THE EMERGENCE OF AFFORDABLE BROADBAND SERVICES FOR REMOTE LOCATIONS USING SFOC TECHNOLOGY

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Abstract: A case study was conducted to compare expanding current Satellite Communications (SATCOM) services or installing a regional Submarine Fiber Optic Cable (SFOC) system for meeting broadband requirements of a remote user currently using SATCOM services for off-island traffic. Based on life cycle costs, a scaled-down, regional SFOC system financed over a 15 year capitalization phase, was shown to be the more cost effective solution at an OC-3 transmission rate. Furthermore, as the remote user's transmission requirements are projected to increase at a moderate growth rate over the 25 year lifetime, the case becomes quite compelling for the installation of a regional SFOC system, with the existing SATCOM service used for restoration until demand increases sufficiently to justify a second cable system.

1. INTRODUCTION

Satellite Communications (SATCOM) have been the traditional transmission delivery system for users in remote locations that do not have a large enough population density to justify the investment of a submarine fiber optic cable system. This scenario has been particularly true for developing nations where the PC and broadband access is not yet an essential lifestyle requirement in each home. Satellite services currently provide bandwidth for these isolated regions to the outside world for internet and voice communications. Even within the U.S., satellite transmission has also been the enabling source of transmission for isolated segments such as offshore platforms in the Gulf of Mexico.

Remote and maritime users with low bandwidth requirements will undoubtedly remain a mainstay of satellite communications providers for the foreseeable future. However, a paradigm shift is emerging for some remote regions from a satellite to a Submarine Fiber Optic Cable System (SFOC) based servicing infrastructure as the requirements for broadband data transfer are driving the economics to the strength of cable systems. This paper provides a summary of a business case study that compared the cost and performance of broadband transmission services into a remote Pacific location of a newly installed SFOC system with expansion of the existing commercial SATCOM service. The life cycle costs of meeting the telecommunications requirements using a submarine fiber optic cable system proved to be cost competitive as well as technically enabling for providing broadband to this remote location.

2. ANALYSIS

2.1 Problem Setup

Life cycle costs for representative remote user requirements were developed with expansion of the current SATCOM system and compared with installation of a dedicated SFOC system.

Assumptions used for the pricing comparison include:

- 25 year lifetime, with a 15 year period to recover initial capital investments
- Combination of debt and equity financing resulting in a cost of capital of 9%
- Existing customer premise MAN/LAN equipment (to be interfaced with the long haul transmission equipment) is a sunk cost
- Additional services at the commercial teleport/cable station end will be the same for both delivery systems and not a discriminating factor for consideration
- No commercial SFOC system currently in operation in the country
- Current SATCOM earth station at remote site supports one DS-3; additional capacity requires additional electronics equipment
- Bandwidth Requirements for off-island traffic as shown in Figure 1 were considered:

Moderate Growth: OC-3 initially, with an additional DS-3 every five years

No Growth: OC-3 for 25 years

The approach used in determining SATCOM costs was to:

a. Conduct a satellite link budget calculation to determine the satellite transponder requirement for selected levels of transmission

b. Price the SATCOM service using current commercial rates for an initial 15 year lease period, with follow-on pricing discounted at 3% per year for years 16 through 25

The approach used in determining the SFOC costs was to:

a. Size a new SFOC regional cable system (~3000 km) including wet and dry plant

b. Initial capacity to provide two 10 Gbps wavelengths of transmission (1+1 protection)

c. In-cable restoration acceptable with SATCOM backup during a cable repair

d. 12 month timeframe for construction phase

e. Customer IRU using investor funding for capital costs of SFOC system; customer makes level yearly payments over 15 year capitalization period

f. Cable repairs covered with commercial spot market rate

g. After completing payment of capital costs, IRU payments drop to 5% of yearly payment during capitalization phase.

SATCOM System

Detailed link budget calculations were conducted to establish the satellite transponder requirements at varying transmission rates for developing SATCOM lease pricing.

The critical design parameters for the SATCOM links are provided in Table 1 and pricing for the links to meet the requirements of Figure 1 are provided in Tables 2 and 3.

The T-1 design parameters are provided as a point of reference to reinforce that circuits at this end of the broadband spectrum will remain within the domain of SATCOM services for remote locations. Scalability limitation of SATCOM for broadband services is readily seen in Table 1 when considering that the DS-3 requires a full C-band transponder to close the link. Furthermore, the link budget could not be closed to meet the OC-3 requirement using either C-band or Ku band. Therefore, seven DS-3s were used to satisfy the Moderate Growth requirement; and three DS-3s were used to satisfy the No Growth requirement. The costs for meeting both Moderate Growth and No Growth requirements using SATCOM leases over the 25 year lifetime of the service are provided in Tables 2 and 3.

SFOC System

The SFOC facilities required include all components of the wet and dry plant, with repeater spacing sufficient to provide scalability to 16 wavelengths. The system description factors are shown in Table 4.

The bandwidth is shown in the same units as the SATCOM transmission rates (Mbps) to highlight the tremendous difference in magnitude for the fiber based facilities. The SFOC system provides a dedicated regional cable with ample capacity to service growth in the foreseeable requirements for a developing nation with scalable capacity to 160 Gbps. The downtime is dominated by the number of cable repairs that would be required, as only 1 hour per year can be expected for downtime due solely to routine maintenance; whereas the high end average of 62 hours per year reflects routine maintenance and one cable repair expected every 11 years, with each cable repair taking 4 weeks to complete. This expectation of infrequent cable breaks is based on a maritime environment with extremely deep waters for virtually the entire length of the cable system.

The turnkey capital cost for the SFOC system is $45 million (US), which is amortized with constant monthly payments over 15 years. After pay-off of capital costs, the monthly payment is reduced to an O&M payment comprised of a yearly repair vessel fund and landing party support services for dry plant maintenance. These monthly payments are shown in Table 5.

2.2 Comparison of Systems

A comparison of the Remote User SATCOM and SFOC monthly recurring costs over the 25 year lifetimes of the respective systems is provided in Figure 2. The requirement of OC-3 is met by SATCOM with three DS-3s versus the minimum threshold for SFOC of OC-192. For the No Growth requirement option, the SFOC payment is slightly higher than the SATCOM payment until the capitalization phase of the new cable system is completed starting in year 16. At that time, the SFOC yearly payments drop to about the level of a discounted single DS-3 lease. For the Moderate Growth requirement option, the SFOC payment is initially higher than the SATCOM services until year 6, then drops below the SATCOM services for the remainder of the 25 year lifetime.

One must not loose sight of the asymmetries in bandwidth provided by the respective transmission mediums when considering these cost differences. Table 6 provides insight into these differences. The net result is that the lifecycle cost of a new SFOC system providing OC-192 transmission is about the same as the cost of a SATCOM service providing three DS-3s of transmission. Furthermore, the SFOC system has dramatic advantages in transfer rate, scalability, significantly lower latencies, with the same average yearly downtime based on system availabilities for these transmission alternatives.

3. CONCLUDING REMARKS

The cost of SFOC systems has declined as a result of the dramatic downturn in new system orders in the post-2001 timeframe and the performance improvements of next generation amplifiers and terminal equipment. SATCOM pricing has not experienced the same dramatic decline in customer demand, particularly in remote regions of the world in which no other options exist for servicing the growth of data transfer and internet requirements. The impact of these asymmetries in price trends for the two transmission mediums has been a closing of the gap between the lifecycle costs of SFOC and SATCOM systems for remote users. As demand in these developing regions increases to synchronous transport levels, a fiber based solutions becomes the only technical option to meet high bandwidth requirements with currently deployed commercial systems.

While the economics of transport alternatives will vary on a case by case basis, the case study results summarized in this paper show that the lifecycle costs of new regional cable system can compete quite favorably with a SATCOM service. It was shown that an SFOC system has about the same cost for the No Growth Requirement profile and dramatically lower lifecycle costs than SATCOM for a Moderate Growth User Bandwidth Requirement profile. The key factor here is the scalability of the SFOC system in meeting increasing demands of the customer. The breakeven for SFOC over SATCOM from a life cycle cost perspective is OC-3 transmission. As bandwidth requirements exceed this threshold, the SFOC system is the preferred solution.

In reality, a remote region deploying a new cable system should expect to use both transmission mediums in a synergistic mode of operation. Initially, the redundant fiber pair required for self-healing can be expected to be an in-cable restoration system until a second cable is deployed. So, the existing SATCOM earth station should be maintained for servicing occasional use requirements when cable repairs are required. Until the region has developed to the stage where it no longer qualifies its designation as being 'remote', cost considerations will dictate that an evolutionary design approach of the communications architecture will require both systems to be in operation simultaneously during the transition phase that can extend over many years. Toward this end, the synergistic strengths of a high bandwidth, low latency SFOC transport system and an affordable backup SATCOM service will provide a complementary solution for meeting the growth needs of the developing region.

4. FIGURES AND TABLES

Transmission Service	Data Rate	Modulation	FEC Code Rate	Satellite Allocation	Link Availability	Downtime
	(Mbps)			(MHz)	(%)	(hours per year)
T-1	1.5	QPSK	3/4	6.0	99.929	6
DS-3	44.7	16-QAM	7/8	35.8	99.768	20
OC-3	155	No solution as link can't be closed over 36 MHz C band or 72 MHz Ku band				

Table 1: SATCOM Design Parameters

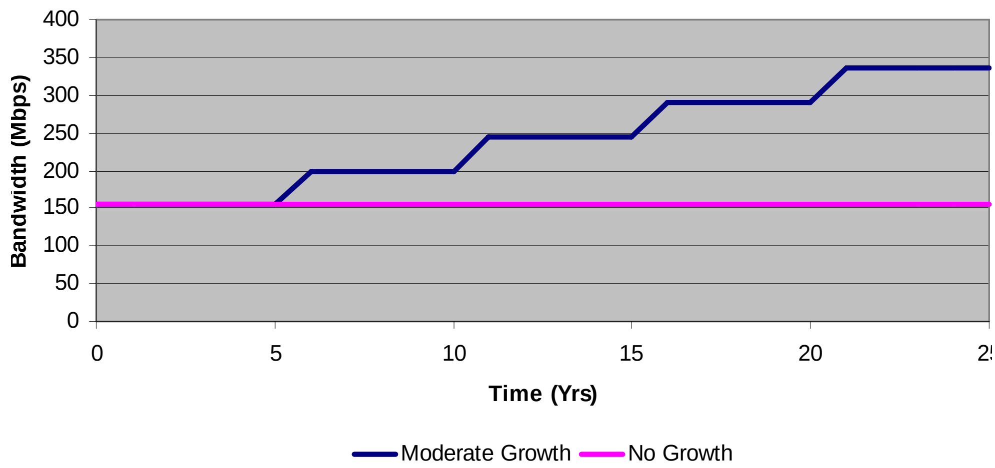

Figure 1: User Requirements over 25 Year Lifetime

Timeframe	Bandwidth	No. DS-3s Req'd	Ave Cost/mo	Ave Cost/yr	Total Payments
(years)	**(Mbps)**		**(US $)**	**(US $)**	**(US $)**
1 to 5	155	3	$519,001	$6,228,015	$31,140,073
6 to 10	200	4	$689,561	$8,274,735	$41,373,673
11 to 15	245	5	$860,121	$10,321,455	$51,607,273
16 to 20	290	6	$979,110	$11,749,319	$58,746,594
20 to 25	335	7	1,068,888	$12,826,655	$64,133,275
Total			**$823,336**	**$9,880,036**	**$247,000,889**

Table 2: SATCOM Service Lease Lifecycle Costs for Moderate Growth Requirement

Timeframe	Bandwidth	No. DS-3s Req'd	Ave Cost/mo	Ave Cost/yr	Total Payments
(years)	(Mbps)		(US $)	(US $)	(US $)
1 to 25	155	3	$485,166	$5,821,996	$145,549,891
Total			**$485,166**	**$5,821,996**	**$145,549,891**

Table 3: SATCOM Service Lease Lifecycle Costs for No Growth Requirement

Transmission Service	Bandwidth	No. of Fiber Pair	Initial Configuration	Scalability	Link Availability	Ave Downtime
	(Mbps)			(MHz)	(%)	(hrs per year)
OC-192	10,000 comprised of multiple OC-12s and OC-3s	2	2λ (1+1)	16λ	99.990	62

Table 4: SFOC System Description

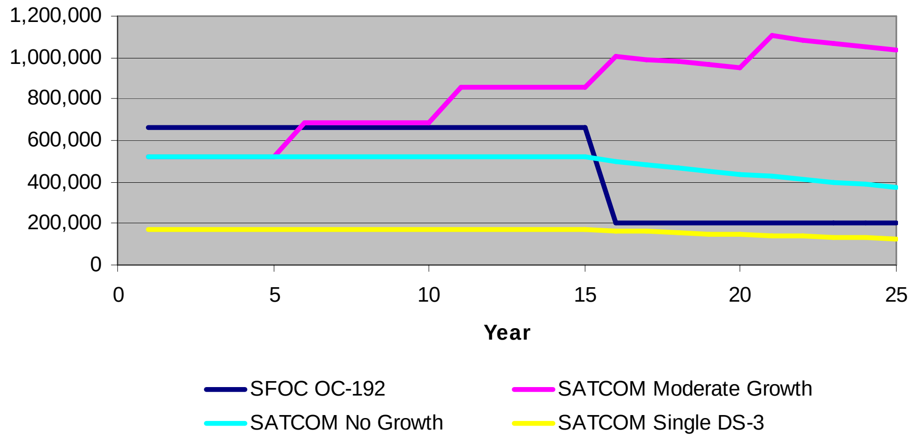

Figure 2: Comparison of Monthly Payments for a new SFOC System and SATCOM Service over a 25 Year Lifetime

Period	Cost/mo	Cost/yr	Total Payments
System IRU			
Yrs 1 to 15, capital	$456,420	$5,477,040	$82,155,600
Yrs 1 to 25, O&M*	$203,701	$2,444,412	$61,110,300
Total	**$660,121**	**$7,921,452**	**$143,265,900**

Table 5: SFOC Lifecycle Costs

*Annual O&M payment includes cost of SATCOM service during cable repair

	Transmission Service	Max Bandwidth	Ratio of Transfer Rates	Total Payments 25 Yrs	Unit Cost	Scalability	Downtime
		(Mbps)		(US$)	(US$/Mbps)		(hours/yr)
SATCOM Moderate Growth	Seven DS-3s	335	2.2	$247,000,889	737,316	Limited	142
SATCOM No Growth	Three DS-3s	155	1	$145,549,891	939,032	Limited	61
SFOC	OC-192	10,000	65	$143,265,900	14,327	160 Gbps (16λ)	62

Table 6: Comparison of SATCOM and SFOC Systems