COMMUNICATIONS
FORUM

FIBER OPTICS vs. SATELLITES

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Seminar Notes

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Walter R. Hinchman
INTELSAT

Anthony Rutkowski
FCC

Jack M. Sipress
AT&T Bell Laboratories

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Jack M. Sipress - AT&T Bell Laboratories

Sipress began by tracing the history of undersea cables. He stated that this industry is quite old and showed a sketch of the first cable ship that laid an undersea telegraph cable across the Atlantic 120 years ago. The first cables were telegraph cables. He said that some of the analog coaxial cables laid 35 years ago are still functioning. Design improvements produced major capacity improvements compared with the original coaxial cables. The capacity improvements were due to larger bandwidth and TASI (Time Assignment Speech Interpretation). However, the newer cables were large with short repeater spacing. Also, analog cables were inefficient for new digital services.

The new lightwave technology requires much smaller cables and is able to handle larger capacities. In addition these cables have longer repeater spacing resulting in significant cost reduction. The new lightwave technology also permits long unrepeatered systems, broadband digital services, and new networking configurations.

Sipress stated that AT&T's first generation lightwave cables were called SL280 and were capable of handling 280 Mb/sec on a single lightguide pair. This cable had a signaling rate of 296 megabauds and 1, 2 or 3 pairs of light guides.

He then went on to describe in detail (using slides) the use of these lightwave cables in transmission from land to sea and land again. Repeaters in the underwater portion of the cable are used to electronically regenerate the signal. Branching repeaters are used at the point underwater where the cable divides and proceeds in two different directions.

Sipress in describing the cable stressed the need for it to be very strong in order to survive. The cable together with repeaters are designed to last for at least 25 years. The central fiber has to be very strong. It has to be able to withstand 200,000 lbs/square inch. In addition to strength, the cable quality has to be such that losses are minimised. He then described the structure of the repeater in detail. The repeater is a pressure vessel within which is contained the electronic system. The electronic system converts the light signal to electrical impulses which are then regenerated and converted back to light again.

Sipress then gave examples of different types of lightwave systems that are either currently in use or are being planned.

(1) Short haul unrepeated system - this is a 147 Km cable currently used by the US government. Because of its limited length it does not use repeaters.
(2) Field trial of SL280 - between Tenerife and Gran Canaria

(two of the Canary Islands). The cable is 120 Kms in length and reaches a maximum depth of 1800 fathoms (about 3300 meters). It has two service lines and one protection line. The system uses three repeaters and carries 560 Mb/s of data back and forth.

(3) The long haul Trans Atlantic cable - this is a 560 Mb/s cable of length 6700 Km which is currently being manufactured. The cable will extend from New Jersey across the Atlantic branching just south of the United Kingdom - one branch to the UK and the other to the continent (via France). 87% of cable (New Jersey to branching point) will be the responsibility of AT&T. STC will be responsible for the 500 Km branch to UK (8%), and Submarcom will be responsible for the French portion of 300 Kms. This system is expected to be in service by June '88.

(4) The long haul Pacific cable network - California to Hawaii and then to a branching point for Japan and the Philipines (via Guam). Most of these cables are due to be completed by the end of 1988.

Finally, he discussed the future of lightwave technology. Cost reduction he said was the most important factor. This is possible by developing the system to handle a higher transmission rate and lower power losses. In this regard the following areas are currently being ivestigated.

- Coherent transmission with single frequency laser (to see if laser can transmit in single wave length).
- Halide glass (to reduce power loss). This is not expected to be achieved for many years.
- Extensive use of 1.5 um transmission.

The ultimate aim is not to have repeaters at all. This would be achieved, if ever, many years in the future.

Walter R. Hinchman - INTELSAT

Hinchman began by asserting that satellites are and will remain the least cost means of carrying international telecommunications' traffic for the foreseeable future. He further stressed that it is neither a simple nor an easy task to develop meaningful comparisons of the fiber optic cable or satellite communication. They have different capabilities, ownership, operating structures, different policy and regulatory responsibilities and constraints. Unless some of these factors are taken into consideration, any effort to make a comparison will be meaningless.

He then commented on the respective capabilities of cables and satellites. The fiber optic cable like most undersea cables performs essentially one basic function, which is to carry a single traffic stream from a landing point on one side of the ocean to a similar landing point on the other side. For a sufficient volume of traffic and a reasonable distance between the respective landing points, a fiber optic cable can perform this function quite efficiently. The efficiency drops quite significantly for thinner traffic streams and/or longer distances. In effect such cables exhibit significant economies of scale and diseconomies of distance.

Satellites in general and INTELSAT satellites in particular can perform several different functions. They provide a high capacity link between two gateway locations on opposite sides of an ocean. This could be achieved by a low-cost satellite with two relatively high power broadband beams focussed on the two gateway locations. Though satellites have not been designed, deployed, and used in this limited role, Hinchman was confident that it could be done for a lower cost than the typical cable installation. Satellites he said, can also be configured to perform many other functions which cannot be performed by the undersea cable. Using broader antenna coverages they can provide many transmission links of varying traffic densities between and among many locations encompassing nearly 1/3rd of the earth's surface. The cost of these links are largely insensitive to distance, upto 6000 miles or more. This allows satellites to function as a combined switching and transmission node (complete communication network). In addition satellites receive and transmit signals and are therefore useful for both "broadgathering" and "broadcasting".

Because of these significant differences in the inherent capabilities between undersea cables and satellites as well as other social and political considerations, the world's political and regulatory institutions have created quite different ownership and operating structures, and have also assigned these facilities, quite different social, economic and political objectives and responsibilities. Satellites, because they are capable of performing so many different functions for so many different countries and services, the ownership, operation and use of international satellite facilities have been vested in a single international cost sharing cooperative called INTELSAT.

Hinchman said that INTELSAT has been instructed not to design and operate satellites simply as cable alternatives, but rather to design and operate them in a manner which exploits all their various capabilities for the mutual benefit of all 110 member countries. Costs are globally averaged among all the routes served by the satellites to produce a common unit charge per circuit irrespective of distance or traffic volume. These constraints on design and pricing have a benefitial effect for many international routes which could not possibly sustain even the low-cost cable alternative. This has created an operational and economic structure for satellites that cannot realistically or meaningfully be compared with that of undersea cables.

Hinchman then pointed out several other factors which make it difficult to meaningfully compare cable and satellite operation costs. As an example he quoted the case of satellites being used to provide backup and restoration for cable failures (i.e. combined use). Also he noted the importance of comparing not just costs of transmission from landing point to landing point but rather the end to end cost. He stated that what the future holds for these respective facilities is far more dependent on the institutional arrangements, policy and the regulatory environments in which they are used than on their basic technical and economic characteristics.

Finally Hinchman identified the cost of the INTELSAT resources required to fully replace or substitute a transatlantic fiber optic cable such as the TAT-8 currently being costructed. He presented two cost analysis. In the first case he calculated the annual per circuit costs of the amount of INTELSAT capacity required to replace a fully loaded TAT-8 fiber optic cable, and compared this with the annual per circuit costs of such a fully loaded TAT-8 cable. The results show that the INTELSAT capacity is only 1/4th as much as the TAT-8 costs. In the second case he performed a similar analysis of the per circuit costs of a TAT-8 cable and a comparable amount of INTELSAT and associated earth station capacity, based on the actual traffic forecasts and planned loading of these facilities over the 1987-1992 period. While at the beginning of this period, the INTELSAT alternative enjoys the same 4:1 cost advantage, by the end of the period (due to the much higher traffic loading proposed for the TAT-8 cables) the cost per channel of utilized INTELSAT capacity and the cost per channel of utilized cable capacity are essentially equal. This results primarily from a much heavier loading forecast for the TAT-8 cable. This demonstrates the fact that the ultimate results are more dependent on institutional decisions than on true costs.

Anthony Rutkowski - Federal Communications Commission

Rutkowski began by defining three fundamental areas of development that continue to profoundly affect the telecommunication and information environments: photonics, large scale integration, and software. Each of these areas is subject to constant evolution in basic physics and intellectual creativity that is pushing boundaries by orders of magnitude. He said that the long-term result should be to optimize radio systems of all kinds for the transport of information within physically dynamic architectures or for other specialized applications, while the basic backbone of integrated information services becomes fully photonic. The point is that each medium will inevitably coexist and flourish to serve largely separate needs and applications within a common integrated environment. He then went on to describe the significant developments.

Rutkowski said that during the past year some development had occured for the provision of duplex communication over a single fiber in local loops. Optical fibers transmit information at rates approaching 1 THz and increased spectral purity of laser devices allow for the implementation of coherent transmission methods by which maximum transmission rates can be approached. The available exotic halide glasses combined with long wavelength laser devices bring the ultimate transmission distances within reach - a continuous, repeaterless, fiber link between the continents. Current research he said, is aimed at improving the following factors relating to fiber optics: fiber diameter, cost upgradability, longevity, reliability, bit error rate, security, transmission time delay and finally photonic integration. In the area of security transmission, fiber optics is not vulnerable like satellites which are susceptible to signal interception. Also satellites have the disadvantage of transmission time delay where transmission is via the satellite located 36,000 kms away. With reference to photonic integration Rutkowski noted that in the more distant future optical fiber will prove a particularly desirable transmission medium as optical switching technology becomes available and integrated with optical processing and storage devices.

Rutkowski then discussed the implementation of fiber optics as a preferred transmission medium among many users of communication and information. He said that many giga-dollars are now being spent for such facilities around the world, especially in the US. Rutkowski quoted cases from around the world where fiber technology is being implemented.

(a) US - Most of the interexchange transmission capacity being installed in the US (as in most industrialized countries) is now fiber. The past year was marked by the establishment of extensive private fiber optic facilities spanning the US under the corporate umbrella of the national telecommunications network. The last major frontier, the local loop, is beginning to rapidly fall. This year the US fiber market is expected to exceed one billion dollars.

(b) Canada - Fiber technology is being implemented as a special project among the remote Georgian Bay islands in nothern Canada. This is part of a commitment by Bell Canada to implement a nationwide fiber network; effectively a backbone fiber network.

(c) Japan - Its newest communication link using optical fiber technology was put into practical service in early February, 1985 transmitting bulk information over most of the length of the Japanese archipelago. The 3300 km circuit is expected to serve as the "artery" of Japan's telecommunications system in the advent of the information society.

(d) Europe - Here it is occuring within an European community (EC) program known as Research on Advanced Communication in Europe (RACE). All switching in the network would be digital, transmission would be completely via optical fiber cable, and the integrated network would be end to end compatible in all the EC member countries.

(e) China - Among third world countries, the People's Republic of China (PRC) is clearly the leader in optical fiber systems in research and development.

(f) India - Has announced the allocation of funds for telecommunications indicating that a "quantum jump is going to be made into digital electronic and optic fibre".

(g) South America - The Peruvian telephone company is installing a fiber optic link in Lima as part of an integrated digital service network. The Ecuadorean Telecommunications Institute outlined (February 1985) long-range domestic telecommunication objectives including optical fiber transmission equipment for developing and expanding intra and inter urban facilities.

(h) Africa - The Ivory Coast is studying a fiber optic link pointing out that "fiber optic technology is ideally suited to the conditions of tropical climates".

(i) Soviet Bloc - During the past year, Poland appears to have emerged as one of the leaders in fiber optics in the Eastern Bloc.

Rutkowski mentioned that on the international front, the first fiber optic transatlantic cable (TAT-8) will be brought into use in 1988, as will the transpacific cable (TPC-3). TAT-9 is sheduled for use in 1992 and its routes planned. He stated that within the international organizations the International Telecommunication Union (ITU), and the International Consultative Committee on Telegraph and Telephone (CCITT), have been active in focussing on optical fiber developments. A considerable number of contributions now focus on broadband ISDN services and some priliminary decisions are being reached.

Rutkowski discussed the FCC's role in authorizing domestic and international fiber optic cables. In this regard he cited several examples. The FCC does not regulate private domestic fiber optic facilities. However, during the past year, the issue of Commission jurisdiction over these facilities has arisen for the sole purpose of preempting state regulation. He stated that the past year had been especially marked by increased activity in many domestic technical, standards making, and network operations forums on the subject of broadband integrated networks oriented around fiber capacities.

In conclusion Rutkowski said that in the remarkable space of three years, the telecommunications community had undergone a metamorphosis on the subject of fiber optics vs. satellites. The first stage was disbelief that satellite applications could be affected by fiber optics. The second stage was marked by a fear that an "intermodal" showdown was imminent and the future of satellites was dark. The third and current stage he said, recognizes that transitions will occur, but each medium has its own ideal applications. In the end, we all benefit by the synergism among the markedly increased transmission capacity, lower costs, and innovation to make the lives of everyone fuller and more interesting.

Speakers' Comments and Responses to Questions

A member of the audience commented that he felt there was a lot of synergy between fiber optics and satellites and as an example he cited the possibility of satellite transmission being used as a backup to fiber optic cables in some areas. In response Rutkowski stated that there were some places that could be reached only by satellite (e.g. Indonesia). Sipress confirmed that satellite certainly has particular exclusive services which fiber optic cables cannot serve. However referring to the transatlantic cable, he said that in that instance because of the large traffic it was cheaper to use cable and not satellite. Hinchman disagreed saying that transmission by transatlantic cable was not cheaper if compared strictly against the satellite. It was only cheaper because satellites are used for other purposes and as such ther is a premium on its opportunity cost. Further, regarding the issue of synergy he stated that satellite also has economics of scale and cannot just act only as a backup to the fiber optic cable.

A question was raised about the use of satellites and fiber optics on a national scale. Hinchman in responding stated that satellites were attractive domestically because of its multipoint ability (broadgathering and broadcasting). Rutkowski commented that fiber was suitable for equatorial communications - geostar type of applications with short messages going back and forth. Sipress added that the bulk of other common carriers used fiber.

In response to the question of the FCC's role in fiber optics, Rutkowski said that the FCC's involvement was required because of existing regulation - Cable Landing Act. However he said that it was just a proforma operation.

The issue of universal/equitable service was raised by a member of the audience. He referred to the equity of service between urban and rural areas in the US. Sipress stated that the issue was decided 5-6 years ago and Rutkowski argued that you cannot have the same price for both types of locations, as the costs varied. Hinchman added that even before the advent of these new technologies it wasn't universal service. He said that it was impossible to have competition and government involvement.

Responding to the question of investment justification relating to NASA's next generation satellite (AX program), Sipress highlighted the fact that submarine cables were developed with private funds unlike in the case of satellites.

The question was raised about satellite vulnerability and whether it was sufficiently secure for transmission. Hinchman pointed out that neither cable nor satellites have been targets so far. Rutkowski added that the degree of security depended on the type of application. He said that if necessary vulnerability relating to satellites could be reduced using spread spectrum. Hinchman noted that digital technology also helps increase security.
