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ABSTRACT

The technology of cable television (CATV) is one area in which local community officials need to develop knowledge so that their decisions about the structure of CATV within the community will be informed. Thus, this paper is designed to familiarize local decision makers with the technological aspects of cable communications, to isolate specific questions which local officials must consider as they plan for CATV in their communities, and to note and explain options available to franchising authorities in dealing with those questions. Section One of the report describes cable technology past, present and future; the second section considers issues involved in systems design technical performance standard, and the implementation of future technology. (Author/SH)

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TECHNOLOGY OF CABLE TELEVISION

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PREFACE

This document was prepared by the Cable Television Information Center under grants from the Ford Foundation and the John and Mary R. Markle Foundation to The Urban Institute.

The primary function of the center's publications program is to provide policy makers in local and state governments with the information and analytical tools required to arrive at optimum policies and procedures for the development of cable television in the public interest.

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INTRODUCTION

Cable television's entrance into a community poses special problems for local officials. Although it is an opportunity to determine how the community wants to regulate a new service — a new medium of communication — it is an opportunity often overlooked. Taking full advantage of the opportunity usually requires a basic educational effort so that decisions can be made on the basis of a working knowledge of how cable television operates, how local citizens can make use of it, and what decisions local authorities can take responsibility for making.

The technology of cable television is one area in which local officials need to develop the knowledge on which to base their decisions. It is important that local decision makers understand cable television technology for several reasons. First, because a cable television system's technical design importantly influences its social and entertainment usefulness, systems should be planned with thorough consideration of local demographic, social, and political characteristics and the service demands which these characteristics may make on that system. Second, since there must be reliable delivery of high quality television signals if cable is to perform adequately any of its existing or projected functions, franchising authorities should establish technical standards against which the performance of a system can be measured. Third, because cable technology will continue to grow in sophistication, local officials will want to develop regulations that will permit their community to accommodate changes in that technology.

This publication has three goals:

- To familiarize local decision makers with the technological aspects of cable communications;
- To isolate specific questions which local officials must consider as they plan for cable television in their communities; and
- To note and explain, where applicable, options available to franchising authorities in dealing with those questions.

Section 1 of this report describes cable technology — the first goal of this paper. The basic components of a cable television system are explained both in the historical context of how most systems were built before governments and citizens were aware of cable's potential importance, and how systems are being planned today. Discussion is also directed to the role of cable communications in the future.

The second and third goals are treated in Section II. The issues involved in system design, technical performance standards, and the implementation of future technology are examined from the perspective of the local public official faced with decisions.

TECHNOLOGY OF CABLE TELEVISION

This chapter explains how traditional community antenna TV (CATV) systems work, discusses the technical characteristics of modern cable television, and examines problems and prospects for broadband cable communications — the advanced systems that exist now only in prototype.

A. Traditional CATV Systems

Cable television began by providing a service which extended the range of broadcast television stations, or, differently put, brought broadcast TV to those who could not otherwise receive it. Broadcast television service is most attractive economically when the area it covers (a radius of roughly 35 miles around the transmitter) is heavily populated. The reason is that broadcast television station revenue is derived almost entirely from advertisers, who pay for "time" on an amount-per-viewer basis. The more viewers a TV station reaches, the more it can charge for audience time.

However, the ability to saturate an area, while important to the station owner and advertiser, poses certain disadvantages. Once a television station begins to broadcast, the same assigned frequency, or channel number, cannot be used by any other broadcaster within 200 miles; the two signals will interfere with one another.

Further, a local station broadcasting on a VHF (broadcast channels 2-13) channel adjacent to the channel of another station within 100 miles will interfere with the distant signal. The 12 VHF channels are not all adjacent to one another. But interference problems among those that are, limit the number of VHF broadcast television stations a viewer can receive to seven.¹ Table 1 illustrates this problem in Baltimore and Washington.

In practice, the economics of broadcast television usually limit the number of stations even further. Small cities and towns simply do not have

¹Any of two TV channels are considered adjacent when their video carriers are 6 MHz apart. Channels 4-5 and 6-7 are the only non-adjacent channels.

enough viewers to support more than one or two stations. It is this economic limit which has retarded the development of UHF television — once thought to be the key to diversity and localism in television service because of the number of channels.

CATV systems grew in towns whose citizens received either poor reception or no signals at all. These systems typically provided one to five broadcast TV signals to subscribers, and thus were not radically different from broadcast television service.

However, cable TV systems do use coaxial cable as a medium for delivering television signals, with characteristics different from broadcast TV. A single cable can carry as many as 40 television signals that do not interfere with each other from one point to another. Further, because signals carried by cable "leak" only slightly from the inside of the cable, the frequencies used in one cable can be used again in another cable next to it.

Hence, the number of stations that can be carried is limited by the number of cables one can afford to lay — not by any fundamental restrictions as in broadcasting.

Finally, since the cable protects signals it carries from outside interference, it potentially can deliver higher quality signals than those received off-the-air.

A CATV system consists of three components:

- A headend, or control center
- A distribution system — a network of cables which deliver signals to subscribers' homes
- A subscriber terminal — in this case, merely the subscriber's television set.

HEADEND

The headend includes an electronic control center (see Figure 1), which may or may not be housed near a 100 to 500 foot tower with a sensitive antenna mounted on it for each broadcast televi-

Table 1. TV Channel Allocations (VHF)

CHANNEL	BALTIMORE	WASHINGTON	OTHER
2	→ WMAR-TV		
3			→ Harrisonburg, Va. and Philadelphia, Pa.
4		→ WRC-TV	
5		→ WTTG	
6			→ Richmond, Va. and Philadelphia, Pa.
7		→ WMAL-TV	
8			→ Richmond, Va. and Lancaster, Pa.
9		→ WTOP-TV	
10			→ Altoona and Philadelphia, Pa.
11	→ WBAL-TV		
12			→ Richmond, Va., Wilmington, Del. and Lynchburg, Va.
13	→ WJZ-TV		

But separate cable systems in Baltimore and Washington could each carry a full twelve channels (2 through 13) without the possibility of major interference.

Source: Charles Tate, ed., *Cable Television in the Cities: Community Control, Public Access and Minority Ownership* (Washington: The Urban Institute, 1971), p. 9.

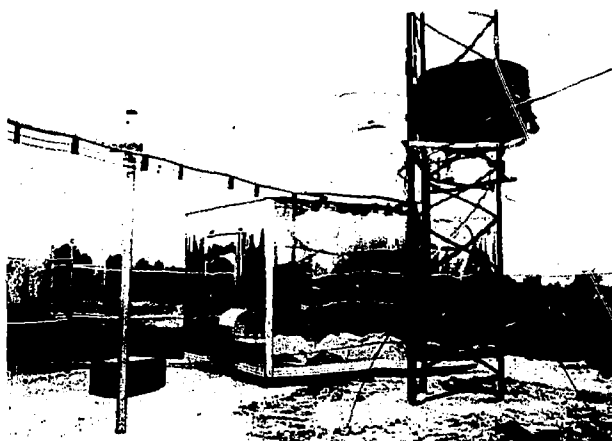


Figure 1. Control Center for a Cable Television System Headend.

sion signal received by the system (see Figure 2). The antenna is sited to provide the best available signal reception. Each received television signal passes through a processing amplifier, which separates the sound and picture components, and adjusts the signal levels to prevent a strong signal from one channel from overpowering another on an adjacent channel (as often happens in broadcast television). Thus, all 12 VHF channels can be used. The amplifier then reassembles the picture and sound signals for transmission throughout the distribution system.

UHF signals are broadcast at levels above the range of frequencies which can be transmitted via cable electronics. In a cable system which also carries UHF television signals, the headend includes electronic equipment to convert UHF signals to unused VHF channel frequencies within the cable system spectrum.

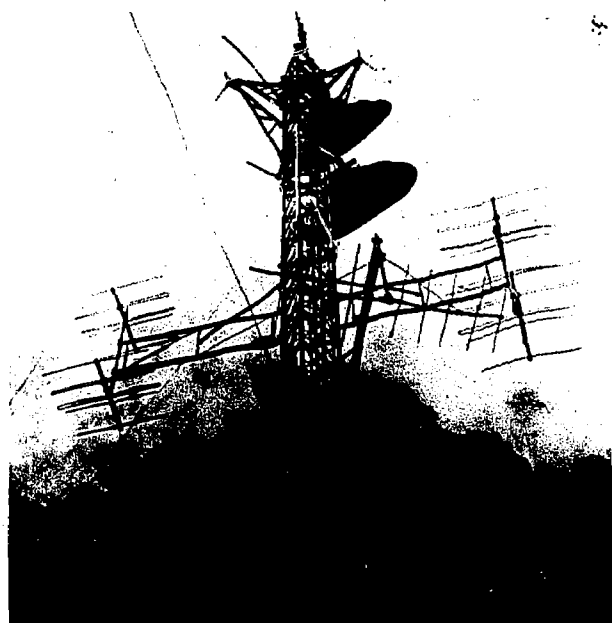


Figure 2. Antennas and Tower for a Cable Television System Headend.

DISTRIBUTION SYSTEM

The process of transporting signals from the headend to the subscriber is commonly referred to as "downstream" communication; the traditional cable system is capable of communication in the downstream direction only. The distribution system for one-way communication consists of a coaxial cable and the electronics necessary to transport signals from the headend to the subscriber. The basic element is a coaxial cable; the cable consists of an inner conductor, generally made of copper or copper-clad aluminum surrounded by an insulator (such as extruded foam polystyrene or extruded foam polyethylene) which is in turn enclosed by an outer conductor, typically aluminum (see Figure 3). Coaxial cables used by the cable television industry range in diameter from one-quarter to one inch.

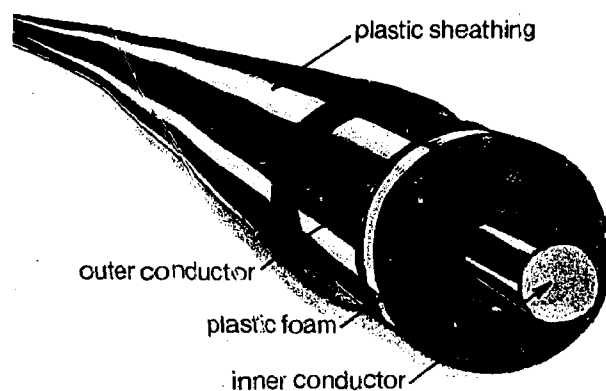


Figure 3. Coaxial Cable.

The distribution network, or "plant," is divided into two portions, trunk lines and feeder lines. Trunk lines, which are constructed of one-half to three-quarter inch coaxial cable, are the major arteries of the cable system. They transport the signals from the headend to the extremities of the cable system. Feeder lines, which are connected to the trunk lines, carry signals past each home. In a typical distribution plant, there is two to five times as much feeder cable as trunk cable. Although individual trunk lines are longer than feeder lines, there are a far greater number of feeder lines.

Both the trunk line and feeder lines employ electronic amplifiers which are installed at specific intervals to boost the cable signal, as shown in Figure 4. Feeder lines are connected to the trunk lines by an electronic device called a bridger amplifier. This amplifier draws signal power from

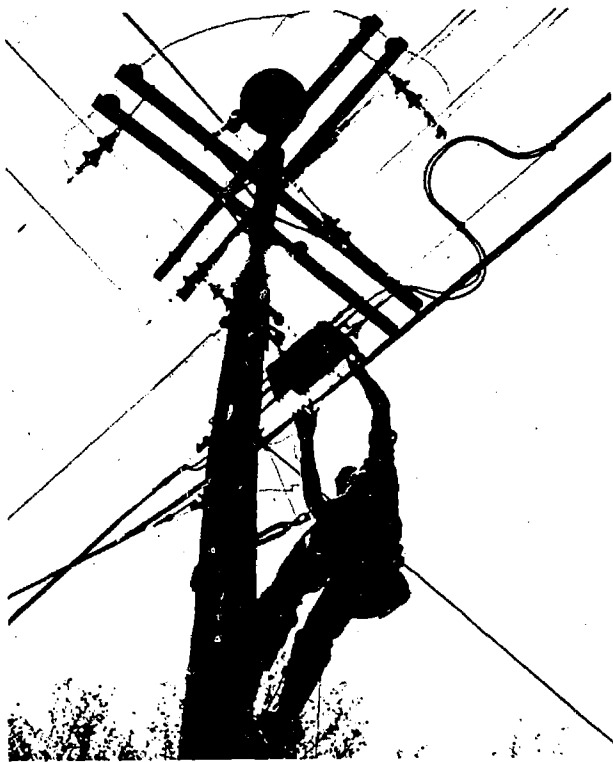


Figure 4. Cable and Amplifier.

the trunk for further distribution, and protects the trunk lines from electronic disturbance in the feeder lines.

Subscribers' television sets are connected to the feeder lines with a subscriber "drop" line. The subscriber drop consists of a tap at the feeder, the drop cable (typically one-quarter inch diameter cable), and a room wall plate connector. A short length of coaxial cable runs from the wall plate and is connected to the antenna terminals of the television set via a matching transformer.

An understanding of the electronics in the distribution system is helpful in making decisions about system layout and capacity.

Two problems in the electronic operation of cable system distribution limit the size of the geographical area a single cable system can serve. They are termed attenuation and distortion.

Coaxial cable attenuates, or weakens, a signal it carries. As a television signal flows through cable, the signal strength, or power of the television signal, diminishes; a typical coaxial cable trunk line has its signal reduced to 1/100 of its original strength for approximately every 2,000 feet of cable. The reduction of signal strength becomes perceptible to the viewer as a 'snowy picture. To counteract this attenuation, amplifiers are connected to the coaxial cable to boost signal strength.

Unfortunately, the amplifiers themselves cause the second problem — distortion. Both

cable and amplifiers introduce random electronic impulses into the television signal as it travels through the distribution system. These impulses are called "noise," and appear on the television screen as snow. Since each amplifier boosts both the signal and the noise, there is a limit to the total number of amplifiers which can be attached to a length of cable. Current design permits signals to be processed by 18 to 25 trunk amplifiers in a row ("cascade") before the amount of snow becomes objectionable.

The distance between amplifiers depends upon the degree to which each amplifier boosts the signal. The amount of boost is limited because at high signal output, the amplifier produces other kinds of signal degradation. These degradations, called intermodulation and cross-modulation distortion, appear on the television set as moving bars or stripes.

Trunk cable amplifiers are operated at low power levels to minimize amplifier-produced degradation. In practice, the distance between trunk amplifiers is about 2,000 feet. Thus, in combination, the amplifier cascade limit and the maximum distance between amplifiers defines the maximum distance for trunk cable to be 7 to 10 miles.

Feeder cable amplifiers (sometimes called line extenders) feed signals to the subscriber. They are operated at higher power levels than trunk amplifiers in order to permit more subscribers to be fed from a single amplifier. Since the feeder amplifiers are operated at higher power levels than the trunk amplifiers, the number of cascaded feeder amplifiers is normally limited by distortion considerations to three. The distance between feeder amplifiers is less than between trunk amplifiers, because the large number of subscribers drain signal from the feeder cable. In prac-

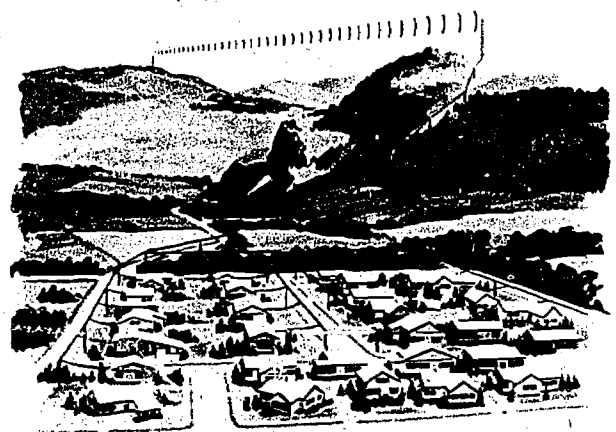


Figure 5. Cable Distribution Network for a Cable Television System.

tice, feeder cable extends no more than 4,000 feet from the trunk, and often less. Figure 5 illustrates a typical trunk and feeder network.

SUBSCRIBER TERMINAL

"Subscriber terminal" is a term more appropriate to the description of advanced rather than contemporary systems. Here, in the case of traditional CATV systems, the term refers simply to the subscriber's television receiver; in an advanced cable system it would consist of a television receiver in addition to other facilities, and would be capable of two-way communication and other services.

The standard television receiver is capable of receiving two bands of television broadcast frequencies: VHF and UHF. Unfortunately, as Figure 6 illustrates, present cable electronics design frequencies are not broad enough to encompass UHF television frequencies. System operators deal with this problem partially, by converting UHF signals at the headend to unused VHF channels. But while the operators can deliver as many as 35 channels to subscribers' homes, the standard television receiver can receive no more than 12 of those channels.¹

The standard receiver is equipped with electronic circuits that enable it to tune and receive broadcast signals. These circuits are not necessary for cable reception and may introduce unwanted broadcast signals that will interfere with cable systems. This problem can be reduced if the cable operator is permitted to modify the inside of the television receiver or connect the cable directly to the tuner.

A more practical solution is the development of a special cable receiver, designed to receive all 35 channels from the cable. Research and development is taking place, but as yet there is no such cable receiver on the market. In the meantime, other arrangements have been devised to increase capacity. These arrangements will be discussed later in more detail.

B. Modern Cable Television

Traditional cable television was developed to provide television service to communities too

¹Although cable electronics permit transmission of 40 television channels simultaneously, at present no manufacturer has designed a system that delivers more than 35 channels to subscribers. Thus, although the electronic capacity of cable is 40 channels, subscriber service for the time being will probably be limited to 35 channels.

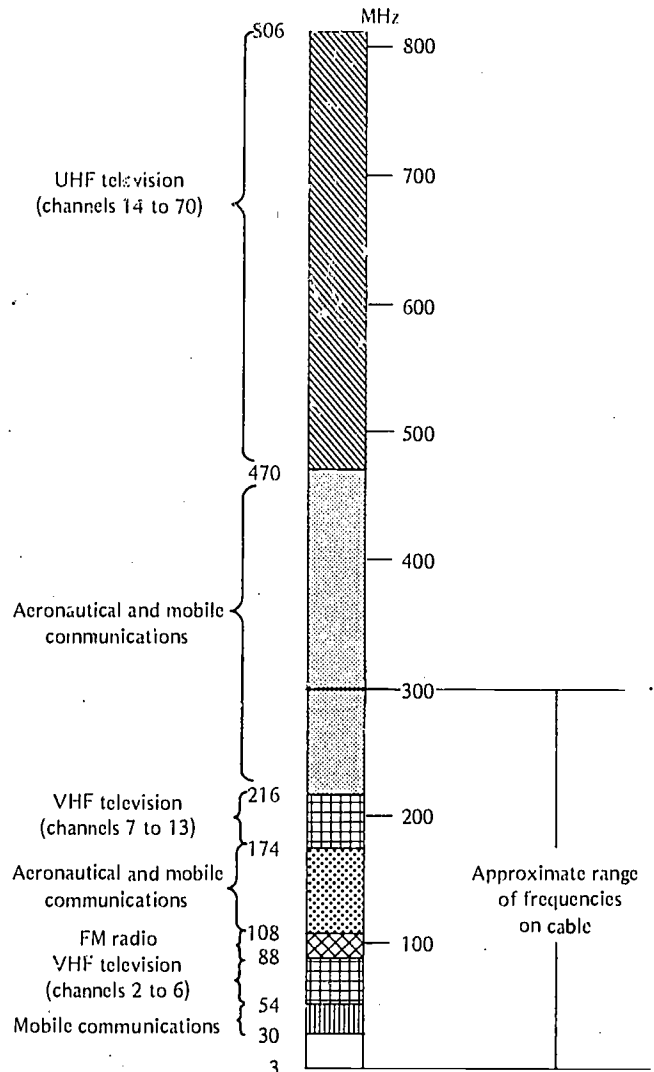


Figure 6. Television Frequency Spectrum

small to support a television station, or too far from cities that did have stations. Traditional CATV was essentially a retransmission service; but as the cable industry flourished, traditional systems provided the economic base for the further development of cable television technology.

Traditional cable television systems developed in areas where broadcast television is poor. Today, systems are built in areas where broadcast television service is available. Consequently, the provision of standard television signals will not be enough, and cable operators in urban environments will have to provide new and more diverse services. The result will be a more technically complex cable system.

1. Headends are becoming more sophisticated, with the addition of new features:

- Electronic importation of distant television stations

- Live studio programming exclusively for the cable system
 - Automated programming of news and weather
 - Multiple headend interconnection for large systems.
2. Distribution systems are beginning to have more capacity — as many as 35 channels delivered to subscribers.
 3. Subscriber terminals will include devices that bypass weaknesses of the television receiver.

HEADEND

As in the traditional cable system, the headend in a modern system includes the antennae, and the electronic control center for amplifying broadcast signals received and converting UHF signals to VHF frequencies before transmitting them through the distribution system. Additional facilities are now required to produce the new services.

Electronic Importation of Distant Television Signals

Cable systems are required to carry certain television stations which place a signal over the system's service area. Cable operators offer additional program services by importing television signals from distant markets. Since the signals are received near the distant market and transported to the local headend by microwave radio systems, one additional feature of a modern headend is the equipment necessary to receive and modulate microwave signals.

Microwave transmission is a system of broadcasting from one point to another 20 to 35 miles distant. To import a television station, a transmitter near the station radiates the signal in a specific direction — toward the distant receiver — rather than uniformly in all directions as is done with radio and television broadcasting. Microwave stations must be cascaded when stations from great distances are imported. For example, importing a television station from a market 200 miles away might require "hops" between three to five microwave stations. Microwave service may be provided by the telephone company, or by specialized common carriers, or it may be owned by the cable system operator himself.

Live Studio Programming

System operators frequently operate local studios to program a channel. The Federal Com-

munications Commission now requires that all systems with more than 3,500 subscribers must operate to a significant extent as a local outlet by origination cablecasting.¹

Studio facilities for cablecasting vary in cost, ranging from as low as several thousand dollars for facilities built around a half-inch black and white video tape recorder, to a full color professional studio that may cost \$1 million or more.

Automated Programming

Many system headends now include automated origination providing specialized services other than conventional telecasts. Automated equipment packages provide time, weather, stock ticker and news (AP or UP) wire services, many with alphanumeric message capability. At least one manufacturer markets a computer controlled videocassette player, which permits the system operator to play pre-recorded three-fourth inch videotapes automatically.

Multiple Headend Interconnection

Headends are now becoming increasingly complex because of the need for interconnection of systems. Interconnection is necessary when a community is so large that it must be served by several headends and distribution systems (called "hubs"): It may also develop when several contiguous cable systems in neighboring communities interconnect to share local programming.

Interconnection can be achieved by cable (including a new one inch cable with low signal loss characteristics, called "supertrunk"), or by microwave. This microwave is not the one-point-to-another kind used to import distant television signals, but a new service called Local Distribution Service (LDS). These microwave systems have the capability of transporting a large number of television pictures (from 8 to 38) from one site to a number of receiving locations, without visible degradation of signals (see Figure 7). Supertrunk is usually favored over LDS where weather conditions do not allow reliable LDS operation or where two-way capability is required, such as in a system with a number of local origination studios that need to be interconnected. However, in urban

¹In *United States v. Midwest Video Corp.*, 406 U.S. 649 (1972), the Supreme Court upheld the FCC's authority to impose the origination requirement. In the course of that litigation, however, the commission stayed the effect of the rule. Upon affirmation by the Supreme Court, the commission did not move to vacate the stay. There is some question, though, whether such action was necessary and the commission has not stated whether the rule is in effect.

environments where underground construction is necessary, microwave may be the least expensive one-way interconnection system. In some circumstances, a combination microwave and cable system for two-way interconnection may be less expensive than an all-cable system.

If interconnection of cable systems is desired (either presently or in the future), the technical standards for the distribution system must be more strict than those for a "stand alone" system. Whether microwave or cable is used to interconnect hubs, some additional distortions — both more noise (snow) and more intermodulation and cross-modulation (moving bars) — will occur. As a result, to obtain the same quality signals as those carried by a single hub system, the number of trunk and feeder amplifiers cascaded in a multiple hub system must be smaller.

Traditional systems use a one-way "tree" layout that can be likened to a party line — that is, all subscribers share the same facilities and receive the same programming (see Figure 8). A "fully switched" system such as the nationwide telephone network permits two-way private line communications by connecting each subscriber directly to a vast network of switching centers and alternate signal routes (see Figure 9). Interconnection, if properly designed, helps offset the party line character of cable system.

Interconnection permits headends to act as switching centers. Interconnection switching facilities allow one hub to receive programs of particular interest to its subscribers, while another hub does not. Or, switching facilities within a hub may also permit subscribers connected to a specific trunk to receive special programming (for example, a locally cablecast high school baseball game) while other trunks do not. Such limited switching capabilities are not nearly as sophisticated as the fully switched telephone system, but they do increase the flexibility of downstream one-way service and in the future may increase the efficiency of two-way services.

Although switched cable systems exist, they are not widespread in the United States. Switching centers are costly, and urban communities would require a large number of centers. Furthermore, the cost of laying the large number of cables required might be prohibitive, especially if the cables were placed underground.

DISTRIBUTION SYSTEM

The modern distribution system consists of the same elements as the traditional one — coaxial cable, amplifiers, and so on. However, with the

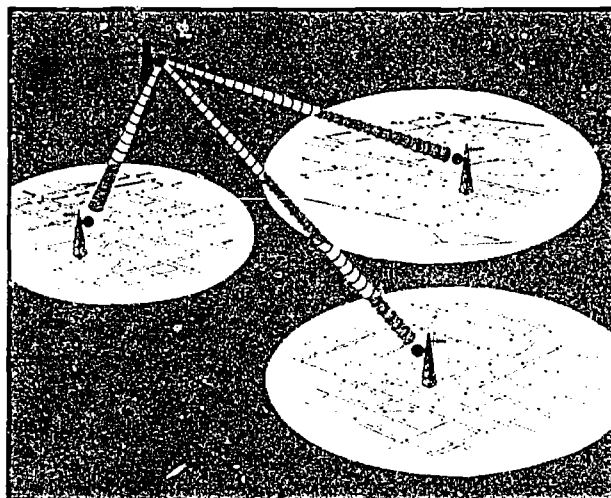


Figure 7. Microwave Interconnection of Cable Television Systems.

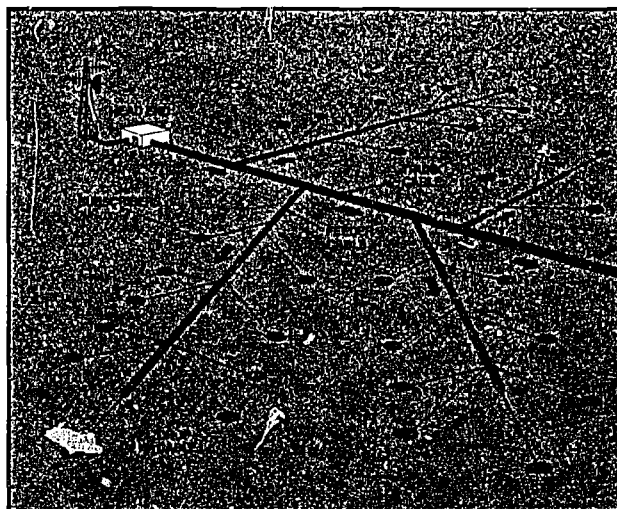


Figure 8. Cable Television Systems Use a Tree-Shaped Network.

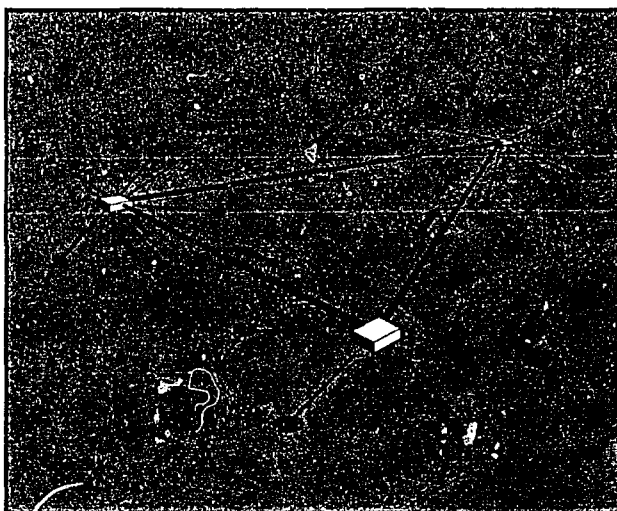


Figure 9. Telephone Systems Use a Switched Network.

increase in the number of services provided, several problems arise. As mentioned earlier, a standard television receiver is capable of receiving only 12 of the 35 channels cable can carry. Further, a strong local broadcast signal will interfere with a cable signal carried on the same channel when the two signals meet in the television receiver, making that channel unusable. Thus, distribution systems have to be modified to overcome these limitations.

Two approaches have been developed to solve these problems. The first, and generally the most expensive, is to bring additional cables to each home and provide a switch allowing the subscriber to switch from cable to cable, receiving up to 12 channels on each one. This approach uses only 12 of the 35 channels in each distribution cable — but it does provide a means of receiving more than the 12 channels on the television set. Further, this approach led the cable industry to develop prototype advanced two-way systems based on the presumption of a dual cable distribution system.

The second approach does not involve the distribution system, but rather the subscriber terminal.

SUBSCRIBER TERMINAL

More recently, system operators have increased capacity by installing a converter instead of extra cables. Depending on the model, the converter permits the subscriber to tune any of 26 to 35 cable channels. The converter translates the incoming signal selected by the subscriber to a VHF frequency — the best suited to reception by the television set. Thus, with a converter, a subscriber may receive from 26 to 35 channels from a single cable. Greater channel capacity can be achieved by using both multiple cable and converters.

The converter rests on top of the television receiver and takes the place of the receiver's tuning mechanism (see Figure 10). Current versions cost about \$23 to \$35 each.

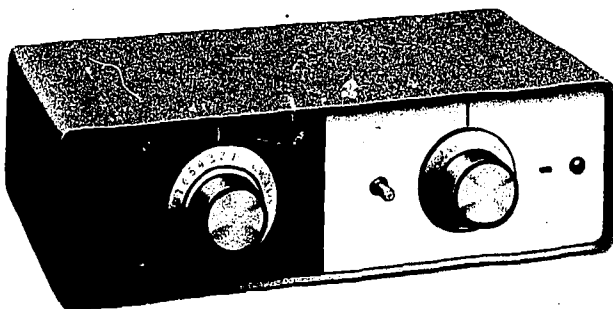


Figure 10. A Switched Converter.

C. Broadband Communications — Cable's Future

Modern cable television has evolved from a retransmission system providing basic reception to an expanded medium for delivering one-way services to subscribers. With the addition of imported signals, automated origination, and local programming, cable television has surpassed the capabilities of broadcast television and is well on the way to becoming the "television of abundance" envisioned by the Sloan Commission.¹

Cable technology promises two-way communications for subscribers, and the potential of broadband communication networks in the future.

THE EVOLUTION OF CABLE TECHNOLOGY: TWO-WAY COMMUNICATION

Cable's most glamorous aspect is its "bi-directional," or two-way, capability. For the most part, this capability exists now only in prototype. Little is known about the future market for two-way communications; system operators, therefore, are likely to be cautious when considering investment in two-way equipment.

Two fundamental kinds of two-way systems are envisioned for cable communications: institutional two-way systems for a few users, and subscriber systems for all subscribers. Institutional two-way systems may involve two-way data communications or two-way video communications. Most of the electronics for these systems are already on the market.

Subscriber systems involve three prospective levels of capability.

Subscriber response systems — very limited, party line digital communications between subscriber terminals and a computer at the headend, permitting such services as opinion polling. These systems exist in prototype and should soon be market tested by several multiple system operators (MSO's). They may be available commercially in two to three years.

Subscriber initiated systems — expanded digital communications between advanced terminals and the headend. This approach may permit computer assisted instruction, remote facsimile reproduction, or other services. An experimental system of this type has been constructed in Reston, Vir-

¹*On the Cable: The Television of Abundance*, Report of the Sloan Commission on Cable Communications, Edward S. Mason, chairman (New York: McGraw-Hill Book Co., 1971).

ginia. They are likely to be available commercially in less than six years.

Switched video communications — exists commercially; the telephone company offers limited switched video communications (video telephone service) in Chicago. Two-way video telephone service is not suitable for cable television systems, because cable distribution systems do not have sufficient switching facilities, and cable systems are not widely interconnected.

In the next few years, only subscriber response and closed circuit services are likely to be offered on cable systems. Later, subscriber initiated services may be available. The technical description that follows deals with each of these kinds of services.

Headend

For subscriber response systems, the major additions to the headend will consist of a computer to control communications with subscribers, and many more interconnection facilities — perhaps including links with satellites — to connect the local cable system with (projected) national video and data networks. The computer will send short, individually addressed electronic messages to each of thousands of subscriber terminals. Each terminal will respond with short data messages back to the computer at the headend. The responses would indicate the status of the terminal, which might include the channel being watched, subscriber requests for information, subscriber responses to questions posed by a television show, or the status of a remote monitoring device such as a water meter or fire alarm. The exchange of messages between headend computer and terminals will take place in split seconds.

Distribution System

The electronics for two-way transmission are quite straightforward, if two cables are used. Amplifiers in one cable boost signals in the forward direction (headend to subscriber); amplifiers in the other cable boost signals in the return direction.

Two-way signal transmission in the same cable is more complex. A housing which contains a cable amplifier is enlarged to permit these additional components:

- A second amplifier, to strengthen signals being sent upstream
- A pair of electronic filters, which separate the signal traffic by routing one set of frequencies

to one amplifier, and the other frequencies to the other amplifier.

Depending upon planned uses, the filters may permit either a roughly equal number of upstream and downstream channels (a "midband split"), or the majority of the channels — about 35 — downstream with a few — three or four — upstream (a "subband split"). Figure 11 illustrates the differences in spectrum use.

The choice between these two methods of controlling electronic traffic in the cable depends upon planned use. Midband split arrangements are intended for closed circuit uses; there are a large number of upstream channels. The subband split arrangement permits 35 channels downstream and only four upstream; it is designed for subscriber response systems.

Subscriber Terminals

Advanced systems depend heavily upon the use of sophisticated home terminals that will include, besides the television receiver, such equipment as facsimile printers, computer keyboards, and videotape recorders. Most subscriber services are predicated on a system of limited subscriber return communication called a "subscriber response" system. A small push-button terminal in the home (similar to a touch-tone telephone keyboard) receives periodic data messages from the headend computer. A separate message is addressed to each subscriber terminal. The terminal, as shown in Figure 12, responds with a short data message upstream to the computer, which interprets and stores the messages from each subscriber. Since the messages are short, many thousands of them can be sent in sequence over the cable. Current versions of this system, now being tested, involve a computer which can interrogate as many as 30,000 subscriber terminals in 22 seconds.

Subscriber response systems, though limited to digital communications between the headend computer and subscribers, will permit several unusual kinds of services:

Opinion polling. Subscribers indicate their opinion regarding an issue posed on a cablecast program. The results are tabulated by the computer and presented to those televising the program.

Home shopping by cable. Retail shops lease a channel and display goods to subscribers, who may make orders by keying ordering instructions into their terminals. The goods are later delivered and the customers billed by the cable system.

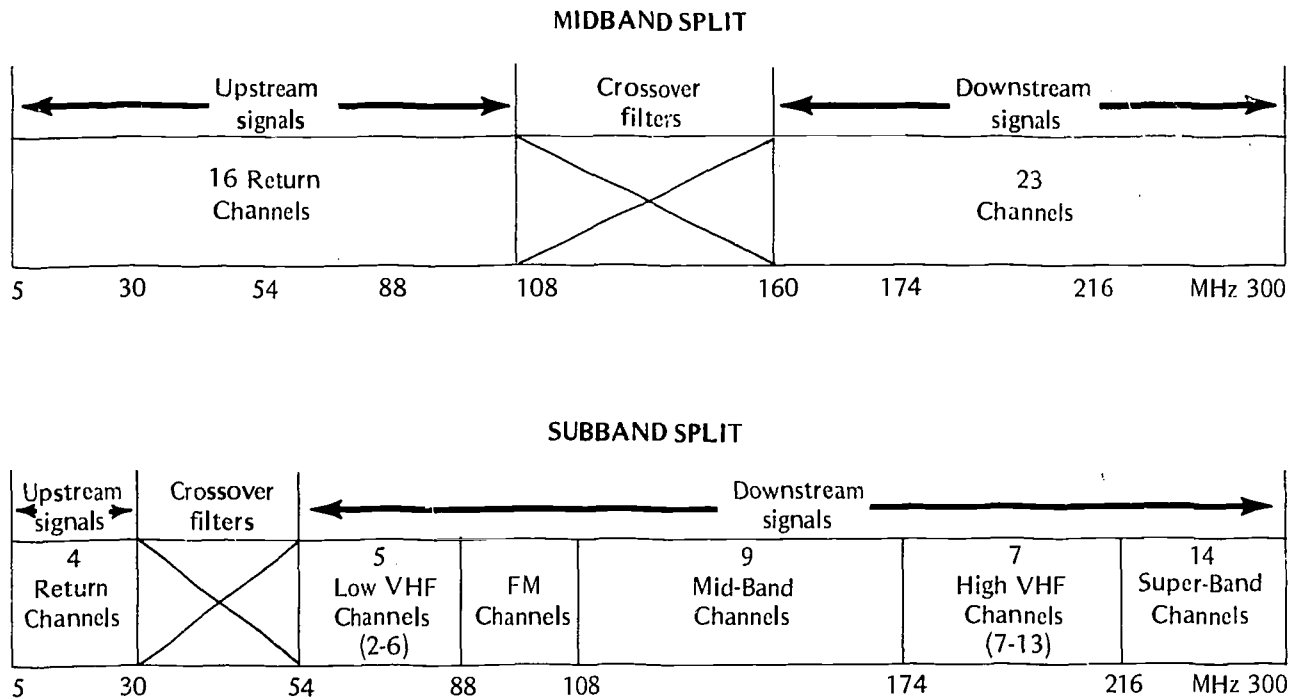


Figure 11. Difference in Spectrum Use

Pay television. Some channels will be scrambled, unless unscrambled by a command from the headend computer. A subscriber may view first run movies or other special programs, paying a fee-per-program, by indicating to the computer through the home terminal to unscramble the pay television channel. The subscriber is billed at the end of the month.¹

Remote sensing. The headend computer records signals sent via the home terminal from fire and burglar alarms, or automatic reading of utility meters.

At a considerably higher level of technical sophistication and cost than the subscriber response system is the "subscriber initiated"

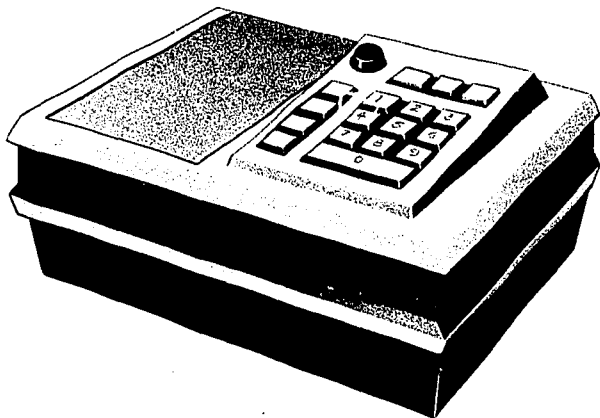


Figure 12. A Subscriber Response Terminal.

system. On this level of service, communication between subscriber terminals and headend computer is greatly expanded, though still digital. The subscriber may initiate communications by sending data messages to the computer, rather than waiting to respond to computer electronic interrogation. This gives rise to potential uses such as computer assisted instruction, random access to library materials (assuming they have been converted to digital form), ticket reservations, directory services, and catalog shopping. In addition to the television receiver, subscriber initiation terminals might include several other devices, such as a remote printer, a video tape recorder, and a full alphanumeric keyboard. One conception of such a terminal is shown in Figure 13.

Implementation of all two-way services is still at the experimental level. The necessary technology is reasonably well developed, but the market for services is not known and the costs connected with providing them are hard to estimate. Cable hardware costs are easily determined; but nearly all two-way applications require the use of computers. The cost of programming these and the computer associated software may be a critical factor in the economic feasibility of two-way applications. Another important element

¹Pay TV can be provided without subscriber response capability in the cable system. Several different systems which do not require two-way capability are being market tested.

is the cost of terminal equipment in the subscriber's home. One-way cable requires only a television set and perhaps a converter. Present estimates of the cost of terminal equipment for each home indicate that subscriber two-way services will be very expensive. However, technological advances and mass production techniques may reduce terminal costs to economically feasible levels — as they did in the production of television receivers — and subscribers may well be willing to pay more if they feel the services provided are worthwhile.

Institutional Two-Way Systems

Subscriber services are limited because of the large number of users. If, for example, all subscribers were equipped with conventional video cameras as part of a video telephone system, 20 two-way video conversations would exhaust the capacity of a single cable.

However, if there are few users, a full range of communications services, including two-way video and high speed data, can be offered. Applications of this kind are called institutional uses because they are normally operated outside the general home subscriber network, as for example, in businesses, schools, hospitals, or public agencies. But, if an institutional function does not use many channels, it may be provided on some of the unused frequencies of the main distribution system. Uses which require a large number of channels are best provided with a private cable connecting the few users.

Some of the projected services for closed circuit uses are:

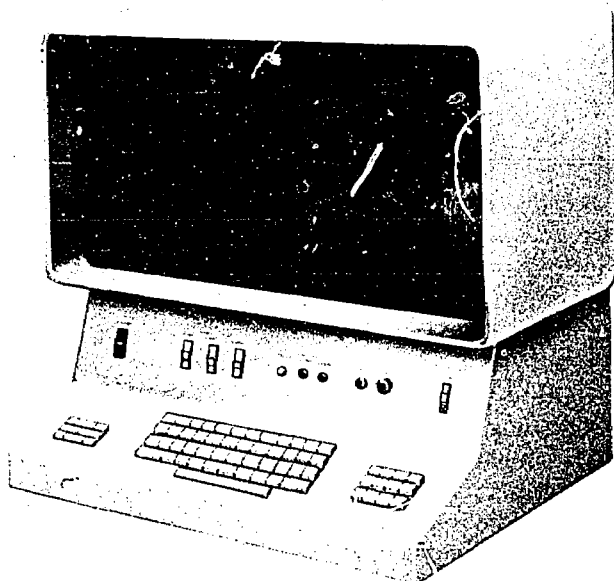


Figure 13. One Conception of a Subscriber Initiation System Terminal.

Two-way video. As an example, a video link between a doctor and a paraprofessional who is located at a remote medical clinic could be used to improve health care in rural areas.

Data interconnection. A computer in one department of a city could be interconnected to another department's computer. Banks and branches, hospitals and clinics, downtown retail stores and suburban branches each have data interconnection needs.

FUTURE COMMUNICATION SYSTEMS AND THE CONVERGENCE OF TECHNOLOGIES

How well two-way approaches meet the test of the market depends not only upon cable television technology, but also upon the parallel development of competing technologies. Cable television is neither the only new development in modern telecommunications, nor the answer to all communications needs. It is worthwhile here to examine what things cable cannot do, and to note developments in competing technologies as well.

Capacity Limits

Theoretically, there are no real limits to cable capacity: new capabilities can be purchased in blocks of 40 channels simply by adding more cables. In practice, however, cable is limited to the capacity that can be provided competitively when the costs of other modes of telecommunications are considered.

Systems equipped with subband split subscriber two-way electronics (see page 13) are not suitable for widespread use of two-way video. Typically, 2,000 or more subscribers would share the three to four return video channels on a single feeder equipped with subband split amplifiers (35 channels downstream, three to four channels upstream). Even closed circuit cable with midband split amplifiers permits only 16 channels of upstream video signals.

One frequently mentioned use of cable technology would permit an individual subscriber to request a specific videotape from a library of tapes. This application must be viewed in terms of the number of potential downstream channels. While current systems may have reserve capacities of 20 to 30 channels per cable, the sharing of these downstream channels by thousands of subscribers could quickly exhaust the resources and create a shortage of channels. Clearly, a typical cable

system could not expect to respond to the request for the simultaneous viewing of more than a few tapes, certainly not hundreds, before all the available downstream capacity was exhausted.

If the demand for these types of services becomes high, additional capacity could be installed. But, for the near future, cable systems may not be installed with such additional capacity. Further, there are limits to the number of cables that telephone poles and underground ducts can carry.

One means to increased capacity, where continuous motion video is not required, is in the use of "frame-stoppers," which permit timesharing of a video channel. A television picture — just as a motion picture — consists of a series of still pictures or "frames." Every one-thirtieth of a second a new frame is transmitted electronically. Each frame is a complete picture. If there is no movement in a TV picture then each frame transmitted is the same as the previous frame.

A frame-stopper terminal receives a frame, displays it on a TV screen as a normal TV set does, and stores it electronically. Then instead of receiving the next frame transmitted as an ordinary TV set does, the frame-stopper ignores the new frame and replays the stored frame for a specified period. It is possible to electronically "address" a frame as it is being transmitted. A frame-stopper terminal can then look at the address on each frame and receive only those frames addressed to it.

Thus, if all subscribers are equipped with frame-stoppers programmed to replay a stored frame for 10 seconds, 300 subscribers can view still pictures addressed individually, using only one television channel. This mode of "slow speed television" would be useful for such applications as computer-assisted instruction, remote catalog shopping, or listing poison antidotes.

Frame-stopping technology is still in a state of flux and no commercial firm has yet mass produced a low cost frame-stopper, (under \$100 per terminal), although \$500 to \$700 per terminal now appears to be a feasible cost.

Most future subscriber applications discussed in the general literature, like frame-stopping technology, require the use of sophisticated home terminals. To date, no inexpensive units have been developed. As currently projected, home terminals would range in cost from \$90 to \$300 — less converter (converter costs are \$30 per subscriber). Widespread implementation of two-way cable services is dependent upon the development of highly reliable, low cost terminals.

New transmission mediums

A frequently suggested "cure" for more capacity is new transmission mediums. Two that have been frequently mentioned are wave guides and fiber optics. Both hold promise of huge channel capacities.

Wave guides are carefully fabricated hollow metal tubes which efficiently carry Super High Frequency radio waves. Potentially, wave guides may carry from 400 to 800 television channels of capacity.

Fiber optics involve transmission of light through very thin glass fibers. The light signals are coded to carry television signals or data information which are carried by the light beam as it travels through the fiber. The bandwidth capacity of optical fibers is breathtaking — as many as 2,000 television channels or more.

Both systems are in the development stage. Current work on wave guides is several years from fruition and is designed to provide long distance telephone transmission. Several characteristics of the current work make it totally unsuited for local distribution of TV signals. The use of fiber optics for transmission is evolving rapidly, but development of devices to connect the fiber lines to headend or terminal facilities is lagging. Development of a broadband communications system with fiber optic transmission may be 5 to 10 years away.

It is possible that coaxial cable will become obsolete, but the role of cable television as a broadband local distribution communications system will remain for the foreseeable future.

Prospects for Switched Video Communications

Cable television communication with a tree shaped distribution system is an awkward base for the development of a fully switched network that will allow one subscriber to dial another, as with the existing telephone network. It does not use local exchanges which permit flexible and reliable connection between random subscribers, except through the headend. A cable television system may never be convertible to a switched broadband network, without costly rebuilding.

Further, the cost of a completely switched video telephone system service nationwide would be extremely expensive. One estimate is \$12,000 per subscriber (as compared to \$600 per subscriber for the existing telephone network). Any decision to build complete video switching between all subscribers would involve a national policy commitment of at least the magnitude of the Interstate

Highway System. The switching capability that is currently feasible is based upon very limited access because of the small number of upstream (subscriber to headend) video channels. A few manufacturers have produced hardware that would provide for limited switching but the projected costs have been two to eight times the cost of unswitched cable systems and so have not been popular with cable operators.

Other Communications Media

Other telecommunications media offer some of the same services envisioned for cable television, notably pay television and data transmission. The first pay television services were offered commercially via Multiple Distribution Service (MDS) microwave. MDS broadcasts television signals to special receiver systems of the type that could economically serve a number of TV sets at a single location — such as motels, hotels, and apartment buildings.

The telephone system already provides data transmission service. In addition, the telephone industry is building an all digital network which will eventually lower the costs of data transmission. Other companies have been created to serve as specialized common carriers and will provide a digital network for computer communications. In such systems, however, cable may still serve as the local distribution system between the carrier and the subscriber.

SUMMARY

Cable television has evolved from a retransmission medium as traditional CATV, to modern cable television — an important and exciting medium on its own merits. Most of cable television's technical magic lies in the future. But its present capacity to deliver an expanded "menu" of one-way video programming results from major technological developments in the past 10 years.

In the near future, subscriber response and closed circuit two-way developments are likely to be developed and perfected, opening prospects for a vast new range of services. In the more distant future, broadband communications may move from coaxial cable to a new medium, such as optical glass fibers, or some yet undiscovered medium. But regardless of its mode of transmission, cable television as a local broadband distribution system is likely to remain in existence for the foreseeable future. Plans and decisions made now by franchising authorities are unlikely to be invalidated by rapid technological evolution.

II. MAJOR ISSUES FOR FRANCHISING AUTHORITIES

Understanding cable technology is important to local officials because they are faced with technical decisions about cable television in their community. This part of the report examines three kinds of technical questions local officials must deal with.

— Design decisions must be made before any operator is franchised, and are nearly irreversible once the system has been constructed.

— Performance issues must be decided before franchising, but they also present a continuing responsibility to the franchising authority for ensuring that performance standards are met.

— State of the art issues cannot be resolved since they will be future problems. However, local officials must decide what mechanism they will create in the franchise to ensure that the franchising authority has a role in keeping the system technologically up-to-date.

A. Design Decisions

Some design decisions are of such importance to the community that they should not be left entirely in the hands of the system operator. Local officials ought to take a large share of the responsibility for making decisions on at least these six questions:

1. What kinds of facilities should be constructed for public use of the system?
2. How much present and future capacity should be built into the cable system?
3. What kind of two-way facilities should be installed at the outset?
4. How should service areas be defined?
5. What interconnection capacity is needed?
6. What can be done to extend service to less dense areas?

Local officials are not required by the FCC to answer each of these questions, but failure to do so leaves the decisions entirely in the hands of the system operator. Once made, the decisions are often practically irreversible because of the high cost of cable system plant and installation.

WHAT KINDS OF FACILITIES SHOULD BE CONSTRUCTED FOR PUBLIC USE OF THE SYSTEM?

The commission's rules require only that cable operators in the 100 largest television markets fur-

nish channel space for access cablecasting, and maintain production facilities within the franchise area for use on the public access channel.¹ However, the system operator may also agree to furnish equipment as a condition of the franchise agreement and it is in the interest of the franchising authority to develop specific priorities of facilities desired before a franchise is granted. Further, the full public value of a cable system will not be realized without investment in public facilities, such as educational programming studios, that will not be provided by the system operator. Local authorities interested in promoting the public services on cable television will have to plan for the development of additional facilities, the manpower to use them, and the money to pay for them.

For policy planning purposes, facilities for the cable systems fall into two general categories:

- Studios and equipment for public access and local origination
- Other public facilities.

Studios and Equipment for Public Access and Local Origination

The origination facilities provided by a system operator should be designed to meet the needs of the community served. The range of studio options is so broad that facilities can be designed only after the franchising authority has weighed its planned uses against capital costs. The costs of live studio facilities, whether owned by the system operator or the community, vary enormously. The following figures illustrate some possibilities.

Low Cost Black and White Studio – \$25,000

- Two live black and white cameras
- One 16mm film chain
- Three 1/2" black and white portable video tape recorders and cameras

Moderate Cost Black and White Studio – \$50,000

- Three black and white studio cameras
- Film projector
- Slide projector
- Studio lighting and equipment
- Special effects generator
- Two 3/4" video tape recorders
- Two 1/2" portable recorders and cameras

Moderate Cost Color Studio – \$150,000

- Three color studio cameras
- Special effects generator
- Control room electronics
- Film and slide projectors
- Two color video tape recorders
- Three black and white video tape recorders

¹Cable Television Report and Order, 47 C.F.R. 76.251(a)(4), (1972).

Test equipment

Studio lighting and equipment.

It should be emphasized that these studio packages represent a relatively austere investment in comparison with broadcast studio facilities, which may run into \$1 million or more. Further, these figures represent only capital outlays. Operating expenses can easily total from \$20,000 to several hundred thousand dollars a year. Planning for studio facilities, therefore, should include careful operating budgets as well as capital costs.

Other Public Facilities

Many communities tend to think of public cable services in terms of the three access channels defined by the FCC's rules. However, cable television systems offer exciting possibilities for closed circuit uses that may enhance the quality of in-school education, health services delivery, and other public services. Planning for such possibilities involves consideration of a broad range of terminal equipment. Listed below are some illustrative examples.

School Facilities

- Taps to each school
- Taps to each classroom (far more expensive)
- Videotape recorders
- Studio facilities for local program production within the school
- Closed circuit network connecting all schools
- Facilities to permit school studio programming to be distributed to all subscribers

Hospital Facilities

- Patient room taps
- Operating room studio equipment
- Closed circuit interconnection of hospitals and clinics

Library Facilities

- Videotape recorders and tapes
- Camera equipment.

HOW MUCH PRESENT AND FUTURE CAPACITY SHOULD BE BUILT INTO THE CABLE SYSTEM?

Most discussions about cable system capacity center on channel capacity of the distribution system. But distribution capacity questions are difficult to resolve without an estimate of local programming demands on the system. For example, a ten channel local education network, in conjunction with TV signal carriage, would nearly saturate a 35 channel system. Decisions about present and future channel capacity should be made in conjunction with estimates about the development

of various sources of local users. Unfortunately, it is very difficult to develop meaningful estimates about communications uses that presently exist only on a very small scale. FCC requirements for educational, government, and public access channels provide little guidance for the development of future programming.

Further, system operators tend to view imported signals as more attractive offerings to subscribers, than local programming. Thus, the development of local programming will depend on the quality of local planning and interest.

There is no proven method for accurately assessing the elements of any community which will make use of local programming. Not many examples of productive uses exist, and few local institutions are in a position to plan precisely how they will use such an unknown resource. Local officials are faced with very difficult choices about capacity demands, and the elements of the choices are not clearly defined.

Local officials can, however, consider the cost of system capacity, and weigh it against an assessment of the number of users in the community who will make use of local programming. Any assessment is bound to be uncertain and speculative, since few potential users will be able to predict accurately what demands they will make on the system. Nonetheless, an informal canvass — of public school or university activities and resources, for example — may give local officials a sense of some of the demands that will be placed on system capacity. Decisions about capacity may then be more informed.

Local officials should also consider the cost of system capacity, since costs ultimately will be reflected in both subscriber rates and the economic viability of the system. In the discussion that follows, distribution alternatives are

examined in terms of capacity — now and in the future — and cost implications. The special case of low cost service to less dense areas is evaluated later in another section.

Within present cable industry practice, there are five primary methods of sending signals from the headend to the individual subscriber; four of these methods comply with FCC requirements for the top 100 television markets, and the fifth is suitable for cable television systems outside the major markets. Since all cable systems consist of trunk cable and feeder cable, the major distinctions between these alternatives involve the number of each type of cable required to provide customer service. The alternatives are:

1. *Single Trunk – Single Feeder (see Figure 14).*

A single electronically active trunk cable is laid from the hub to the neighborhood; a single active feeder cable is then laid past each home; a single drop cable enters each home and is connected to the subscriber's television set.

"Active" cable is installed with the necessary electronics to carry electronic signals in one or both directions. The electronics, depending upon the cable's purpose, include amplifiers to boost signal strength, splitters to divide the signal at the cable junction, taps to draw the signal into the subscriber's home, etc.

The capacity of this system is restricted by the capacity of the television receiver — 12 channels. This system does not satisfy FCC requirements for systems in the 100 largest television markets, although it might be appropriate for smaller systems outside the top 100 markets.

2. *Single Trunk – Single Feeder – Converter (see Figure 15).*

A single active trunk cable is laid from the hub to the neighborhood; a single active feeder cable

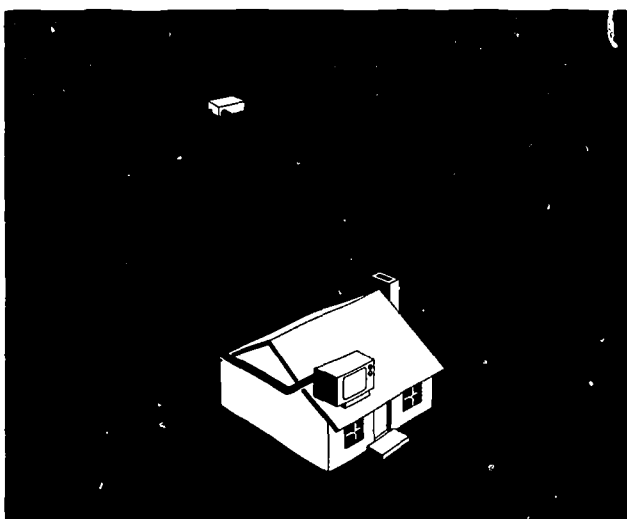


Figure 14. A Single Trunk – Single Feeder System without a Converter.



Figure 15. A Single Trunk – Single Feeder System with a Converter.

is then laid past each home; a single drop line enters each home; and a home converter is attached to each subscriber's TV set.

The capacity of such a system — standard coaxial cable with available converters — is approximately 26 to 35 channels. Installation of two-way electronics permits four channels to be carried from subscribers back to the headend. Current design approaches within the industry are probably reaching a consensus that this option is a relatively inflexible alternative, not permitting economical future expansion.

However, there is a legitimate argument for this alternative. If cable services develop slowly, then it will be less expensive to install one cable and wait to install another cable until uses are generated. In other words, this argument asserts that because of the time-value of money — despite inflation and higher installation costs — the dollars invested in the future might be less than the cost of installation of the second cable presently.

If local officials should prefer a single cable system, the principal financial impact of such a choice would be

- lower capital costs; and
- the probability that the system would earn an acceptable return on investment.

3. Dual Active/Inactive Trunk — Single Feeder — Home Converters (see Figure 16).

This distribution system includes two trunk cables; however, only one of the two contains the electronics necessary for signal transmission. The other, a "shadow" cable, contains no electronics. The system includes a single active feeder cable, and a home converter which substitutes for the television set's channel selector. This system is capable of delivering 26 to 35 channels to the home at the time of installation.



Figure 16. A Dual Trunk — Single Feeder System with a Converter.

Installation of two-way electronics again permits four channels from subscribers to the headend. With the installation of midband split, two-way electronics, the second trunk cable may be used for closed circuit uses. This arrangement provides point-to-point communications up to 23 channels downstream and 16 channels upstream

4. Dual Active Trunk — Dual Active Feeder — A/B Switch (see Figure 17).

This distribution system includes two active trunk cables, two active feeder cables, and a switch at the home TV set enabling the subscriber to switch from cable A to cable B. In order to select one of 12 channels on each cable, the channel selector on the set is used.

The theoretical maximum channel capacity of this alternative is 24 channels. The actual maximum is often less since a strong off-the-air signal causes interference to the signal carried on the same channel in each cable. With three or more strong local VHF stations, the maximum number of channels that can be obtained with dual cable is less than 20. Thus, this alternative has, in the short term, relatively low channel capacity. Expansion to high capacity in the future is relatively easy, with the addition of a converter (provided the system is initially constructed with electronics capable of carrying 35 channels of signal bandwidth). Except in very densely populated areas, this alternative involves higher capital costs per user than the other alternatives.

5. Dual Active/Inactive Trunk — Dual Active/Inactive¹ Feeder — Home Converter (see Figure 18).

This distribution system, like the previous alternative, includes two trunk cables and two feeder cables. However, only one trunk and one feeder cable are active; the other trunk and feeder cables are inactive. The system includes a converter and is thus capable of delivering 26 to 35 channels to the home immediately. Expansion to 70 channels per subscriber is made possible by the addition of electronics to the second cable.

¹A number of the issues involved here are matters of contention within the cable industry. Particularly controversial are the general choices between #3 and #4 above. Choice #3 requires a high number of subscribers per mile to be immediately comparable in costs. On the other hand, choice #3 is easily expandable. Choice #4 involves the use of converters — which are undergoing rapid technical evolution and whose maintenance costs are in doubt — and expansion requires adding electronics. Yet, choice #4 yields more immediate capacity. The most accurate general statement that can be made is that an appropriate choice depends in part upon the particular community, in part upon the development of converters and cable electronics, and in part upon the speed with which new uses require the expansion of cable capacity.

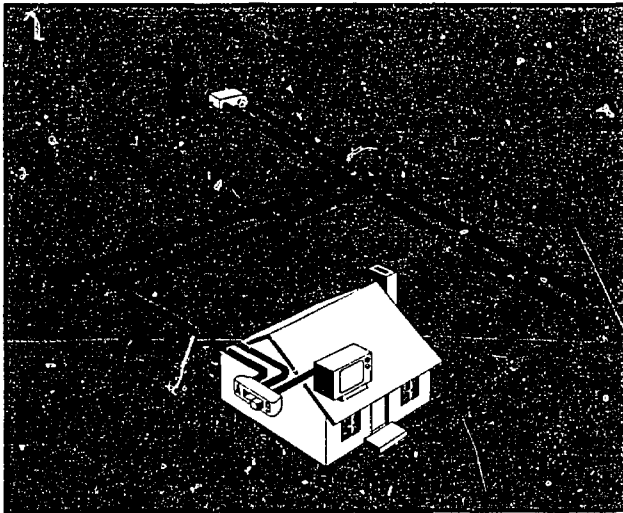


Figure 17. A Dual Trunk - Dual Feeder System with an A/B Switch.

The distribution alternatives are summarized in Table 2. An important aspect of each of these distribution alternatives is a basic fact of construction economics: although cable and electronics cost the same regardless of when installed (discounting inflation), installing a second cable along with the first is far cheaper than installing it later.

Alternatives #3 and #5 make use of these construction economics. Each has dual trunk cables; in addition, alternative #4 has dual feeder cables. A dual trunk-single feeder system includes shadow trunk and shadow feeder cables. There is a substantial difference between the two alternatives in terms of capital costs as well as expecta-

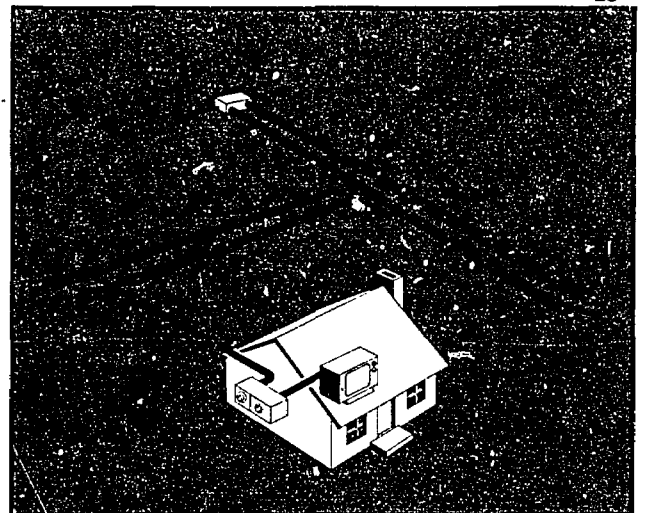


Figure 18. A Dual Trunk - Dual Feeder System with a Converter.

tions about the development of future services and capacity needs.

Depending upon geographical layout and density, a cable system will require from two to five times as much feeder cable as trunk. Thus, the installation of a second feeder cable is expensive no matter when it is undertaken. If a shadow feeder cable is installed at the outset, distribution costs, including cable, increase about 20 to 40 per cent. But if the second feeder is installed at a later date, it will cost at least twice as much as the first feeder.

This does not imply that activating the second cable will be easy or inexpensive. Conversion of

Table 2. Distribution System Alternatives

Alternative	Capacity	Expansion without Rebuild
1. Single Trunk-Single Feeder	24 channels or less to subscribers	35 channels to subscribers; 4 channels subscriber return
2. Single Trunk-Single Feeder - w/Converter	35 channels to subscribers	4 channels subscriber return
3. Dual Trunk-Single Feeder - w/Converter	35 channels to subscribers; some institutional two-way	35 channels to subscribers; 4 channels subscriber return; institutional two-way
4. Dual Trunk-Dual Feeder	24 channels or less to subscribers	35-70 channels to subscribers; 4 channels subscriber return; institutional two-way
5. Dual Trunk-Dual Feeder-w/Converter	35 channels to subscribers; some institutional two-way	70 channels to subscribers; 4 channels subscriber return; or institutional two-way

shadow to active trunk involves not only the installation of both forward and reverse trunk amplifiers, filters, and accessories, but also the connection of feeders from cable A to trunk cable B and adjusting cable B electronics for two-way.

The second feeder decision involves more than financial outlays. A dual trunk-single feeder system can accommodate subscriber response two-way technology without a second feeder. The main "downstream" trunk is retained for one-way delivery of 35 channels to subscribers. When electronics are installed in the second trunk, and it is connected to the feeder, subscriber response traffic can be carried back to a computer installed at the headend. The second trunk is two-way, and thus can also be used for two-way, point-to-point (closed circuit) uses.

The use of the second trunk cable for closed circuit applications is limited by the fact that trunk passes only about one-quarter of the homes and buildings in a city; the remainder are reached with feeder cables. Unless a prospective closed-circuit user is located near a trunk, he cannot use the service. The cable industry, for the time being, solves this problem by extending the second trunk to areas where closed circuit users are located, or by installing a special feeder.

But, in general, it is difficult to predict prospective closed circuit users and the kinds of services that will be required. If the decision is left to the system operator, extra trunk or a second feeder cable may be installed only to those places where closed circuit users have been clearly identified.

That decision is properly one for the franchising authority, not the system operator. The great expense of a second feeder, installed later, would naturally make a system operator reluctant to undertake the investment, regardless of the city's needs. If the franchising authority anticipates great educational or local government demands for closed circuit uses (or more than 35 channels of subscriber services), it may wish to require the immediate investment in a second shadow feeder.

To summarize these arguments:

- Single trunk and feeder systems, although limited in expansion capacity, are less expensive options and do not require investment in cable that might not be used.
- Converters are more economical for systems with few subscribers per mile; A-B switches are a better initial step for systems in densely populated areas.
- The decision to invest in a second feeder depends upon judgment as to which kind of two-way services will develop most rapidly: closed circuit uses, or subscriber services.

HOW MUCH TWO-WAY CAPACITY SHOULD BE INSTALLED AT THE OUTSET?

Subscriber two-way systems are still in the prototype stage, and, for the time being, few communities will enjoy subscriber response service. There are, however, several other ways that two-way cable communications can be employed presently. They can be conveniently grouped in three categories:

- Two-way systems for origination at locations away from the headend
- Two-way closed circuit systems
- Community information and service center systems.

Origination Away from the Headend

There are two means by which programs can be originated away from a main studio: mobile vans, and remote studio facilities.

A mobile van permits origination virtually anywhere, but programs cannot be carried live without a microwave hookup to the headend. Similarly, a permanent studio cannot originate live programs if it is not connected electronically to the headend.

The franchising authority must decide whether live programming uses planned for origination facilities justify the costs of interconnection with the headend for live programming. Even if there are no formal cablecasting facilities, origination from such places as high school basketball gymnasiums may warrant installation of the cable to permit live cablecasting.

Institutional Two-Way Systems

Two-way services such as data interconnection and video teleconferencing are feasible on cable, providing the number of users is limited. Institutional uses can be provided on unused channels on the main system of cables, or by designating particular cable for institutional users. For example, each of 40 schools or libraries might be assigned a channel on a cable interconnecting all of them. With studio facilities at each school, any school could transmit to all the others. Or, alternatively, as many as 20 video conferences between two schools (for debates, for example) could take place simultaneously.

Hospitals and local clinics might be interconnected to permit remote diagnosis (video signals from the clinic to the hospital), or to permit remote observation of complex surgery (video signals from the hospital to clinics).

Community Information and Service Centers

Three problems have become apparent to many of those concerned about cable's possible public benefits.

- Not everyone will subscribe to the system
- Two-way services — which seem to have great public possibilities — will be activated on a large scale only upon evidence that they can make money
- Implementation of two-way service requires expensive terminal equipment in the homes of subscribers.

These problems, taken together, mean that the public benefits of cable television may not be available to those who need them most, and that the most interesting public uses — those involving two-way cable — may have to wait for the development of profitable commercial uses. In the meantime, local officials might consider the possibility of establishing public community information and service centers.

Such centers could provide a central point to which citizens could bring questions and problems relating to a wide variety of governmental services, linking the public to local government and public service agencies via two-way communications systems. They would make cable TV free to those who could not afford it, ensuring that 100 per cent of the population could receive public services by cable television. They might allow the limited introduction of two-way services; and they might assist in making local government more responsive and comprehensive.¹

The information and service centers would probably have their greatest value and most use if they were located in multipurpose community facilities. A neighborhood center combining adult education, recreation, library services, meeting rooms, social services counseling, and other municipal services would be an optimum choice.

Cable receiving facilities could be arranged for individual and group viewing (see Figure 19). And two-way terminals could be situated in carrels affording user privacy but allowing for easy access to assistance when needed. A small number of

terminals could be located in each center initially, with the ability to increase the number as demand warranted. A one-way only receiving point would require merely a television-set — preferably color — and a converter; a two-way terminal would, in addition, have an electronic keyboard, headphones, and auxiliary electronic equipment. Audio and video cassette machines could be situated on carts and checked out when needed.



Figure 19. A Community Information Center Terminal.

The MITRE Corporation, which has done extensive research on remote access to computers via cable and on computer assisted instruction, has estimated the cost of such a system:

Excluding system integration and installation costs, but including the cost of the computer and all required hardware for audio, color and video tape capabilities, the pro-rated cost amounts to \$3,600 per terminal ... If a moderate (25 systems) number of systems were constructed in mass in 1975, the total cost of the system will fall to \$2,000 per terminal and probably further.²

These figures do not include software development costs which usually represent the "hidden part of the iceberg" in programs of this kind.

Activation of two-way capability on a wide scale represents a substantial investment in system electronics and home terminals. It is not likely to be undertaken except on the expectation of adequate return. At the present time, there is no convincing evidence to support such an expectation.

¹See Alan R. Siegel and Calvin W. Hiebner. *Special Services to Neighborhood and Home: A Community Telecommunication Demonstration Concept, Paper for the International Telemetering Conference, October 10, 1972.* Siegel, director, and Hiebner, program analyst, Community Environment and Utilities Technology Division, Office of the Secretary for Research, and Technology, U.S. Department of Housing and Urban Development, state in a footnote that neighborhood facilities under specified circumstances are eligible for federal support for up to three-quarters of facility construction. See Title VII, Housing and Urban Development Act of 1965, 42 U.S.C. 3101.

²*Toward a Market Success for CAI - An Overview of the TICCIIT Program* (McLean, Virginia: MITRE Corporation, June, 1972). An excellent discussion of computer assisted instruction.

An intermediate step that might be considered would be to first implement two-way service only to community information and service centers. This would both lessen the investment in hardware and share the benefit of that investment among a large number of users. Information centers could then test the feasibility and public acceptance not only of social services on cable but of many commercial services as well.

HOW SHOULD SERVICE AREAS BE DEFINED?

The actual layout of the cable distribution system is an important issue for the entire community: the layout design will arbitrarily bring together or segment existing neighborhoods and communities of interest unless careful planning is performed in advance.

This character of the cable distribution layout will be reinforced if different parts of the cable system can, as the need arises, receive separate programming. This would be the case if the system were made up of several interconnected hubs. However, when a single system is equipped with relatively inexpensive switching equipment at the headend, it is possible to distribute programming to subscribers connected to one of the system's main trunks, without distributing it to subscribers on the other trunks. The area served by each main trunk thus becomes a subdistrict, in which subscribers may receive programming transmitted only to them.

This approach to localizing the programming provided by the cable system can be duplicated by extravagant use of channel capacity. Local programming for a neighborhood can be provided simply by designating a channel for that community. However, that approach rapidly exhausts system channel capacity. Districting arrangements conserve channel capacity by allowing channels to be used over and over again in different parts of the system.

The boundaries of a trunk district are shaped principally by the technical limitations of cables and distribution electronics. In practice, these limitations are not overly restrictive. The feeder network connected to a single trunk extends service about three-quarters of a mile on each side of the trunk. Thus, a trunk district can be as large as 1.5 X 7-10 miles, or smaller, if desired (see Figure 20).

Within those constraints, boundaries can frequently be defined to coincide with neighborhood boundaries, school districts, or political jurisdictions. Of course, it is not mandatory that trunk

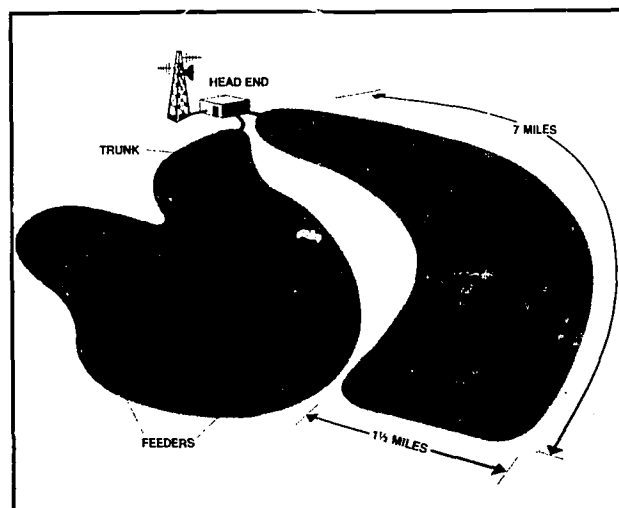


Figure 20. Subdistricts Defined by the Cable Television Distribution Layout.

districts be defined. Districting carries with it the possibility that undesirable community boundaries (such as railroad tracks which have separated communities racially or by socioeconomic status) will become reinforced. If the franchising authority elects to define trunk subdistricts, it should then consider locating origination facilities within the subdistrict, to permit local programming for residents within that community to flourish.

If the cable system involves more than one headend, the franchising authority must make service area decisions. Fundamentally, there are two kinds of decisions involved.

- Can (and should) the boundaries for a single hub be defined to coincide with other political and social boundaries?
- Should the hubs be defined in terms that will permit each hub service area to be franchised to a different owner?

The question of boundaries is not one of technology, but rather of local community feelings and expectations about education and public access programming. The second question, that of multiple franchises, involves a different set of issues — mostly economic and organizational — and implies a positive role for experimentation and competition between types of ownership and management. The few communities large enough to face the prospect of a multiple hub system hold opportunities for making the cable system socially more productive, if intelligently planned decisions are made.

WHAT INTERCONNECTION CAPACITY IS NEEDED?

There are generally two interconnection situations. Each involves vastly different procedures for solving the problems to be encountered even

though the technical means may be identical. Interconnection issues arise under these two circumstances:

- Interconnection of hubs within a multihub system serving a single city.
- Interconnection of systems serving several adjacent communities (a development that is likely to increase as communities share educational cablecasting, etc.).¹

Interconnection of hubs in a multihub system is a design issue that should be planned and decided upon before a franchise (or several franchises) is issued. The planning process is complicated by the fact that each kind of microwave interconnection mode imposes different FCC licensing requirements. In some cases, the franchising authority has no regulatory role because the microwave service is fully regulated by the commission.

Interconnection of cable systems in separate political jurisdictions differs procedurally from multihub interconnection within the same jurisdiction in two respects:

- Interconnection is an issue that usually arises after franchises in each community have been granted. As a result, it is difficult to anticipate the precise form of interconnection requirements and provide for them in each franchise.
- Interconnection of systems under different franchising jurisdictions creates problems for local officials, both in terms of planning and in terms of acting in concert. If no central authority exists to bring about agreement between system operators and each of the communities involved, planning for and developing interconnection may turn out to be an extremely complex problem, one that is mainly political. For this reason, interconnection of communities for exchange of local and regional programming may be appropriate for state regulation.

This paper does not address the procedural differences between the two kinds of interconnection. Instead, it focuses on the specific technical alternatives available to interconnect systems for different purposes.

There already exists a great deal of interconnection for long distance carriage of television signals. This service is provided by the telephone companies and by specialized common carriers, who offer the service to both broadcast television networks and to cable television systems.

¹There is a third kind of interconnection for delivery of commercial programming — in effect, cable networks. These are not considered since franchising authorities have no jurisdiction.

However, local interconnection is relatively new. There are several different kinds of interconnection means, with different costs and capabilities, and the regulatory framework for each is different. The discussion that follows contains costs and capabilities of the basic possibilities and a description of the FCC's regulatory requirements.

Cable

Headends can be linked with cable to provide as many channels as needed, one-way or two-way. Each cable can provide up to 40 channels one-way at a cost of about \$2,800 per mile, or 20 channels each way for two-way at a cost of about \$3,300 per mile. The commission has not acted explicitly to define its role in cable interconnection of headends.

Local Distribution Service Microwave (LDS)

With a single transmitter (\$100,000) and multiple receivers (\$7,000 each), a system can distribute up to 18 channels one-way to many headends. Doubling the number of transmitters and receivers permits up to 38 channels one-way. LDS could be used to provide 18 channels of two-way service between two headends, but it would normally be more expensive than common carrier microwave (see below).

The FCC regulates LDS fully in accordance with Section 78 of its rules. It licenses the service explicitly for the distribution of signals from one or more receiving points, from which the communications are distributed to the public by cable.

Long Distance Microwave

Chains of receivers and transmitters provide efficient point-to-point microwave interconnection one-way or two-way over great distances. A transmitter for one channel costs \$10,000; the receiver \$5,000. This kind of service is suitable for interconnecting a headend with a distant station, but it is less efficient for interconnection of several local headends serving contiguous districts.

The FCC regulates common carrier microwave service by licensing the carrier.

Instructional Television Fixed Service (ITFS) Microwave

This low cost service is designed to interconnect schools and colleges, but is occasionally used for other public services as well. A four channel trans-

mitter costs \$36,000; each four channel receiver \$500. It is clearly far less expensive than other forms of microwave service.

The FCC fully regulates the provision of ITFS through Part 74 of its rules:

A license for an instructional television fixed station will be issued only to an institutional or governmental organization engaged in the formal education of enrolled students or to a nonprofit organization formed for the purpose of providing instructional television material to such institutional or governmental organizations, and which is otherwise qualified under the statutory provisions of the Communications Act of 1934, as amended. A nonprofit organization which would be eligible for a license for a noncommercial educational television broadcast station is considered to be eligible for a license for an instructional television fixed station.¹

Planning for capacity, as for distribution system capacity, depends upon expectations about programming resources. If a multihub system is constructed to provide programming at each hub headend, then interconnection of hubs should be two-way to allow programming to be distributed to the entire system from each hub.

If several communities interconnect to share facilities, such as a college television studio or access programming facilities, interconnection needs may be met with a multipoint one-way interconnection system such as LDS or ITFS microwave.

Despite the regulatory jurisdiction problems related to interconnection, planning by local officials should consider interconnection in conjunction with service areas and distribution capacity. These combinations should then be evaluated in terms of present and projected programming uses of the system, and plans should be oriented toward adequate capacity to handle anticipated demands users will place on the system.

WHAT CAN BE DONE TO EXTEND SERVICE TO LESS DENSE AREAS?

Cable service cannot be economically feasible if there are not enough subscribers to keep the shared cost of the cable distribution system low. In areas of low population density, cable service has often been economically infeasible in the past. New developments in amplifier technology permit a decrease in per mile costs of distribution electronics. In the future, as cable systems become technically more complex, the provision of service to small or sparsely populated communities

becomes more expensive. Local officials faced with the problem of low population density (e.g., 20 homes per mile) must be concerned with minimum service at lowest cost, rather than the provision of excess capacity in the system for future use.

Recent technical developments permit significant opportunities to reduce the capital cost per mile, and make the service available to more rural subscribers.¹

Modern broadband solid state line extender amplifiers are cheaper than older trunk amplifiers, and provide better performance. These line extenders are not as sophisticated as transistorized trunk amplifiers, but for small communities they will provide up to 35 channels of service and the prospect of two-way subscriber response in the future, at a fraction of conventional costs.

A smaller system can use smaller size cable and low cost line extender amplifiers spaced to provide 35 channels of service. Further savings can be achieved through the use of messenger cable — coaxial cable which has the supporting steel cable built into it. Table 3 below indicates the difference in cost per mile of installed aerial cable:

3/4" cable using trunk & bridger amplifiers, typical construction	\$4,500
1/2" messenger cable using line extenders only	\$2,200

These savings can be achieved if the trunk cable, using line extenders, feeds subscribers directly. This eliminates added feeder cables and associated bridger amplifiers. It is sufficient for radial distances of about two miles, feeding as many as 100 homes per mile, as long as the homes are within approximately 300 feet of the trunk.

¹Before the development of transistors (and, more recently, integrated circuits), high performance requirements made tube-type cable amplifiers very expensive. Cost savings were achieved by lowering performance requirements for the feeder cable amplifiers (called line extenders). These amplifiers could be built to less stringent standards since they were not cascaded excessively on the numerous short lengths of feeder cable. The savings achieved were substantial overall, since so many line extenders were used in a system.

The distortions introduced by transistorized trunk and feeder amplifiers are less than those generated in the finest tube type trunk amplifier a few years ago. Further, all modern amplifiers have a new circuit design (called "push-pull") which eliminates a complex kind of distortion and permits the use of additional frequencies outside the standard 12 VHF channels.

¹47 C.F.R. 74.901 et seq., (1972).

Savings in capital cost per subscriber are important to local officials only if they can be translated into lower subscriber rates, or provision of service to rural residents who live in sparsely populated areas that otherwise would not receive service.

B. Technical Standards

A second area in which local officials should make decisions is that of technical performance standards;¹ a malfunctioning system defeats the purpose of good planning and design. It is possible to leave the enforcement of system performance to the influence of the market place; the subscriber, who is the ultimate consumer of cable service, may discontinue service if the quality of service is poor. Theoretically, if the system operator begins to lose subscribers, he will make attempts to improve the systems' performance.

However, there are several reasons why the franchising authority should assume a role in the development and enforcement of technical standards. In the first place, the technical standards set by the Federal Communications Commission in Subpart K of the February, 1972 *Cable Television Report and Order* are not considered comprehensive by the commission. Moreover, they do not preclude the establishment of more restrictive requirements by local governments. In its reconsideration of the *Report and Order*, the commission stated:

The general question of federal pre-emption of technical standards has been informally raised by a number of parties. Our technical standards provide only a start. They will be expanded to meet changes in the state of the art. We see no reason why franchising authorities may not now require more stringent technical standards than those in Subpart K.²

Franchising authorities faced with decisions immediately may not wish to wait for further commission deliberation. It should be noted that some states have already developed technical standards for cable systems. Franchising authorities in those states should refer to such regulations before developing their own technical standards.

¹A guide for technical standards is developed more comprehensively in *Technical Standards and Specifications: Ordinance Supplement Section VII*. (Washington, D.C.: Cable Television Information Center, 1973.)

²*Reconsideration of Cable Television Report and Order*, 36 FCC 2d 359 (1972).

In addition, the FCC does not consider its measurement procedures an adequate guarantee that system performance standards will be met. The Rules require that each system be tested annually, and that measurements be taken at three widely separated points. In its report, the commission stated:

Many advised that requiring performance measurements at only three vaguely defined points would fall short of rigorously testing the system. Consideration has been given to requiring measurements at more than three points in order to insure "representative" sampling of system performance. But our view is that this requirement is not intended to establish that each subscriber will receive service in accordance with the standards — that can come only with a measurement at each subscriber terminal. The performance check is, rather, assurance to the operator and to the Commission (should the performance be questioned) that the signal path from headend to check point is capable of conforming to the standards. We are therefore retaining the proposed requirement for three measurement points. *Many systems, as a matter of good practice, will make routine observations at more than three points.* The ultimate requirement, in any event, is that the technical standards must be met at each subscriber terminal.³

A franchising authority may wish to set forth measurement procedures that give reasonable assurance to local officials that standards are in fact being met.

The establishment of technical standards by local governments is desirable for other reasons. The initial high signal quality may, over time, slowly degrade to a point where the signal quality is not completely acceptable. Subscribers who are unhappy with the quality of service may not regard discontinuing service as an acceptable alternative, especially if off-air television reception in the community is poor. Furthermore, cable television's promise lies in its potential for public service; as this service grows, the franchising authority will have a strong interest in the technical quality of services provided.

The franchising authority also has an interest in seeing that cable television facilities are safely constructed and operated, and that the system's component parts are durable and reliable. Several federal agencies have set forth regulations that deal with such issues, but no comprehensive standard for safety, ruggedness and reliability in cable television systems exists in one place. Therefore,

³*Cable Television Report and Order*, 36 FCC 2d (1972) (emphasis supplied).

the franchising authority may choose to set forth more comprehensive standards.

Finally, technical standards work no magic by themselves. A system operator has little incentive to adhere to a comprehensive testing program if his records are not examined by the franchising authority. In a letter to the president of a large multiple system operator, the Chief of the FCC's Cable Television Bureau suggested the commission's view of local governments' responsibilities with regard to technical standards.

The Commission will not, however, assume responsibility for enforcement of more stringent technical standards. Local authorities should therefore be prepared to assume the burden of such enforcement.¹

Specifically, the center recommends a regulatory program consisting of the following elements:

- Construction standards to insure a safe and reliable cable system
- Technical standards for the reception of broadcast television signals received either off-the-air or via microwave
- Technical standards for ensuring overall system performance
- Procedures for testing system performance to ensure that all technical standards are being met
- The development of a record keeping log book that supports the technical standards and testing procedure programs.

CONSTRUCTION STANDARDS AND SPECIFICATIONS

Construction specifications for cable TV systems focus upon two main elements: system safety and system reliability. A cable system which is designed to meet very high technical and performance standards can be ineffective if the antenna breaks the first time it snows or the amplifiers short out during the first rain.

The development of safety specifications in a cable TV ordinance permits the municipality to observe, check and monitor and ensure system safety. While this aspect of the ordinance is not directly related to system performance and quality of signal received, it is, nonetheless, important. The construction of a cable system involves some degree of coordination and cooperation between such various municipal departments as highways (rights of way) utilities (pole agreements), engineering (electrical standards), and federal agencies (e.g., Federal Aviation Agency for tower

permits). As such, those standards relating to the quality of construction can be specified in the ordinance though it is not necessary to do so. The franchising authority may also want to examine local codes to determine whether any of them might affect cable.

The community's interest in construction standards for system reliability is based upon subscriber concerns that service be uninterrupted. Frequent system failure due to poor design, construction, or equipment should not be tolerated by the franchising authority, and can effectively be prevented only by monitoring construction of the system from the outset. Further, as public agencies make more and more use of the cable system, reliability of service becomes a direct concern of local officials.

Construction standards generally deal with those elements directly exposed to weather and the elements. Thus, provisions should be developed for the following:

- Antennas — protection against wind, ice loading and corrosion
- System grounding — proper grounding of the power supply and metal components of the system to ensure that the system is protected against lightning, power surges, and electrical interference
- Aerial cable plant — provision to ensure that the cable is properly supported, that electronics are weatherproofed and protected from corrosion, and that equipment is accessible for maintenance
- Underground cable plant — provision to ensure that conduit is rugged and large enough to permit adding cable in the future when it is needed. Provisions to protect cable under heavily traveled roadways.

The substance of reliability and safety standards should be a comprehensive collection of relevant provisions from the National Bureau of Standards, the Federal Aviation Agency, state regulations, and local provision for the use of the community's streets.

Compliance for construction centers mainly on the monitoring of the system as it is built. Thereafter, the franchising authority's role diminishes.

STANDARDS FOR RECEPTION OF BROADCAST TELEVISION SIGNALS OFF-THE-AIR OR VIA MICROWAVE

Cable television systems may meet very high performance standards yet still deliver low quality pictures to subscribers. Broadcast television signals carried on the cable may be poor because the

¹Letter from Sol Schildhause, Chief of Cable Television Bureau, Federal Communications Commission, to Edward M. Allen, August 11, 1972.

headend antenna is badly situated, poorly designed, badly installed, or because the television station broadcasting the signal is defective.

From the subscriber's viewpoint, poor service is poor service, regardless of the cause. The franchising authority, however, must be able to pinpoint responsibility for poor performance. Standards for reception of broadcast signals define for a system operator the minimum quality of the signal the system must secure with its antenna before it distributes the signal to subscribers. These standards also provide a way of grading the quality of each off-the-air signal received, against which the performance of the system in delivering that signal to subscribers can be measured.

The first step in defining specific standards for signal acquisition in a community is to require that a signal survey be conducted. This survey can be performed either by the municipality or by the system operator. In either case, it is done to determine what television signals can be received, what quality of pictures to expect and what possibilities there are for the headend — the desired site location, height of tower, antenna array designs and sources of interference.

Armed with results of a signal survey, the franchising authority is in a position to require the system operator to place his antennas and design them to receive the best quality of signal possible, given the character of local geography.

OVERALL SYSTEM PERFORMANCE

The FCC has set technical standards only for the delivery of broadcast television signals by a cable system. The commission expects soon to develop standards for cablecast programs, and ultimately, two-way communications.

In the meantime, effective performance standards for broadcast television signal carriage is the most appropriate means for assuring that the cable system is capable of doing what it is designed to do.

One way of defining performance standards is to specify exactly how each component of the cable system will perform, and to require the system operator to install the specified equipment. This is an unsatisfactory approach because it does not guarantee the overall performance of the system.

A more effective approach is to require the system to deliver a specified quality of signal to subscribers, without specifying how it should do so. The franchising authority can require that for a given grade of signal received at the cable system

headend, the system must deliver a specific standard of signal quality to subscribers. Since standards for the acquisition of broadcast signals have already been defined, ordinance provisions for signal delivery standards should be developed to complete performance standards.

PROCEDURES FOR TESTING THE SYSTEM TO ENSURE THAT STANDARDS ARE MET

No standard has meaning unless procedures are developed for its enforcement. The franchising authority should set forth reasonable and effective procedures to test the ability of the cable system to meet prescribed technical standards. These procedures should be built around three kinds of tests.

First, as a condition of the franchising agreement, the franchising authority might require an initial, exhaustive, proof of performance prior to the provision of service. The main trunks should be tested without exception, and parts of the feeder network selected at random. Finally, a representative number of subscriber taps should be tested. The locations might be as follows:

- At the last trunk amplifier in widely separated points in the system
- At the last line extender in widely separated feeders of the system (feeders not fed by the trunk tested above)
- At multitap locations as selected at random to provided coverage of the entire area.

The purpose of the test in each case would be to build for the franchising authority a statistically sound "portrait" of the system's capability. Initial testing should occur with the completion of construction of each section of the system and should be tied to the construction timetable established by the franchising authority.

Many performance tests involve an interruption of service. Once service has begun, tests which interrupt service should be conducted only as often as is necessary to ensure that performance standards are maintained. A second kind of test should take place once a year when the franchising authority should require the system operator to ensure that the system complies with both FCC and local performance standards.

Finally, the franchising authority could require a series of monthly, inexpensive tests that do not require the disabling of the system. Initial and annual tests can be prepared for, by judicious "tuning" of the system. An effective monthly testing program should result in high quality system performance all the time. Monthly tests, con-

ducted by the system operator and reported to the franchising authority, provide a mechanism to ensure that the system operates near its rated capability.

RECORDS TO BE KEPT

The system operator should permanently maintain detailed records which show exactly how the system was constructed, in order to facilitate the modernization or overhaul of the system in the future.

Initial and annual proof of performance tests should be evaluated by a competent engineer, preferably someone not involved with the system operator. Monthly tests should be examined by an agent of the franchising authority, but they are likely to be simple enough to be interpreted by a layman, with assistance from the system operator.

Finally, the system operator should be required to keep a record of his responses to subscriber complaints, including tests made of what was wrong and proof that the problem was satisfactorily resolved.

Technical standards work no magic by themselves. A system operator has little incentive to adhere to a comprehensive testing program if his records are not examined by the franchising authority.

C. Role in the Evolution of Cable Technology

Local officials planning for cable should keep in mind that they are dealing with a rapidly developing technology. A system that is well-designed and meets high technical performance standards for today can become out-of-date tomorrow if the community does not provide adequate safeguards to ensure that the system can evolve along with technology. System design should be such as to minimize obsolescence, and system operators should be encouraged to experiment with new technological innovations.

There are two essential ingredients to this process. First, the franchising authority should develop the capacity to monitor independently technological developments in cable communications. No procedural mechanism will protect the interests of the community unless it is activated by intelligent monitoring efforts by a specific agency in the local government.

Second, there must be a procedure which gives the franchising authority the power to negotiate

with the system operator for installation in the system of new technical capabilities.

In order to monitor state-of-the-art developments, many communities have formed citizen advisory commissions. The commissions are comprised of civic, technical and municipal leaders who periodically meet with the cable system management and interested citizen groups to exchange ideas and provide feedback to local legislative and administrative officials.

The example below from New York City illustrates a similar approach. It provides a procedural basis for making changes that consider both the consumer and the system operator. A cable commission might perform the same function as New York's Director of Franchises. The required changes may involve heavy expenditures, so that those responsible for technical review must not only be familiar with the development of the technology but also its usefulness to the community, and the costs involved.

After consultation with the Director of Communications, if the Director of Franchises determines, giving due regard to technological limitations, that any part or all of the System should be improved or upgraded (including, without limitation, the increasing of channel capacity, the furnishing of improved converters, and the institution of two-way transmission), he may order such improvement or upgrading of the System, to be effected by the Company within a reasonable time thereafter. If the Company disputes any such determination or the reasonable time within which it is to be implemented, it may, within twenty (20) days after the issuance of such order, demand that the matter be arbitrated pursuant to Section 20 of this contract.

Section 20. Arbitration

Matters which are expressly made arbitrable under provisions of this contract shall be determined by a panel of three arbitrators appointed by the Presiding Justice of the Appellate Division of the Supreme Court of the State of New York for the First Judicial Department. The fees of the arbitrators shall be fixed by said Presiding Justice. The expenses of the arbitration, including the fees of the arbitrators, shall be borne by the parties in such a manner as the arbitrators provide in their award, but in no event will the City be obligated for more than half the expenses. The determination of a majority of the arbitrators shall be binding on the parties. In the event that an arbitrable matter

arises contemporaneously under another franchise, involving the same issue as that to be arbitrated under this franchise, the Company will not claim or assert that it is prejudiced by or otherwise seek to prevent or hinder, the presentation of the arbitrable matter under such other franchise for determination by a single panel.

III. CONCLUSION

In the future, cable must find markets for the new services that can be provided by current cable technology and for those services that the emerging two-way cable technology will soon be capable of providing. Markets must be found in an arena of competing telecommunications technologies such as telephone, broadcast television, radio, and specialized common carriers.

Nonetheless, there is little doubt that an important role will develop for cable no matter what the ultimate configuration of urban telecommunications. More importantly, local officials cannot wait until the future is clear. Franchising decisions which will establish the frame of reference for cable television development are being made now.

It is probably not too much of an exaggeration to state that the public promise of cable television depends more upon the quality of franchising decisions than upon any other single factor. An understanding of the fundamentals of cable television technology and its implications on design, technical performance, and future developments, is vital to the quality of local decisions.

Technological decisions are difficult to make because they are complex and not easily understood; but, more fundamentally, because they are

essentially efforts to both define and chart the future.

Cable television technology is no exception. Such abstract terms as "attenuation," "frequency response," "second order distortion," and others do not inspire confidence in the minds of those who must make decisions without the benefit of an engineering degree. Those terms evoke a feeling on the part of public officials that only technically trained experts can make technological decisions.

The reverse, however, may more often be the truth. Technological decisions are seldom purely technical — rather, they concern our values, our world view, our sense of the kind of society we wish to build. Decisions of this kind should be made by responsible officials, not by technicians.

This may be particularly true in the case of cable television. Imbedded in seemingly technical decisions about dual or single cable, converters or switches, trunks, feeders, or drop lines, is the form of a new communications medium which may affect in important ways the manner in which we lead our lives.

This report does not lighten the responsibility of decision making, nor does it make the decision easier. What it does, hopefully, is explain the aspects of cable technology with which decision makers should be familiar, point up the principal questions decision makers must confront, and state alternative responses to these issues so that the opportunity for decision will not be lost.

In the final analysis, we all must realize that technology drives us back to ourselves. It offers wide choices — for good or for bad. It expands our capacities — but with effects we can never completely comprehend. We must be as analytical as we can be in making such choices; but in the long run our best guide to technological decisions may be carefully considered human values.