APPENDIX D

TECHNOLOGY

This Appendix describes the technologies included in the assessment and comments upon some of the economic factors governing their use. The technologies described are:

- coaxial cable (cable television)
- translators
- telephone
- microwave
- communications satellite
- fiber optics

Coaxial Cable

Cable television depends on coaxial cable which consists of a metallic shield and a hardwire core separated by insulating material. The cable distributes signals collected at a central point (headend) to the viewing audience. Cable systems were initially developed to provide service in small towns. Today, more than two decades after the first systems began operation , almost half of the 3000 systems in operation still serve towns with less than 1000 subscribers (1).

Twenty million homes are now within reach of cable and about 10 million subscribe to the service at rates of $5-10 per month (1). The capital investment per home served averages around $100 and ranges from approximately $500 in sparsely settled areas (15-20 households per square mile) down to $40 in more densely settled areas (greater than 1000 households per square mile). Cable plant costs are $3000 and up per mile (2-67). Because of these high costs, cable installation's are generally made only in areas with population densities of at least 30-40 households per cable mile (2-4). Although 30-40 households per mile is a rough rule of thumb used by private cable operators, it has been suggested that, in rural areas, as few as 7 subscribers per cable mile (14 households per cable mile at 50 percent penetration) may be economic (3-107). The reduced costs of installation in easily accessible rural areas is one factor favoring the lower figure.

More than two-thirds of the cable systems in operation have a channel capacity of less than twelve channels. More typically, the capability is on order of six channels. By comparison, coaxial cable now available offers the capability of furnishing 30 to 40 full television channels.

Translators

Federal Communications Commission Rules and Regulations define translators as broadcast stations ". . . operated for the purpose of retransmitting the signals of a television broadcast station, another television broadcast translator station, or a television translator relay station by means of direct frequency conversion and amplification of the incoming signals. . ." (4-74701). Translators are used to *receive* signals at strategically located points and to distribute those signals to areas where acceptable signals cannot be received directly from the originating broadcast station. Distribution is accomplished by "translating" the signals to another channel to avoid interference with the originating station, and rebroadcasting the signal over the air. One translator is required for each signal received and rebroadcasted.

As stated in Broadband Communications in Rural Areas prepared by the Denver Research Institute (2-4) :

> "Translators provide the lowest cost way of providing one-way broadband service in rural areas. In Utah, which has a well-developed translator network, virtually the entire population receives several channels of television, and cable television has made few inroads. In countries such as Japan, extensive translator networks provide television service in rural areas at low cost."

The capital costs per household to supply six channels of television with good signal quality in sparsely settled areas (15-20 households per square mile) will range from $10-50 depending on the equipment used and the height of the broadcast antenna. These costs will be approximately $70 in communities with 100 homes and $7 in communities with 10,000 homes (2-35).

Although approximately 3000 translators are in operation in the United States, there is no accurate estimate of how many households depend on translators for television service (5). Several factors, such as regulatory impediments (discussed in the next section) and the fact that subscriber revenues are difficult to obtain since those not paying can still receive the signal, have limited the use of translators in the United States (2-5).

Two technical considerations limit translator use. First, as mentioned above, because translators broadcast[1] over the airwaves, anyone can pick them up making it difficult to collect revenues. This could be remedied with "scramblers" which would make the signal meaningless for television sets without decoding equipment. Such equipment could be charged for monthly as in cable systems. However, hardware costs are about $50 per household, a cost which might be reduced by further technical development *(2-5)*. (Scramblers would also require regulatory changes.) Another technical characteristic of translators is that signal quality degrades so as to be unusable after several translations. One reason is that translators use amplitude rather than frequency modulation. Another is the simple and relatively inexpensive design of many translators (2-5). If translators are to see more frequent use in rural areas, the tradeoffs in these characteristics should be examined.

As indicated previously one translator is required for each signal. Signals from more than one translator can be transmitted from a given antenna. However, spectrum availability limits the number of channels which can be provided to six to eight. There is the possibility of more in very remote regions *(2-4)*.

Translators provide one-way signals to the consumer. Return capability could be provided via telephone.

Telephone

The telephone system depends on a variety of transmission media to transmit voice and data. Signals are distributed locally over small gauge, narrowbandwidth copper wires; transported intermediate distance by coaxial cable trunks; and transported long distances by terrestrial, or satellite-borne, high frequency (microwave) radio systems. Telephone systems have effectively served the general public (more than 94 percent of the households in the United States), business and government. New services are being continually proposed (e.g., automatic meter reading) to more efficiently utilize the extensive local residential distribution network.

However, as stated by the Denver Research Institute (2-6).

> "It is unlikely that telephone lines can be used for video signals in analog form or with present digital coding techniques. As digital telephone systems are introduced in rural areas subscriber response capability for applications such as polling could be provided for minimal additional distribution plant cost. However, because subscriber response services have not yet been defined as a need or a potential market, current digitally-based telephone systems designed for rural areas do not provide such capability. There is potential for shared telephone and television plant as the technology of digital television transmission is further developed over the next ten to twenty years."

Microwave

Integration of rural telecommunications systems; whether cable or translator, both can be accomplished with microwave relay systems (however, present regulations prohibit such use for translators). Microwave relays are used for transporting large amounts of information point-to-point over line-of sight distances (15-30 miles) or further if repeaters are used.

Capital costs for transmit-only or receive-only equipment for transporting 12 television channels, using 10-foot dish antennae are $80,000-$100,000 each. Repeaters (receive/transmit stations) cost approximately $160,000-200,000 each (2-95ff.). For two-way communications, transmitter and receiver equipment would be required at each location. It is also possible for subscribers to lease channel space on established common-carrier microwave systems. The typical rate for one-way, CATV-type service, if, for example, eight channels were transported 100 miles, would be approximately $20 per channel-mile per month, or $16,000 per month. Rates will vary as a function of distance and number of channels (6).

Communications Satellites

A communications satellite serves as a microwave relay in space. Such satellites are placed in a geostationary orbit so that their position remains fixed over a particular location on earth. Because microwave repeaters transmit along a line-of-sight path, location of such repeaters on a satellite permits coverage of a large portion of North America by each repeater, rather than, as in land-based relays, requiring one repeater every 20 to 30 miles.

Receive-only earth stations are now available for $65,000-75,000 and can be located at the head-end of a single cable television system or centrally located to provide direct service to a number of cable systems, Alternately, cable or terrestrial microwave systems would be used to transport the signals from the earth receiving station to the head ends of these systems. Although regulations do not currently permit such use, the signals could also be distributed by translators.

It is currently very unlikely that in the United States signals will be distributed directly to home receivers from broadband satellites, Development of a $50-200 home receiving unit would require a capital investment of $100 to 400 million, exclusive of satellite costs, to reach the three percent of U.S. households not currently receiving any television (2-6),

Fiber Optics

Recent developments in fiber optics, light emitting diode and laser technologies make it possible to consider glass fibers as a communications medium much sooner than has been predicted. According to statements in a recent issue of the Bell Lab News reliable fibers can now be fabricated reproducibly through which light can travel over a half a mile and lose "less intensity than it would in passing through ordinary window pane". The problem of splicing optical cables, one of the major obstacles in the development of optical communications, appears to have been resolved. Powerful and reliable semiconductor light sources; methods of encoding information on the light beam; and repeaters, to amplify or regenerate signals weakened by traveling great distances, have all been **developed** in recent years. Light detectors, needed at the receiving end to convert the coded information back into electrical signals compatible with the rest of the network, have been available for a number of years. Once all of these elements are tied together into an economical system it **will** be a communications system with the potential for carrying far more information than any available today. Fiber optics could eventually be used to distribute television signals at costs lower than coaxial cable distribution costs. Some perspective on the potential impact of fiber optic communications can be obtained from the following table which compares telephone, coaxial cable and fiber optical systems.

Table D-1

Comparison Of Telephone, Coaxial Cable And Fiber Optics Technologies

TYPE OF SYSTEM →	TELEPHONE WIRED PAIR	COAXIAL CABLE CATV TYPE	FIBER OPTICS LED LIGHT SOURCE PHOTO DIODE DETECTOR	FIBER OPTICS LASER LIGHT SOURCE AVALANCHE DIODE DETECTOR
Transmission Medium Diameter (in mm)	[illegible]		.02	.02
Bandwidth (in M Hz)	.004	300	10-20 (3)	(4)
approximate number of TV channels	0 (1)	30-40	2-3 Analog 1 Digital	10 Digital
Throughput Capacity (in mbps)	.0048(2)	300	100	1000
Capacity of Cable with Dia = CATV Coaxial (in mbps)	.150-.250	300	3-5X10[7]	3-5X108
Repeater Spacing (in km)	1.8	.5	10	10
approximate Present Costs (per meter)	$.05	*$.70-.80*	$1.00(5) (typical cable)	$1.00(5) (typical cable
Approx. No. TV Channels for Cable with Dia. = CATV Coaxial	O (1)	*30-40*	Analog: 600,000(6) -1,500,000 Digital: 300,000	Digital: (6) 3,000,000 -5,000,000

Notes:

(1) Can be increased under special conditions.

(2) Recent developments suggest that one TV channel can be transmitted over short distances.

(3) Will vary according to light intensity and distance.

(4) Analog service will probably not be considered.

(5) .10/meter anticipated when production quantities achieved.

(6) Provided to illustrate potential. Cables of this size may not be practical.

References

1. National Cable Television Association. Cable/Info., Washington, D.C., April, 1975.

2. Bortz, P., Spongberg, R. and Vendetti, F., Broadband Communications in Rural Areas, Denver Research Institute, Final Report to the Executive Office of the President, Office of Telecommunications Policy, November, 1973.

3. Nicholson, V., Rural Extension Techniques and Systems, NCTA 74-105.

4. FCC Rules and Regulations

5. Paper delivered at the National Telecommunications Conference, December, 1975.

6. Interview with Robert Ottman, Western Telecommunications, Inc.