high latency.

We can characterize the traditional and thin route submarine cable markets as follows:

Traditional Market

- Fat routes, i.e. require at least hundreds of Gbps and often require many Tbps
- Usually characterized by multiple cables and optional routes for diversity
- Can be any length from short, e.g. UK to Ireland, regional e.g. intra-Asia, or very long e.g. Trans-Pacific or anything in between
- Focus for major industry suppliers sales and R&D

Thin Route Market

- Typically has a population of less than 100K and relatively low per capita GDP, therefore, difficult economic proposition
- Provides service for a location that today is only served by satellite
- Bandwidth requirements may be satisfied for the foreseeable future by a single or very low wavelength count
- Typically relatively short overall length, from 200 km to 1500 km per island served
- Does not represent significant returns to industry suppliers

According to a recent World Bank report, broadband penetration accelerates economic growth more than any other telecommunications service, Figure 2-1. In addition, its economic impact, on low and middle-income countries is even higher than on high-income countries.

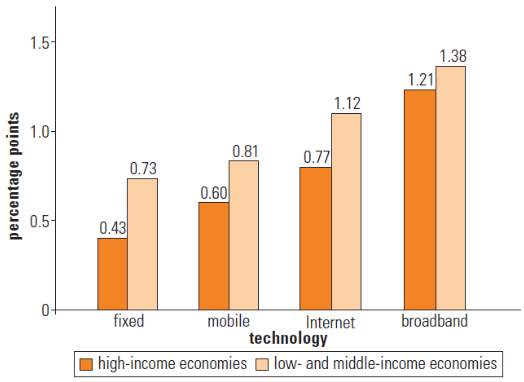

Figure 2-1: Broadband Penetration Impact on Local Economies

The net effect of the lack of submarine cable connectivity and the resulting lack of broadband services is the creation of a new Digital Divide. A submarine cable has become a necessity for economic growth and even survival. [1]

Recently, the authors undertook an exhaustive study to identify islands without submarine connectivity that had populations of roughly 10,000 and which are too distant to be served by microwave systems. Twelve such islands are shown in Figure 2-2.

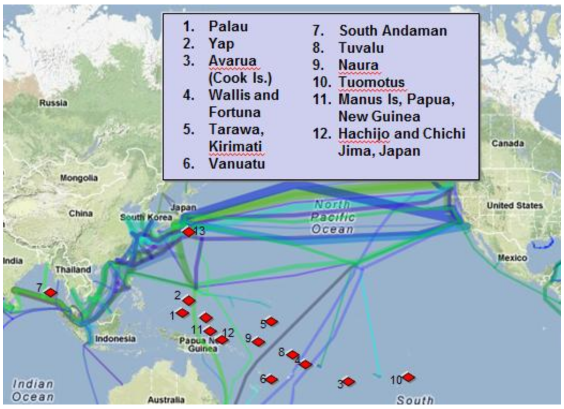

Figure 2-2: Primary Locations of Thin Route Market

As shown, all the islands are in the Pacific Ocean with the exception of South Andaman which is in the Bay of Bengal. The authors' study examined the most likely route or routes that a new submarine cable might take in order to connect to currently existing submarine cable systems and landing. In some cases, the shortest routes are less likely given geopolitical forces. For example, while South Andaman is closest to the SEA-ME-WE 3 landing in Pyapon, Myanmar, since South Andaman is part of India, it is more likely that a cable would be run to Chennai. In some cases, it is not clear which of two routes is most likely, and so both were considered.

Table 2-1 summarizes these twelve islands and associated routes.

Island	Population	Cable Route	Distance
Palua	21,000	To Yap and then to Guam	500 km to Yap
Yap	5,300	To Guam	900 km
Cook Islands	20,000	Avarua to Moorea (French Polynesia)	1200 km
Wallis and Futuna	15,000	Wallis to Samoa	500 km, 200 km more to Futuna
Tarawa, Kirimati (Gilbert Islands)	45,000	From Majuro to Bairiki, Kiribati or Makin Island	670 km or 460 km
Vanuatu	224,000	From Port Vila to New Caledonia or Fiji	350 km or 1150 km
South Andaman	180,000	To India	1400 km
Tuvalu	10,500	To either Fiji or Samoa	1000 km or 1100 km
Nauru	9,300	To Majuro	1000 km
Tuamotus	18,000	From Papeete to Rangiroa	320 km
Manus Island, Papua New Guinea	43,000	Lorengau to Madang	300+ km
Hachijo and Chichi Jima	8,300	To Tokyo	700 + 220 km

Table 2-1: Twelve Potential Market Islands

There are several results that we can draw from Table 2-1. The distance required to connect to an existing cable system ranges from 300 km up to 1500 km. While these twelve island nations are in the southwestern Pacific, aggregating them onto a single system would be prohibitively expensive. There are a few cases where it would make sense for two islands to join together, such as Palau and Yap and onward to Guam. Therefore our recommendation is to optimize for each specific island or in some cases, a pair of islands.

3 SYSTEM COST ANALYSIS AND COST CONTRIBUTORS

Each system is unique, and cost can vary considerably. **Thin route market** system implementations are especially expensive when one considers $/required bit.

Figure 3-1 identifies the significant cost contributors associated with **thin route market** systems of up to 1500 km length. The two principal contributors are the wet transmission plant and the marine services associated with survey and installation operations. Dry terminal equipment plant and project management and engineering follow as cost contributors.

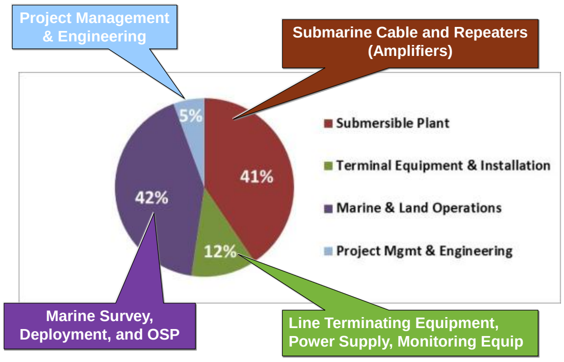

Figure 3-1: The Significant Cost Contributors

The temptation for controlling costs is to focus on each specific contributor. While this approach would certainly control costs by local optimization, a holistic approach results in greater cost savings.

4 ADDRESSING THE ISSUE

Thin route market systems are small systems, resulting in lower absolute profits for the Suppliers; they are normally single system purchases with limited prospects for new systems, extensions, and even upgrades, consequently, while the risks are the same as long haul systems, the Supplier profits are lower. **Thin route market** Purchasers often do not have in-house technical depth or staff breadth to undertake project management, system design, or implementation, resulting in the perception that there are limited options. However, the submarine telecom cable market is evolving into a commodity market as evidenced by the emergence and acceptance of third party upgrade suppliers and the blending of terrestrial and submarine transmission technologies. In addition, there are a number of second tier suppliers now available to execute various aspects of the project, and are often subcontracted by the primary Suppliers. Lastly, there now exist consultancy resources that can augment the Purchaser's in-house resources and experience from viability, negotiations, project management, procurement, and system testing and acceptance.

4.1 Project Ownership

Addressing costs for the Thin Route Project begins with Project Ownership; By Ownership, what is meant is the Purchaser controlling the project approach, requirements, risk assessments, implementation approach trade-offs studies, decision processes, and procurement of material, equipment, and services. Ownership that understands that meeting a Target Price Objective requires managing RISK.

4.2 Requirements Definition

Ownership of the Project begins with defining the Top Level Requirements for the project – Price, Performance, and Schedule. Each project is unique, and using baseline requirements, conceptual implementation scenarios can be developed and compared to one another to decide upon the optimal Implementation Approach. The two fundamental approaches are the Turnkey Supplier or the General Contractor approach

The General Contractor Approach has the greatest potential for cost savings, albeit with increased, but manageable, risk to the Purchaser.

4.3 Executing the Program

Project execution flow tends to be independent of the implementation approach. However, the associated responsibilities for each phase and tasking will vary considerable depending on the approach. It is the difference in the details of each Task and their coupling with other tasks where cost savings can be achieved when the Purchaser is the General Contractor.

The key element in the General Contractor approach is an in-depth understanding of the entire process from concept to Ready for Service (RFS). Expertise to support this can be found in the market if it does not exist in-house; evolution to a commodity market.

4.3.1 Project Management

Project Management and Engineering account for approximately 5% of the cost of a Project. The General Contractor approach reduces overall system costs by reducing margin on margin pricing, enabling procurement of the lowest cost equipment or services required. These cost savings can be achieved through a strong level of technical expertise and procurement logistics whereby system architecture, assemblies, and components are specified and contracted, and Purchaser and Supplier schedules are leveraged to the best cost advantage.

4.3.2 *System Transmission Design*

The transmission system requirements, and the resulting design, will have a very significant impact on total **thin route market** system cost. In many cases, the submersible plant and terminal equipment represent more than 50% of the cost. It is imperative to analyze each element of the requirements to understand how it will impact the total result. For example, since the bandwidth requirements are small relative to the capacity of a single fiber pair, why specify two fiber pairs, as is almost always done, instead of only one? This will reduce the cost for the cable by 7% to 15%; a substantial savings. In a repeatered system, this will reduce the number of optical amplifiers per repeater, also saving money. Other key decisions that must be addressed include whether to go repeaterless or repeatered, power requirements, and fiber type.

The key to achieving cost savings is avoidance of over-specifying performance requirements. For example, if 10 Gbps is a magnitude greater than the current international bandwidth, why specify more for initial provisioning? With required capacity defined, it is now possible to determine if a repeaterless design can be achieved. This is where understanding the full stream costs become critical. In 2010, a 600 km repeaterless single wavelength transmission at 10 Gbps was demonstrated in the laboratory. [2] Using the newest, low loss (down to 0.154 db/km), high effective area (130µm² or more) fibers, it is now possible for one or two wavelengths to achieve system distances of up to 600 km with the aid of Raman and ROPA on both ends. The higher costs of these newer fibers and the expense of the Raman and ROPA are offset by equipment savings (e.g. no repeaters, no power feed equipment and lower cost cable constructed without a power conductor). In addition, cable shipping costs may be reduced. In Figure 4-1, the standard industry approach and proposed repeaterless approach are schematically represented for a 600 km system.

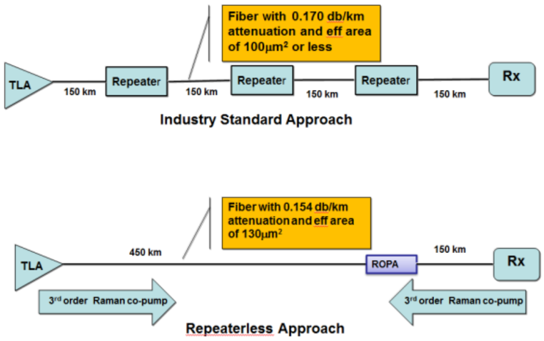

Figure 4-1: 600km Link Design Approaches

We believe this represents an optimal approach for 600 km or even slightly beyond. Below 600 km, it may be possible to use less high performance fibers and below 400 km, it may become possible to eliminate the Raman or ROPA or both. So the first general rule is to reach for a repeaterless.

Beyond something over 600 km, it becomes absolutely necessary to use repeaters. However, minimizing the number of repeaters will generally save cost. As in the repeaterless case, there will be tradeoffs between the number and type of fiber and number of repeaters needed and their cost.

In the repeatered system, cable with a power conductor is required; however, it is still advisable to consider a single fiber pair utilizing high performance fibers with minimum wavelengths at lower data rates (10 Gbps or 40 Gbps). Repeater spacing can be increased and amplifiers per repeater are minimized. This may require tweaking repeater designs so that more gain can be realized. We have examined in detail the trade-offs involved in the design of a 1200 km system using standard industry practices and developed an optimal configuration for the **thin route market**, shown in shown in Figure 4-2.

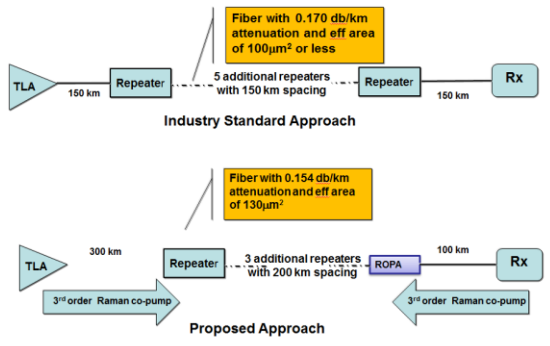

Figure 4-2: 1200km Link Design Approaches

As shown, the number of repeaters can be reduced from seven to four by using several of the same techniques that were employed in the repeaterless case. This includes use of Raman and ROPA to increase the distance between shore and the first repeater. In addition, use of lower loss fiber enables repeater spans to increase about 10%; the remainder of the increase is achieved by increasing repeater gain from 25 db to 35 db. Since the system contains only 4 repeaters, an acceptable OSNR can still be achieved.

Figure 4-3 provides a comparison of the number of repeaters for a standard approach and the proposed approach. As shown a significant reduction in repeater numbers can be realized, with attendant cost savings.

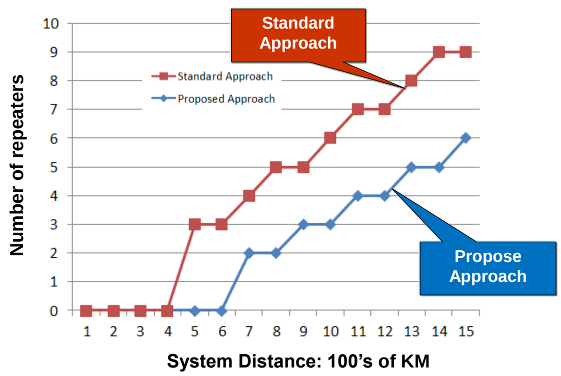

Figure 4-3: Repeaters vs. Length Standard and Proposed Approach

Our study has shown that there are opportunities to save on the cost of terminal equipment. Several power supply manufacturers make high quality, high voltage supplies which are sufficient for these applications where less than 1500 volts and 1.5 kW are required. 2,000 volt, 2.5 kW programmable supplies are available for under $7000 vs. the $100Ks for a standard PFE. These can be provisioned in redundant configurations, or one in use and the other as a spare. Employing a single ended feed should be considered, as should the need for continuous line monitoring. The trade-off between infrequent short outages vs. the cost savings may well be worthwhile.

4.3.3 Marine and Land Operations

As shown in Figure 3-1, Marine and Land Operations account for approximately 40% of the system costs. The Marine Survey and the Wet System Deployment are the primary cost contributors. Each of these two contributors involve one or more marine platforms, each with mobilization costs, daily transit fees to and from site, daily operations fees, and contingency fees (e.g. weather). Outside Plant and Cable Landing Station construction and readiness fill out remainder of the costs for the Marine and Land Operations.

Multiple vessels involve multiple mobilization, transit, and operations fees. Up to four vessels might be required; cable transport, a marine survey, near shore pre-laid shore end installation, and deep water installation. These costs are compounded for the **thin route market**, since these tend to be distant from large marine ports, cable depots, and cable manufacturing facilities; all of which increase transit costs for vessels. The key to controlling Marine Operations costs is the right vessel for the shortest period of service, and this in turn depends on the requirements defined early in the project execution process.

4.3.3.1 *Cable Transport*

There are multiple options for cable transport from the cable manufacture site to the point of use. These options range from cable stored in ISO Containers and shipped as freight, to specialized shippable cable pans, to dedicated freighter, to use of the deployment vessel. Prices can vary from $25,000 for an ISO Container shipment to $100,000/day for transit of a cable ship.

Short systems with small diameter cable are candidates for ISO container or specialized shipping pans, but as cable diameter (armoring) increases, the need for a dedicated freighter or utilization of the deployment vessel correspondingly increases. Multiple ISO Containers or specialized shipping pans will require near site splicing and system integration. The cost and logistics of splicing need to be factored into the project planning and cost development. Cable splicing require various suites of equipment depending on the splice design; low voltage splicing can be accomplished without polyethylene overmolding in a relatively short period of time, but a high voltage system will require a full poly molding suite and a 20 hour operation per splice, increasing ship operational costs. The cost of near site jointing versus shipping, ship standby, and equipment costs need to be compared. Refer back to the section on transmission design and the decisions on repeaterless and repeatered systems.

4.3.3.2 *Marine Survey & Wet Plant Deployment*

The Desktop Study (DTS) is the most valuable tool for early decision making in planning the route of the cable system. The DTS results in a preliminary route developed based on public information, marine charts, and private databases. It is often accompanied by site visits to the planned landing locations. A significant output of the DTS is external threat assessment which drives the need for cable armoring and/or burial which in turn impact cable transport and the performance capabilities of the installation vessel – both impact costs.

For **thin route market**, where one or more endpoints tend to be low population centers, the threat of external aggression by anchor drag or fishing gear needs to be realistically assessed, since these may both be low probability events, or might be mitigated by local government regulation, cable awareness, or local monitoring. Reduced armoring, and elimination of burial can significantly reduce the cost of wet plant and its installation. Cost savings need to be weighed for each unique system and assessed risk

Depending on water depth, and the required marine survey performance requirements, a variety of options are available for attaining this data from a dedicated deep water survey vessel to provisioning local vessels, to transportable AUVs. As an active owner, the Purchaser is well advised to open discussions with the survey contractors on the requirements, the costs, and data collection options.

The deep water route survey: Is it necessary? What additional information will be obtained, and how will that information be used effectively? Are there mitigating options that might be used in lieu of a deep water survey; such as increased slack, reduced deployment speeds, and active monitoring and cable slack control by the deployment vessel during deployment ahead of the cable touchdown point?

Decisions made early on from the DTS and external threat assessments, and from transmission system design decisions regarding system voltage lead to the required capabilities of the deployment vessel. These include plow operations, ROV operations, cable load capacity, position keeping, and at-sea splice capabilities.

Options available to the Purchaser/General Contractor of the project include leveraging project schedule flexibility against cost by either awaiting the availability and proximity of either a dedicated vessel or a vessel of opportunity outfitted with deployment equipment.

4.3.3.3 Combined Survey and Deployment Vessel – An Industry Initiative

Within the industry, there are active discussions regarding combined survey and deployment vessels. The obvious benefits are single mobilization costs, reduced transit costs, and a vessel that retains significant capabilities (station keeping, ROV operations, etc.). Disadvantages include the potential reduced impact of survey results on cable manufacture due to scheduling constraints to limit ship time, and smaller cable loads, both of which seem manageable for the **thin route market**.

4.3.3.4 Outside Plant and Cable Landing Station Construction

The **thin route market** also has the advantage of landing sites where the local labor rates result in significant advantage to site built facilities for the Cable Landing Station over pre-fabricated and provisioned units shipped to site. Environmental conditioning units, alternative power generation units, battery plant, and fire detection and suppression equipment are readily commercially available and have straight forward installation.

Outside Plant construction is also straightforward, and local labor can be utilized to minimize these costs. Third party expertise in OSP and CLS is available, if needed.

5 SUMMARY – RISK AND REWARDS

The **thin route market** is best served through OWNERSHIP of the project by the Purchaser enabling flexibility in project organization, control of specifications, risk analysis and mitigation, and a la carte procurement of equipment and services.

Table 5-1 summarizes the risk and rewards addressed by this study.

Focus	Typical	Option	Risk	Potential Savings
Repeaterless System Wet Plant	Short Repeatered Wet Plant	Extended Unrepeatered Wet Plant	Transmission Performance	High
Repeaterless System Terminal Equipment	Standard SLTE	Terrestrial	Transmission Performance	Modest
Repeatered System Wet Plant	Standard Spacing & Amp Pairs Repeatered Wet Plant	Reduced Repeater Wet Plant	Transmission Performance	Modest
Repeatered System Terminal Equipment	Standard PFE	Commercial Power Supply Single End Feed	Redundancy & Availability	High
	Monitoring Equipment	No Monitoring	System Availability	High
Marine Survey	Standard to 1500m WD	Reduced Near Shore Survey Portable Survey Gear & Local Vessel	External Threats beyond 500m WD	Modest
	Standard Deep Water Survey	No Deep Water Survey	Bottom Suspensions	High
System Deployment	Burial - Cable Ship with Plow Capability	No Burial - ship of opportunity with transportable deployment suite	External Threats	High
	Standard UJC with Overmolding Equipment	Uitlize Quick Joint, No Overmolding Equipment	Non-UJC	Modest
Survey and Deployment	Two separate vessels	One Dual-Purpose Vessel	Survey Data on Cable Manufacture	High
OGB, OSP, CLS, and Land Cable	OGB and Land Cable Installation	Purchaser Implemented	None	Modest

Table 5-1: Risk - Reward Summary

Technology advancements in fiber optic transmission performance are providing an increasingly varied and capable suite of design options for the Purchaser. Coupled with options in marine survey techniques and system implementation these enable the cost–conscious **thin route market** Purchaser to custom fit equipment and services to their specific needs and requirements; rejecting the one-size-fits-all model for submarine telecom cable systems.

6 CONCLUSIONS

With the submarine telecommunications industry in a state of rapid change reflected in the blending of terrestrial and submarine cable technology and the commoditization material, equipment, and services, opportunities now exist to close the **thin route market** digital-divide. That OPPORTUNITY begins with embraced OWNERSHIP of the project manifested in control of all key decisions, processes, and risk management, built upon in-house or 3rd party expertise in design, project management, and system implementation.

7 REFERENCES

[1] " 2009 Information and Communications for Development Report", The International Bank for Reconstruction and Development /The World Bank, 2009, eISBN 978-0-8213-7606-5.

[2] "Ultra-long 10 Gb/s Unrepeatered WDM Transmission up to 601 km", H. Bissessur, P. Bousselet, D. A. Mongardien, I. Brylski, Alcatel-Lucent Corporation, presented at OFC/NFOEC 2010.

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