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Below are responses ~~from the North American Submarine Cable Association~~ to the two follow-up questions directed to Paul Shorb by Admiral Watkins' letter of August 28, 2002. This response was prepared by Paul Shorb and NASCA staff person Jerry Tourgee, with input from several NASCA members.

1. What is the future outlook for the submarine cable industry in light of other telecommunication technologies that have been developed in recent times?

Submarine telecommunication cables are the least expensive and most commonly used method of transoceanic transmission of voice and data. The only other contender for the transoceanic voice and data market is satellite transmission. No other technologies have emerged which can approach undersea optical networks in bandwidth or reach. Technological advances are expected to continue to increase the bandwidth (i.e., capacity) of both cables and satellites. However, cable performance will continue to greatly outpace satellite performance in terms of both total potential capacity and capacity per unit cost, as further detailed below. Therefore no technologies are expected to replace the primacy of submarine cables for transoceanic communication in the foreseeable future.

The key to fiber-optic technology is its massive capacity. A single modern submarine cable network is capable of transmitting up to 5.12 terabits, or the equivalent of 640,000,000 voice calls simultaneously. In addition, such a network typically has a high degree of resiliency based on a "ring" configuration, which is capable of maintaining full transmission capability even if one segment of the ring is severed. As noted in Paul Shorb's presentation to the OPC, continuing improvements in the underlying technology of fiber-optic transmission of laser light are expected to continue to increase, year over year, the bandwidth possible in a new submarine cable.

Satellite telecommunications have several drawbacks compared to fiber-optic submarine cables. First, due to the cost of launching and maintaining satellites in orbit, and limited power and size, satellite transmission has limited bandwidth and is very expensive. Therefore it generally is used only where other alternatives are not available or where the local telecom incumbent is supporting artificially high telecom termination rates. Trying to replace the capacity of a modern submarine cable using satellites would be either impossible or tremendously more expensive. Second, because the geosynchronous orbit of current satellites places them some 28,000 miles above the earth's surfaces, voice transmission is adversely affected by a noticeable round trip delay, which is annoying to the telephone users at both ends. Consequently, satellite transmission is used primarily for data transmission.

There have been some recent technology advances that may improve satellite transmission of voice and data. One is the attempted introduction of a "net" of low earth orbit satellites (i.e., the projects known as Iridium and Celestri). Low earth orbits reduce the round trip delay characteristic of geosynchronous orbits, but require vastly greater numbers of satellites to provide earth coverage (60 to 100 satellites). Such a system is very expensive compared to a fiber-optic based system, due not only to the large number of satellites needed initially, but also to the need to replenish them as they fall from orbit due to short orbit life (5 to 7 years), and again the bandwidth limitations per satellite.

Second, over the past few years researchers have been testing laser-based satellite communication. Successful implementation of this technology could significantly increase the bandwidth of satellite transmission. However, satellite bandwidth would still fall significantly below what a single submarine cable system could provide, since capacity per cable also continues to increase exponentially.

In the near term, the submarine cable industry faces a significant economic challenge resulting from the introduction of so much new capacity in the last few years. That construction boom seems to have led to a bandwidth "glut" both undersea as well as terrestrially, resulting in the bankruptcy of several major players (Global Crossing, 360networks, FLAG Telecom, Asset Channels, and others). This presumably will reduce the impetus for deploying new systems, until demand growth absorbs much of the existing capacity. However, demand for telecommunication capacity does continue to increase, even if only at the rate of 40% rather than 1000% per year.[1] When additional capacity is needed for transoceanic communication, it seems clear that submarine cables will remain the primary technology relied upon.

2. During the public hearing, the question was raised about what kinds of incentives the Commission could ask Congress to put in place to have the cable industry help provide the scientific community access to existing cables. Also, it was asked if there is a map of existing cables available for scientific use and if there is a paper discussing this issue. Could you provide any information regarding this to the Commission?

There are several different types of access that may be of value to the scientific community. This response will describe each type, since we are not sure which would be of

[1] See, e.g., "Behind the Fiber Glut", The Wall Street Journal, Sept. 26, 2002, p. B-1.

interest, and the rough cost to the cable installer of providing each type. This response then will identify and comment upon types of incentives that Congress in theory might put into place to encourage providing such access to the scientific community. Lists of retired and active cables terminating in the U.S. are attached, and links to more information about scientific use are included below.

To discuss incentives, some background on submarine cable ownership is relevant. Under the traditional "consortium" model of financing the construction of new submarine cable systems, each system is owned by a group or telecommunication companies (e.g., AT&T Corp., Sprint, WorldCom, British Telecom, France Telecom, Deutsche Telecom, etc.) that intend to use much of the capacity themselves. Each system is separately owned by a different mix of owners, so it may be difficult provide an incentive to one system in exchange for access to another system. Since the mid-1990's, a " private ownership" model emerged with companies such as Level 3, 360networks, Global Crossing and others building cables primarily to sell the capacity. In this segment of the market, there may be more than one cable owned by a single owner.

Normal access to commercially available capacity

We can identify three potential modes of scientific use of a submarine cable. One would be normal access to cable bandwidth, such as is commercially available to all users. This however would be limited to communication from one shore to the other shore. For example, an existing or future transatlantic cable system has capacity that could be acquired by or donated to research institutions in the U.S. and in Europe for transmitting large amounts of data to each other.

The price of capacity is currently falling at a rate of > 3.5% month. Prices have been exacerbated recently by capacity owners in distress, and over-build on common routes. A standard of transoceanic capacity, 155 Mbps (known as an OC-3 or an STM-1), can be leased for 10 years at prices ranging from $75,000 to upwards of $1,000,000 (with an annual 5% operations and maintenance fee), depending on the specific region of interest, and local route supply and demand. Bandwidth brokers such as Band-X and Dynegy can be consulted for specific route capacity costs.

Scientific use of retired cables

A second mode involves scientific use of an existing, but retired cable system. The decision to allow the science community to utilize a retired cable system is entirely up to the owner(s) of the system. However, in general such approval probably will not be hard to obtain. Numerous cables that have been taken out of telecommunications service are already being used by the scientific community; see the following websites for more information and a generalized map of these cables:

http://www.iscpc.org/cabledb/science.htm
http://www.pmel.noaa.gov/wbcurrents/cables_map.html
www.cg.nrcan.gc.ca/mtnet/confs/1997/cables97.txt

So far, only retired analog cables and the copper (electricity-conducting) element of active fiber-optic cables have been converted to scientific use.[2] However, opportunities to use the fiber optic element of submarine cables use are beginning to emerge, now that the earliest fiber-optic cables are starting to be retired. TAT-8, the first fiber-optic cable landed in the U.S., was also the first to be retired, in May of this year. Between 5 and 10 of other fiber-optic cables landed in the U.S. may be retired in the next several years.

Attached is a list of retired analog cables landed in the U.S. Also attached is a list of fiber-optic cables landed in the U.S. (all active, except for TAT-8).

The cost to the cable owner(s) of allowing access to a retired cable is relatively modest. The cost to the scientific community of installing sensors needed for scientific purposes would depend on the study design, so this response cannot go far in addressing those costs. As a general matter, one can say that it is possible to attach new monitoring equipment to a retired cable, using a cable repair ship to grab the cable, pull it to the surface, and then drop it back to the seafloor after attaching the desired equipment. Repair ships can thus act on cables that lie on ocean bottoms, even miles deep. The current cost to operate a cable repair ship is about $ 70,000 per day, which means a typical repair job may cost on the order of $1 million. The U.S. Navy, like other operators of submarine cables, has contracts under which cable repair ships are standing by. Any beneficiary of such a contract in theory could choose to allow such a stand-by ship to be used for a scientific retrofit job.

<u>Attaching undersea sensors to active cables</u>

As this question was presented at the July public meeting, the context suggested an interest in using the fiber-optic capacity of an active submarine cable to convey data collected from the seafloor. In general, attaching new scientific equipment to a commercially active cable would not be feasible from the point of view of the cable operator. Although physically possible, doing so would require taking the cable out of service, which would be inconsistent with the cable's mission to provide highly reliable telecommunications services to high-volume customers.

Alternatively, scientific use in theory could be designed into a new fiber-optic submarine cable prior to its installation. For example, a "branching unit" can be made part of a submarine cable. A modern fiber-optic cable can contain up to eight fiber pairs; a branching unit creates, in effect, a fork in the road for one or more fiber pairs. If one fiber pair was dedicated to scientific use, one or more branching units could be added to carry information back to the cable station from seafloor sensors. However, one-eighth is a substantial portion of a cable system whose total cost to install may be $300 million to $1 billion. In addition, each additional branching unit may cost $1 million to $1.5 million, aside from the scientific equipment that may be connected to it.

Instead of using a branching unit to access a dedicated fiber pair, "multiplexing" technology probably could be developed for this undersea application, to access only a fraction of the capacity of one fiber pair. This would allow the scientific project to use only the needed amount of a submarine cable's capacity, which probably would be much less than an

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[2] As an example of the latter, NOAA is using the Eastern Caribbean Fiber-Optic System to monitor the Grenada Passage between the islands of Grenada and Trinidad for water transport fluctuations, by measuring the voltage changes in the copper wire that are induced by water movement. NOAA since 1982 has been monitoring the Florida current by using an AT&T cable from the Bahamas.

entire fiber pair. Doing so may reduce the cost impact of the scientific use. However, an investment of time and R&D resources would be necessary to develop the technology, and the cost per multiplex unit may still be on the same order as the cost of a branching unit.

The above possibilities must be considered not only in terms of their cost but also in terms of their potential impact on the reliability of the submarine cable. The cable operator and its telecommunication customers seek the most reliable network that technology can provide, since repair of a system is expensive, and the cost of supplying alternate telecom service during an outage can be extremely expensive. Undersea telecom systems are extremely reliable (at significant experience, design, and assembly costs). Consequently, the telecom entity would probably require that the scientific hardware be so reliable as to not significantly impact the reliability of the system as a whole. The cable operator also would probably want to retain control and decision making ability over the entire system.

<u>Possible incentives for cable owners</u>

Based on the above, one can see that retired cables can be made available for scientific use without the need for substantial Congressionally mandated incentives. On the other hand, the cost and other issues associated with adding scientific monitoring and transmission equipment to an active cable, even assuming it is designed-in, would be so substantial that it may not be feasible to encourage doing so through Congressional incentives. That said, several types of possible incentives can be identified:

?? Direct government funding of the incremental costs associated with the scientific project.
?? Tax incentives.
?? Relief from regulatory requirements that otherwise might be imposed (e.g., to inspect the cable's burial status, or to remove it at the end of its commercial life).
?? Streamlining of the approval process for the new cable system (i.e., reducing the time needed to gain all approvals, and adding certainty to the permitting schedule).

NASCA's comments previously filed with the Commission identified the unpredictability of the approval process, and especially of the total; time required, as one of the biggest problems for the installation of new systems in response to market demand. NASCA suggested formation of a unified federal process to replace the current multi-agency process and to decide on proposed projects in a timely manner based on standardized, predictable criteria. The opportunity to be reviewed through such a process would provide a substantial incentive to the developers of a new system. Of course, to connect this incentive with the objective of scientific access, the technical basis for the scientific access would have to be developed and made known well in advance, so that it could be included in the cable system design process.

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~~Fiber Optic Cable Systems Landing in North America~~

~~RFS Date~~	~~Cable System~~
~~Transatlantic Cable Systems~~	
~~December, 1988~~	~~TAT-8 (Retired)~~
~~November, 1989~~	~~PTAT-1~~
~~March, 1992~~	~~TAT-9~~
~~1992~~	~~TAT-10~~
~~September, 1993~~	~~TAT-11~~
~~November, 1994~~	~~CANTAT-3~~
~~December, 1994~~	~~Columbus-2~~
~~October, 1995~~	~~TAT-12~~
~~September, 1996~~	~~TAT-13~~
~~May, 1998~~	~~Atlantic Crossing -1~~
~~March, 1998~~	~~Gemini~~
~~November, 2000~~	~~Atlantic Crossing-2 / Project Yellow~~
~~May, 2000~~	~~Atlantis-2~~
~~May, 2001~~	~~360atlantic-1~~
~~April, 2001~~	~~FLAG Atlantic-1~~
~~March, 2001~~	~~TAT-14~~
~~July, 2001~~	~~TGN Atlantic~~
~~September, 2002~~	~~Apollo~~
~~TBD~~	~~Asia America Network~~

March, 2001	360americas

Caribbean Cables w/ Landings in United States

Sept, 1994	Americas I
Aug, 2000	Americas II
May, 2001	ARCOS I
December, 1994	Columbus II
December, 1999	Columbus III
October, 2000	Maya I
June, 1990	Transcaribbean Cable System
February, 1999	Pan Americas
August, 1997	Saint Thomas - Saint Croix

Gulf of Mexico

December, 1999	FiberWeb

Other Atlantic Cables w/ Landings in United States

June, 1997	Bahamas-2
November, 1997	Bermuda - US (BUS)
October, 1995	CANUS-1 (Canada - US)
September, 1996	TAT12/13 Interlink
March, 2001	TAT-14 Interlink
September, 2000	Mid-Atlantic Crossing

Transpacific Cable Systems

April, 1989	TPC-3/HAW-4
May, 1991	North Pacific Cable (NPC)
November, 1992	TPC-4
January, 1993	HAW-5
January, 1996	TPC-5
January, 2001	China-US Cable Network
December, 2000	Pacific Crossing -1
November, 2000	Southern Cross Cable Network
April, 2001	Japan-US Cable Network
TBD, 2002	TGN Pacific (Installing)

Other Pacific Cables w/ Landings in United States

September, 2001	Global West
July, 1994	Hawaii Inter-Island
February, 1997	Hawaiian Island Fiber Net
September, 1999	Northstar
January, 2001	Pan-America Crossing

~~February, 1999~~ ~~Sea-Van-1~~
~~February, 1999~~ ~~Alaska United~~