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ABSTRACT

A research study was conducted for the Office of Telecommunications Policy to determine the capital outlay and operating costs of community antenna television (CATV) systems. Six major tasks were undertaken: 1) the development of a body of technical information about CATV; 2) the production of a complete work breakdown structure; 3) a cost analysis of headend components; 4) a cost analysis of distribution components; 5) an operating cost analysis; and 6) the development of a cost handbook. This procedure allows one to build and compare detailed cost models for alternative kinds of CATV systems. The cost handbook makes it possible for policy-makers to recognize what inputs are needed to develop system costs, to proceed in heuristic fashion to make simplifying assumptions, and to construct a complete ten-year system cost estimate. Six appendixes provide highly detailed information about costs and technical standards, as well as a short list of reference works. (PB)

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RMC INCORPORATED

Report UR-170

# COST ANALYSIS OF CATV COMPONENTS

*Final Report*

Gary Weinberg

June 1972

Prepared for

The Office of Telecommunications Policy
Executive Office of the President

Under

Contract OTP SE-72-101

*a division of Resource Management Corporation*
[illegible]

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CONTENTS

# INTRODUCTION

RMC, Inc. was asked to develop cost estimating relationships for the investment and operating costs of cable TV, or community antenna television (CATV), systems. This report presents the results of that research study.

Our research centered around six major subjects:

(1) development of technical information about CATV systems and the industry,

(2) development of a realistic and complete work breakdown structure,

(3) cost analysis of headend components,

(4) cost analysis of distribution components,

(5) operating cost analysis, and

(6) development of a cost handbook and illustrative examples.

Understanding how a system is constructed and works is essential to the successful completion of any cost analysis study. This technical knowledge forms the framework around which costs are developed and presented.

The development of a realistic work breakdown structure is another key element in any cost analysis study; it specifies the data that must be collected and the levels of output available from the study. It also serves to ensure the completeness of the data collection and the analysis.

All cost factors and estimating relationships developed during this study are at the component level. Because of the almost infinite number of equipment combinations and construction techniques that may be required in an actual system, a building block technique of estimating costs was considered the most applicable in meeting the objectives of this research activity. The building block concept enables the analyst to specify the exact equipment combinations and construction techniques appropriate for his problem.

To aid in the development of major component costs, hypothetical examples have been developed in each appendix to illustrate the use of these cost factors. A system handbook chapter describing the inputs required in analyzing CATV systems and realistic assumptions to reduce the number of combinations of equipment and construction techniques is also contained in this report. Through the use of a hypothetical system and its operating and subscriber characteristics, a complete system cost example has been worked out. In this example, capital costs and ten-year operating costs have been calculated.

Chapter 2 of this report highlights current industry practices, the problems involved in analyzing CATV costs, the work breakdown structure, and the methodology of our approach. Chapter 3 presents the results of our headend cost analysis, while Chapter 4 presents the distribution cost analysis. Chapter 5 analyzes the operating costs of CATV systems and Chapter 6 illustrates the development of total system costs.

Appendices A, B, and C contain the component cost examples. Detailed backup to the construction costs is contained in Appendix D; this appendix also contains a set of normalized construction cost equations. Appendix E is an example of technical standards used by a major multiple system owner (MSO) in system design. Appendix F presents the references and documentation for this study.

# 2

## BACKGROUND

From its beginning in isolated portions of the country, CATV has experienced both rapid growth in the number of subscribers[1] and in the technological evolution of its channel or signal capability. The original intent of cable TV was to transmit television signals to communities that were not within line-of-sight of the nearest television antennas. More recently, through the use of microwave relay equipment, high-performance electronics, low-cost local-origin equipment, automatic services (such as continuous time and weather), etc., the concept and intent of CATV is undergoing major changes.

Coupled with its historical growth pattern and future potential is a history of regulatory rules and franchising laws that have not always been consistent. Federal, state, and city agencies, all of whom are involved in this regulatory/franchise process, have sometimes made decisions based upon incomplete or misleading information. One means of improving the decision-making capability is to determine the impact of policy decisions while these policy decisions are still in the proposal stages. To measure the impact of these decisions, two analytic models are required. The first measures the demand for a CATV system as a function of subscriber service change, the number of available channels, and the content of the channels, and the second analyzes the capital and operating costs of a CATV system that satisfies both the

1. From 14,000 subscribers in 1952 to 5,900,000 subscribers in 1971. Television Digest, Inc., Television Factbook, 1969-1970 (Washington, 1969) and Report of the Sloan Commission on Cable Communications, On the Cable: The Television of Abundance (New York, 1971).

demand model in terms of the number of available channels and the criteria specified in the proposed regulation.

The purpose of this study was to develop the second analytic model--a detailed cost model to be used in estimating the costs of alternative CATV systems. While this model, which is described in Chapters 2 through 6 of this report, is self-explanatory, a brief description of the technology of the cable system and basic industry practices will clarify certain terms and techniques for the non-technical reader. This background is also useful because it sets the scene for the methodology used in deriving the cost model.

## TECHNOLOGY

The basic concept behind television is the transmission of information from a camera to a television receiver. The transmission is accomplished, after the sight and sound received by the camera is converted into a form of electric current, by the radiation of electromagnetic waves from a transmitting antenna. Through the use of a receiving antenna, the signal is "captured" and transmitted to the television receiver that decodes the electric current back into sights and sounds.

The electromagnetic waves travel, essentially, in a straight line outward from antenna. For a distance of about 75 miles from the antenna, the si can be captured and converted. Beyond this distance, the curvature of the earth begins to block reception and the signal is lost.

This straight-line travel of signals is one of the reasons for the development of CATV. Communities built at the base of mountain valleys cannot receive signals transmitted outside the valley. By installing a tower at the top of the mountain, the signal could be captured, amplified, and then distributed by cable to the households in the community.

This basic system involved in the "capturing," amplifying, and distributing of signals is the heart of a CATV operation. In such a system, a typical operating plant would consist of:

- the Headend,
- the Distribution System, and
- the Home Terminal.

The headend is the programming source of the system. It receives signals from over-the-air sources, distant sources through the use of microwave links and equipment, and locally originated programs. One of the major functions of the headend is to process the incoming signals. This essentially means the assignment of channel space to each program, balancing of video carrier levels, and the adjustment of the sound carriers for adjacent operations. UHF channels, because of the high frequencies, are converted to VHF signals to be distributed through the cable. Another function performed by the headend is program control. To protect local broadcasting, the FCC requires the "blacking out" of distant signals that "duplicate" a program on a local station. This requires, at the headend, elaborate pre-programmed equipment to control what time segments on what stations must be removed from the view of system subscribers.

Finally, the headend combines all of the spectrally distinctive signals onto one or more cables at the proper signal levels and feeds these signals into the distribution system.

The physical link between the subscriber and the headend is the distribution system. In its simplest form, a trunk line runs out through the local geographical area. Feeder lines branch out from the trunk in such a manner so as to bring the feeder cable to within 75 to 150 feet of each subscriber. The actual interconnection between the headend and the subscriber is made through a drop cable. The distribution system is analogous to a tree network, where products are carried from the roots through the trunk and then the branches to the individual stems that feed the individual leafs. The cable itself causes losses in the signal strength as the signal moves through the cables. Thus, some form of compensation must be added to the cable to prevent actual loss of signals. Although the cable itself theoretically can carry forty or more channels, the current amplifier characteristics limit the actual channel capability to about 26 channels.

Other electronic components required along the cable are "passive" devices which change the direction of signal flow and connect the subscriber to the cable. For future CATV growth, new passive devices are required: filters to block out part of the spectrum so as to deny a subscriber access to one or more specialized channels and bi-directional amplifiers that can be used to transmit information from the subscriber to the headend (i.e., upstream transmission).

With the trend toward CATV systems to supply more than 12 channels, subscriber converters are becoming increasingly necessary. These converters serve the same function as the channel selector in subscriber television sets. The converters with their 26 channel capacity more than double the capacity of the home receiver.

Additional channels now available from new CATV systems are located in what is called the midband and superband frequencies. These bands and the possible two-way up-stream bands are illustrated in Figure 2-1, which is the frequency spectrum band of television broadcasting.

One of the elements that has influenced the technological growth of CATV components is the evolution of the multiple system owner (MSO). During the late 50's a number of the single owner/operators began to expand their own group of holdings. This expanded base of operation has permitted more dollars to be spent in system planning and engineering. Because their operations have become sizeable, they have been able to influence electronics manufacturers into developing new products.

Because of the high capital requirements of new systems, the trend toward MSO's is understandable. However, this trend is somewhat diminished through the use of turnkey operators, who are equipment manufacturers that specialize in the construction of complete cable systems and then turn their operation over to system owners. Through them, local groups can own and operate new systems without the technological base of the MSO's.

## METHODOLOGY

The previous section on the technology of CATV deliberately understated its complexity. While the technology is straightforward, there does not actually exist a typical or representative CATV system. This lack of a representative system can be traced to three major reasons:

- five basic types of signals (off-the-air VHF, off-the-air UHF, microwave, automated programs, and local origination) available in a large number of combinations.

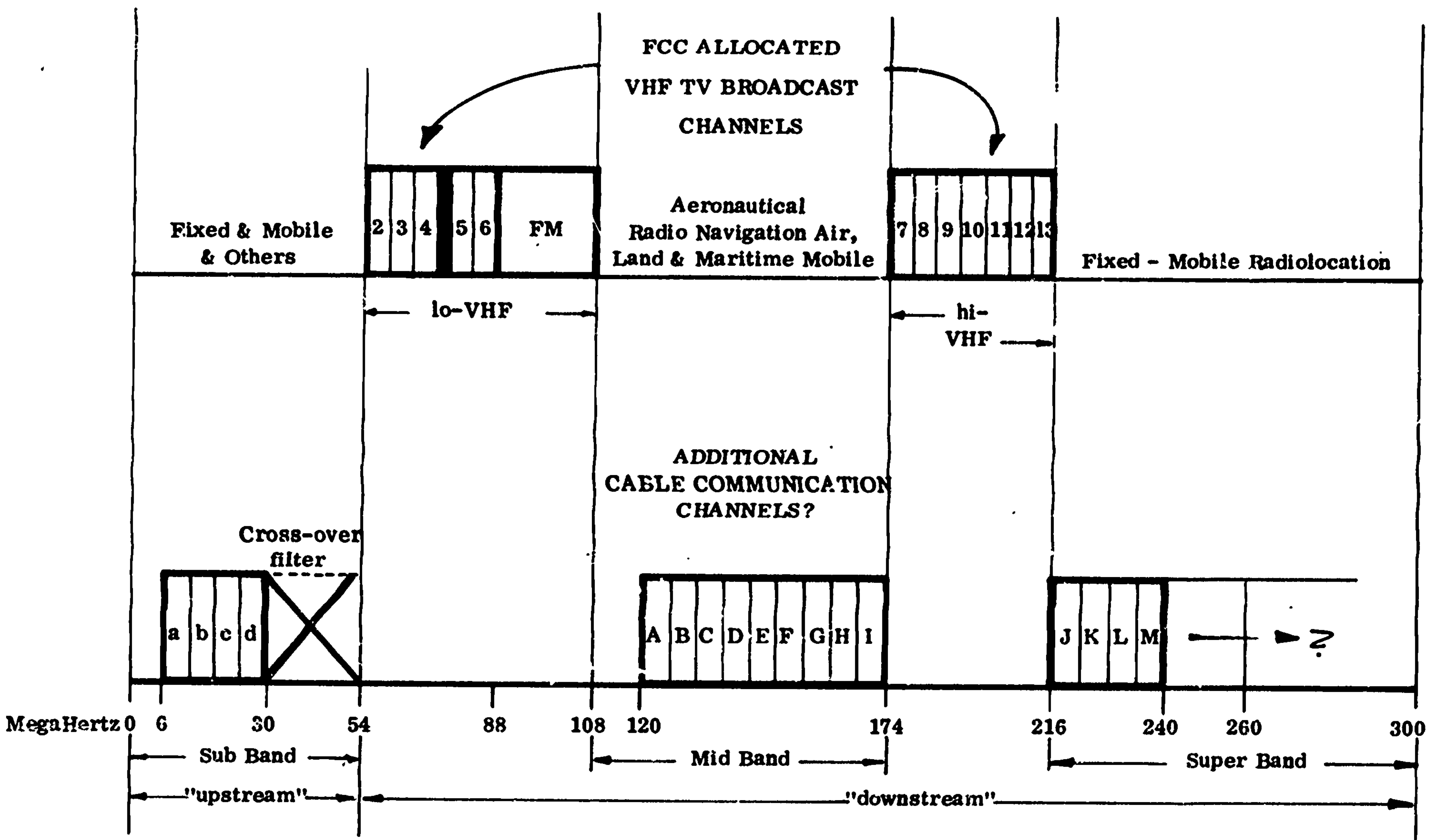


Figure 2-1: FREQUENCY SPECTRUM CHART

- alternative equipment combinations that can accomplish system objectives; and
- wide variations in ground conditions for underground systems.

This large number of signals, electronic components, and construction requirements preclude an "average" or "typical" system approach to cost analysis. What is suggested by all the combinations, and what, in fact, has been used in this study is a modular approach to developing cost estimates. The modular approach develops cost estimating relationships at the component level and then aggregates these components and their costs into systems that are being analyzed. The heart of such a modular approach is the work breakdown structure (WBS), a framework that specifies the lowest level at which cost data are collected and the lowest level that cost estimating relationships are developed.

Using the WBS in both data collection and the development of total system costs ensures both the completeness of data collection and the completeness of the estimates. The WBS that has been developed in this study is shown in Table 2-1.

Of equal importance in the development of system costs is the proper use of the cost factors and the development of realistic assumptions that reduce the possible combinations being considered. Each of the major appendices of this report make use of illustrative examples in explaining the use of the cost estimating relationships. Chapter 6 serves the purpose of a handbook and shows what inputs are needed to develop total system costs, what simplifying assumptions can be made to reduce the complexity of the problem, and finally, how a complete ten-year system cost is developed.

All of the cost relationships developed in this report reflect current state-of-the-art technology. The analysis contained in this report is limited, by contractual definition, to "off-the-shelf" equipment items. For example, the complete costs of two-way systems has not been examined. The assumptions that have been developed to reduce the magnitude of the specification process are based upon current industry best practices. These assumptions are, however, flexible, and can be changed by the analyst to suit individual needs.

Table 2-1

WORK BREAKDOWN STRUCTURE

CAPITAL COST

I. Headend Equipment

A. Tower(s)

B. Antennas

1. VHF
2. UHF
3. FM

C. Headend Building

D. Preamplifiers and Power Supplies

E. UHF/VHF Converters

F. Pass Band Filters

G. Signal Processors

H. Pilot Carrier Generators

I. Combining Networks, Splitters and Couplers

J. FM Equipment

1. Preamplifiers and Power Supplies
2. Tuners

K. Microwave

1. Demodulator
2. Transmitters
3. Antennas
4. Receivers
5. Modulators

L. Studio Retransmission Equipment

M. Non-Duplicating Equipment

II. <u>Cable and Related Equipment</u>

A. Main Trunk Amplifiers

B. Bridger Amplifiers

C. Line Extender Amplifiers

D. Automatic Slope Amplifiers

E. Passive Electronic Devices

1. Splitters
2. Couplers
3. Taps
4. Etc.

F. Subscriber Drop Equipment

G. Converters

H. Subscriber Drop Cable

I. Coaxial Cable

1. Trunk

a. Underground

i. In Conduit
ii. Non-conduit

b. Above Ground

i. Jacketed
ii. Non-jacketed

2. Distribution

a. Underground

i. In Conduit
ii. Non-conduit

b. Above Ground

i. In Conduit
ii. Non-conduit

J. Cable Power Supplies

K. Microwave Retransmission Equipment (i.e., LDS)

1. Transmitters
2. Receivers
3. Channel Modules
4. Redundancy Modules

## III. Construction and Miscellaneous Costs

A. Strand Mapping and Make Ready Costs

B. Construction Costs

1. Underground Construction

a. With Conduit

i. Type 1 Soil Condition
ii. Type 2 Soil Condition
iii. Type 3 Soil Condition
iv. Asphalt
v. Concrete
vi. Conduit Material and Installation

b. Without Conduit

i. Type 1 Soil Condition
ii. Type 2 Soil Condition
iii. Type 3 Soil Condition
iv. Asphalt
v. Concrete

c. Cable Pulling and Burying
d. Pedestals
e. Equipment Installation and Balancing

2. Aerial Construction

C. Pole Rearrangement Costs

OPERATING COSTS

I. Plant Operating Costs

A. Personnel: Salaries and Benefits

1. Manager
2. Chief Technician
3. Installers
4. Maintenance Technicians
5. Bench Technicians
6. Microwave Technicians
7. Benefits

B. Repair and Maintenance

1. Headend
2. Distribution System
3. Microwave Maintenance (or Rental)

C. Rental Costs

1. Poles
2. Tower Site

D. Power

1. Headend
2. Distribution

E. Parts and Supplies

1. Initial Inventory and Spare Parts
2. Test Equipment
3. Tools

F. Truck Rental

## II. Office Operating Costs

A. Personnel: Salaries and Benefits

1. Bookkeeper/Office Manager
2. Secretarial/Clerical

B. Office: Rental

C. Office: Postage and Supplies

D. Furniture and Leasehold Improvements

E. Professional and Legal Services

F. Insurance

1. Property
2. Miscellaneous

G. Taxes and Licenses and Fees

1. Property
2. Franchise
3. Sales
4. Payroll
5. Licenses and Fees

H. Telephone, Utilities, and Maintenance

1. Telephone
2. Utilities and Maintenance

I. Billing and Bookkeeping

J. Promotion and Sales

K. Drop Replacement and Turnover

L. Travel and Entertainment

M. Membership

N. Contributions

O. Bad Debts

P. Freight

Q. Sales Commission

# 3

## HEADEND EQUIPMENT

Developing cost factors for headend-related equipment raises the same types of problems that were encountered with "typical" systems. The possible, even feasible, combinations and permutations of input signals (UHF, VHF, microwave, studio and FM), number of channels, antenna types, and number of trunk cables are so extensive that complete enumeration is neither possible nor warranted. Similarly, using a conventional average per channel cost is not recommended. Because differences in equipment requirements exist between VHF and UHF systems, it is obvious that some middle-ground display is needed. The technique discussed in this section is based, where possible, upon these differences and reflects this middle-ground approach.

### REPRESENTATIVE SYSTEMS

Although this report does not attempt to discuss the technical aspects of cable television, a brief description of the components of a headend system is useful as background. Figure 3-1 presents a typical headend system in which signals are received "off the air," either through UHF or VHF signals. The equipment shown in the diagram can be either dependent on or independent of the number of channels. This dependency categorization is one means of expressing those fixed and variable cost portions of headend equipment. Table 3-1 is an example of this categorization process.

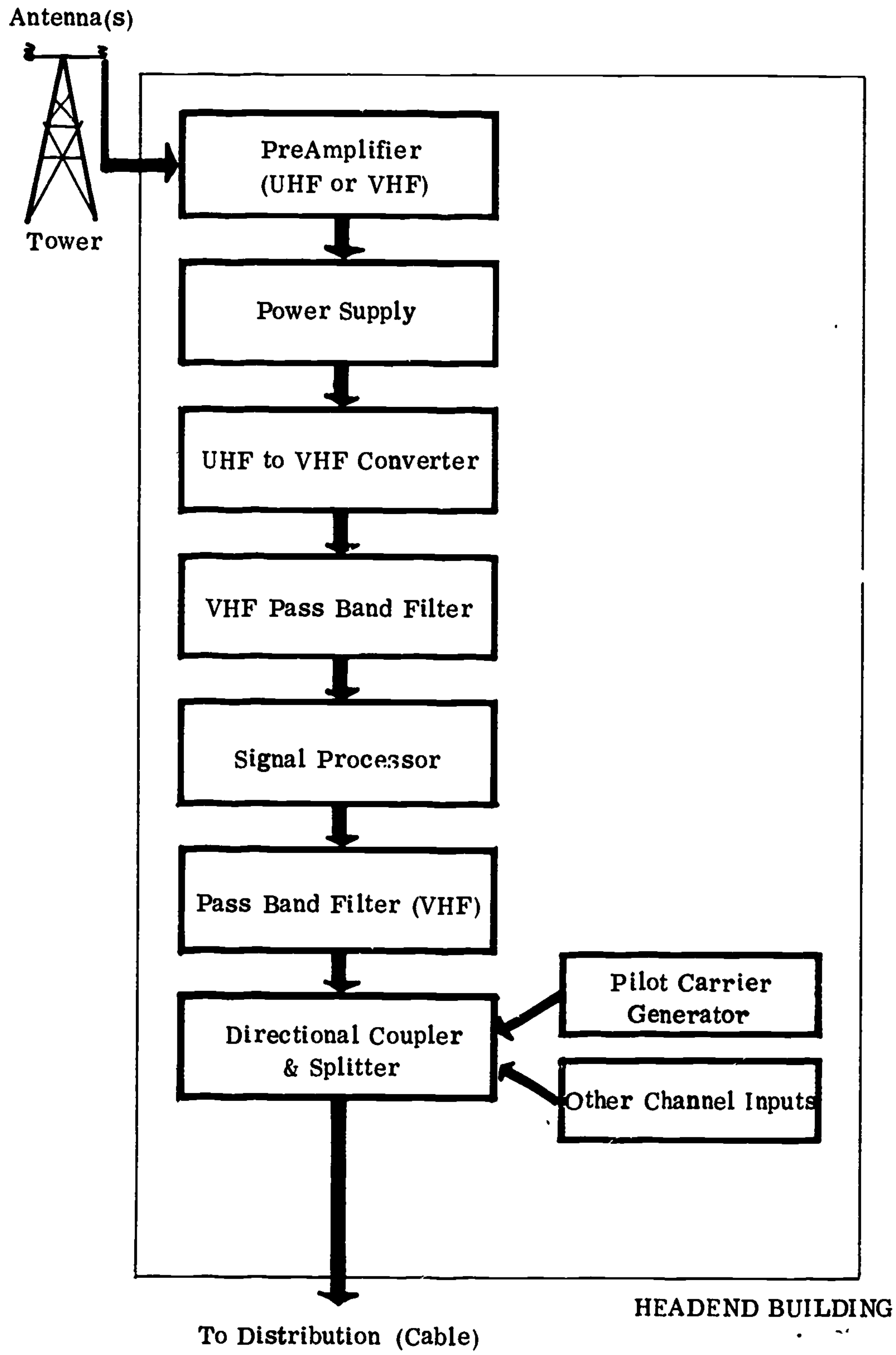


Figure 3-1: TYPICAL VHF/UHF HEADEND

Table 3-1

DEPENDENCY CATEGORIZATION FOR HEADEND EQUIPMENT

| Items Required for Each Channel | Items Required for System (Independent of Number of Channels) |
|---|---|
| Antenna | Tower |
| Preamplifier | Pilot Carrier Generator (Two per Cable) |
| Power Supply | Headend Building |
| Pass Band Filters (Two per channel) | Combining Network |
| UHF to VHF Converters (each UHF channel) | Splitters & Couplers |
| Signal Processor | Non-Duplicating Equipment |

A number of assumptions have been made to develop this "typical" headend system. In some cases, the assumptions are based upon a "best practice" or existing operating procedure. For example, signals received from the antenna may not need to be amplified before they reach the signal processor. Whether to include such preamplifiers depends upon the available signal strength and the distance between the tower and headend building. However, discussions with turnkey operators and manufacturers indicate that preamplifiers are usually required. For this reason, it is assumed that preamplifiers are always required when UHF or VHF signals are received off the air. Pass band filters are another example of an equipment item that may be needed. In general, one filter is used to remove unwanted signals after preamplification, and a second after the signal leaves the signal processor. Since the inclusion of a second filter reflects current industry practice, it is assumed that headend costs will also reflect the practice. A similar case exists for pilot carrier generators. The pilot carrier generator controls the operation of all automatic gain control units in the distribution system. Two carrier generators may be used for slope and gain control. To reflect current trends, two pilot carrier generators are included in each representative system.

Representative schematics have also been developed for single-channel microwave-type systems and local studio retransmission (Figures 3-2 and 3-3). A major problem in a microwave system is the determination of what equipment items constitute a microwave system. If a common carrier is supplying both microwave transmit and receive facilities on a leased basis, then only the modulator and the equipment behind it must be purchased by the owner. If the system owner is transmitting signals from a local studio some distance from the headend, he may decide to purchase his own system. A typical single-channel microwave system would include:

| Specification | Equipment | Owner Option | |
|---|---|---|---|
| | • Demodulator | Lease Option Number 1 | Lease Option Number 2 |
| | • Transmitter | | |
| Complete Single Channel Microwave = System | • Transmitter Antenna | | |
| | • Receiver Antenna | | System Owner Purchase |
| | • Receiver | | |
| | • Modulator | System Owner Purchase | |

The third alternative would be to assume that the common carrier is supplying the microwave signal that the system owner must receive and modulate in order to produce standard VHF TV signals.

All of the three possibilities represent typical microwave options. Although the costs for each equipment item have been included in a later section, the illustrative cost examples that will be developed in Appendix A and in Chapter 6 have been based upon Lease Option Number 2. This option was chosen because it represents a "median" cost for microwave systems. In this regard, the complete microwave purchase would represent the "high initial investment cost" microwave system and Lease Option Number 1 would represent the "low initial investment cost" microwave system.

A number of alternative systems can be selected to represent the retransmission of local origination equipment. If, as discussed earlier, the studio is located some distance from the headend, then a microwave system might be used to transmit the signal from the studio to the headend. It is also possible that the studio is at the headend. In this case, the major equipment item would be a modulator. Because the microwave system selected for analysis includes a microwave receiver and antenna, the "simple" studio system has been selected as representative. As Figures 3-2 and 3-3 show, the difference between the microwave system and the studio system is in the receiver and antenna. By adding the cost of these components to the basic studio system, it is quickly possible to "construct" a microwave type of studio system.[1]

The studio system, as it is now arranged, requires an input signal to function as an active channel. Input signals can come from such diverse sources as local programming, i.e., local sporting events, automated origination, etc. Since local programming equipment and their costs were not part of this study, they have not been included as headend equipment.

The reproduction of FM signals is included as an option in the headend equipment section. FM retransmission capability can be readily included in a CATV system without significant increases in cost. Such a system is shown in Figure 3-4.

One final common equipment item is included: the automatic or pre-set non-duplicator. This equipment prevents the transmission of similar signals on different channels. When any two affiliates are broadcasting the same program, this equipment would prevent both of these signals from being retransmitted.

## EQUIPMENT

With the exception of antennas, there does not appear to be varying levels of quality within or between manufacturers for major headend equipment items. Jerrold and Scientific Atlanta, for example, each manufacture only one signal processor, one UHF or VHF preamplifier, etc. Furthermore, the list price for similar equipment

1. In this case, a microwave studio system would also include a demodulator, transmitter, and transmitter antenna.

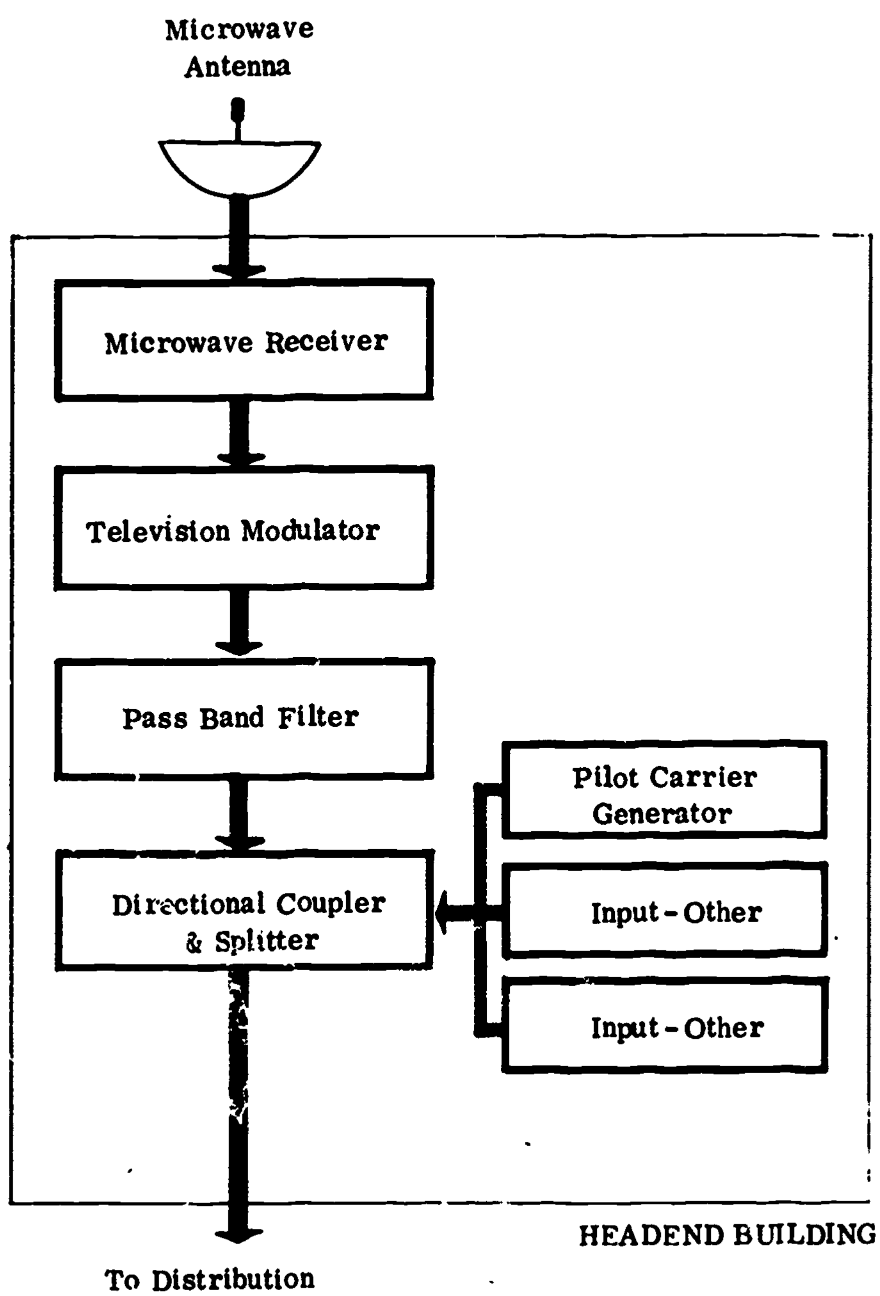


Figure 3-2: TYPICAL MICROWAVE HEADEND

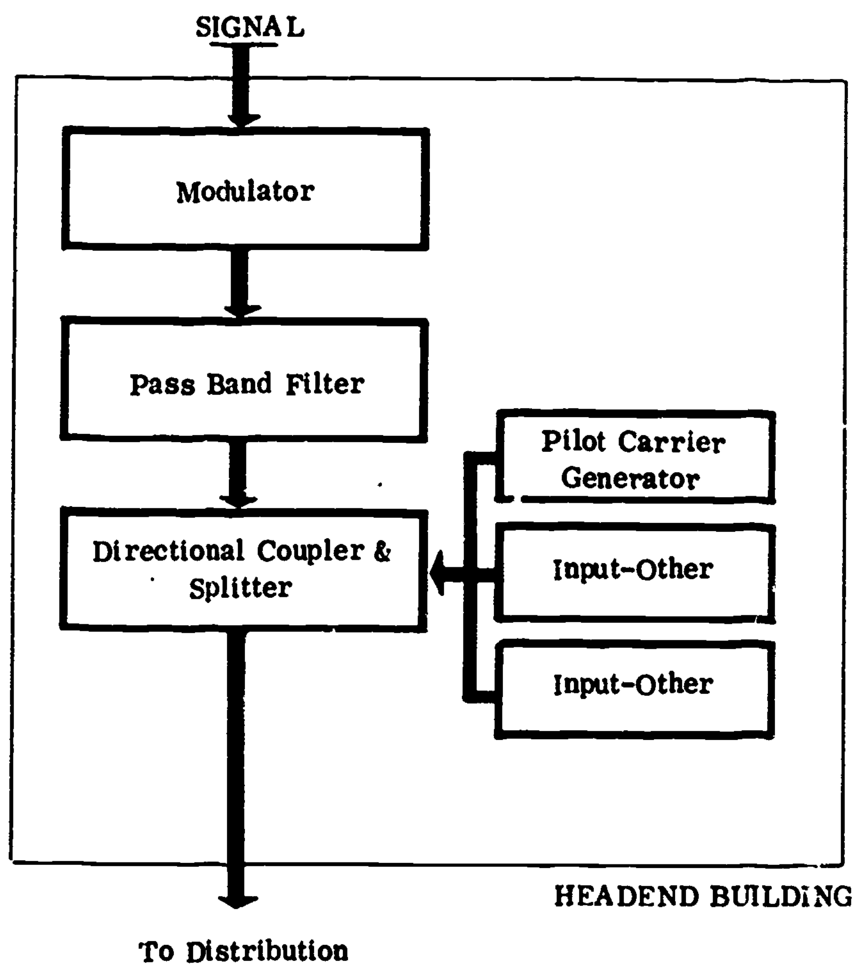


Figure 3-3: TYPICAL STUDIO HEADEND

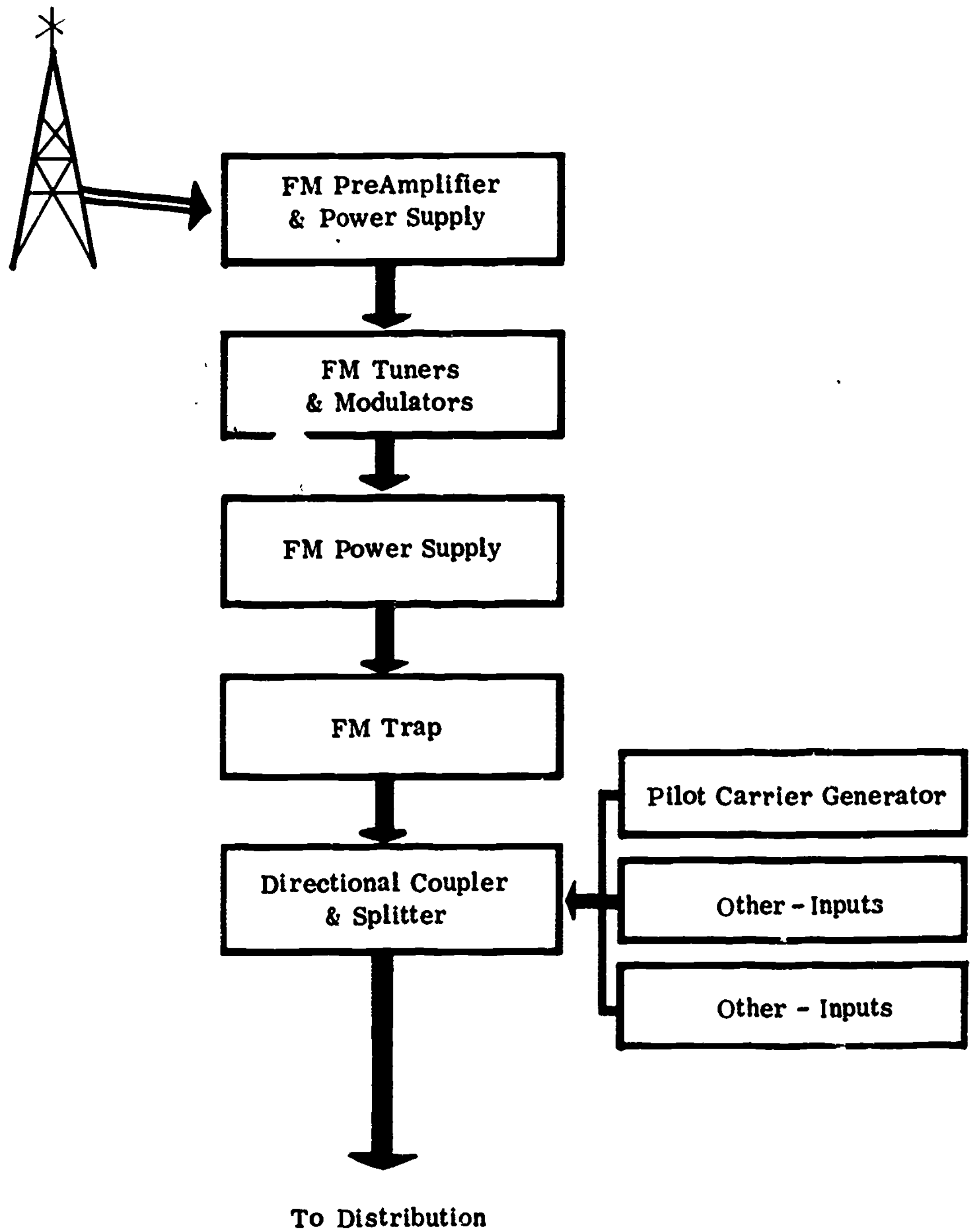


Figure 3-4: TYPICAL FM HEADEND

is competitive (i.e., Jerrold Channel Commander II vs. Scientific Atlanta's 6100 signal processor). Thus, there is no need to develop statistical cost estimating relationships for headend equipment. Where differences between manufacturers' prices exist, the differences are either averaged[1] or a range of costs is presented.

Catalogue prices do not include the costs of system design, installation and wiring, or check-out and test. These labor costs must be added to material costs in order to derive realistic cost factors.

## COMPONENT COSTS

Equipment costs, as stated earlier, have been developed from catalogue prices.[2] Although these catalogues are readily available, the costs for major headend equipment are displayed in this section. This serves two purposes. The first is to gain an appreciation of the relative costs of the components and the second is to enable the development of typical headend system costs.

### Towers

Two basic types of tower structures are used in most CATV systems: the guyed tower and the self-supporting tower. In selecting one of these two, the major criteria are not differences in performance but rather differences in land costs. For equal tower heights, the self-supporting tower requires less land. Thus, when land is at a premium (i.e., in cities), the self-supporting tower is usually selected.

Figure 3-5 illustrates the installed cost curves for both the self-supporting and guyed towers. Although the curves have been drawn continuously, this does not reflect actual building practices; towers are available (usually) in 25-foot increments. The decreasing cost portion of the curve reflects a high degree of fixed costs: assembling of crews, equipment, preparation, etc. The increasing cost portion of the curve reflects changes in construction technique and crew skills.

1. Assuming no differences in capability or performance exist.

2. This does not include towers. Towers are not included in equipment catalogues.

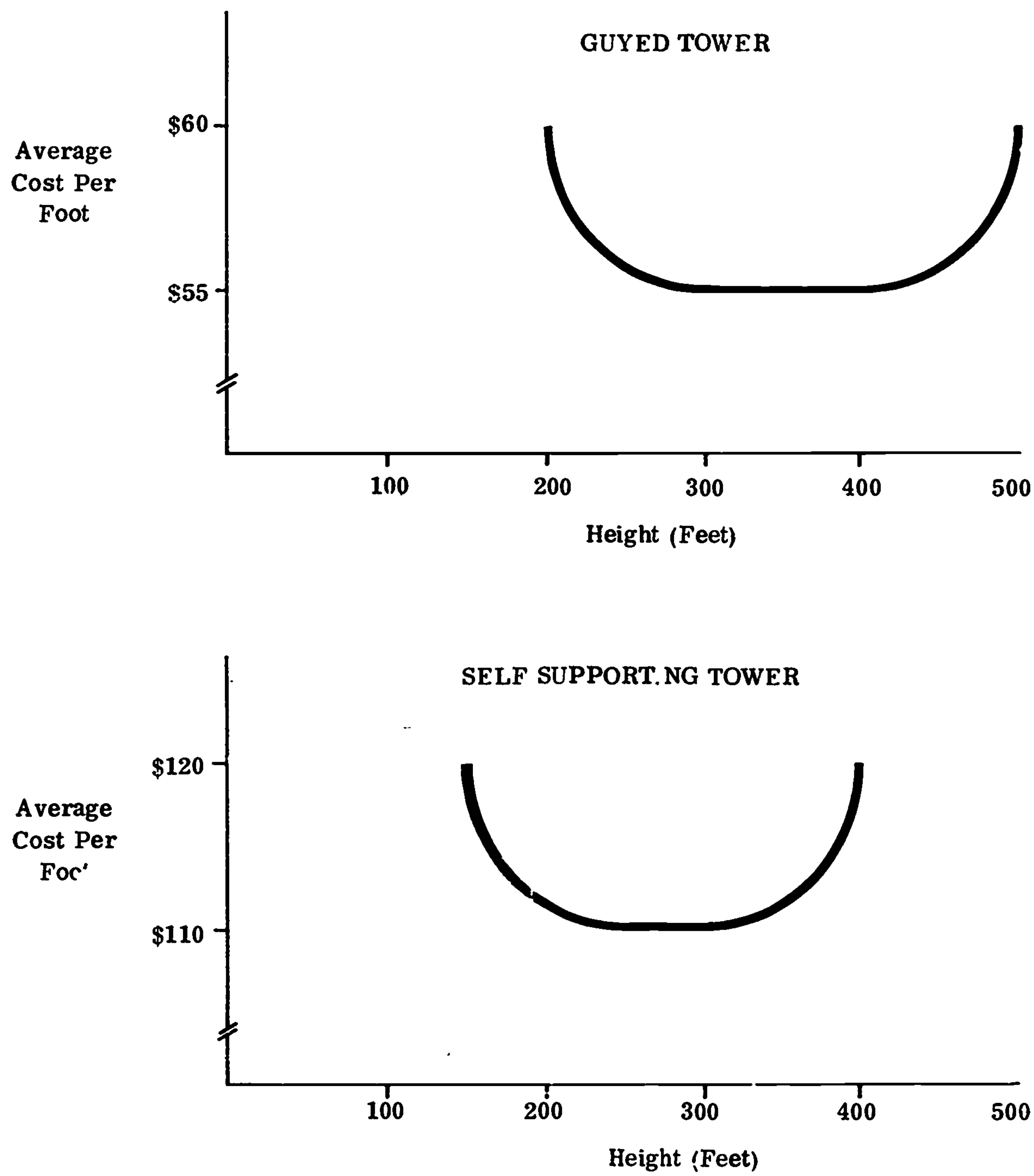


Figure 3-5: TOWER COST CURVES

The installed cost includes the cost of the tower,[1] tower crew, material, and equipment as well as the cost of hoisting and installing the antennas. It does not include the engineering supervision and site visits. The supervision cost usually ranges from $1,500 to $2,000.

Based upon the U-shaped cost curves, total installed tower costs have been developed. These are presented in Table 3-2.

Table 3-2

TOTAL INSTALLED TOWER COSTS
(Without Supervision)

| Guyed Tower | | Self-Supporting Tower | |
|---|---|---|---|
| Height | Total Cost | Height | Total Cost |
| 200 | $ 12,000 | 150 | $ 18,000 |
| 300[a] | 16,500 | 250[a] | 27,500 |
| 400 | 22,000 | 300 | 33,000 |
| 500 | 30,000 | 400 | 48,000 |

a. Represents average height for that type of tower.

## Antennas

Antennas are the most variable component in any CATV headend system because the number and types of antennas required are directly related to the location of the transmitters and receivers and the signal gain required. The log periodic antenna, the standard for VHF reception, and the broad band parabolic antenna, the standard for UHF reception, are each designed to receive a number of signals simultaneously.

1. For example, the guyed tower cost ranges from 30 to 40 dollars per foot.

For example, by employing 3 VHF antennas, it is possible to receive all 12 VHF channels. One antenna is designed to receive Channels 2 and 3; the second antenna Channels 4 - 6; and the third receives Channels 7 - 13. But, for this case to be true, each group of channels (i. e., Channels 2 and 3, 4-6, and 7-13) must be broadcasting within close proximity of one another (CATV antennas are highly directional) and the signal strengths of each transmitter almost identical to prevent one signal over-powering another. This case is somewhat unrealistic. It does, however, represent the minimum number of required VHF antennas: 3[1]. The maximum number of antennas required for a 12-channel VHF system would be twelve. This case arises when each VHF signal requires a separate antenna. A realistic rule-of-thumb is that the number of antennas required equal 80 percent of the number of off-the-air VHF or UHF signals desired (rounded to the next whole number). For a 12-channel system then, 10 antennas would be required. The maximum case and the 80 percent rule both will be used to develop a realistic range of total VHF and UHF antenna costs for this report.

The required number of FM antennas does not usually vary as a function of the number of FM channels desired. A single omni-directional antenna is usually sufficient.

A second constraint on antennas is the signal strength required. VHF and UHF antennas are available in three major designs: single, dual, and quad arrays, with the quad array having the highest gain and the single, the lowest gain. The antenna gain represents a measure of the signal strengths: the single antenna represents the "strong" signal, the double array represents the "average" signal, and the quad array represents the "weak" signal. Typical antenna costs (without installation) are presented in Table 3-3.

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1. Although the case is unrealistic, a real example does exist. In New York City, channels 7, 9, 11, and 13 do satisfy the location and signal strength criteria and can be received by a single antenna.

Table 3-3

ANTENNA COSTS

| Signal | Array | VHF Antenna Cost | UHF Antenna Cost | Average FM Antenna |
|---|---|---|---|---|
| Strong | Single | $470 | $266 | $500 |
| Average | Dual | 955 | 613 | 500 |
| Weak | Quad | 1983 | 975 | 500 |

The antenna cost includes antenna elements, array support structure, assembly hardware, mounting hardware and brackets, and coaxial feed harness. The cost of installing the antennas is included in the tower cost. A supervision cost of $1,500 to $2,000[1] must be included with the antenna equipment to derive a total cost.

Headend Building

The headend building serves as the collection and processing center for CATV signals. The building contains all signal processing equipment not on the tower. Microwave receivers and test equipment are also contained in the headend building. Temperature controi (air conditioning and heating) is usually required for these buildings. When microwave equipment is used, temperature control is mandatory.

Headend buildings cost between $35 and $38 dollars per square foot. This is an installed on-site cost and includes heating and air conditioning. For small systems, the building is usually 8 x 8 feet, single story, which is just enough room for the consoles. Large systems require larger, more elaborate facilities; the dimensions for these buildings would be about 8 feet by 20 feet. Table 3-4 represents the costs of headend buildings.

1. Basically independent of the number of channels.

Table 3-4

HEADEND BUILDING COSTS

| Building Type | Dimensions | Square Feet | Cost per Square Foot | Total Cost |
|---|---|---|---|---|
| Small | 8' x 8' | 64 | $35 | $2240 |
| Large | 8' x 20' | 160 | $38 | $6080 |

Major Electronic Components

The remaining components of the headend system are electronic in nature and are not dependent upon location. The total electronic package can be determined by specifying the number of signals by type required for retransmission. By constructing representative formats which specify both types and number of the components required for a specific type of signal, the translation from components into total systems and total system costs is straight-forward.

The first step in this procedure is to determine which components are dependent upon the type of signal and which components are required to support the headend system, independent of signal type. This step was illustrated for the UHF/VHF system discussed earlier. Table 3-5 illustrates the result of this step for all major signal types.

Table 3-5

MAJOR HEADEND EQUIPMENT

| VHF Signals | UHF Signals | Microwave | Studio | FM | Common Equipment - Independent of Signal Type |
|---|---|---|---|---|---|
| VHF Preamplifier<br>VHF Power Supply<br>VHF Pass Band Filter<br>Signal Processor | UHF Preamplifier<br>UHF Power Supply<br>UHF/VHF Converter<br>Signal Processor<br>UHF Pass Band Filter | Antenna*<br>Receiver<br>Modulator<br>VHF Pass Band Filter | Modulator<br>VHF Pass Band Filter | Pre Amplifier<br>Pre Amp Power Supply<br>Tuner<br>Tuner Power Supply<br>Console<br>FM Trap | Pilot Carrier Generator<br>Combining Networks<br>Splitters<br>Directional Couplers<br>Non-duplicating Equipment |

* Because of the unique nature of microwave, the microwave antenna is included in the electronic component section instead of the antenna section.

The next step in the specification process is to determine the quantity of each component needed for the retransmission of one channel. This determination per individual component is based upon either system requirements and design philosophy (i.e., a signal processor is designed for a single-channel retransmission) or standard operating procedures (i.e., 2 pass band filters per channel).

Based upon these criteria, it is possible to derive realistic complete system specifications. The results are shown in Table 3-6.

Table 3-6

COMPLETE HEADEND SPECIFICATIONS

| VHF Signals | UHF Signals |
|---|---|
| VHF Preamplifier - One per channel | UHF Preamplifier - One per channel |
| VHF Pre Amp Power Supply - One per channel | UHF Pre Amp Power Supply - One per channel |
| VHF Pass Band Filter - Two per channel | UHF/VHF Converter - One per channel |
| Signal Processor - One per channel | Signal Processor - One per channel |
| VHF/VHF Converter - As required[a] | VHF Pass Band Filter - Two per channel |
| **Microwave Signals** | **Studio Signals** |
| Demodulator - One per channel | Modulator - One per channel |
| Transmitter - One per channel | VHF Pass Band Filter - One per channel |
| Transmit Antenna - One per channel | |
| Receive Antenna - One per channel | |
| Receiver - One per channel | |
| Modulator - One per channel | |
| VHF Pass Band Filter - One per channel | |

a. VHF/VHF converters may be required in areas of high over-the-air signal strengths. The cost for this item is included in Table 3-7 but has not been used in developing system costs. If required, they should be included with one converter per channel as the requirement.

Table 3-6 (continued)

| FM Signals[1] | Common Equipment |
|---|---|
| FM Pre Amp - One required for entire band | Pilot Carrier Generator (PCG) - Two per cable or two per 24 channels |
| FM Pre Amp Power Supply - One required for entire band | Combining Networks - One for each 6 channels (not counting FM or PCG inputs) |
| FM Tuner - One per FM channel | Splitter - One per cable |
| FM Power Supply - One per 14 FM Tuners | Directional Coupler - One per cable |
| Console and equipment - One with Power Supply and 4 FM Tuners | Non-Duplicating Equipment - One per system |
| Console and equipment - One for 5 tuners | |
| FM Trap -One per system | |

Agreement on the number of channels that can be transmitted on a single cable is not resolved. The range is anywhere from 20 to 40 channels. The upper number is suspect because no single-cable 40-channel system is in existence. There is agreement between manufacturers and MSO's that 24 channels on a single cable is both technologically and operationally sound. For this reason, it is assumed that two pilot carrier generators are required for every cable or each set of 24 channels. The use of splitters, combining networks, and directional couplers is mandatory but the exact arrangement is variable. Although the cost for this equipment is minor, it has been included for completeness.

This completes the specification of the system. The next step is to develop costs for each component. Average catalogue prices were used. Table 3-7 represents a matrix of component cost and component use.

The complete specification process, which includes input specifications, is shown in Figure 3-6. The figure is a cost model that describes the derivation of total head-end electronic costs. The only input required from the user is the required number of each type of signal.

1. There are a number of alternative ways of transmitting FM on a cable system. This approach is one typical way of carrying FM signals.

Table 3-7

COMPONENT COSTS

| Components | Unit Cost | VHF | UHF | Microwave | Studio | FM | Common |
|---|---|---|---|---|---|---|---|
| VHF Pre Amplifier | 208 | X | | | | | |
| VHF Pre Amp Power Supply | 30 | X | | | | | |
| VHF Pass Band Filter | 101 | X | X | X | X | | |
| UHF Pre Amp | 290 | | X | | | | |
| UHF Pre Amp Power Supply | 51 | | X | | | | |
| UHF/VHF Converter[1] | 750 | | X | | | | |
| VHF/VHF Converter[1] | 240 | X | | | | | |
| Signal Processor | 1150 | X | X | | | | |
| Microwave Antenna (Transmit or Receive) | 535 | | | X | | | |
| Microwave Receiver | 3335 | | | X | | | |
| Microwave Transmitter | 2855 | | | X | | | |
| Television Modulator | 1225 | | | X | X | | |
| Television Demodulator | 1630 | | | X | | | |
| FM Pre Amp & Power Supply | 85 | | | | | X | |
| FM Tuner | 120 | | | | | X | |
| FM Trap | 45 | | | | | X | |
| FM Power Supply & Console | 260 | | | | | X | |
| FM Console | 160 | | | | | X | |
| Pilot Carrier Generator | 350 | | | | | | X |
| Combining Network | 105 | | | | | | X |
| Splitter | 30 | | | | | | X |
| Directional Coupler | 30 | | | | | | X |
| Non-Duplicating Equipment[2] | 4500 | | | | | | X |

1. Includes Power Supply.
2. Includes installation.

X Required for specific system.

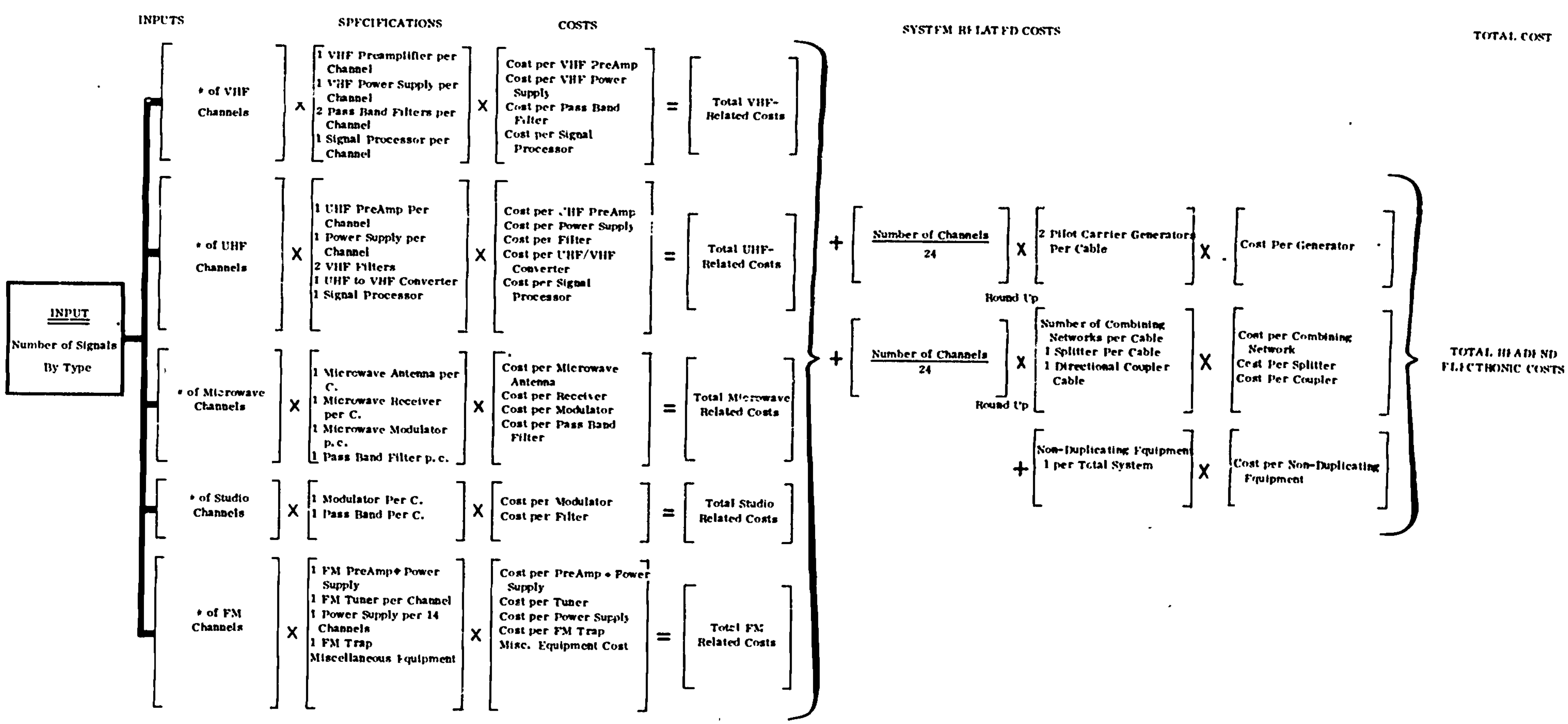


Figure 3-6 HEADEND SPECIFICATION PROCESS

It should be noted that the above costs do not reflect the costs associated with installation, racks and consoles, wiring, checkouts, etc. Some of this work can be completed at the factory by the manufacturer and some must be completed at the site.

However, Table 3-7 is actually a list of material prices, to which the cost of assembling a system must be included to develop a realistic total price. Pre-wired headend consoles add an additional two hundred dollars to the cost of each channel, and include the following:

- Racks,
- Consoles,
- Slides,
- Cabling,
- Engineering, and
- Checkout.

Whether this cost is charged by the manufacturer or is performed by the MSO with its own crew, the cost must be included in the system cost. Another task must be performed before the headend is operational. The prewired console must be installed, tested, proof-of-performance specifications met and the completed work accepted as a finished product. For small systems (less the 20 channels), this usually costs about \$1500; for systems with more than 20 channel capacity, the cost is about \$3000. The latter costs are not for microwave systems. That is, if a large system has both off-the-air signals and microwave signals, the \$3000 would apply only to off-the-air and studio type signals. An additional microwave dependent installation cost must be added to the \$3000. The average installation cost for microwave equipment is \$750 per channel. The cost for non-duplicating equipment includes installation.

# 4

## DISTRIBUTION SYSTEM

The distribution system includes the cable and all the equipment necessary to carry the signals from the headend to each of the subscriber terminals. The components that constitute a distribution system are dependent upon the specific system being analyzed, and as was the case for headend equipment, not all of the components discussed here need be present in every system.

Specific sections will discuss representative system equipment, component costs, construction costs, and the cost of representative systems. Unlike the headend components, the cost of the distribution system is critically dependent on construction techniques and geography. For this reason, the specific components that comprise a distribution system are arranged for analysis as follows:

- Hardware
  - Cable

    Trunk
    Feeder
    Drop
  - Amplifiers

    Trunk
    Bridge
    Line
  - Passive Devices Including House Drop Equipment

    Splitters
    Taps
    Converters

- Power Supplies
- Microwave Systems - Local Distribution Service (LDS)

A separate section of this chapter is devoted to the installation and construction costs associated with the distribution system. Both aerial and underground costs will be examined.

It is possible to estimate total headend costs by specifying the number and type of each signal selected for retransmission. This same straightforward specification process is not possible for distribution systems. Although certain assumptions about selected equipment can be made to reduce the magnitude of the specification problem, the cost of burying cable is dependent upon so many variables that care and detail is required in the specification of inputs.

## REPRESENTATIVE SYSTEMS

A basic distribution system, which is independent of construction techniques, can be described by broad catagories of equipment. This basic system would consist of cables, amplifiers, passive devices, and other hardware arranged in such a manner so as to carry a specified number of signals (channels) from a headend to any given subscriber.

Three types of cable are required in any system. The first is the trunk cable. This cable carries the signal from the headend to the extremities of the area served and does not contain taps to which subscribers can be connected. It is analagous to the main power lines of a power distribution net. In general, 3/4" or 1/2" dia. coaxial cable is used as trunk cable. The second type, feeder cables, are comparatively short runs of cable to serve a local area. General practice is to use 0.412" dia. coaxial cable for feeder lines. Actual connections to the subscriber are made from the feeder line using a splitter or tap and RG-59/U coaxial cable. This cable is called the drop cable.

If the cables and passive devices did not impose power losses, then amplification of signals would not be required. Such is not the case, however, so amplifiers must be inserted into both the trunk and feeder lines to compensate for those losses. Leaving aside some technical considerations for the moment, there are basically three types of amplifiers to be considered. The trunk amplifier, which is the first type of amplifier, is stationed at specific intervals along the cable to maintain a required level of gain throughout the trunk cable. The interval is referred to as "22db" spacing; and represents the average gain of high-quality trunk amplifiers. The number of trunk amplifiers that can be connected in series is called the cascade number. A cascade is a sequence of amplifiers. Each amplifier in a series contributes noise and distortion, thus degrading the quality of signal received by distant subscribers. A current rule of thumb limits cascades to about 50 trunk amplifiers. Beyond that point quality performance is no longer possible.

Bridging amplifiers, which are also located along the trunk line, are the second type of amplifiers. These amplifiers differ from trunk amplifiers in that they usually have no affect on the trunk signal, but have multiple high-level feeder outputs isolated from the main line. The purpose of this amplifier is to connect the feeder cable to the trunk cable and, at the same time, amplify the signals upon entering the feeder cable. There is no set distance between bridger amplifiers along the trunk. They are usually installed when enough subscribers, who are located parallel or perpendicular to the trunk cable, are available. The distance between these amplifiers is inversely propotional to the subscriber's density: the higher the density, the smaller the distance between amplifiers.

The final amplifier used in a distribution system is called a line extender. In order to recover losses in the feeder cable arising from the cable and the inclusion of many passive devices, amplifiers are required. Since the average length of any feeder cable is much shorter than a trunk cable (usually a maximum of about a mile), the performance requirements of line extender amplifiers is less critical than trunk amplifiers and usually no more than four line extenders are cascaded in a given feeder cable.

Passive equipment is defined as that line of equipment that does not provide any gain or amplification to the signals. They require no electrical power. They divide, split, add, isolate, reject, or discriminate as to the direction of flow. Splitters divide the power from a single cable, equally between two or more output cables. When used in reverse, they become adders. A tap is a form of splitter. Its purpose is to "tap" a sufficient amount of power from a feeder cable to serve a subscriber's TV receiver input.

Power supplies are needed to power all the active components in a distribution system. Power can be supplied in one of two ways. Each amplifier can have its own internal power supply that must be connected to a source of 120-volt 60-cycle power or can be supplied with power through the cable. This last technique, called cable powering, is the most frequently used. Almost all cable systems are cable powered. The coaxial cable itself provides the conductors over which operating power is brought to the active components in the cable line with a 30 to 60 volts, 60-cycle source inserted into the cable at convenient points.

The house connections to the subscriber require a number of small components to complete a hookup (terminal boxes, transformers, etc.). The major equipment item that may be required in addition to the above components is a converter, which is a well-shielded channel tuner. It permits the subscriber to bypass the channel selector dial on his television and enables the reception of more than the common 12 VHF channels. Single converters are presently available that permit the reception of 26 channels and with the addition of a cable-to-cable switch up to 52 channels.

The extensive amount of required equipment (some of which are dependent upon geography) can be further expanded; for example, if the system requires one or two cables or if two-way operation is desired.

As a typical example, three alternative two-say systems can be constructed:

- Single trunk, single feeder,
- Dual trunk, dual feeder,
- Dual trunk, single feeder.

Other examples are systems designed for future growth. If the franchise owner assumes that at some later date he would like to increase the capability of his system, he might construct a dual cable system. The first cable would be the active cable--it would contain all the electronic and passive equipment needed to supply his subscribers. The second cable would be a "shadow" cable. This cable would be installed on poles or buried underground but without electronics and the ends of the cable would be sealed to prevent cable degradation and decay. The cable could then be activated at a later date.

These examples illustrate the range of possible distribution systems as well as the need for detailed input specifications in order to develop meaningful total distribution costs. Other examples of alternative equipment useage will be shown in the section on component costs. Some rule of thumb assumptions will also be made to reduce the number of alternatives considered.

One of the measures of density in a CATV system is the ratio of feeder to trunk cable. The higher the ratio, the more advantageous the system is to the operator.[1] Figure 4-1, which does not contain a description or indication of electronic components, illustrates the typical use of trunk, feeder, and drop cable in an average community. In this particular example, the line extender amplifiers are 700 feet apart, the bridger amplifiers 1,500 feet apart, and 500 feet of trunk cable exists before the first bridger amplifier. The feeder to trunk ratio is:

$$\frac{8 \times 2 \times 2100'}{5000'} = \frac{33{,}600}{5000'} = 6.7{:}1$$

Figure 4-2 represents typical active and passive interconnections for distribution systems. This illustrates the use of bridger amplifiers and such passive devices as splitters and terminators.

1. This arises because one mile of trunk cable (as will be shown) with electronics is more expensive than one mile of feeder cable and electronics.

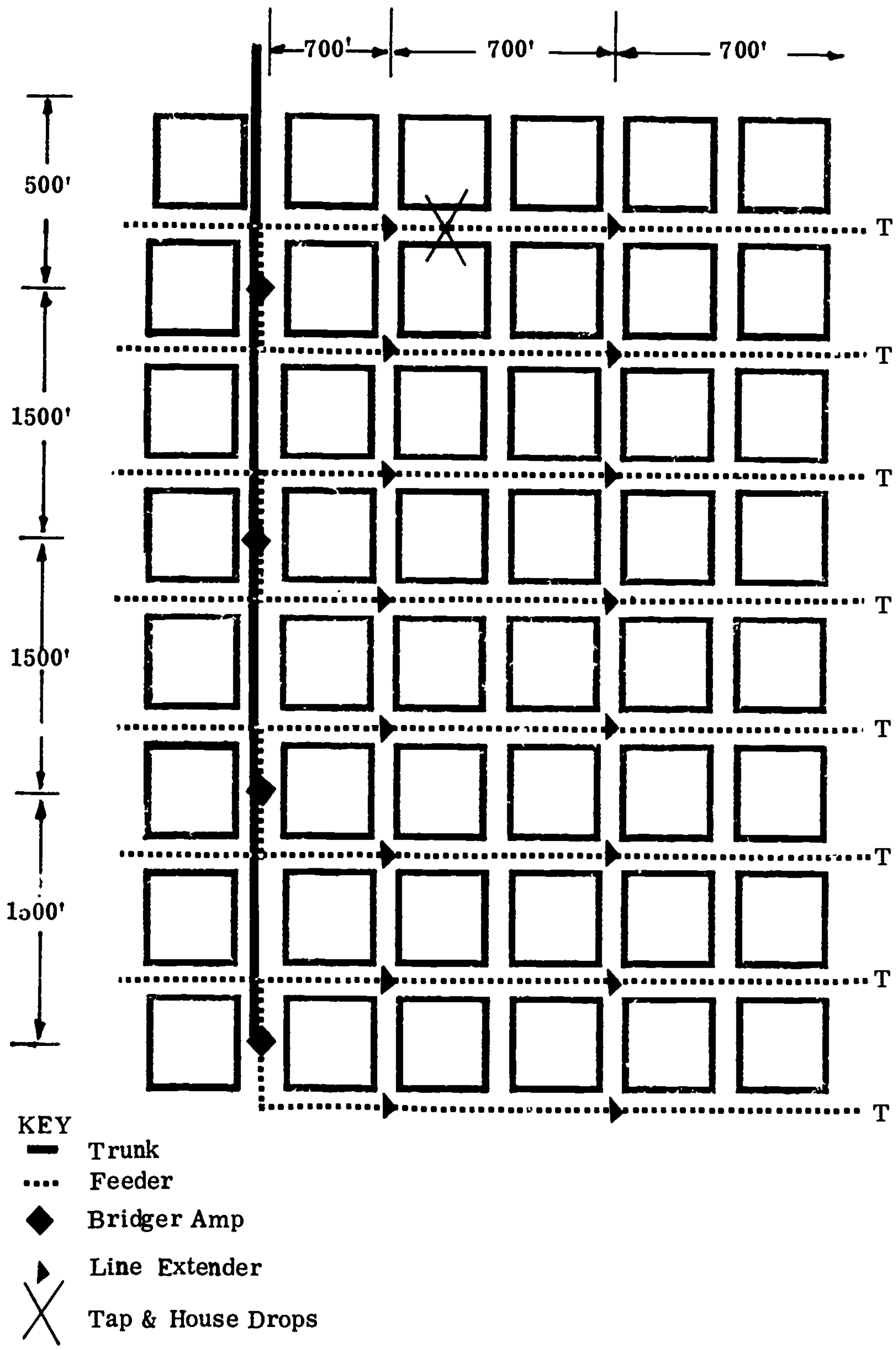
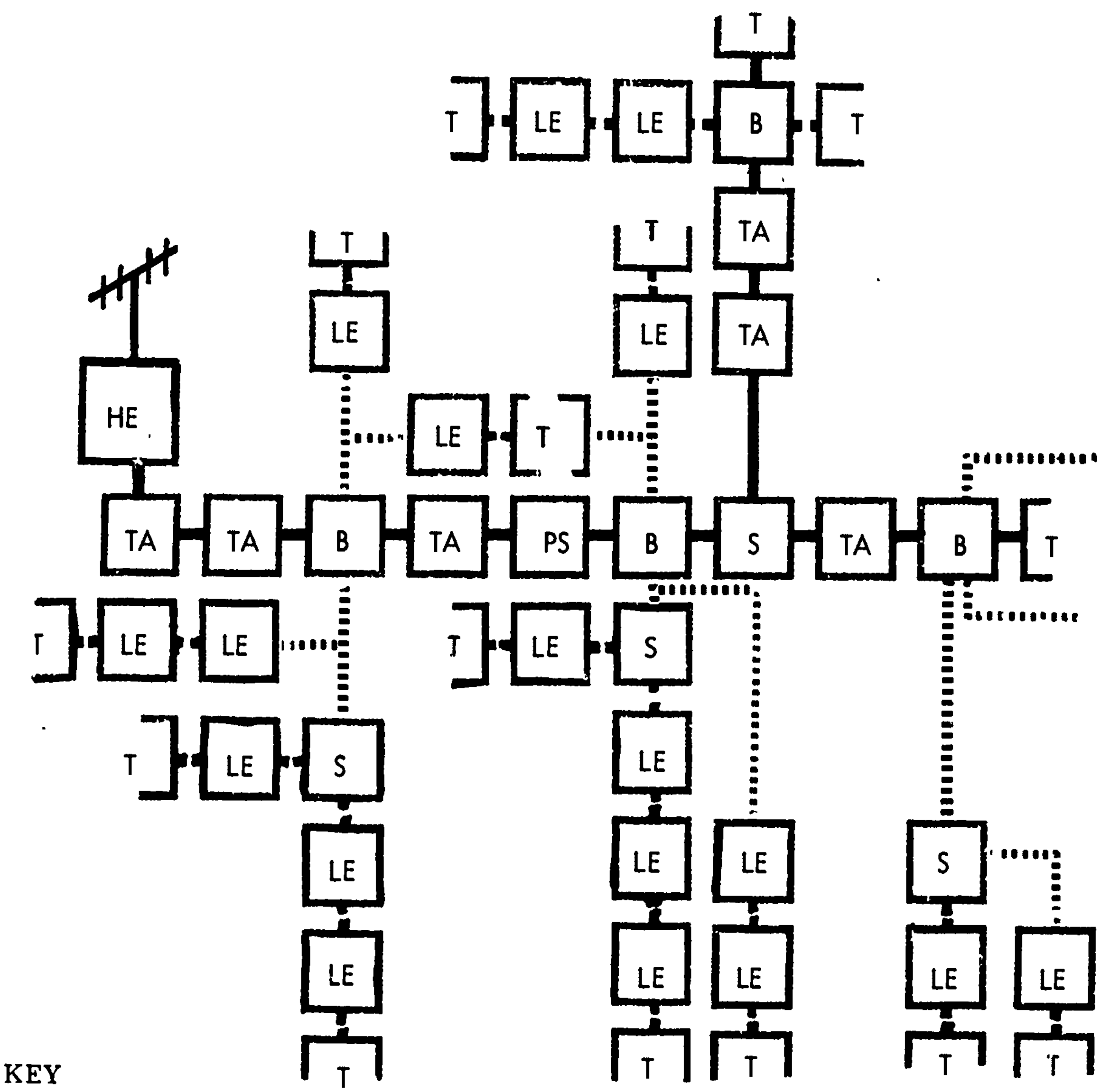



Figure 4-1: REPRESENTATIVE DISTRIBUTION SYSTEM




KEY

| | |
|---|---|
| ▬ | Trunk |
| ▪▪▪ | Distribution |
| HE | Headend |
| TA | Trunk Amplifier |
| B | Bridging Amplifier |
| LE | Line Extender Amplifier |
| T | Terminator |
| S | Splitter |
| PS | Power Supply |

Figure 4-2: BASIC DISTRIBUTION BLOC℃ DIAGRAM

The preceding discussion dealt with a "generalized" distribution system. The installation of such a system was not mentioned. This was done for a very specific reason: the installation adds yet another dimension to the complexity of the problem and the complexity of specification. If all cable systems were to be installed on telephone poles, only minor variations would exist. Variations in pole rental and pole rearrangements costs are not as significant as the variations that arise when cable must be buried. When cable must be buried, the associated costs vary by orders of magnitude: from $6,000 per mile (in sand) to over $100,000 per mile (NYC). With such variations present, the development of an average "underground" cable cost becomes meaningless. It then becomes mandatory to examine such costs as a function of terrain and soil conditions, with and without conduits and for single and double cable systems.

The high cost of burying cable in urban city centers has led to the development of alternative retransmission mechanisms. One alternative is multi-channel 12 GHz microwave equipment. By using this system, the entire VHF television spectrum is translated directly to the Community Antenna Relay Service (CARS) 12 GHz band,[1] and transmitted in the exact form and frequency to be received and put directly on to the trunkline cable for further distribution. The distance between transmitter (usually located adjacent to the headend) and receiver can be up to 20 miles. Additionally, any number of receivers can be served in a single path of transmission for up to 20 miles distance requiring no higher output from the transmitter than for a single receiver located at the same distance as the last receiver. The total number of receivers which can be served by one transmitter depends upon the distances, the topography, the size of the antennas, and the number of receivers located in the same paths.

As illustrated in Figure 4-3, the VHF signals from the headend cable system input are simply translated into microwave frequencies by mixing and amplifying. The signals are filtered and sent to a summing network. From the transmitter,

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1. Section 74.101, Subpart I; FCC Rules and Regulations (Revised), May 1971.

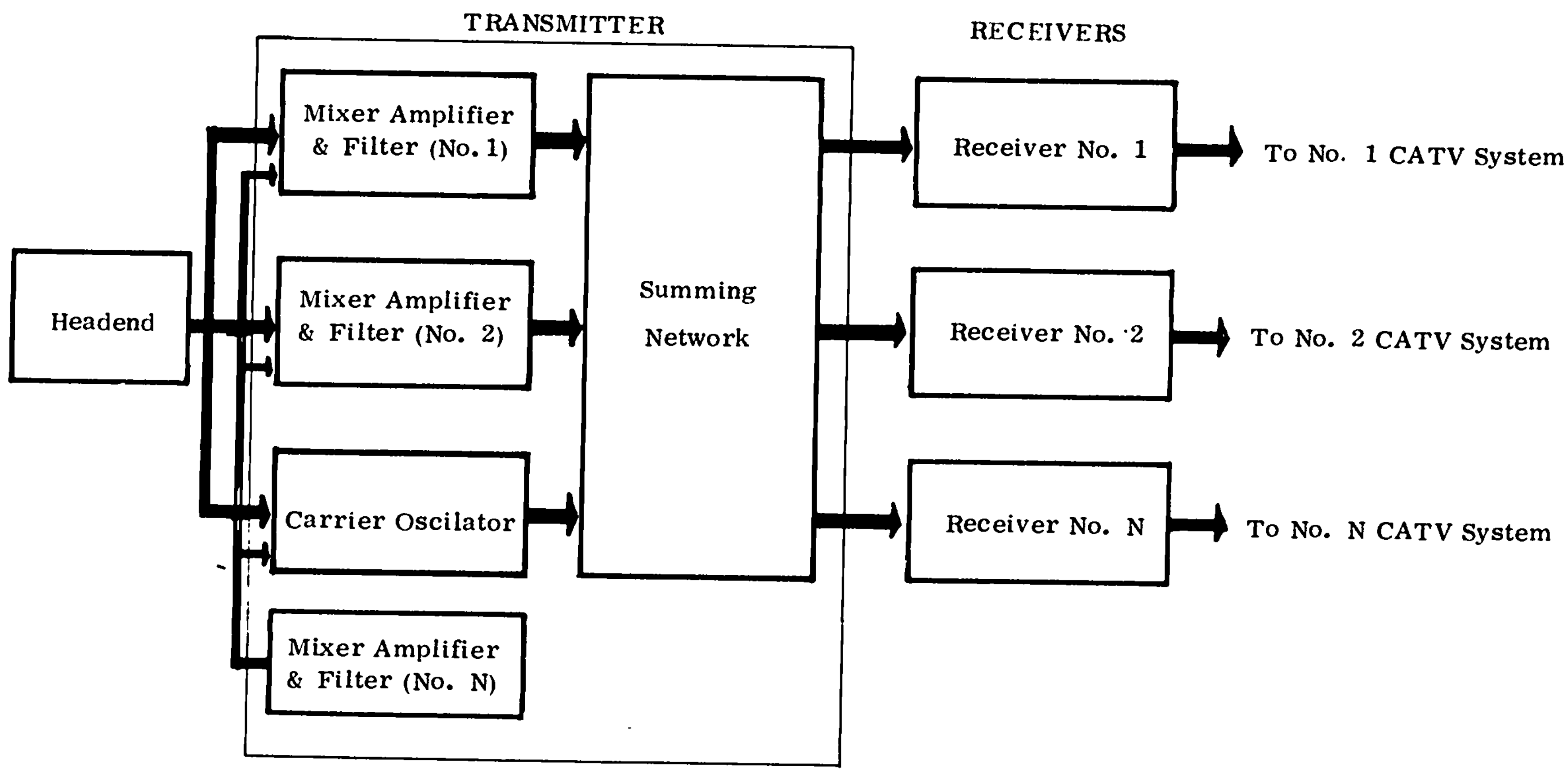


Figure 4-3: TYPICAL MULTICHANNEL MICROWAVE SYSTFM

they are sent by line-of-sight to the receiving antennas. The receiver is located either immediately behind or near the receiving antenna. The microwave signals are converted to the original VHF spectrum at their exact input frequencies and format.

An entire system would consist of: a transmitter, a transmitter antenna for each path of transmission desired, and a receiver and receiving antenna for each microwave link desired.

EQUIPMENT

In examining specifications for distribution systems, a number of observations can be made. The first is that it is possible to accomplish system objectives through the use of discretely different equipment items (i.e., 3/4" cable instead of 1/2" cable) and that within a given item, significant differences in capability exist (i.e., conventional amplifiers versus push-pull amplifiers versus two-way amplifiers). The availability of such an extensive selection of equipment items is significantly different from that encountered in the headend analysis. While the number of equipment options is still not large enough for statistical analysis, it is large enough to eliminate the use of average costs. For example, an average trunk amplifier cost will not be developed. Rather a range of costs will be presented and the range will be keyed to system capability.

For comparable equipment items, no major differences in cost between manufacturers exist. Finally, the costs shown in the catalogue do not include installation and balance costs for electronic equipment or construction costs for the cable itself. All of these "non-hardware" costs must be added to catalogue costs to derive total costs. A separate section of this chapter analyzes the installation and construction costs associated with the distribution system.

## COMPONENT COSTS

Component costs presented in this section are derived from manufacturers' costs and turnkey historical data. The basic components of the distribution system will be analyzed independently of construction techniques. This analysis will discuss the basic components and suggested combinations of these components. These suggested combinations are just an approach at reducing the number of feasible alternatives to a manageable size. The next section will present the costs associated with the actual construction of a cable system. For this reason, no attempt has been made in this section to analyze installation costs of the electronic components.

### Coaxial Cable

Three basic types of coaxial cable are used in a cable TV system: trunk, feeder, and drop. Cable manufacturing has been standardized to the cable dimensions and for the following usages: the trunk cable is either 0.750" dia. or 0.500" dia. coaxial cable[1], the [illegible]er cable is 0.412" dia. coaxial cable[1], and RG 59 or RG 6 cable is used as drop cable.

The trunk and feeder cables are available in a number of different forms. The center conductor can be made of either solid copper or copper-clad aluminum and the dielectric can be filled with two different poly foams. In addition, the cable is available in jacketed form (a poly jacket over the outer conductor), in a special outer jacket that is moisture-resistant (outer jacket filled with a flooding compound), or with a steel ribbon inserted between the two outer jackets (for rodent control).

The first set of alternatives influence the performance of the cable and the complete distribution system, while the second set of alternatives are influenced by geographical considerations.

The major measure of performance for coaxial cable is its attenuation, which can be considered the loss of signal through the cable and is usually expressed in db's

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1. The diameter refers to the diameter of the outer conductor. The diameter of the entire cable for a .500" conductor varies from .600" (cable with a poly jacket) to .700" (cable with jacket, steel armour, and an outside poly jacket).

per 100 feet of cable. The objective in selecting cable is to minimize the loss through the cable. As the loss increases, the number of trunk amplifiers required increases. While the differences in center conductor type do not influence the attenuation, the change in dielectric material does. For this reason, the study will assume that the center conductor is solid copper,[1] and that two distinct types of foam dielectrics are available. Table 4-1 illustrates the differences in performance for these two dielectrics.

Table 4-1

TYPICAL CABLE LOSS

| Cable Diameter (inches) | Conventional Foam (Poly) Max loss/100 ft. at Channel 13[a] | "Super" Foam (Styrene) Max loss/100 ft. at Channel 13[a] |
|---|---|---|
| 0.412 | 1.65 | 1.38 |
| 0.500 | 1.38 | 1.10 |
| 0.750 | 1.00 | 0.74 |

If the gain of conventional trunk amplifiers is about 22db, then the attenuation figures shown in Table 4-1 can be converted into a theoretical spacing between amplifiers (which, in turn, could be translated into amplifier cost per mile). The 22db spacing is shown in Table 4-2.

Table 4-2

THEORETICAL CABLE LENGTHS FOR 22db AMPLIFIER SPACING

| Cable Diameter (inches) | Conventional Foam Distance Between Amplifiers (feet) | "Super" Foam Distance Between Amplifiers (feet) |
|---|---|---|
| 0.412 | 1333 | 1594 |
| 0.500 | 1594 | 2000 |
| 0.750 | 2200 | 2973 |

1. The primary difference between solid copper and copper-clad aluminum is in power requirements. The solid copper conductor is more efficient and requires fewer power supplies. Best practice principles would indicate the use of solid copper when possible.

The standard against which the attenuation is measured is 216 MHz (Channel 13). Attenuation losses increase as frequency increases. If superband channels are required[1] (i.e., above Channel 13), then the amplifier spacings would be reduced.

For each basic type of cable (i.e., .412" dia conventional foam coaxial cable), four alternative jacket configurations are available. These configurations can be readily identified with a specific type of construction technique:

- Aerial--unjacketed;
- Aerial--jacketed;
- Underground in conduit--jacketed with flooding compound; and
- Underground direct--jacket with flooding compound and steel armour.

Two prices have been included for each trunk and feeder option. The first is a standard price and the second is for quantity purchase. The standard price is valid for up to 10 miles of cable, while the quantity discount price applies to quantities from 40 to 100 miles of cable.[2] Cable costs from more than one manufacturer were used in deriving the costs shown in Table 4-3, and thus are average costs.

## Amplifiers

As was discussed in the section on representative systems, three basic types of cable amplifiers are required for system operation: trunk amplifiers, bridger amplifiers, and line extenders. It should be noted that the list represents a deliberate understatement of the complexity of the amplifier specification problem. In actual practice, this list can be expanded to include 9 separate types of amplifiers. These are:

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1. From 216 MHz to 240 MHz.

2. These quantities were selected because they represent the most frequent examples of cable purchases. The small quantity reflects either usual stockage levels or replacement cable in small systems. For large systems in excess of 100 miles of cable, the additional quantity discounts are nullified by increased specification requirements. Thus, for large systems, the quantity discount shown in the 40-to 100-mile column is appropriate.

Table 4-3

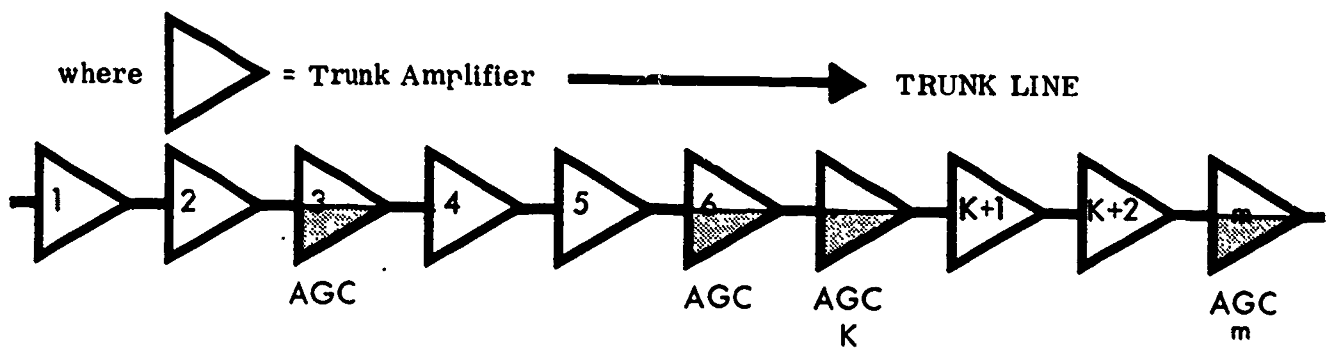
COAXIAL CABLE COSTS PER MILE

| Cable Size & Type | Conventional Foam | | Super Foam | |
|---|---|---|---|---|
| | Up to 10 Miles | From 40 to 100 Miles | Up to 10 Miles | From 40 to 100 Miles |
| <u>0.412" Dia. - Feeder Cable</u> | | | | |
| Non Jacketed | $ 470.00 | $ 422.00 | $ 546.00 | $ 496.00 |
| Jacketed | 578.00 | 510.00 | 653.00 | 581.00 |
| Jacketed with Flooding Compound | 607.00 | 551.00 | 688.00 | 611.00 |
| Jacketed with Flooding & Armour | 919.00 | 855.00 | 1040.00 | 913.00 |
| <u>0.500" Dia. - Trunk Cable</u> | | | | |
| Non Jacketed | $ 649.00 | $ 570.00 | $ 750.00 | $ 665.00 |
| Jacketed | 777.00 | 681.00 | 860.00 | 762.00 |
| Jacketed with Flooding Compound | 812.00 | 737.00 | 904.00 | 805.00 |
| Jacketed with Flooding & Armour | 1188.00 | 1088.00 | 1346.00 | 1214.00 |
| <u>0.750" Dia. - Trunk Cable</u> | | | | |
| Non Jacketed | $1267.00 | $1183.00 | $1447.00 | $1373.00 |
| Jacketed | 1428.00 | 1295.00 | 1579.00 | 1500.00 |
| Jacketed with Flooding Compound | 1513.00 | 1408.00 | 1644.00 | 1535.00 |
| Jacketed with Flooding & Armour | 2016.00 | 1890.00 | 2295.00 | 2225.00 |
| RG-59/U or RG-6/U Drop Cable | N.A. | $ 194.00 | N.A. | N.A. |

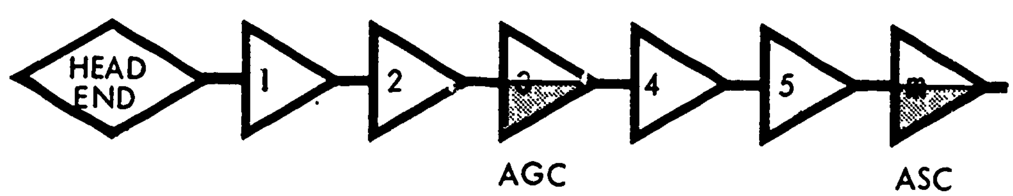
- Trunk Amplifier,
- Trunk Amplifier with Automatic Gain Control (AGC),
- Trunk Amplifier with Automatic Slope and Gain Control (ASC or ASG),
- Trunk Amplifier with Bridging Amplifier,
- Trunk Amplifier with Bridging Amplifier with AGC,
- Trunk Amplifier with Bridging Amplifier with ASC,
- Bridging Amplifier,
- Line Extender Amplifier, and
- Automatic Slope Amplifier.

Amplifiers with AGC or ASC are selected to maintain a constant output level from the amplifier for a range of input levels. Electronic components "age" differently in each amplifier and this aging process affects the signals being amplified; distortions result and the gain of the amplifier can vary above and below its specified levels. In addition, temperature changes in both the amplifier and the cable attenuation can also affect the output of any amplifier. To compensate for these problems, automatic slope and gain control equipment is built into the trunk amplifier. To be effective as a control device, amplifiers with AGC or ASC replace every third regular trunk amplifier (at a minimum) along the trunk line. This concept is shown in Figure 4-4. In environments where wide temperature fluctuations occur, the trend is for every amplifier to be either AGC or ASC. The variation in costs due to changes in the ratio of AGC/ASC amplifiers to regular trunk amplifiers[1] will be examined in a later section. Automatic slope amplifiers are used to compensate for any residual tilt from 50 MHz to 260 MHz in a CATV system not compensated for by the normal equalizing circuitry. Installed directly after a trunk amplifier in the system, the number of units installed varies with the requirements of a particular system; i.e., in some systems the unit may be required after every seventh, eighth, or ninth

1. Based upon standard operating procedures, the ratio will be allowed to vary from 1:3 to 1:1.




A. Generalized Trunk System with AGC Trunk Amplifiers




B. Generalized Trunk System with AGC & ASC Truck Amps.

Figure 4-4: TRUNK AMPLIFIER CONFIGURATIONS amplifier, while in others only one may be required for the whole system. For this study, it will be assumed that two automatic slope amplifiers are required for each system (independent of the length of the system). This assumption is based upon discussions with manufacturers and MSO's.

An ideal system, if one existed, would attempt to place combined trunk/bridger amplifiers at every location where a trunk amplifier was required. This would reduce the number of bridger amplifiers required and reduce system cost because a combined trunk/bridger amplifier costs less than separate trunk and bridger amplifiers. Since the "best case" does not always exist, this study will assume that no combined trunk/bridger amplifiers exist. Although this would tend to increase slightly the cost of the distribution system, its impact upon total CATV system costs is negligible.

Having reduced the number of possible amplifier types from nine to the following six:

- Trunk Amplifier,
- Trunk Amplifier with AGC,
- Trunk Amplifier with ASC,
- Bridger Amplifier,
- Line Extender Amplifier, and
- Automatic Slope Amplifier,

the next major step is to determine how many of each type is required. For the line extender and trunk amplifiers, this is a manageable problem. The line extender amplifiers are limited in the number that may be cascaded; the maximum number may be assumed to be three for this study. Thus, for any feeder line, the number of line extender amplifiers will range from one to three. The exact number is determined by system performance and density (e.g., if the number of subscribers can be satisfied through the use of two amplifiers, only two will be used).

In the section on coaxial cable, Table 4-2 was developed that showed the approximate cable lengths for "22 db" of spacing. This spacing was based on the assumption that this represents the average trunk amplifier gain. Even though a number of trunk amplifiers with differing quality exist, this assumption is still valid. By dividing the spacings shown in this table into 5,280 feet, the approximate number of trunk amplifiers per mile can be determined. This is shown in Table 4-4:

Table 4-4

THEORETICAL NUMBER OF TRUNK AMPLIFIERS REQUIRED PER MILE OF CABLE[a]

| Trunk Cable Diameter (inches) | Conventional Foam (Amplifiers Per Mile) | "Super" Foam (Amplifiers Per Mile) |
|---|---|---|
| 0.500 | 3.30 | 2.64 |
| 0.750 | 2.40 | 1.78 |

a For 22db gain at Channel 13.

These numbers represent a theoretical minimum. It does not consider losses due to bridger amplifiers and passive taps and splitters. In addition, the standard at which cable attenuation is measured is at Channel 13. For super band transmission, the attenuation per 100 feet is higher than at Channel 13. This would reduce the spacing for 22 db's of gain. In addition, the gain of the trunk amplifiers decreases with frequency; a "22 db" standard may be only 21db's at 260 $MH_Z$. To compensate for these additional, non-specified losses, the number of amplifiers per mile have been increased by 20 percent. The results are shown in Table 4-5.

Table 4-5

NUMBER OF TRUNK AMPLIFIERS
REQUIRED PER MILE OF CABLE

| Cable Diameter (inches) | Conventional Foam (Amplifiers Per Mile) | Super Foam (Amplifiers Per Mile) |
|---|---|---|
| 0.500 | 3.96 | 3.17 |
| 0.750 | 2.88 | 2.14 |

The results of the super foam case agree with estimates obtained by two MSO's and the Rand Dayton study.[1]

Bridging amplifiers are a function of subscriber density and location. A rough approximation that can be used to determine the number of these amplifiers can be made from the feeder to trunk ratio. As shown earlier, this ratio is a measure of potential subscriber density. If the distance between line extenders is assumed to be 800' and the maximum number of line extender amplifiers is three, then any tap off of a bridger will be about 3,200 feet long.[2] Since the bridger supplies four outputs, the maximum length of feeder cable per bridger amplifier is 12,800 feet. If the ratio of feeder to trunk is (for example) 5:1, then one mile of trunk cable corresponds to 5 x 5,280 or 26,400 feet. Since one bridger amplifier feeds 12,800 feet, the number of required bridger amplifiers per mile of trunk is $\frac{26,400}{12,800}$ or 2.06. To calculate the required number of bridger amplifiers, the feeder to trunk ratio is required. With this as an input, the following formula is applicable:

$$\text{Number of bridger Amplifiers per mile} = \left(\frac{\text{feeder}}{\text{trunk}}\right)\text{ratio} \times \left(\frac{5,280}{12,800}\right)$$

1. The Rand Corporation, Economies of Scale in Urban Cable Television: The Dayton Urban Area, WN 7586 KF/FF, Nathaniel E. Feldman, September 1971.

2. The length is not obtained by multiplying three x 800'. The distance between amps is 800' and the distance between the last amplifier and the termination is also assumed to be 800'.

The following might be considered a "best case" formula. Two output bridger amplifiers are available in addition to the four output amplifiers assumed here. The use of this amplifier could double the number of required bridger amplifiers. As a suggested upper bound, the above formula should be increased by 50 percent. This then becomes:

$$\text{Number of bridger amplifiers per mile (upper bound)} = \left(\frac{\text{feeder}}{\text{trunk}}\right) \text{ratio} \times 0.6188.$$

This completes the basic specification process for cable amplifiers. However, each case discussed above has a number of additional counterparts. Three ranges of quality (and performance) are available for each amplifier. These represent low capacity systems (12 or fewer channels), high capacity systems (more than twelve channels), and two-way systems. Table 4-6 summarizes the amplifier requirements.

As was the case with cable costs, equipment from more than one manufacturer was used in deriving amplifier cost. Thus, the costs shown in Table 4-7 are an average cost.

Finally, complete two-way systems were not analyzed. The last column is for two-way amplifier without the necessary filters and return amplifiers.

Table 4-6

AMPLIFIER REQUIREMENTS

| Amplifier Type | Required | Notes |
|---|---|---|
| Trunk Amplifier | | |
| 0.500 Conventional Foam | 3.96 per mile | Higher than theoretical number |
| 0.750 Conventiona Foam | 2.88 per mile | |
| 0.500 Super Foam | 3.17 per mile | |
| 0.750 Super Foam | 2.14 per mile | |
| Trunk with AGC | Every 6th amp (min) | Maximum: every other amp |
| Trunk with ASC | Every 6th amp (min) (i. e., two out of every six amps is either AGC or ASC) | Maximum: every other amp (i. e., system contains only AGC and ASC amps) |
| Automatic Slope Amplifiers | 2 per total system | |
| Line Extender Amplifiers | Max. of 3 per feeder line | Can range from one to three |
| Bridger Amplifier | Minimum $\left(\frac{\text{feeder}}{\text{trunk ratio}}\right) \times 0.4125$ <br> Upper bound $\left(\frac{\text{feeder}}{\text{trunk ratio}}\right) \times 0.6188$ | System sensitivity to this assumption will be checked. |

Table 4-7

AMPLIFIER COSTS

| Amplifier Type | Low Capacity System | High Capacity System | Two Way System[a] |
|---|---|---|---|
| Trunk Amplifier | $382.00 | $568.00 | $628.00 |
| Trunk Amplifier with AGC | 474.00 | 663.00 | 744.00 |
| Trunk Amplifier with ASC | NA | 755.00 | 825.00 |
| Automatic Slope Amplifiers | 635.00 | 635.00 | 635.00 |
| Line Extender Amplifiers | 132.00 | 230.00 | 295.00 |
| Bridger Amplifiers | 544.00 | 661.00 | 745.00 |

a. Two-way capability: requires filters and return amplifiers before it can be used as a two-way system.

Passive Devices Including House Drop Equipment

The number of passive devices required in any CATV system is totally dependent upon the specific "layout" or mapping of the systems and the density of subscribers per mile of feeder cable. The passive devices required to complete the installation and operation of a given CATV system are as follows:

Layout Dependent

(1) Line Splitters

(2) Connectors

(3) Inserts

(4) Cable Splices

(5) Terminators

(6) Cable Fittings

(7) Directional Couplers

<u>Density Dependent</u>

(8) Directional Taps

(9) Connector Blocks

(10) Ground Rods

(11) Subscriber Transformers

(12) Dual Cable Switch

(13) Subscriber Converter

(14) Miscellaneous Hardware

The average per-item cost for the first set of devices is less than $5.00. Even though the required quantity per item may be large, its total cost is still insignificant compared with the total system cost. For this reason, the study effort will not include the cost of these items.

For those items that are dependent upon subscriber density, a per subscriber drop cost will be developed based upon certain assumptions regarding quantities per subscriber. The assumptions and the resultant specifications are shown in Table 4-8. Five specific cable options have also been included in this specification process. These are:

Single cable--less than 12 channels,

Single cable--more than 12 channels,

Dual cable -- one cable activated, more than 12 channels,

Dual cable--both cables activated, more than 12 channels, and

Dual cable--both cables activated, less than 12 channels per cable.

Table 4-8

SUBSCRIBER DROP EQUIPMENT REQUIREMENTS

| Equipment Item | Assumption | Requirement | Single Cable (12 or less channels) | Single Cable (more than 12 channels) | Dual Cable One Cable Activated | Dual Cable Both Cables Activated | Dual Cable Both Cables Activated (12 channels or less per cable) |
|---|---|---|---|---|---|---|---|
| Directional Tap | One per customer per cable, assume 4-way tap and an average of 3 out of 4 taps will be utilized | One per cable | 1 | 1 | 1 | 2 | 2 |
| Connector Block | One per cable | One per cable | 1 | 1 | 1 | 2 | 2 |
| Ground Rod | One per customer | One | 1 | 1 | 1 | 1 | 1 |
| Subscriber Transformer | One per customer | One | 1 | 1 | 1 | 1 | 1 |
| Dual Cable Switch | One for every two activated cables | One | 0 | 0 | 0 | 1 | 1 |
| Subscriber Converter | Required for a system with more than 12 channels | One | 0 | 1 | 1 | 1 | 0 |
| Miscellaneous Hardware | Required | Yes | Required | Required | Required | Required | Required |

The costs for these items, which are based upon manufacturers' prices and MSO estimates, are shown below:

Table 4-9

SUBSCRIBER DROP EQUIPMENT COSTS

| Equipment Item | Cost | Cost per Subscriber |
|---|---|---|
| Directional Tap | $18.00 | $6.00[a] - 12.00 |
| Connector Block | 1.50 | $1.50 - 3.00 |
| Ground Rod | 1.50 | $1.50 |
| Subscriber Transformer | 1.50 | $1.50 |
| Dual Cable Switch | 4.50 | $4.50 |
| Subscriber Converter | 30.00 | $30.00 |
| Miscellaneous Hardware | $1.00 - 1.50 | $1.00 - 1.50 |
| Labor | $6.00 - 9.00 | $6.00 - 9.00 |

a. Assumes four-way tap with 3 out of 4 taps utilized. Cost includes installation of tap on cable.

The requirements and costs are combined to develop a subscriber drop cost. This cost does not include the cost of the drop cable.

Table 4-10

SUBSCRIBER DROP COSTS

| Equipment Item | Single Cable (12 or less channels) | Single Cable (more than 12 channels) | Dual Cable (one cable activated) | Dual Cable (both cables activated) | Dual Cable (12 channels or less per cable) |
|---|---|---|---|---|---|
| Directional Tap | $ 6.00 | $ 6.00 | $ 6.00 | $12.00 | $12.00 |
| Connector Block | 1.50 | 1.50 | 1.50 | 3.00 | 3.00 |
| Ground Rod | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 |
| Subscriber Transformer | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 |
| Dual Cable Switch | N.A. | N.A. | N.A. | 4.50 | 4.50 |
| Subscriber Converter | N.A. | 30.00 | 30.00 | 30.00 | N.A. |
| Miscellaneous Hardware | 1.00 | 1.00 | 1.00 | 1.50 | 1.50 |
| (Subtotal) | $11.50 | $41.50 | $41.50 | $54.00 | 24.00 |
| Labor | 6.00 | 6.00 | 7.00 | 9.00 | 9.00 |
| Total | $17.50 | $47.50 | $48.50 | $63.00 | $33.00 |

## Power Supplies

Cable powering will be assumed for this study. In this case, the coaxial cable itself provides the conductor over which the operating power is brought to the active equipment on a cable system line. Thus, electrical power can be inserted onto the cable at more convenient spots.

A single power supply can supply power to about two miles of cable.[1] The cost for these power supplies is independent of the A. C. voltage required (either 30 or 60 volts, 60 cycles). The power supply requires an internal power coupler to supply AC power to the cable. The cost for this item is shown below:

Power Supply Cost (with internal coupler) = \$278.00 (for two miles of cable)

or

Power Supply Cost per mile = \$139.00

## Microwave System

A basic multichannel microwave system consists of a transmitter, channel and redundance modules, receivers and antennas. The microwave system receives its outputs from the headend and the output from the receiver is directly connected to the trunk cables. The transmitter and receiver operate on either FCC Group C (12,700.5 - 12,758.5 MHz, 12,820.5 - 12,886.5 MHz) or FCC Group D (12,759.7 - 12,817.7 MHz, 12,879.7 - 12,945.7 MHz) and transmit and receive low, high, mid, and super band VHF baseband signals.

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1. Assuming ordinary spacing of amplifiers.

The specification process for multichannel microwave equipment is similar to the headend electronic specification process. Table 4-11 specifies the equipment needed for a complete system and how the equipment quantity varies as function of the number of channels. The cost per equipment item is also included in this table.

The transmitter rack contains all the necessary microwave equipment--power supplies, klystron tubes, oscillators, filters, etc. Each rack accommodates up to 8 channel modules. Redundancy modules are required to provide backup operation in the event of klystron tube failure. One module is required for a dual-rack transmitter, and two for a triple-rack transmitter. Representative headend systems were developed under the assumption that two pilot carrier generators would be required for each system. This assumption is continued in the determination of the number of channel modules required: one module per TV channel, plus two modules for pilot tone, plus one module for FM. The number of receivers required depends upon the system configuration. As stated earlier, the total number of receivers that can be served by one transmitter can be almost unlimited depending upon their location.

The costs shown in the table do not include parabolic transmitter and receiver antennas, wave guides, mounts, etc., nor installation and field engineering. Current estimates for these items ran from about 10 percent to 20 percent of total hardware costs. To estimate this cost, the following factors will be used:[1]

| Number of Channels (up to and including) | Miscellaneous Engineering & Hardware (as a percentage of total hardware costs) |
|---|---|
| 8 | 10% |
| 16 | 15% |
| 24 | 20% |

1. Based upon discussions with manufacturer and MSO's.

Table 4-11

MULTI-CHANNEL MICROWAVE SYSTEM

| Component | Requirements | Unit Cost |
|---|---|---|
| Single-Rack Transmitter | Up to 8 channel modules | $19,100 |
| Dual-Rack Transmitter | Up to 16 channel modules | $31,600 |
| Triple-Rack Transmitter | Up to 16 channel modules | $45,900 |
| Channel Module | One for each TV channel plus two for pilot tone (plus one for FM, if required) | $ 2,200 |
| Redundancy Module | One for dual rack transmitter Two for triple rack transmitter | $ 3,200 |
| Receiver | Up to 20 channels including pilot tone | $ 5,400 |

CONSTRUCTION AND INSTALLATION COSTS

The previous sections have concentrated almost exclusively on the hardware costs associated with a CATV distribution system. At best, however, the hardware costs only amount to about forty percent of the total distribution costs.[1] The remainder of the cost is associated with the actual construction of the cable system and the installation and balancing of electronic components. Two alternative construction techniques are examined in this section: Aerial and Underground.

## Aerial

Aerial plant refers to cable that is suspended in the air on utility poles. The cable operator can either "rent" the poles or obtain a "lease-back" agreement from either the telephone or power company. The rental arrangement or pole line contract usually requires the utility company to modify or rearrange the existing poles to permit the installation of coaxial cable and electronic equipment. After paying for this rearrangement, the MSO can then install his cable on the poles. In the lease-back arrangement, a long-term contract is signed whereby the utility company installs and maintains the cable plant under tariffs related to the number of channels and miles of plant. The pole rental form is the most common type of aerial plant and only this option will be considered in this section.

The basic cost components of an aerial plant are:

- Pole rearrangement cost,
- Hardware and parts cost,
- Construction cost,
- Technical supervision cost,
- Electronic equipment installation and balance cost, and
- Preliminary engineering, strand mapping, design, inspection, applications, tree trimming, etc. cost.

1. In an extreme case (New York City), cable and electronic costs were less then five percent of the total distribution costs.

Cost estimates for each of these items have been obtained from MSO's and manufacturers. Two installation plans are considered single plant and dual plant. These costs for a single mile of plant are shown in Table 4-12.

Table 4-12

TYPICAL CONSTRUCTION COSTS--
AERIAL PLANT ONE MILE IN LENGTH

| | | |
|---|---|---|
| **Single Cable** | | |
| Pole rearrangement cost (per mile) | = | $ 700 |
| Hardware and parts cost (per mile) | = | $ 400 |
| Construction Costs at $.25 per foot | = | $1320 |
| Technical Supervision (per mile) | = | $ 150 |
| Electrical Equipment Installation and balance (per mile) | = | $ 150 |
| Miscellaneous Engineering[a] | = | $ 150 |
| TOTAL COST | = | $2870 |
| **Second Cable** (Installed at time of initial installation) | | |
| Hardware and Parts cost (per mile) | = | $ 400 |
| Construction cost (15% of 1st construction cost) | = | $ 198 |
| Electrical equipment installation and balance (per mile) | = | $ 150 |
| Technical supervision | = | $ 50 |
| TOTAL COST | = | $ 798 |

a. Includes preliminary engineering, strand mapping, design, inspection, etc.

The cost for pole rearrangement varies widely as a function of location and proximity to large urban areas. For example, the Comanor & Mitchell report shows a range of $300 to $750 per mile. The higher figure is for the top 100 markets. Discussions with MSO's indicate that the lower cost is no longer reasonable or applicable. They suggest that a more appropriate range would be from $500 to $700 a mile, with the $700 figure being the most realistic. While this range could be continued throughout the cost estimates, it was decided to drop the lower estimate to reduce the number of options considered.

Construction costs are average costs based upon a number of existing systems and are independent of location. The cost increment for the construction of a second cable is also based on historical data.

The cost associated with electronic equipment installation and balance is constant for a reasonable range in the number of amplifiers. Again, these were derived from existing systems where wide variations in the number of amplifiers did not occur. The cost would not be valid if the number of trunk amplifiers per mile, for example, increased to seven or eight.

Underground Cable Systems

The analysis of construction costs is a very specialized and unique field of cost analysis. Because the physical conditions that are encountered on an actual construction job vary from job to job, and because the specifications for each job are different, no attempts by the civil engineering community have been made to develop generalized cost estimating procedures. When bidding on jobs, the usual practice is to build up the costs from basic components, i.e., trenching, back filling, etc. To aid in this process, a number of standard cost handbooks have been developed. These handbooks show basic machine and labor rates for different types of jobs and conditions. To produce realistic estimates, these handbooks must be used with judgment and experience.

Because judgment and experience gained from previous jobs are so important in this industry, the primary source of historical cost data should be those companies who actually install underground cable systems. During the course of this study, RMC has contacted a number of construction companies who specialize in this field. These companies were reluctant to release this data because of its proprietary nature. The next logical source for this data was the MSO's and companies involved in electrical power distribution or communications. The data obtained from these sources was too aggregated to be of use. A MSO could say that the cost of underground cable for one of his systems averaged $X per mile. The variation in cost due to changes in soil and surface composition was unknown. Obviously, these costs could not satisfy the needs of this study.

The most realistic alternative that remained was to work with construction cost consultants who were knowledgeable in this field. The costs developed in this study reflect this approach.

To develop costs for the construction of underground cable systems, the actual steps in the construction process must be understood. Table 4-13 illustrates these steps for four specific cases:

Case I: Direct burial in Asphalt/concrete surfaces

Case II: Conduit burial in Asphalt/concrete surfaces

Case III: Direct burial in non-asphalt/concrete surfaces[1]

Case IV: Conduit burial in non-asphalt/concrete surfaces[1]

Per mile costs have been developed for all of the required steps. These costs, as shown in Figures 4-14 through 4-21, vary as a function of soil material, depth of concrete or asphalt, size of conduit, and cable diameter. It should be noted that these costs were based upon Washington, D. C. labor rates. Appendix D contains a set of normalized equations for each of these steps that permit the use of any labor rate. The Washington, D. C. labor rates will be used in this chapter to illustrate the use of per mile construction costs in developing total distribution system costs. Chapter 6 will use both these costs and the normalized equations in analyzing representative systems.

1. Topsoil, sand, loam, gravel, clay, or rock.

Table 4-13

CONSTRUCTION PROCEDURES FOR BURYING CABLE

Case I

1. Break up concrete or asphalt
2. Load, haul and dump concrete or asphalt
3. Machine trenching for cable trench and pedestals[a]
4. Bury cable
5. Install amplifiers
6. Back fill trench
7. Compaction of trench
8. Pour new concrete or lay asphalt

Case II

1. Break up concrete (or asphalt)
2. Load, haul and dump
3. Machine trenching for cable trench and pedestals
4. Install conduit
5. Pull cable(s) through conduit
6. Install amplifiers
7. Back fill trench
8. Compact trench
9. Pour new concrete (or asphalt)

Case III

1. Machine trench
2. Bury cable
3. Install amplifiers
4. Back fill trench
5. Compact trench

Case IV

1. Machine trench
2. Install conduit
3. Pull cable(s) through conduit
4. Install amplifiers
5. Back fill trench
6. Compact trench

a. For underground plants, amplifiers and taps must be installed in steel or concrete boxes. These boxes protect the equipment and enable maintenance to be performed without ripping up sidewalks. The iids are similar to man-hole covers.

A basic trench dimension has been assumed to derive per mile costs; its dimensions are 12 inches wide by 18 inches deep.

The per mile cost for each step is shown in Tables 4-14 through 4-21. The following examples will illustrate the procedure involved in determining a total per mile cost:

Example 1:

1 mile of 0.750" dia trunk cable, 2" PVC conduit.

5" thick concrete (assume type 3 always under concrete or asphalt)

| | | | |
|---|---|---|---|
| (1) | Break up cost | = | $ 1,222 |
| (2) | Hauling cost | = | $ 530 |
| (3) | Trenching, back filling and compacting | = | $ 3,432 |
| (4) | Conduit cable installation | = | $ 3,066 |
| (5) | 2" PVC (includes material and installation) | = | $ 8,591 |
| (6) | Paving cost | = | $ 2,493 |
| | TOTAL COST | = | $19,334 |

Example 2:

Dual 0.750" Trunk Cable, 3" PVC Conduit

5" Thick Concrete - 1 Mile of Cable

| | | | |
|---|---|---|---|
| (1) | Break up cost | = | $ 1,222 |
| (2) | Hauling cost | = | $ 530 |
| (3) | Trenching back filling and compacting | = | $ 3,432 |
| (4) | Conduit cable installation | = | $ 5,519 |
| (5) | 3" PVC (includes material and installation) | = | $12,605 |
| (6) | Paving cost | = | $ 2,493 |
| | TOTAL COST | = | $25,801 |

In this case, the addition of a second cable increases the total cost (less cable and electronics) by 33 percent.

The next two examples illustrate the difference between direct burial and conduit burial for a Type 2 soil condition.

Example 3:

Single 0.750 Trunk Cable - Direct Bury

Type 2 Soil - 1 Mile of Cable

| | | | |
|---|---|---|---|
| (1) | Trenching, back filling, and compacting | = | $ 2,904 |
| (2) | Direct burial | = | $ 2,759 |
| | TOTAL COST | = | $ 5,663 |

Example 4:

Single 0.750 cable 2" PVC

Type 2 Soil - 1 Mile of Cable

| | | | |
|---|---|---|---|
| (1) | Trenching, back filling, and compacting | = | $ 2,904 |
| (2) | Conduit cable installation | = | $ 3,066 |
| (3) | 2" PVC (includes material and installation) | = | $ 8,591 |
| | TOTAL COST | | $14,561 |

The difference between the conduit case and non-conduit case is 157 percent.

It should again be noted that the per mile costs are typical costs and were developed using representative production and labor rates. They should not be used as is to estimate construction costs in any other location than Washington without changing labor rates. A set of conversion equations that permit the use of other labor rates is contained in Appendix D.

Table 4-14

PER MILE BREAK UP COSTS

| | | | |
|---|---|---|---|
| 1. Breaking up concrete | | | Per Mile Cost |
| | 2" deep | = | $ 489 |
| | 3" deep | = | 733 |
| | 4" deep | = | 978 |
| | 5" deep | = | 1,222 |
| | 6" deep | = | 1,467 |
| | 7" deep | = | 1,711 |
| | 8" deep | = | 1,956 |
| | 9" deep | = | 2,200 |
| | 10" deep | = | 2,444 |
| | 11" deep | = | 2,689 |
| | 12" deep | = | 2,933 |
| 2. Breaking up asphalt | | | Per Mile Cost |
| | 2" deep | = | $ 163 |
| | 3" deep | = | 244 |
| | 4" deep | = | 326 |
| | 5" deep | = | 408 |
| | 6" deep | = | 489 |

Table 4-15

PER MILE HAULING COSTS

| | | | |
|---|---|---|---|
| 1. Concrete | | | Per Mile Cost |
| | 2" deep | = | $ 212 |
| | 3" deep | = | 318 |
| | 4" deep | = | 423 |
| | 5" deep | = | 530 |
| | 6" deep | = | 635 |
| | 7" deep | = | 741 |
| | 8" deep | = | 847 |
| | 9" deep | = | 954 |
| | 10" deep | = | 1,059 |
| | 11" deep | = | 1,165 |
| | 12" deep | = | 1,271 |
| 2. Asphalt | | | Per Mile Cost |
| | 2" deep | = | $ 212 |
| | 3" deep | = | 318 |
| | 4" deep | = | 423 |
| | 5" deep | = | 530 |
| | 6" deep | = | 635 |

Table 4-16

PER MILE TRENCHING, BACK FILLING, AND COMPACTING COSTS

| | | |
|---|---|---|
| Trenching (Independent of depth - up to 18") | | Per Mile Cost |
| Type 1 - Topsoil, loam, sand, etc. | = | $ 528 |
| Type 2 - Clay or mixture of | = | 634 |
| Type 3 - Small rock or mixture of | = | 792 |
| Hand Back filling | | Per Mile Cost |
| Type 1 | = | $1,056 |
| Type 2 | = | 1,214 |
| Type 3 | = | 1,373 |
| Compacting | | Per Mile Cost |
| Type 1 | = | $ 898 |
| Type 2 | = | 1,056 |
| Type 3 | = | 1,267 |
| Total | | Per Mile Cost |
| Type 1 | = | $2,482 |
| Type 2 | = | 2,904 |
| Type 3 | = | 3,432 |

Table 4-17

DIRECT BURIAL CABLE INSTALLATION COSTS
(Per Mile)

| Cable Diameter (Assumes armoured cable) | | Per Mile Cost |
|---|---|---|
| 0.412" | = | $1,303 |
| 0.500" | = | 1,685 |
| 0.750" | = | 2,759 |

NOTE: For a second cable add 80 percent.
Cost does not include the cost of cable.

Table 4-18

CONDUIT CABLE INSTALLATION COSTS
(Per Mile)

| Cable Diameter (Assumes flooding compound) | | Per Mile Cost |
|---|---|---|
| 0.412" | = | $1,533 |
| 0.500" | = | 1,839 |
| 0.750" | = | 3,066 |
| Drop Cable | = | 460 |

NOTE: For a second cable add 80 percent.
Cost does not include the cost of cable.

Table 4-19

CONDUIT MATERIAL AND INSTALLATION COSTS

| Rigid Steel | | Per Mile Cost |
|---|---|---|
| Single Cable (2" conduit) | = | $10,043 |
| Dual Cable (3" conduit) | = | 15,393 |
| Drop Cable (3/4" conduit) | = | 4,343 |
| **Rigid PVC** | | **Per Mile Cost** |
| Single Cable (2" conduit) | = | $ 8,591 |
| Dual Cable (3" conduit) | = | 12,605 |
| Drop Cable (3/4" conduit) | = | 3,937 |

Table 4-20

PER MILE PAVING COSTS

| Concrete | | Per Mile Cost |
|---|---|---|
| 2" deep | = | $1,382 |
| 3" deep | = | 2,024 |
| 4" deep | = | 2,229 |
| 5" deep | = | 2,493 |
| 6" deep | = | 2,816 |
| 7" deep | = | 3,098 |
| 8" deep | = | 3,432 |
| 9" deep | = | 3,778 |
| 10" deep | = | 4,019 |
| 11" deep | = | 4,424 |
| 12" deep | = | 4,664 |
| **Asphalt** | | **Per Mile Cost** |
| 2" deep | = | $ 452 |
| 3" deep | = | 698 |
| 4" deep | = | 927 |
| 5" deep | = | 1,114 |
| 6" deep | = | 1,367 |

Table 4-21

MISCELLANEOUS CONSTRUCTION COSTS

| | |
|---|---|
| 1. Amplifier Installation Cost | $29.00 each |
| Including balancing | |
| 2. Tap Installation Cost | $ 7.00 each |
| 3. Pedestal Installation Cost: includes excavation and pedestal | $75.00 each |
| 4. Resodding Cost | $ 0.23 per foot |
| 5. Asphalt Paving | |
| One time equipment move-in cost | $250.00 |

# 5

## OPERATING COSTS

Operating costs for CATV systems result from either plant or office operating expenses, and many of these are related to system capacity--either miles of plant or number of subscribers. Since system capacity is dynamic, the total operating costs increase over time. Therefore, these costs must be estimated on an annual basis to reflect the current capabilities of the system.

The major problem in deriving operating cost factors for CATV systems is the lack of historical data at the component level. Neither the manufacturers nor MSO's record operating histories at this level. The records obtained from these sources indicate that, when preparing individual budgets for their systems or when developing pro forma estimates for new systems, total system operating costs only are used. This precludes, for lack of supporting data, the development of "life-cycle" cost tradeoffs between competing equipment items. In fact, it is doubtful if any "formal" tradeoff analysis is performed by the MSO's. The decision to buy specific equipment items from selected manufacturers is based upon reports from the chief technicians at existing CATV sites or through experience about the quality and reliability of a given manufacturer's line of equipment. Because this study is constrained by the availability of existing data, the cost factors developed in this chapter reflect the system level of detail.

The specific elements that constitute total operating costs for a given CATV system were presented in the total work breakdown structure shown in Chapter 2 (Table 2-1). The operating cost components of that work breakdown structure are reproduced here as Table 5-1.

Table 5-1

OPERATING COSTS

1. Plant Operating Costs
   - A. Personnel: Salaries and Benefits
     1. Manager
     2. Chief Technician
     3. Installers
     4. Maintenance Technicians
     5. Bench Technicians
     6. Microwave Technicians
     7. Benefits
   - B. Repair and Maintenance
     1. Headend
     2. Distribution System
     3. Microwave Maintenance (or Rental)
   - C. Rental Costs
     1. Poles
     2. Tower Site
   - D. Power
   - E. Parts and Supplies
     1. Initial Inventory and Spare Parts
     2. Test Equipment
     3. Tools
   - F. Truck Rental

2. Office Operating Costs
   - A. Personnel: Salaries and Benefits
     1. Bookkeeper/Office Manager
     2. Secretarial/Clerical
   - B. Office - Rental
   - C. Office - Postage and Supplies
   - D. Furniture and Leasehold Improvements
   - E. Professional and Legal Services
   - F. Insurance
     1. Property
     2. Miscellaneous
   - G. Taxes and Licenses and Fees
     1. Property
     2. Franchise
     3. Sales
     4. Payroll
     5. Licenses and Fees
   - H. Telephones, Utilities, and Maintenance
     1. Telephone
     2. Utilities and Maintenance
   - I. Billing and Bookkeeping
   - J. Promotion and Sales
   - K. Drop Replacement and Turnover
   - L. Travel and Entertainment
   - M. Membership
   - N. Contributions
   - O. Bad Debts
   - P. Freight
   - Q. Sales Commission

It should be noted that items 1.E.1, 1.E.2, and 2.D are actually capital expenditures. Because the procedures involved in estimating their costs are similar to actual operating expenses, these elements have been included in this section.

## PLANT OPERATING COSTS

Based upon discussions with major MSO's, each of the elements associated with plant operating costs can be categorized with regard to its requirements and the costs associated with these requirements. Table 5-2 illustrates this process.

These costs are based upon actual operating histories of MSO's and include a mixture of old systems and new systems. The plant operating maintenance and personnel costs do, however, reflect modern technology and hardware (i.e., solid-state as opposed to tube technology).

One of the major problems in collecting operating cost data from multiple sources is the possibility that definitions can be inconsistent. To avoid double-counting in both the collection of certain cost data elements and the use of these cost elements, the following definitions have been used:

- Installer. Outside plant men engaged primarily in making subscriber drops, and with a limited knowledge, at most, in trouble-shooting distribution system problems.
- Technicians. Men capable of maintaining all components of CATV distribution plants and of routine maintenance of head-end components (maintenance technicians). Men capable of repairing all CATV electronic components (except microwave equipment: Bench technicians.
- Benefits. Employer's share of premium for Group Insurance and Hospitalization, saving plan, pension plan, tuition refund, employee acquisition, relocation expense, etc.
- Repairs and Maintenance. This element covers all expenses for maintenance to the cable distribution plant. It covers the cost of painting a tower, repairing a pole that has been knocked down, the cost of repairing a customer drop, the cost of normal maintenance hardware such as strand clamps, amplifiers, connectors, etc. It will also cover all normal maintenance items of the outside plant and the headend site.

Table 5-2

PLANT OPERATING REQUIREMENTS AND COST

| Cost Element | Requirement | Annual Cost |
|---|---|---|
| A. Personnel | | |
| Manager | 1 per system | $15,000 + $1 for every subscriber over 3000. Maximum of $25,000. |
| Chief Technician | 1 per system | $12,000 |
| Installers | 2 for year 1 through 3000 subscribers<br>1 per each additional 1500 new subscribers | $7,000<br>[Divide new subscribers by 1500 - round up to next highest number, minimum = 2] |
| Maintenance Technician | 2 for year 1<br>1 per each additional 60 miles of strand (per cable) | $8,000 |
| Bench Technician | 0 if system $<$ 75 miles of strand<br>1 if 75 $<$ system $<$ 300 miles of strand<br>2 if system $>$ 300 miles of strand | $8,000 |
| Microwave Technician | one required if system owns microwave equipment of more than one hop<br>and/or<br>one technician per two LDS systems | $8,000 |
| Benefits | For all plant employees | (Total Salary) x 12 percent |

Table 5-2 (Continued)

PLANT OPERATING REQUIREMENTS AND COST

| Cost Element | Requirement | Annual Cost |
|---|---|---|
| B. Repairs and Maintenance | | |
| Headend | For all systems | $1,000 per year |
| Distribution System | Function of strand miles and age of system | $46 per mile Years 1-3<br>$66 per mile Years 4-6<br>$88 per mile Years 7-10 |
| Microwave | If required | 10 percent of microwave capital expenditures |
| C. Rental | | |
| Poles | 40 poles per mile | $4-5 per pole per year |
| Tower Site | One per tower | $600 per tower per year |
| D. Power | Function of strand miles and headend | $28 per strand mile + $700 for headend |
| E. Parts and Supplies | | |
| Inventory and Spare Parts | Function of headend + distribution system cost ÷ number of final subscribers (one-time cost) | 1 percent (total headend + distribution cost)<br>+ $6,000 if less than 5K final subs or<br>+ $15,000 if 5K to 10K final subs or<br>$25,000 over 10K final subs.<br>(does not include construction cost) |

Table 5-2 (Continued)

PLANT OPERATING REQUIREMENTS AND COST

| Cost Element | Requirement | Annual Cost |
| --- | --- | --- |
| E. Parts and Supplies (Continued) | | |
| Test Equipment | Function of headend and distribution system cost (one-time) | 1 percent (total headend + distribution cost) (does not include construction cost) |
| Tools | | $1,500 per year |
| F. Truck Rental | one for manager<br>one for chief technician<br>one per installer<br>one per maintenance technician | $2,100 per vehicle per year |

- Power. The cost of electric power to energize the cable distribution system and the cost of electricity for the headend location.

- Inventory and Spare Parts. A one-time purchase to cover replacement of worn or broken equipment items in either headend or distribution system. Includes spare modules, filters, cable, etc.

- Test Equipment. Includes signal level meters, spectrum analyzers, sweep generators, marker generators, high performance and wide-band oscilloscopes, time domain reflectrometers, test signal generators (multi-bust, stairsteps, windows, color bars, 20 T pulses), etc.

- Tools. All small tools and devices that cost less than $200 and that are utilized in the technical use of the operation. This includes such devices as electrical drills, drill bits, staplers, pliers, small field strength meters, climbing tools, hooks, safety belts, etc.

- Truck Rental. Basic rental charge for a six-cylinder, van-type truck yearly cost includes complete maintenance and insurance.

OFFICE OPERATING COSTS

Each of the office operating cost elements can also be categorized in terms of its requirements and costs. A number of these elements are, however, dependent upon non-system considerations. This would include office rent, insurance, taxes (especially franchise fees), and memberships and dues. In such cases, the cost factors that have been developed are based upon historical evidence and can be omitted if more specific information is available. The requirements and cost factors are shown in Table 5-3.

Table 5-3

OFFICE OPERATING REQUIREMENTS AND COST

| Cost Element | Requirement | Annual Cost |
|---|---|---|
| A. Personnel | | |
| Bookkeeper/Office Manager | 1 | $7,000 |
| Secretary/Clerks | One per 1,500 subscribers (include bookkeeper in calculation) maximum of 15 | $5,000 |
| Benefits | For all office employees | 12 percent x (total salary) |
| B. Office--Rental | Required | $3,600/year<br>Add 1,200/year for each additional secretary over 3 (include bookkeeper in calculation) |
| C. Office--Postage and Supplies | Required | Dollars per Sub. / Year<br>$1.35 / 1<br>1.20 / 2<br>.60 / 3<br>.55 / 4<br>.50 / 5-10 |
| D. Furniture and Leasehold Improvements | Estimated expense of installing lighting and air conditioning facilities and developing office and studio facilities (one time cost) | $5,000 + $1,500 per 1,000 final subscribers. Maximum of $100,000 |

Table 5-3 (Continued)

| Cost Element | Requirement | Annual Cost |
|---|---|---|
| E. Professional and Legal Services | Function of Subscribers | Under 10K sub. $4,000/yr.<br>Over 10K subs. $5,000/yr. |
| F. Insurance | | |
| Property | Insurable value =<br>80 percent of Total Capital Expenditures<br>(Headend and distribution and test equipment and vehicles and drops and convertors and furniture and leasehold improvements) | $.35 per $100 of Insurable value |
| Miscellaneous | | 0-10,000 subs. $500<br>Over 10,000 subs. $1,000 |
| G. Taxes and Fees | | |
| Property Tax | As required | 1/2 percent (total capital expenditures) |
| Franchise | Unless otherwise known<br>-- FCC minimum -- | 3 percent of service receipts |
| Sales | Unless otherwise known | 2 percent of 60 percent of Total Capital expenditures |

Table 5-3 (Continued)

| Cost Element | Requirement | Annual Cost |
|---|---|---|
| Payroll | Reasonable approximation | 5.5 percent of total salaries |
| Licenses and Fees | Business licenses, use permits, occupational permits, etc. | 0-10K subs. $200/yr.<br>Over 10K $400/yr. |
| H. Telephone, Utilities, and Maintenance | | |
| Telephone | Required | $4,000/yr. average |
| Utilities and Maintenance | 1/2 annual office rent | |
| I. Billing and Bookkeeping | Computer system includes cash handling, follow-up, postage and reports | $1.50 per subscriber + $.25 per subscriber conversion cost - 1st year |
| J. Promotion and Sales | Based upon projection of number of subscribers added annually | $10 per new subscribers per year |
| K. Drop replacement and Turnover | Based upon total number of subscribers in previous year x 26 percent (26 percent is turnover rate) | For Year n<br>= (Total number of subscribers in Year n-1) x .26 x $20 |

Table 5-3 (Continued)

| Cost Element | Requirement | Annual Cost |
|---|---|---|
| L. Travel and Entertainment | Required | 15 percent (manager's salary) |
| M. Membership and Dues | As required (NCTA, Chamber of Commerce, etc.) | $630 for 1st 1,000 subs.<br>60¢ each for next 4,000 subs.<br>54¢ each for next 5,000 subs.<br>48¢ each for next 5,000 subs.<br>42¢ each for next 5,000 subs.<br>etc. |
| N. Contributions | Red Cross, Community Chest, etc. | $600/yr. |
| O. Bad Debts | Required | 1.5 percent of service revenue |
| P. Freight | Required for suppliers, inventory, etc. | 100 miles and under of cable = $200/yr.<br>Over 100 miles of Cable = $700/yr. |
| Q. Sales Commission | May be necessary | $3.00 per new subscriber |

As in the case of plant operating costs, these costs also are based upon actual operating histories from MSO's. The office operating costs are not sensitive to technology and modern hardware cost implications. The definitions that have been used for collecting historical data are as follows:

- Office Rental. The cost of leases for offices and warehouses.
- Office Supplies. All normal stationery expenses such as paper, envelopes, pencils, rubber stamps, typewriter ribbons, letterheads, etc. are included as well as the cost of floor wax, paper towels, soap, utensils, etc. All charges for postage are also included.
- Professional and Legal Services. All expenses and fees for legal and audit services, as well as the cost of specialized professional services such as consultant engineers, surveyors, etc.
- Insurance. The premium cost of all insurance coverage and the cost of Bonds required by pole agreement contracts, franchises, etc.
- Licenses and Fees. All expenses for business licenses, use permits, occupational permits.
- Telephone. This includes charges for normal telephone and telegraph service. It does not include any pole rental charges or pole make-ready charges.
- Office Utilities. Gas, electricity, and water are the three office utilities included in this cost element.
- Office Maintenance. Covers such items as adding machines, typewriter repair, desk repair, etc. Also, covers the cost of janitor service, lawn care, repair of office building, painting of office, etc.
- Billing and Bookkeeping. A computer billing service which includes all mail-cash handling, follow-up notices, postage, and statistical and financial reports.
- Promotion and Sales. All expenses incurred for radio advertising, television advertising, newspaper and printed matter, illumination signs (billboards), etc. Also included is the cost of all premiums, activities, give-a-ways, and other promotional devices.
- Drop Replacement and Turnover. Approximately 26 percent of the previous year's subscribers are assumed to relocate in a given year at a cost of reinstallation and drop replacement of \$20 per turnover-subscriber.

- Memberships and Dues. The cost of NCTA membership, State Association membership and authorized local memberships such as Rotary Clubs, Chamber of Commerce, etc.
- Contributions. Contributions to Red Cross, Community Chest, Community Fund and similar charitable institutions.
- Sales Commissions. This element covers commissions paid to direct salesmen whether employees or independent contractors.

# 6

## SYSTEM HANDBOOK

The preceeding chapters have developed a complete set of cost factors and cost equations for estimating the total cost of any new CATV system. Although each of these chapters has used hypothetical examples to illustrate the development of component cost estimates, no one chapter specified the complete inputs and methodology required to develop total life cycle cost. This chapter provides the framework needed to develop total costs and is divided into three major sections:

- Input Specifications
- Assumptions
- System Example and Sensitivity Analysis

### INPUT SPECIFICATIONS

The inputs required to estimate the cost of CATV systems fall into two broad categories: required and secondary. An example of a required input would be the number of required VHF signals; a secondary input is the total number of VHF preamplifiers required. In most cases, because of the way the specification process has been developed, the secondary input is immediately specified when the required input is determined. In the above example, one preamplifier is required for each VHF signal. Thus, the total number of required preamplifiers is equal to the number of VHF signals.

Tables 6-1 through 6-3 present the required and major secondary inputs needed in estimating total system costs.

Table 6-1

HEADEND SYSTEM: INPUTS

(1) Number of VHF Signals
(2) Number of UHF Signals
(3) Number of Microwave Signals
(4) Number of Studio Signals
(5) Number of FM Channels
(6) Type of Tower
(7) Height of Tower
(8) Number of Antennas
(9) Signal Strength of Antennas

Table 6-2

DISTRIBUTION SYSTEM: INPUTS

(1) Cable Diameters and Type of Foam
(2) Cable Jacket Configuration
(3) Number of Miles of Cable by Cable Type
(4) Is System Two-way?
(5) Ratio of AGC and ASC Amplifiers to Regular Trunk Amplifiers
(6) Feeder/Trunk Ratio
(7) Number of Cables
(8) Number of Multichannel Microwave Systems Required
(9) Number of Strand Miles of Aerial Plant
(10) Relationship Between Strand Miles and Trunk And Feeder Miles
(11) Number of Strand Miles of Underground Plant
(12) Construction Process and Labor Rates
(13) Type of Conduit

Table 6-3

OPERATING ENVIRONMENT: INPUTS

(1) Number of Subscribers by Year
(2) Number of Miles Added Annually
(3) Total Headend and Distribution Cost
(4) Franchise Fee
(5) Sales Tax
(6) Service Receipts on an Annual Basis

## ASSUMPTIONS

The tables of major inputs can be significantly reduced through the use of realistic assumptions that are based upon either accepted industry best practices or expected conditions. For example, unless otherwise indicated, a guyed tower would always be selected over a self-supporting tower because of its lower cost. The difference in cost between these two towers (assuming equal height) is approximately $16,000, which, as the example in this chapter will illustrate, is about 1/10 of 1 percent of the total capital costs. The assumptions and the resultant list of required inputs are as follows:

### Headend

- Tower is of guyed design.
- Tower height is 300 feet.
- Number of antennas is equal to number of UHF and VHF signals.
- Signal strength is average and implies double array antennas.
- Nine FM channels are assumed for any FM retransmission capability.

### Distribution System

- For systems with 12 or more channels of capacity. .750" dia cable may be used as trunk cable and high capacity equipment must be used.
- Jacket configurations are as follows:
    - Aerial--Jacketed
    - Direct Burial--Jacketed with Armour
    - Burial in Conduit--Jacketed with Flooding
- Minimum case for AGC and ASC amplifiers will be used (i. e., two out of every six trunk amplifiers are either AGC or ASC amplifiers).
- Rigid PVC conduit will be used.

- Unless otherwise specified, average concrete depth is 7" and average asphalt depth is 4".

  - $X_1$ = \$6.50 where $X_1$ = General Laborer Hourly Rate
  - $X_2$ = \$9.10 $X_2$ = Electrician Hourly Rate
  - $X_3$ = \$7.00 $X_3$ = Concrete/Asphalt Worker Hourly Rate

- Unless otherwise specified, the following relationships will be used to calculate total construction costs:

  - Total Aerial Construction Costs = Aerial Construction Cost per mile x number of strand miles.
  - Total Underground construction Costs = Underground Construction Cost per mile x number of strand miles.
  - If only trunk and feeder miles are known, calculate strand miles as follows:

    1 Strand Mile = (Feeder mile) x 1.06

  - If only strand miles are known, calculate trunk and feeder miles as follows:

    Feeder Miles = Strand Miles x .94

    Trunk Miles = Strand Miles x .25

These equations are based upon actual data from more than twenty-five systems. The relationship between strand and feeder miles is, essentially, independent of system size, while the relationship between strand and trunk miles does appear to vary as a function of system size. If more sensitivity is required in total costs, the following relationships may be used:

Trunk miles = Strand miles x .22 (if strand miles $<$ 100)

Trunk miles = Strand miles x .28 (if strand miles $>$ 100)

## Operating Environment

- Unless otherwise specified, the following franchise fee and sales tax will be assumed:

  Franchse fee = 3 percent of service receipts

  Sales tax = 2 percent of 60 percent of total capital expenditures

The resultant required inputs are shown in Table 6-4.

## SYSTEM COSTS

To illustrate the use of both the cost factors and model framework, this section will develop the complete capital and operating costs for a hypothetical CATV system. The time period convered in this example is installation and ten years of operation. In addition to developing total costs, the example will examine the sensitivity to total costs of the following alternatives:

- Two cables each with 12-channel capacity and no converter.
- All aerial construction (single cable)
- All underground construction (single cable)

It should be noted that whatever conclusions are drawn from this hypothetical example they are not universal conclusions. They are applicable only to this example and its underlying assumptions.

### A. Description and Input Specifications

- 24 Channel CATV System with
  - 12 VHF signals
  - 3 UHF signals
  - 5 studio signals
  - 4 microwave signals
- FM retransmission capability
- Trunk miles = 100
- Feeder miles = 600

Table 6-4

MODEL INPUTS

**Headend**

(1) Number of VHF signals.
(2) Number of UHF signals.
(3) Number of microwave signals.
(4) Number of studio signals.
(5) Is FM retransmission desired?

**Distribution System**

(1) How many miles of plant are aerial?
(2) How many miles of plant are underground?
(3) Is conduit required?
(4) Are parallel trunk cables required?
(5) Is two-way capability required?
(6) What is the feeder/trunk ratio?
(7) Number of multichannel microwave systems required.
(8) Soil conditions.

**Operating Environment**

(1) Number of subscribers by year.
(2) Number of miles added annually.
(3) Service receipts--annually.

A. (continued)

- Strand miles = 630
- Aerial strand miles = 315
- Underground strand miles = 315
- Single cable
- Conduit required
- Asphalt road conditions
- One-way system only
- With following system characteristics:

| Year | Strand Miles | Cum. Strand Miles | Sub | Cum. Sub. | Revenues |
|---|---|---|---|---|---|
| 1 | 32 | 32 | 1,380 | 1,380 | $ 99,360 |
| 2 | 220 | 252 | 9,900 | 11,280 | $ 812,160 |
| 3 | 95 | 347 | 7,500 | 18,780 | $1,352,160 |
| 4 | 63 | 410 | 8,520 | 27,300 | $1,965,600 |
| 5 | 50 | 460 | 7,680 | 34,980 | $2,518,560 |
| 6 | 38 | 498 | 5,340 | 40,320 | $2,903,040 |
| 7 | 38 | 536 | 5,760 | 46,080 | $3,317,760 |
| 8 | 38 | 574 | 5,580 | 51,660 | $3,719,520 |
| 9 | 38 | 612 | 4,380 | 56,040 | $4,034,880 |
| 10 | 18 | 630 | 3,840 | 59,880 | $4,311,360 |

B. Headend Costs

Headend electronics cost are based upon the specification process and cost model shown in Figure 3-7.

- Tower costs (see Table 3-2)

  Guyed tower
  300-foot height
  Cost = $16,500
  Supervision $1,500

  Total Tower Cost = $18,000

- Antenna Costs (see Table 3-3)

  12 VHF Antennas - Dual Array
  3 UHF Antennas - Dual Array
  1 FM Antenna - Omni-Directional

Cost = 12 x 955 + 3 x 613 + 1 x 500 = $13,799

Supervision = $1,500

Total Antenna Cost = $15,299

- Headend Building (see Table 3-4)

  Large Building - 160 sq. ft.

  Total Cost = $6,080

- Headend Electronics (see: Table 3-6, Table 3-7, and Figure 3-7)

  12 VHF with FM retransmission
  3 UHF
  5 Studio
  4 Microwave

  - <u>VHF Signals</u>

$$12 \text{ VHF signals} \times \begin{bmatrix} \text{1 Pre Amp} \\ \text{1 Power Supply} \\ \text{2 Filters} \\ \text{1 Signal Processor} \end{bmatrix} \times \begin{bmatrix} 208 \\ 30 \\ 101 \\ 1,150 \end{bmatrix} = \$19,080$$

  - <u>UHF Signals</u>

$$3 \text{ UHF signals} \times \begin{bmatrix} \text{1 PreAmp} \\ \text{1 Power Supply} \\ \text{1 UHF/VHF Converter} \\ \text{2 Filters} \\ \text{1 Signal Processor} \end{bmatrix} \times \begin{bmatrix} 290 \\ 51 \\ 750 \\ 101 \\ 1,150 \end{bmatrix} = \$\ 7,329$$

  - <u>Studio Signals</u>

$$5 \text{ Studio signals} \times \begin{bmatrix} \text{1 Modulator} \\ \text{1 Filter} \end{bmatrix} \times \begin{bmatrix} 1,225 \\ 101 \end{bmatrix} = \$\ 6,630$$

  - <u>Microwave Signals</u>

$$4 \text{ Microwave signals} \times \begin{bmatrix} \text{1 Antenna} \\ \text{1 Receiver} \\ \text{1 Modulator} \\ \text{1 Filter} \end{bmatrix} \times \begin{bmatrix} 535 \\ 3,325 \\ 1,225 \\ 101 \end{bmatrix} = \$20,784$$

- Common Equipment

$$\begin{bmatrix} \text{2 Pilot Carrier Generators} \\ \text{4 Combining Network} \\ \text{1 Splitter} \\ \text{1 Directional Coupler} \end{bmatrix} \times \begin{bmatrix} 350 \\ 105 \\ 30 \\ 30 \end{bmatrix}$$

$$+ \begin{bmatrix} \text{1 Non-Duplicating System} \end{bmatrix} \times \begin{bmatrix} 4,500 \end{bmatrix}$$

$$= \$5,680$$

- Prewiring Costs

$200/Channel x 24 Channels = $4,800

- FM Signals (9 Signals)

| | | | |
|---|---|---|---|
| 1 PreAmp + Power Supply | 85 | | |
| 9 Tuners | 120 | | |
| 1 Trap | 45 | = | $1,630 |
| 1 Power Supply and Console | 260 | | |
| 1 Console | 160 | | |

- Installation Costs

= 3,000 + 3,000 (Microwave) = $6,000

- Total Headend Electronics

Total Headend Electronics = 19,080 + 7,329 + 6,630 + 20,784
+ 5,680 + 1,630 + 4,800 + 6,000

= $71,933

Total Headend Costs

| | |
|---|---|
| Tower | 18,000 |
| Antennas | 15,299 |
| Building | 6,080 |
| Electronics | 71,933 |

$$\boxed{\text{Total Headend} = \$111,312}$$

The headend costs are assumed to occur in Year 1.

C. Distribution Costs

Strand miles are not equal to the sum of trunk and feeder miles because in many cases, the trunk and feeder cables run parallel to one another. This relationship is significant because the total cost of aerial or underground construction is directly related to the number of strand miles. In this case, because of parallel runs, only 630 miles of construction are required instead of 700 miles if there were no parallel runs.

The parallel runs are assumed to occur equally in both the aerial and underground cases. That is, if the following relationship holds true for the entire system,

$$630 \text{ strand miles} = (600 \text{ feeder miles})(x) \text{ where } x = \frac{630}{600} \text{ or } 1.05$$

or

$$1 \text{ strand mile} = 1.05 \text{ feeder miles}$$

then the relationship holds true for the 315 strand miles of aerial cable and the 315 miles of underground cable.

Thus, 315 strand miles = 300 miles of feeder cable + 50 miles of trunk cable. This distinction is necessary because aerial cable is not the same as underground cable, and the total system costs should reflect this difference.

Based upon this, the following cable and construction requirements can be developed:

| Construction Technique | Total Construction Miles | Miles and Type of Cable |
|---|---|---|
| Aerial | 315 | 300 miles jacketed .412" feeder cable<br>50 miles jacketed .750" trunk cable |
| Underground | 315 | 300 miles jacketed with flooding - .412" feeder cable<br>50 miles jacketed with flooding .412" feeder cable |

The relationship between strand miles and trunk and feeder miles is just one step in the development of total distribution costs. This procedure, illustrated in Figure 6-1, consists of the input specifications, and a set of derived specifications. Both the direct and derived specifications are used to estimate hardware costs (cable, amplifiers, and power supplies), distribution costs (aerial and underground construction), and subscriber drop costs (convertors, cable, equipment, and labor). The exact steps in this specification process and cost model are shown in Figures 6-2 through 6-5.

With this in mind, distribution costs are derived as follows:

- Cable and Electronics Cost (see Table 4-3, 4-6, 4-7, and B-1; Figures 6-1, 6-2, and 6-3)
  - 50 miles of jacketed .750" cable (includes amplifiers)

    50 x $2,816 = $140,800

  - 50 miles of jacketed with flooding .750" cable (includes amplifiers)

    50 x $2,851 = $142,550

  - 300 miles of jacketed .412" cable (includes amplifiers)

    300 x $1,720 = $516,000

  - 300 miles of jacketed with flooding .412" cable (includes amplifiers)

    300 x $1,750 = $525,000

  - Number of Bridger Amps

    per mile = $\left(\frac{6}{1}\right)$ x 0.6188 = 3.71

    Total system = 3.71 x 100 = 371

  - Cost of Bridger Amps

    = 371 x $661 = $245,231

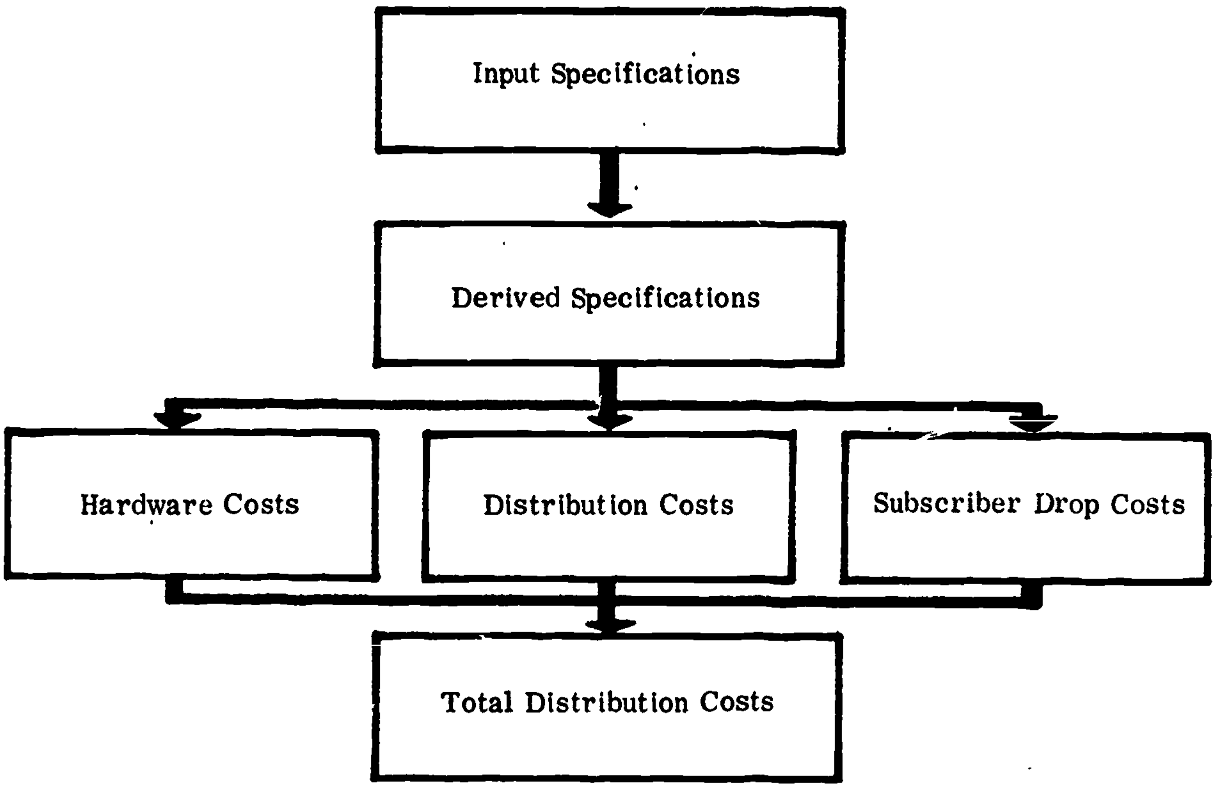



Figure 6-1: DISTRIBUTION SPECIFICATIONS AND COST PROCESS

**Primary Inputs**

Total Trunk Miles
Total Feeder Miles

or

Total Strand Miles--Aerial
Total Strand Miles--Underground

**Plus**

Number of Cables
Conduit ( Yes or No)
Soil Conditions
Annual Miles Added (Strand)
Annual Subscribers Added
System Channel Capacity

**Derived Inputs**

- If trunk and feeder miles known

  Strand miles = feeder miles x 1.06

- If Strand miles known

  Feeder miles = (Strand miles) x .94

  Trunk miles = (Strand miles) x .25

**Outputs**

- Strand miles by construction type
- Feeder miles by construction type
- Trunk miles by construction type

**Distribution Costs**

- Hardware Costs
  +
- Distribution Costs
  +
- Subscriber Drop Costs

Figure 6-2: DISTRIBUTION SPECIFICATION PROCESS

Aerial Jacketed Cable and Electronics Cost

Total Cost = Total aerial trunk miles x trunk cable and electronics cost/mile + total aerial feeder miles x feeder cable and electronics cost/mile.

For two cables, multiply results by 2
(Use Tables 4-22 and 4-23 for costs)

(+)

Underground Jacketed Cable and Electronics Costs

Total Cost = Total underground trunk miles x trunk cable and electronics cost/mile + total underground feeder miles x feeder cable and electronics cost per mile.

For two cables, multiply results by 2
(Use Tables 4-22 and 4-23 for costs)

(+)

Bridger Amplifier Cost

Total Cost = $\left(\frac{\text{feeder}}{\text{trunk}}\ \text{ratio}\right)$ x .6188 x total trunk miles x cost per bridger amp

For two cables, multiply by 2
(Use Table 4-7 for costs)

(+)

Power Supply Costs

Total Cost = $139 per mile x (total feeder + trunk miles)

For two cables, multiply by 2

(+)

Automatic Slope Amplifiers

Total Cost (one cable) = $1,270

Total Cost (two cables) = $2,540

Figure 6-3: HARDWARE COSTS

**Aerial Construction** +

Total Aerial Construction Cost = Per Mile Construction Cost x Total Strand Miles

**A. Single Cable**

Total Aerial Construction Cost = $2,870 x Total Strand Miles

**B. Dual Cable**

Total Aerial Construction Cost = $3,668 x Total Strand Miles

(Note: Do not double strand miles for dual cable case)

**Underground Construction**

A. Select appropriate case (Table 4-13)

B. Determine or specify $T_1$ or $T_2$, $X_1$, $X_2$, & $X_3$ (Appendix 1)

C. Select appropriate equations (Appendix 1)

D. Estimate total per mile cost for all components except cable pulling

E. Multiply total per mile cost x number of strand miles

F. Multiply per mile feeder cable pulling cost x number of feeder miles

G. Multiply per mile trunk cable pulling cost x number of trunk miles

H. Total underground construction cost = (E + F + G)

Figure 6-4: DISTRIBUTION COSTS

A. Determine specific subscriber drop option } Table 4-10

B. Determine cost per option } Table 4-10

C. Add cost of 100' of drop cable (\$3.67) (Table 4-3)

D. If underground system required determines specific case (Table 4-13)

E. Determine or specify $T_1$ or $T_2$, $X_1$, $X_2$, and $X_3$ (Appendix 1)

F. Estimate total per mile cost for all components
(Note: drop cable always requires conduit)

G. Divide per mile cost by 211.2 to estimate per subscriber cost
(assume 25' per customer--underground)

H. Total drop cost = (B + C + G)

Figure 6-5: SUBSCRIBER DROP COSTS

- Cost of Automatic Slope Amplifiers

  = 2 x \$635 = \$1,270

- Cost of Power Supplies

  = 700 miles x \$139 = \$97,300

Total Cable and Electronics Cost

= \$140,800 + \$142,550 + \$516,000 + \$525,000 + \$245,231 + \$1,270 + \$97,300

= \$1,668,151

| Cost Per Strand Mile = \$2,648 |
|---|

Although a total cost has been calculated, since the plant is increasing annually, this cost will be displayed annually in the following manner:

New Strand Miles x \$2,648

- Subscriber Drop Costs (see Tables 4-3, 4-10, Figure 6-2)

| | | |
|---|---|---|
| Single cable with converter | = | \$47.50 |
| Assume 100' of drop cable | = | \$ 3.67 |
| Total Drop Cost | = | \$51.17 |

This is a capital cost that occurs annually. The annual cost to be displayed is equal to:

New Subscribers in Year x \$51.17

- Aerial Construction Costs (see Table 4-12)

  315 miles x \$2,870/mile = \$904,050

The input specifications to this example do not specify what percentage of aerial plant is added annually. It will, therefore, be assumed that half of all cable added annually is aerial. This follows from the ratio of aerial strand miles to total strand miles. Likewise, one-half of all new cable added annually is underground cable. A construction plan that specifies the number of aerial miles and underground miles added annually does not change the total capital costs but rather the time-phasing of capital costs. A simplifying assumption that adds the total aerial construction costs and the total underground construction costs and divides by the total strand miles to obtain an average strand mile construction cost will be used in this example.

- Underground Construction Cost (see Appendix 1 and Tables 4-13 through 4-21, Tables B-1 through B-4; Figure 6-4)

  Asphalt road 4"
  2" PVC conduit

Case II

(a) Breakup asphalt = $16.27\ (T_2) + 10.09\ (T_2)\ (X_1)$ (315 miles)

(b) Haul asphalt = $31.73\ (T_2) + 11.39\ (T_2)\ (X_1)$ (315 miles)

(c) Trench (type 3 soil) = $221.76 + 87.65\ (X_1)$ (315 miles)

(d) 2" PVC conduit - Installation and Material = $2612 + 657(X_2)$ (315 miles)

(e) Pull single .412" cable = $168.50\ (X_2)$ (300 miles)

(f) Pull single .750" cable = $337\ (X_2)$ (50 miles)

(g) Install amplifiers = $3.19\ (X_2)$ { 50 miles - trunk and bridger amps

(h) Install pedestals = $15 + 8.57\ (X_3)$ { 300 miles - line extenders

(i) Backfill trench = $211.20\ (X_1)$ (315 miles)

(j) Compact trench = $595.58 + 103.33\ (X_1)$ (315 miles)

(k) Repave asphalt = $787.95 + 19.86\ (X_3)$ (315 miles)

(l) Move-in cost = \$250

where $T_2$ = 4"
$X_1$ = \$6.50
$X_2$ = \$9.10
$X_3$ = \$7.00

The results of these equations are shown in Table 6-5. For burial of drop cable, the following assumptions are used:

25' of PVC and burial per subscriber
1/2 of total subscribers require underground drop cable.

Steps a, b, c, i, j, k from above are required plus:

(m) 3/4" PVC conduit installation and material = 869 + 337 ($X_2$)

(n) Pull drop cable = 50.50 ($X_2$)

The results of these operations are shown in Table 6-6.

- Total Trunk and Feeder Cable Construction Cost

| | | |
|---|---|---|
| Aerial construction | = | $ 904,050 |
| Underground construction | = | 5,113,577 |
| Total | | $6,017,627 |
| Cost per Strand Mile | = | $9,552 |

- Subscriber Drop Cost

All subscribers = 51.12 per subscriber
Half of all subscribers = 45.00 per subscriber (in addition to above)

or

Prorating the underground costs over all subscribers at $27.50 per subscriber,

Total subscriber drop cost = $51.12 + 27.50 = $78.62

## D. Annual Headend and Distribution Capital Costs

Since the costs associated with the distribution system accrue when the system is actually constructed, these costs should actually be displayed on an annual basis. Utilizing the strand mile and subscriber growth rate shown earlier, the following results are obtained:

Table 6-5

TRUNK AND FEEDER CABLE CONSTRUCTION COSTS

| Operation | Cost Per Mile | Total Cost (315 Strand Miles) |
|---|---|---|
| Breakup Asphalt | 326 | 102,690 |
| Haul Asphalt | 423 | 133,245 |
| Trench (Type 3) | 792 | 249,480 |
| 2" PVC Conduit | 8,591 | 2,706,165 |
| Pull Single .412" cable | 1,533 | 459,900 |
| Pull Single .750" cable | 3,066 | 153,300 |
| Install Trunk Amplifiers and Pedestal[1] | 223 | 11,150 |
| Install Line Extender and Pedestal[2] | 515 | 154,500 |
| Install Bridger Amplifiers and Pedestal[3] | 104 | 19,292 |
| Backfill Trench | 1,373 | 432,495 |
| Compact Trench | 1,267 | 399,105 |
| Repave Asphalt | 927 | 292,005 |
| Move-in Cost | | 250 |
| Total Underground Construction Cost | | 5,113,577 |

Note:

(1) Amplifier Installation and Pedestal Cost = 104.00 x 2.14 Trunk Amplifiers per mile = $223 (50 miles)

(2) Line Extender and Pedestal Cost = 104.00 x 4.95 Line Extender per mile = $515 (300 miles) (Installation)

(3) Total Bridger Amplifier and Pedestal Cost = 104.00 x

$$\frac{\text{Total Number of Bridger Amps}}{2} = 104.00 \times \frac{371}{2} = \$19,292 \text{ (Installation)}$$

Table 6-6

DROP CABLE CONSTRUCTION COST

| Operation | Per Mile | Cost Per Subscriber[1] |
|---|---|---|
| Breakup asphalt | 326 | 1.54 |
| Haul asphalt | 423 | 2.00 |
| Trench | 792 | 3.75 |
| 3/4" PVC | 3,937 | 18.64 |
| Pull drop cable | 460 | 2.18 |
| Backfill trench | 1,373 | 6.50 |
| Compact trench | 1,267 | 6.00 |
| Repave asphalt | 927 | 4.39 |
| Total | 9,505 | $45.00 |

1. At twenty-five feet per subscriber, 5,280/25 or 211.20 subscribers per mile are used in determing cost per subscriber.

Year 1

Complete headend cost at $109,812
32 strand miles and 1,380 subscribers
Cable and electronics cost/strand miles = $ 2,648

Total construction cost/strand mile = $ 9,552

Complete distribution system/strand mile = $12,200
Subscriber drop cost = $78.62

Distribution cost = $12,200 x 32 = $390,400
Subscriber drop cost = 78.62 x 1,380 = $108,496

Year 2

220 strand miles
9,900 subscribers
Distribution cost = 12,200 x 220 = $2,684,000
Subscriber drop cost = 78.62 x 9,900 = $ 778,338

Year 3

95 strand miles
7,500 subscribers
Distribution cost = 12,200 x 95 = $1,159,000
Subscriber drop cost = 78.62 x 7,500 = $ 589,650

Year 4

63 strand miles
8,[illegible]20 subscribers
Distribution cost = $ 768,600
Subscriber drop cost = $ 669,842

Year 5

50 strand miles
7,680 subscribers
Distribution cost = $ 610,000
Subscriber drop cost = $ 603,801

Year 6

38 strand miles
5,340 subscribers
Distribution cost = $ 463,600
Subscriber drop cost = $ 419,830

Year 7

38 strand miles
5,760 subscribers

| | | |
|---|---|---|
| Distribution cost | = | $ 463,600 |
| Subscriber drop cost | = | $ 452,851 |

Year 8

38 strand miles
5,580 subscribers

| | | |
|---|---|---|
| Distribution cost | = | $ 463,600 |
| Subscriber drop cost | = | $ 438,700 |

Year 9

38 strand miles
4,380 subscribers

| | | |
|---|---|---|
| Distribution cost | = | $ 463,600 |
| Subscriber drop cost | = | $ 344,356 |

Year 10

18 strand miles
3,840 subscribers

| | | |
|---|---|---|
| Distribution cost | = | $ 219,600 |
| Subscriber drop cost | = | $ 301,901 |

E. Plant Operating Costs (see Chapter 5)

| Year | Manager |
|---|---|
| 1 | $15,000 |
| 2 | $15,000 + 8,280 = $23,280 |
| 3 | $23,280 + 7,500 = $25,000 |
| 4 | $25,000 |
| 5 | $25,000 |
| 6 | $25,000 |
| 7 | $25,000 |
| 8 | $25,000 |
| 9 | $25,000 |
| 10 | $25,000 |

| Year | Chief Technician |
|---|---|
| 1 | $12,000 |
| 2 | $12,000 |
| 3 | $12,000 |
| 4 | $12,000 |
| 5 | $12,000 |
| 6 | $12,000 |
| 7 | $12,000 |
| 8 | $12,000 |
| 9 | $12,000 |
| 10 | $12,000 |

| Year | Installers |
|---|---|
| 1 | $14,000 |
| 2 | $14,000 + 5 x 7,000 = $49,000 |
| 3 | 5 x 7,000 = $35,000 |
| 4 | 6 x 7,000 = $42,000 |
| 5 | 6 x 7,000 = $42,000 |
| 6 | 4 x 7,000 = $28,000 |
| 7 | 4 x 7,000 = $28,000 |
| 8 | 4 x 7,000 = $28,000 |
| 9 | 3 x 7,000 = $21,000 |
| 10 | 3 x 7,000 = $21,000 |

| Year | Maintenance Technician |
|---|---|
| 1 | $8,000 |
| 2 | $8,000 + 3 x 8,000 = $32,000 |
| 3 | $32,000 + 2 x 8,000 = $48,000 |
| 4 | $48,000 + 1 x 8,000 = $56,000 |
| 5 | $56,000 + 1 x 8,000 = $64,000 |
| 6 | $64,000 |
| 7 | $64,000 + 1 x 8,000 = $72,000 |
| 8 | $72,000 + 1 x 8,000 = $80,000 |
| 9 | $80,000 |
| 10 | $80,000 |

| Year | Bench Technician |
|---|---|
| 1 | - |
| 2 | $8,000 |
| 3 | $8,000 + 8,000 = $16,000 |
| 4 | $16,000 |
| 5 | $16,000 |
| 6 | $16,000 |
| 7 | $16,000 |
| 8 | $16,000 |
| 9 | $16,000 |
| 10 | $16,000 |

| Year | Microwave Technician |
|---|---|
| 1 | $8,000 |
| 2 | $8,000 |
| 3 | $8,000 |
| 4 | $8,000 |
| 5 | $8,000 |
| 6 | $8,000 |
| 7 | $8,000 |
| 8 | $8,000 |
| 9 | $8,000 |
| 10 | $8,000 |

| Year | Total Plant Salary | Benefits |
|---|---|---|
| 1 | 57,000 | $ 6,840 |
| 2 | 132,280 | $15,873 |
| 3 | 144,000 | $17,280 |
| 4 | 159,000 | $19,080 |
| 5 | 167,000 | $20,040 |
| 6 | 153,000 | $18,360 |
| 7 | 161,000 | $19,320 |
| 8 | 169,000 | $20,280 |
| 9 | 162,000 | $19,440 |
| 10 | 162,600 | $19,440 |

## Repairs and Maintenance

| Headend Year | | Distribution Year | | | |
|---|---|---|---|---|---|
| 1 | $1,000 | 1 | 46 x 32 | = | $ 1,472 |
| 2 | $1,000 | 2 | 46 x 32 + 46 x 220 | = | $11,592 |
| 3 | $1,000 | 3 | 46 x 32 + 46 x 220 +46 x 95 | = | $15,962 |
| 4 | $1,000 | 4 | 66 x 32 + 46 x 220 + 46 x 95 + 46 x 63 | = | $19,500 |
| 5 | $1,000 | 5 | 66 x 32 + 66 x 220 + 46 x 95 +46 x 63 + 46 x 50 | = | $26,200 |
| 6 | $1,000 | 6 | 66 x 32 + 66 x 220 + 66 x 95 + 46 x 63 + 46 x 50 + 46 x 38 | = | $29,848 |
| 7 | $1,000 | 7 | 88 x 32 + 66 x 220 + 66 x 95 + 66 x 63 + 46 x 50 + 46 x 38 + 46 x 38 | = | $33,560 |
| 8 | $1,000 | 8 | 88 x 32 + 88 x 220 + 66 x 95 + 66 x 63 + 66 x 50 + 46 x 38 + 46 x 38 + 46 x 38 | = | $41,148 |
| 9 | $1,000 | 9 | 88 x 32 + 88 x 220 + 88 x 95 + 66 x 63 + 66 x 50 + 66 x 38 + 46 x 38 + 46 x 38 + 46 x 38 | = | $45,746 |
| 10 | $1,000 | 10 | 88 x 32 + 88 x 220 + 88 x 95 + 88 x 63 + 66 x 50 + 66 x 38 + 66 x 38 + 46 x 38 + 46 x 38 + 46 x 18 | = | $48,720 |

## Microwave

| Year | |
|---|---|
| 1 | $20,784 x .10 = $2,078 |
| 2 | $2,078 |
| 3 | $2,078 |
| 4 | $2,078 |
| 5 | $2,078 |
| 6 | $2,078 |
| 7 | $2,078 |
| 8 | $2,078 |
| 9 | $2,078 |
| 10 | $2,078 |

**Rental**

| Year | Poles | |
|---|---|---|
| 1 | 40 x 4 x 16 | =$ 2,560 |
| 2 | 40 x 4 x 126 | =$20,160 |
| 3 | 160 x 174 | =$27,840 |
| 4 | 160 x 205 | =$32,800 |
| 5 | 160 x 230 | =$36,800 |
| 6 | 160 x 249 | =$39,840 |
| 7 | 160 x 268 | =$42,880 |
| 8 | 160 x 287 | =$45,920 |
| 9 | 160 x 306 | =$48,960 |
| 10 | 160 x 315 | =$50,400 |

(one-half of total strand miles)

**Tower Site**

**Year**

1-10 $600/year

**Power**

**Headend** Years 1-10 $700

| Year | Distribution | |
|---|---|---|
| 1 | 28 x 32 | = $ 896 |
| 2 | 28 x 252 | = $ 7,056 |
| 3 | 28 x 347 | = $ 9,716 |
| 4 | 28 x 410 | = $11,480 |
| 5 | 28 x 460 | = $12,880 |
| 6 | 28 x 498 | = $13,944 |
| 7 | 28 x 536 | = $15,008 |
| 8 | 28 x 574 | = $16,072 |
| 9 | 28 x 612 | = $17,136 |
| 10 | 28 x 630 | = $17,640 |

### Parts and Supplies

| Year | Inventory | |
|---|---|---|
| 1 | 1% (109,812 + 32 x 2,648 + 51.17 x 1,380) + 25,000 | = $27,652 |
| 2 | 1% (220 x 2,648 + 51.17 x 9,900) | = $10,891 |
| 3 | 1% (95 x 2,648 + 51.17 x 7,500) | = $ 6,353 |
| 4 | 1% (63 x 2,648 + 51.17 x 8,520) | = $ 6,028 |
| 5 | 1% (50 x 2,648 + 51.17 x 7,680) | = $ 5,254 |
| 6 | 1% (38 x 2,648 + 51.17 x 5,340) | = $ 3,739 |
| 7 | 1% (38 x 2,648 + 51.17 x 5,760) | = $ 3,954 |
| 8 | 1% (38 x 2,648 + 51.17 x 5,580) | = $ 3,862 |
| 9 | 1% (38 x 2,648 + 51.17 x 4,380) | = $ 3,247 |
| 10 | 1% (18 x 2,648 + 51.17 x 3,840) | = $ 2,442 |

| | |
|---|---|
| Headend | = $109,812 |
| Cable and Electronics/Strand Mile | = $2,648 |
| Subscriber Drop Cost (without underground) | = $51.17 |

### Test Equipment

Year 1 1% (630 x 2,648 + 51.17 x 59,880) = $47,323

### Tools

Year 1-10 $1,500/year

### Truck Rental

| Year | | |
|---|---|---|
| 1 | 5 x 2,100 | = $10,500 |
| 2 | 13 x 2,100 | = $27,300 |
| 3 | 13 x 2,100 | = $27,300 |
| 4 | 15 x 2,100 | = $31,500 |
| 5 | 16 x 2,100 | = $33,600 |
| 6 | 14 x 2,100 | = $29,400 |
| 7 | 15 x 2,100 | = $31,500 |
| 8 | 16 x 2,100 | = $33,600 |
| 9 | 15 x 2,100 | = $31,500 |
| 10 | 15 x 2,100 | = $31,500 |

## F. Office Operating Costs

**Bookkeeper**

| Year | |
|---|---|
| 1 | $7,000 |
| 2 | $7,000 |
| 3 | $7,000 |
| 4 | $7,000 |
| 5 | $7,000 |
| 6 | $7,000 |
| 7-10 | $7,000 |

**Secretary**

| Year | | |
|---|---|---|
| 1 | 0 | |
| 2 | 7 x 5,000 | = $35,000 |
| 3 | $35,000 + 5 x 5,000 | = $60,000 |
| 4 | $60,000 + 2 x 5,000 | = $70,000 |
| 5 | $70,000 | |
| 6 | $70,000 | |
| 7-10 | $70,000 | |

| Year | Total Salary | Benefits |
|---|---|---|
| 1 | $ 7,000 | $ 840 |
| 2 | $42,000 | $5,040 |
| 3 | $67,000 | $8,040 |
| 4 | $77,000 | $9,240 |
| 5 | $77,000 | $9,240 |
| 6 | $77,000 | $9,240 |
| 7 | $77,000 | $9,240 |
| 8 | $77,000 | $9,240 |
| 9 | $77,000 | $9,240 |
| 10 | $77,000 | $9.240 |

**Office Rental**

| Year | |
|---|---|
| 1 | $ 3,600 |
| 2 | $ 9,600 |
| 3 | $15,600 |
| 4 | $18,000 |
| 5 | $18,000 |
| 6 | $18,000 |
| 7 | $18,000 |
| 8 | $18,000 |
| 9 | $18,000 |
| 10 | $18,000 |

**Office Postage and Supplies**

| Year | | |
|---|---|---|
| 1 | 1.35 x 1,380 | = $ 1,863 |
| 2 | 1.20 x 11,280 | = $13,536 |
| 3 | .60 x 18,780 | = $11,268 |
| 4 | .55 x 27,300 | = $15,015 |
| 5 | .50 x 34,980 | = $17,490 |
| 6 | .50 x 40,320 | = $20,160 |
| 7 | .50 x 46,080 | = $23,040 |
| 8 | .50 x 51,660 | = $25,830 |
| 9 | .50 x 56,040 | = $28,020 |
| 10 | .50 x 59,880 | = $29,940 |

## Furniture and Leasehold Improvements

Year 1 5,000 + 1,500 (59) = $93,500

## Professional and Legal Services

| Year | |
|---|---|
| 1 | $4,000 |
| 2–10 | $5,000 |

## Property Insurance

| Year | | |
|---|---|---|
| 1 | (109,812 + 390,400 + 93,500 + 108,496 + 59,823) x .8 x .0035 | =$ 2,134 |
| 2 | 2,134 + (3,477,338 x .8 x .0035) | =$11,871 |
| 3 | 11,871 + (1,761,150 x .8 x .0035) | =$16,802 |
| 4 | 16,802 + (1,448,442 x .8 x .0035) | =$20,858 |
| 5 | 20,858 + (1,223,801 x .8 x .0035) | =$24,285 |
| 6 | 24,285 + (888,430 x .8 x .0035) | =$26,773 |
| 7 | 26,773 + (926,451 x .8 x .0035) | =$29,367 |
| 8 | 29,367 + (909,800 x .8 x .0035) | =$31,914 |
| 9 | 31,914 + (812,956 x .8 x .0035) | =$34,190 |
| 10 | 34,190 + (524,001 x .8 x .0035) | =$35,657 |

## Miscellaneous Insurance

| Year | |
|---|---|
| 1 | $ 500 |
| 2–10 | $1,000 |

Property Tax

| Year | | |
|---|---|---|
| 1 | ½% (762,031) | = $ 3,810 |
| 2 | ½% (3,477,338 + 762,031) | = $21,197 |
| 3 | ½% (1,761,150 + 4,239,400) | = $30,003 |
| 4 | ½% (1,448,442 + 6,000,600) | = $37,245 |
| 5 | ½% (1,223,801 + 7,449,000) | = $43,364 |
| 6 | ½% (888,430 + 8,672,800) | = $47,806 |
| 7 | ½% (926,451 + 9,561,200) | = $52,438 |
| 8 | ½% (909,800 + 10,487,700) | = $56,988 |
| 9 | ½% (812,956 + 11,397,500) | = $61,052 |
| 10 | ½% (524,001 + 12,210,500) | = $63,673 |

Franchise Fee

| Year | | |
|---|---|---|
| 1 | 3% (99,360) | = $ 2,981 |
| 2 | 3% (812,160) | = $24,365 |
| 3 | 3% (1,352,160) | = $40,565 |
| 4 | 3% (1,965,660) | = $58,970 |
| 5 | 3% (2,518,560) | = $75,557 |
| 6 | 3% (2,903,040) | = $87,091 |
| 7 | 3% (3,317,760) | = $99,533 |
| 8 | 3% (3,719,520) | = $111,586 |
| 9 | 3% (4,034,880) | = $121,046 |
| 10 | 3% (4,311,360) | = $129,341 |

Sales Tax

| Year | | |
|---|---|---|
| 1 | .02 x .60 x 762,031 | = $ 9,144 |
| 2 | .012 x 3,477,338 | = $41,728 |
| 3 | .012 x 1,761,150 | = $21,134 |
| 4 | .012 x 1,448,442 | = $17,381 |
| 5 | .012 x 1,223,801 | = $14,686 |
| 6 | .012 x 888,430 | = $10,661 |
| 7 | .012 x 926,451 | = $11,117 |
| 8 | .012 x 909,800 | = $10,918 |
| 9 | .012 x 812,956 | = $ 9,756 |
| 10 | .012 x 524,001 | = $ 6,288 |

Billing and Bookkeeping

| Year | | | |
|---|---|---|---|
| 1 | $1.75 x 1,380 | = | $ 2,415 |
| 2 | $1.50 x 11,280 | = | $16,920 |
| 3 | $1.50 x 18,780 | = | $28,170 |
| 4 | $1.50 x 27,300 | = | $40,950 |
| 5 | $1.50 x 34,980 | = | $52,470 |
| 6 | $1.50 x 40,320 | = | $60,480 |
| 7 | $1.50 x 46,080 | = | $69,120 |
| 8 | $1.50 x 51,660 | = | $77,490 |
| 9 | $1.50 x 56,040 | = | $84,060 |
| 10 | $1.50 x 59,880 | = | $89,820 |

Promotion and Sales

| Year | | | |
|---|---|---|---|
| 1 | $10 x 1,380 | = | $13,800 |
| 2 | $10 x 9,900 | = | $99,000 |
| 3 | $10 x 7,500 | = | $75,000 |
| 4 | $10 x 8,520 | = | $85,200 |
| 5 | $10 x 7,680 | = | $76,800 |
| 6 | $10 x 5,340 | = | $53,400 |
| 7 | $10 x 5,760 | = | $57,600 |
| 8 | $10 x 5,580 | = | $55,800 |
| 9 | $10 x 4,380 | = | $43,800 |
| 10 | $10 x 3,840 | = | $38,400 |

Drop Replacement and Turnover

| Year | | | |
|---|---|---|---|
| 1 | - | | |
| 2 | .26 x $20 x 1,380 | = | $ 7,176 |
| 3 | $5.20 x 9,900 | = | $51,480 |
| 4 | $5.20 x 7,500 | = | $39,000 |
| 5 | $5.20 x 8,520 | = | $44,304 |
| 6 | $5.20 x 7,680 | = | $39,936 |
| 7 | $5.20 x 5,340 | = | $27,768 |
| 8 | $5.20 x 5,760 | = | $29,952 |
| 9 | $5.20 x 5,580 | = | $29,016 |
| 10 | $5.20 x 4,380 | = | $22,776 |

Payroll Taxes

Year

| | | | |
|---|---|---|---|
| 1 | 5.5% (64,000) | = | \$ 3,520 |
| 2 | 5.5% (174,280) | = | \$ 9,585 |
| 3 | 5.5% (211,000) | = | \$11,605 |
| 4 | 5.5% (236,000) | = | \$12,980 |
| 5 | 5.5% (244,000) | = | \$13,420 |
| 6 | 5.5% (230,000) | = | \$12,650 |
| 7 | 5.5% (238,000) | = | \$13,090 |
| 8 | 5.5% (246,000) | = | \$13,530 |
| 9 | 5.5% (239,000) | = | \$13,145 |
| 10 | 5.5% (239,000) | = | \$13,145 |

Licenses and Fees

Year

| | |
|---|---|
| 1 | \$200/year |
| 2-10 | \$400/year |

Telephones

Years 1-10 \$4,000/year

Utilities and Maintenance

Year

| | |
|---|---|
| 1 | \$1,800 |
| 2 | \$4,800 |
| 3 | \$7,800 |
| 4-10 | \$9,000/year |

Travel and Entertainment

| Year | | | |
|---|---|---|---|
| 1 | .15 x 15,000 | = | $2,250 |
| 2 | .15 x 24,180 | = | $3,627 |
| 3 | .15 x 25,000 | = | $3,750 |
| 4 | .15 x 25,000 | = | $3,750 |
| 5 | .15 x 25,000 | = | $3,750 |
| 6 | .15 x 25,000 | = | $3,750 |
| 7 | .15 x 25,000 | = | $3,750 |
| 8 | .15 x 25,000 | = | $3,750 |
| 9 | .15 x 25,000 | = | $3,750 |
| 10 | .15 x 25,000 | = | $3,750 |

Membership and Dues

| Year | | | |
|---|---|---|---|
| 1 | $630 + 228 | = | $ 858 |
| 2 | $5,730 + 614 | = | $ 6,344 |
| 3 | $8,130 + 1,588 | = | $ 9,718 |
| 4 | $12,030 + 690 | = | $12,720 |
| 5 | $13,530 + 1,195 | = | $14,725 |
| 6 | $15,030 + 38 | = | $15,068 |
| 7 | $15,330 + 65 | = | $15,395 |
| 8 | $15,480 + 50 | = | $15,530 |
| 9 | $15,580 + 21 | = | $15,601 |
| 10 | $15,580 + 98 | = | $15,678 |

Contributions

Years 1-10 $600/year

Bad Debts

| Year | | | |
|---|---|---|---|
| 1 | 1.5% (99,360) | = | $ 1,490 |
| 2 | 1.5% (812,160) | = | $12,182 |
| 3 | 1.5% (1,352,160) | = | $20,282 |
| 4 | 1.5% (1,965,660) | = | $29,485 |
| 5 | 1.5% (2,518,560) | = | $37,778 |
| 6 | 1.5% (2,903,040) | = | $43,546 |
| 7 | 1.5% (3,317,760) | = | $49,766 |
| 8 | 1.5% (3,719,520) | = | $55,793 |
| 9 | 1.5% (4,034,880) | = | $60,523 |
| 10 | 1.5% (4,311,360) | = | $64,670 |

Freight

| Year | |
|---|---|
| 1 | $200 |
| 2-10 | $700/year |

Sales Commission

| Year | | | |
|---|---|---|---|
| 1 | $3 x 1,380 | = | $ 4,140 |
| 2 | $3 x 9,900 | = | $29,700 |
| 3 | $3 x 7,500 | = | $22,500 |
| 4 | $3 x 8,520 | = | $25,560 |
| 5 | $3 x 7,680 | = | $23,040 |
| 6 | $3 x 5,340 | = | $16,020 |
| 7 | $3 x 5,760 | = | $17,280 |
| 8 | $3 x 5,580 | = | $16,740 |
| 9 | $3 x 4,380 | = | $13,140 |
| 10 | $3 x 3,840 | = | $11,520 |

With a cost now developed for each cost element in the work breakdown structure, the complete system costs can be displayed in the following manner:

| | |
|---|---|
| Capital Costs | (Table 6-7) |
| Plant Operating Costs | (Table 6-8) |
| Office Operating Costs | (Table 6-9) |
| Total System Costs | (Table 6-10) |

G. Sensitivity Analysis

A feasible alternative to the single high-capacity cable with home converter is the use of two twelve-channel cables without a home converter. The preceding example was rerun to calculate the cost of this alternative, with the following changes in specifications:

- Dual cable (still retaining high capacity electronics).
- No converter.
- Total strand miles are doubled.

Table 6-11 illustrates the total costs of both options. The capital costs for dual cable are 22 percent higher than for the single cable and the total operating costs 22 percent higher in the dual cable case. The major change in operating costs is plant-derived and this is about 46 percent higher in the dual cable case. The expected converter savings that reduce the subscriber drop cost from $78.62 to $60.17 are more than nullified by the increase in complete distribution costs per strand mile (from $12,200 to $18,326). In addition, the system requires twice as many installers, and the distribution maintenance and power costs are also doubled.

The only advantage the dual cable case has is in growth potential. By adding headend components and home convertors, a 48-channel system is possible, without additional construction. In the single cable case a new distribution system must be constructed. Thus, it would appear that if future expansion is required or desired, the dual cable case might, in the long run, be cost effective.

Table 6-7

CAPITAL COSTS

| Capital Costs | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| A. Headend | (111,312) | | | | | | | | | |
| Tower | 18,000 | | | | | | | | | |
| Antenna | 15,299 | | | | | | | | | |
| Building | 6,080 | | | | | | | | | |
| Electronics | 71,933 | | | | | | | | | |
| B. Distribution (construction, cable and electronics) | 390,400 | 2,684,000 | 1,159,000 | 768,600 | 610,000 | 463,600 | 463,600 | 463,600 | 463,600 | 219,600 |
| C. Subscriber Drop and Converter Costs | 108,496 | 778,338 | 589,650 | 669,842 | 603,801 | 419,830 | 452,851 | 438,700 | 344,356 | 301,901 |
| D. Test Equipment | 47,323 | | | | | | | | | |
| E. Furniture and Leasehold Improvements | 93,500 | | | | | | | | | |
| Total Capital Costs | 751,031 | 3,462,338 | 1,748,650 | 1,438,442 | 1,213,801 | 883,430 | 916,451 | 902,300 | 807,956 | 521,501 |

Table 6-8

PLANT OPERATING COSTS

| Plant Operating Costs | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| A. Personnel | | | | | | | | | | |
| Salary | 57,000 | 132,280 | 144,000 | 159,000 | 167,000 | 153,000 | 161,000 | 169,000 | 162,000 | 162,000 |
| Benefits | 6,840 | 15,873 | 17,280 | 19,080 | 20,040 | 18,360 | 19,320 | 20,280 | 19,440 | 19,440 |
| B. Repair and Maintenance | | | | | | | | | | |
| Headend | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 |
| Distribution | 1,472 | 11,592 | 15,962 | 19,500 | 26,200 | 29,849 | 33,560 | 41,148 | 45,746 | 48,720 |
| Microwave | 2,078 | 2,078 | 2,078 | 2,078 | 2,078 | 2,078 | 2,078 | 2,078 | 2,078 | 2,078 |
| C. Rental | | | | | | | | | | |
| Poles | 2,560 | 20,160 | 27,840 | 32,800 | 36,800 | 39,840 | 42,880 | 45,920 | 48,960 | 50,400 |
| Tower | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 |
| D. Parts and Supplies | | | | | | | | | | |
| Inventory | 27,652 | 10,891 | 6,353 | 6,028 | 5,254 | 3,739 | 3,954 | 3,862 | 3,247 | 2,442 |
| Tools | 1,500 | 1,500 | 1,500 | 1,500 | 1,500 | 1,500 | 1,500 | 1,500 | 1,500 | 1,500 |
| E. Power | 1,596 | 7,756 | 10,416 | 12,180 | 13,580 | 14,644 | 15,708 | 16,772 | 17,836 | 18,340 |
| F. Trunk Rental | 10,500 | 27,300 | 27,300 | 31,500 | 33,600 | 29,400 | 31,500 | 33,600 | 31,500 | 31,500 |
| Total Plant Operating Costs | 112,798 | 231,030 | 254,329 | 285,266 | 307,652 | 294,009 | 313,100 | 335,760 | 333,9[illegible] | 338,020 |

Table 6-9

OFFICE OPERATING COSTS

| Office Operating Costs | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| A. Personal | | | | | | | | | | |
| Salary | 7,000 | 42,000 | 67,000 | 77,000 | 77,000 | 77,000 | 77,000 | 77,000 | 77,000 | 77,000 |
| Benefits | 840 | 5,040 | 8,040 | 9,240 | 9,240 | 9,240 | 9,240 | 9,240 | 9,240 | 9,240 |
| B. Office Rent | 3,600 | 9,600 | 15,600 | 18,000 | 18,000 | 18,000 | 18,000 | 18,000 | 18,000 | 18,000 |
| C. Office Postage and Supplies | 1,863 | 13,536 | 11,268 | 15,015 | 17,490 | 20,160 | 23,040 | 25,830 | 28,020 | 29,940 |
| D. Professional and Legal Services | 4,000 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 |
| E. Insurance | | | | | | | | | | |
| Property | 2,134 | 11,871 | 16,802 | 20,858 | 24,285 | 26,773 | 29,367 | 31,914 | 34,190 | 35,657 |
| Miscellaneous | 500 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 |
| F. Taxes | | | | | | | | | | |
| Property | 3,810 | 21,197 | 30,003 | 37,245 | 43,364 | 47,806 | 52,438 | 56,988 | 61,052 | 63,673 |
| Franchise Fee | 2,981 | 24,363 | 40,565 | 58,970 | 75,557 | 87,091 | 99,533 | 111,586 | 121,046 | 129,341 |
| Sales Tax | 9,144 | 41,728 | 21,134 | 17,381 | 14,686 | 10,661 | 11,117 | 10,918 | 9,756 | 6,288 |
| Payroll Tax | 3,520 | 9,585 | 11,605 | 12,980 | 13,420 | 12,650 | 13,090 | 13,530 | 13,145 | 13,145 |
| Licenses and Fees | 200 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 |
| G. Utilities | | | | | | | | | | |
| Telephones | 4,000 | 4,000 | 4,000 | 4,000 | 4,000 | 4,000 | 4,000 | 4,000 | 4,000 | 4,000 |
| Utilities and Maintenance | 1,800 | 4,800 | 7,800 | 9,000 | 9,000 | 9,000 | 9,000 | 9,000 | 9,000 | 9,000 |
| H. Billing and Bookkeeping | 2,415 | 16,920 | 28,170 | 40,950 | 52,470 | 60,480 | 69,120 | 77,490 | 84,060 | 89,820 |
| I. Promotion and Sales | 13,800 | 99,000 | 75,000 | 85,200 | 76,800 | 53,400 | 57,600 | 55,800 | 43,800 | 38,400 |
| J. Drop Replacement and Turnover | -- | 7,176 | 51,480 | 39,000 | 44,304 | 39,936 | 27,768 | 29,952 | 29,016 | 22,776 |
| K. Travel and Entertainment | 2,250 | 3,627 | 3,750 | 3,750 | 3,750 | 3,750 | 3,750 | 3,750 | 3,750 | 3,750 |
| L. Membership and Dues | 858 | 6,344 | 9,718 | 12,720 | 14,725 | 15,068 | 15,395 | 15,530 | 15,601 | 15,678 |
| M. Contributions | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 |
| N. Bad Debts | 1,490 | 12,182 | 20,282 | 29,485 | 37,778 | 43,546 | 49,766 | 55,793 | 60,523 | 64,670 |
| O. Freight | 200 | 700 | 700 | 700 | 700 | 700 | 700 | 700 | 700 | 700 |
| P. Sales Commission | 4,140 | 29,700 | 22,500 | 25,560 | 23,040 | 16,020 | 17,280 | 16,740 | 13,140 | 11,520 |
| Total Office Operating Costs | 71,145 | 370,369 | 452,417 | 524,054 | 566,609 | 562,281 | 594,204 | 630,761 | 642,039 | 649,598 |

Table 6-10

TOTAL COSTS

| Total Costs | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Capital | 751,031 | 3,462,338 | 1,748,650 | 1,438,442 | 1,213,801 | 893,430 | 916,451 | 902,300 | 807,956 | 521,501 |
| Operating | (183,943) | (601,399) | (706,746) | (809,320) | (874,261) | (856,290) | (907,304) | (966,521) | (975,946) | (987,618) |
| Plant | 112,798 | 231,030 | 254,329 | 285,266 | 307,652 | 294,009 | 313,100 | 335,760 | 333,907 | 338,020 |
| Office | 71,145 | 370,369 | 452,417 | 524,054 | 566,609 | 562,281 | 594,204 | 630,761 | 642,039 | 649,598 |

Table 6-11

SINGLE VS. DUAL CABLE COSTS

| | Single Cable | Dual Cable |
|---|---|---|
| Capital | | |
| Headend | $ 111,312 | $ 116,572 |
| Distribution | 7,686,000 | 11,545,380 |
| Subscriber Drop | 4,707,765 | 3,602,980 |
| Test Equipment | 47,323 | 55,323 |
| Furniture and Leasehold | 93,500 | 93,500 |
| Total | $12,645,900 | $15,413,755 |
| Plant Operating | | |
| Salary | $ 1,466,280 | $ 2,138,715 |
| Benefits | 175,953 | 256,645 |
| Headend Maintenance | 10,000 | 10,000 |
| Distribution Maintenance | 273,748 | 547,496 |
| Microwave | 20,780 | 20,780 |
| Trunk Rental | 287,700 | 462,000 |
| Pole Rental | 348,160 | 348,160 |
| Tower | 6,000 | 6,000 |
| Inventory | 73,422 | 81,422 |
| Tools | 15,000 | 15,000 |
| Power | 128,828 | 250,656 |
| Total | $ 2,805,871 | $ 4,136,874 |
| Office Operating | | |
| Property Insurance | $ 233,851 | $ 285,723 |
| Property Tax | 417,576 | 510,286 |
| Sales Tax | 152,813 | 186,747 |
| Payroll Taxes | 116,670 | 170,182 |
| All Others | 4,142,607 | 4,142,607 |
| Total | $ 5,063,517 | $ 5,295,545 |

To examine the impact of construction alternatives, two additional cases were examined:

- All aerial construction.
- All underground construction.

The major impact of these alternatives is in capital costs. An increase of 162 percent in capital costs occurs when going from the all-aerial to all-underground case. Because pole rentals are not applicable in the underground case, plant operating costs decrease by 17 percent. This decrease is compensated by a 14-percent increase in office operating costs in the all-underground case because of increases in the tax and insurance base. These results are shown in Table 6-12.

Table 6-12

ALTERNATIVE CONSTRUCTION TECHNIQUES VS. TOTAL COST

| | All Aerial | 50%/50% | All Underground |
|---|---|---|---|
| **Capital** | | | |
| Headend | $ 111,312 | $ 111,312 | $ 111,312 |
| Distribution | 3,476,340 | 7,686,000 | 11,895,660 |
| Drops and Convertors | 3,064,060 | 4,707,765 | 5,758,660 |
| Test Equipment | 47,323 | 47,323 | 47,323 |
| Furniture and Leasehold | 93,500 | 93,500 | 93,500 |
| Total | $6,792,535 | $12,645,900 | $17,906,455 |
| **Plant Operating** | | | |
| Pole Rental | $ 696,320 | $ 348,160 | $ 0 |
| All Others | 2,457,711 | 2,457,711 | 2,457,711 |
| Total | $3,154,031 | $ 2,805,871 | $ 2,457,711 |
| **Office Operating** | | | |
| Property Insurance | $ 126,611 | $ 233,811 | $ 331,107 |
| Property Tax | 225,698 | 417,576 | 590,235 |
| Sales Tax | 82,572 | 152,813 | 215,939 |
| All Others | 4,259,277 | 4,259,277 | 4,259,277 |
| Total | $4,694,158 | $ 5,063,477 | $ 5,396,558 |

# APPENDIX A

REPRESENTATIVE SYSTEM COSTS: HEADEND EQUIPMENT

Three specific illustrations have been developed to illustrate the process of obtaining total headend capital costs. These examples, which are purely hypothetical and may not reflect actual practices or procedures, are:

- Case I: 8-Channel System

  with 6 VHF signals
  2 UHF signals

  with guyed tower

  including FM - 9 channels

- Case II: 20-Channel System

  with 10 VHF signals
  3 UHF signals
  3 Microwave signals
  4 Studio signal

  with guyed tower

  including FM - 9 channels

- Case III: 36-Channel System

  with 12 VHF signals
  6 UHF signals
  8 Microwave signals
  10 Studio signals

  with guyed tower

  including FM - 9 channels

The first step is to estimate the tower costs. Without additional information, it can be assumed that the tower is of average height and is a guyed type. The average height for a guyed tower is 300'. Supervision costs for these towers must also be included. Utilizing the previously discussed costs for towers, the results would be:

| | Case I | Case II | Case III |
|---|---|---|---|
| Guyed Tower Cost | $16,500 | $16,500 | $16,500 |
| Supervision | $ 1,500 | $ 1,500 | $ 1,500 |
| Total Tower | $18,000 | $18,000 | $18,000 |

The next item is antennas. It will be assumed that the signals being received at the tower are of medium strength. In addition, both the maximum number of antennas and the 80 percent rule will be employed. Costs for antennas will be selected from Table A-1. The resultant antenna costs are shown below:

| | Case I | | Case II | | Case III | |
|---|---|---|---|---|---|---|
| | 80% Rule | Max | 80% Rule | Max | 80% Rule | Max |
| Antennas | 6,001 | 6,956 | 9,479 | 11,389 | 12,615 | 15,138 |
| FM Antennas | 500 | 500 | 500 | 500 | 500 | 500 |
| Supervision | 1,500 | 1,500 | 2,000 | 2,000 | 2,000 | 2,000 |
| Total Antennas | 8,001 | 8,956 | 11,979 | 13,889 | 15,115 | 17,638 |

A small headend building will be assumed for the 8-channel system and a large building for the 20-and 36-channel systems (Table A-2). With the inclusion of headend building costs, the total costs so far are:

| | Case I | | Case II | | Case III | |
|---|---|---|---|---|---|---|
| | 80% Rule | Max | 80% Rule | Max | 80% Rule | Max |
| Tower | 18,000 | 18,000 | 18,000 | 18,000 | 18,000 | 18,000 |
| Antennas | 8,001 | 8,956 | 11,979 | 13,889 | 15,115 | 17,638 |
| Building | 2,240 | 2,240 | 6,080 | 6,080 | 6,080 | 6,080 |
| Total | 28,241 | 29,196 | 36,059 | 37,969 | 39,195 | 41,718 |

The "model" illustrated in Figure 3-7 and the costs shown in Table 3-7 are reproduced here to determine the total headend electronic costs for all three cases.

1. VHF Signal (1 Signal)

$$= \begin{bmatrix} \text{1 PreAmp} \\ \text{1 Power Supply} \\ \text{2 Filters} \\ \text{1 Signal Processor} \end{bmatrix} \times \begin{bmatrix} 208 \\ 30 \\ 101 \\ 1150 \end{bmatrix} = \$1,590$$

2. UHF Signal (1 Signal)

$$= \begin{bmatrix} \text{1 PreAmp} \\ \text{1 PreAmp Power Supply} \\ \text{1 UHF Converter} \\ \text{2 Filters} \\ \text{1 Signal Processor} \end{bmatrix} \times \begin{bmatrix} 290 \\ 51 \\ 750 \\ 101 \\ 1150 \end{bmatrix} = \$2,443$$

3. Microwave Signal (1 Signal)

$$= \begin{bmatrix} \text{1 Antenna} \\ \text{1 Receiver} \\ \text{1 Modulator} \\ \text{1 Filter} \end{bmatrix} \times \begin{bmatrix} 535 \\ 3335 \\ 1225 \\ 101 \end{bmatrix} = \$5,196$$

4. Studio Signal (1 Signal)

$$= \begin{bmatrix} \text{1 Modulator} \\ \text{1 Filter} \end{bmatrix} \times \begin{bmatrix} 1225 \\ 101 \end{bmatrix} = \$1,326$$

5. FM Signals (9 Signals)

$$= \begin{bmatrix} \text{1 PreAmp and Power Supply} \\ \text{9 Tuners} \\ \text{1 Trap} \\ \text{1 Power Supply and Console} \\ \text{1 Tuner Console} \end{bmatrix} \times \begin{bmatrix} 85 \\ 120 \\ 45 \\ 260 \\ 160 \end{bmatrix} = \$1,630$$

6. Common Equipment - One Cable $6 < \text{Channels} \leq 12$

$$= \begin{bmatrix} \text{2 Pilot Carrier Generators} \\ \text{2 Combining Networks} \\ \text{1 Splitter} \\ \text{1 Directional Coupler} \end{bmatrix} \times \begin{bmatrix} 350 \\ 105 \\ 30 \\ 30 \end{bmatrix}$$

$$\begin{bmatrix} \text{1 Non-Duplicating System} \end{bmatrix} \times \begin{bmatrix} 4500 \end{bmatrix}$$

$$= \$970 + \$4500 = \$5,470$$

7. Common Equipment - One Cable $12 < \text{Channels} \leq 24$

$$= \begin{bmatrix} \text{2 Pilot Carrier Generators} \\ \text{4 Combining Networks} \\ \text{1 Splitter} \\ \text{1 Directional Coupler} \end{bmatrix} \times \begin{bmatrix} 350 \\ 105 \\ 30 \\ 30 \end{bmatrix}$$

$$+ \begin{bmatrix} \text{1 Non-duplicating System} \end{bmatrix} \times \begin{bmatrix} 4500 \end{bmatrix}$$

$$= \$1180 + 4500 = \$5680$$

8. Common Equipment - Two Cables $30 < \text{Channels} \leq 36$

$$= \underbrace{\begin{bmatrix} \text{2 Pilot Carrier Generators} \\ \text{4 Combining Networks} \\ \text{1 Splitter} \\ \text{1 Coupler} \end{bmatrix} \times \begin{bmatrix} 350 \\ 105 \\ 30 \\ 30 \end{bmatrix}}_{\text{Cable 1 - 24 Channels}} + \underbrace{\begin{bmatrix} \text{2 Pilot Carrier Generators} \\ \text{2 Combining Networks} \\ \text{1 Splitter} \\ \text{1 Coupler} \end{bmatrix} \times \begin{bmatrix} 350 \\ 105 \\ 30 \\ 30 \end{bmatrix}}_{\text{Cable 2} \quad 6 < \text{Channels} \leq 12}$$

$$+ \begin{bmatrix} \text{1 Non-Duplicating System} \end{bmatrix} \times \begin{bmatrix} 4500 \end{bmatrix}$$

$$= 1180 + 970 + 6650 = \$6650$$

The prewiring costs for headend consoles must be included for each case. This amounts to \$1,600 for Case 1, \$4,000 for Case II, and \$7,200 for Case III. Supervision, installation, and microwave installation (where applicable) costs must also be added to the equipment costs. The total costs for the electronics are shown below:

Table A-1

TOTAL ELECTRONICS COST

| | Case I | | Case II | | Case III | |
|---|---|---|---|---|---|---|
| | No. of Signals | Dollars | No. of Signals | Dollars | No. of Signals | Dollars |
| VHF | 6 | 9,540 | 10 | 15,900 | 12 | 19,080 |
| UHF | 2 | 4,886 | 3 | 7,329 | 6 | 14,658 |
| Microwave | | | 3 | 15,588 | 8 | 41,568 |
| Studio | | | 4 | 5,304 | 10 | 13,260 |
| FM | 9 | 1,630 | 9 | 1,630 | 9 | 1,630 |
| Common Equip. | - | 5,470 | - | 5,680 | - | 6,650 |
| Subtotal Headend Electronics | | 21,526 | | 51,431 | | 96,846 |
| Prewiring | | 1,600 | | 4,000 | | 7,200 |
| Installation | | 1,500 | | 3,000 | | 3,000 |
| Installation Microwave | | - | | 2,250 | | 6,000 |
| TOTAL Headend Electronics | | 24,626 | | 60,681 | | 113,046 |

The total costs for the complete headend are shown in Table A-2.

Table A-2

TOTAL HEADEND COSTS

| | Case I | | Case II | | Case III | |
|---|---|---|---|---|---|---|
| | 80% Rule | Max. | 80% Rule | Max. | 80% Rule | Max. |
| Tower | 18,000 | 18,000 | 18,000 | 18,000 | 18,000 | 18,000 |
| Antenna | 8,001 | 8,956 | 11,979 | 13,889 | 15,115 | 17,638 |
| Building | 2,240 | 2,240 | 6,080 | 6,080 | 6,080 | 6,080 |
| Headend Electronics | 24,626 | 24,626 | 60,681 | 60,681 | 113,046 | 113,046 |
| TOTAL | 52,867 | 53,822 | 96,740 | 98,650 | 152,241 | 154,764 |

One of the first conclusions that can be drawn from the above results is that the differences in antenna costs between the maximum rule and the 80 percent rule have no major significance in total costs. Going from the 80 percent rule to the maximum case only increases total costs by 2 percent. If the maximum number of antennas were assumed, and the example recalculated to determine the cost differences between the use of weak, average, and strong signal antennas, significant differences do then occur (Table A-3).

Table A-3

TOTAL HEADEND COSTS FOR VARIOUS SIGNAL STRENGTHS
(Maximum Number of Antennas)

| | Case I | | | Case II | | | Case III | | |
|---|---|---|---|---|---|---|---|---|---|
| | Strong | Average | Weak | Strong | Average | Weak | Strong | Average | Weak |
| Tower | 18,000 | 18,000 | 18,000 | 18,000 | 18,000 | 18,000 | 18,000 | 18,000 | 18,000 |
| Antenna | 5,352 | 8,956 | 15,848 | 7,998 | 13,889 | 25,255 | 9,736 | 17,638 | 32,146 |
| Building | 2,240 | 2,240 | 2,240 | 6,080 | 6,080 | 6,080 | 6,080 | 6,080 | 6,080 |
| Headend Electronics | 24,626 | 24,626 | 24,626 | 24,626 | 24,626 | 24,626 | 24,626 | 24,626 | 24,626 |
| TOTAL | 50,218 | 53,822 | 60,717 | 92,009 | 97,900 | 109,266 | 142,362 | 150,264 | 164,772 |

In this case, total costs increase significantly with the need for weak signal antennas. The inc[illegible]e (going from average signals to weak signals) ranges from 13 percent in Case I to 10 percent in Case III. As the number of channels increase, the contribution of antenna costs to total costs decrease in all three signal strength cases. The relative percentages are shown in Table A-4.

Table A-4

ANTENNA COSTS AS A FUNCTION OF HEADEND COSTS

| | 8 Channels | 20 Channels | 36 Channels |
|---|---|---|---|
| Strong Signals | 10.7% | 8.7% | 6.8% |
| Average Signals | 16.6% | 14.2% | 11.7% |
| Weak Signals | 26.1% | 23.1% | 19.5% |

# APPENDIX B

## REPRESENTATIVE SYSTEM COSTS: DISTRIBUTION SYSTEM

The various sections of Chapter 4 presented a series of independent component and per mile component costs. The translation from independent costs into total distribution costs can be performed directly. The process is, however, tedious and involved. For example, to develop a total burial cost per mile in concrete, the costs associated with breakup, hauling, trenching, back filling, etc., must be added together. To simplify this task, a number of total per mile costs have been developed:

- Trunk cable and trunk amplifier per mile costs (Table B-1)
- Feeder cable and line extender per mile costs (Table B-2)
- Total per mile construction costs--various soil conditions (Table B-3)
- Total per mile construction costs: asphalt (Table B-4)
- Total per mile construction costs: concrete (Table B-5)
- Total per mile amplifier installation and pedestal costs (Table B-6)

Not all of the required components have been analyzed on a per mile basis. These items, which include bridger amps, subscriber drop equipment, and drop cable, are dependent upon subscriber density and number of subscribers.

Two hypothetical examples have been developed to show how to estimate total distribution costs. These examples are not meant to portray realistic systems but only how to use the cost tables.

- Example I:

  8-Channel Rural System

  Aerial Construction
  Low Capacity Equipment including conventional foam cable
  Trunk Cable (.500") - 15 miles
  Feeder Cable (.412") - 60 miles
  Feeder/Trunk Ratio - 4:1
  1000 Subscribers
  Strand Miles = 75 miles

- Example II:

  32-Channel Urban System

  3" Asphalt - Direct Bury - No Conduit
  Two Way Capability - High capacity equipment
  Trunk Cable (.750 super foam) - 50 miles
  Feeder Cable (.412 super foam) - 300 miles
  Feeder/Trunk Ratio - 6:1
  15,000 Subscribers
  Dual Activated Cable
  Strand Miles = 350 miles

Procedure - Example I

- 1. Cost of Trunk Cable and Amplifiers (.500 conventional foam, amps with ASC and AGC)

  15 miles x \$2,316/mile = \$34,740

- 2. Cost of Feeder Cable and Amplifiers (.412 conventional foam)

  60 miles x \$1163 = \$69,780

- 3. Number of Bridger Amps

  Per Mile = $\left(\frac{4}{1}\right)$ x (0.6188) = 2.48
  Total System = (2.48) x 15 = 37.2 = 38

- 4. Cost of Bridger Amps

  38 x \$544 = \$20,672

- 5. Cost of Automatic Slope Amplifiers

  2 x \$635 = \$1,270

- 6. Subscriber Drop Cost

  1000 x \$17.50 = \$17,500

- 7. Subscriber Drop Cable

  100' per customer x 1,000 customers = 100,000'

  $\frac{100,000}{5,280}$ miles x \$194/mile = \$3675

- 8. Power Supplies

  $139/mile x 75 miles = $10,425

  Total Equipment Cost (Items 1-8) = $158,062

- 9. Aerial Construction

  75 miles x $2870/mile = $215,250

  Total Fquipment and Installation Cost (Items 1-9) = $373,312

Proc( lure - Example II

- 1. Cost of Trunk Cable and Amplifierf (.750" super foam with armour, two-way with ASC and AGC)

  50 x $3680 = $184,000 x 2 = $368,000

- 2. Cost of Feeder Cable and Amplifiers (.412 super foam)

  300 x $2373 = $711,900 x 2 = $1,423,800

- 3. Number of Bridger Amplifiers

  $\left(\frac{6}{1}\right)$ x (0.6188) = 3.71

- 4. Cost of Bridger Amps

  3.71 per mile x 50 miles x $745.00 = $138,198

  $138,198 x 2 = $276,396

- 5. Cost of Automatic Slope Amplifiers

  2 x $635 = $1270 x 2 = $2540

- 6. Subscriber Drop Cost

  15,000 x $63.00 = $945,000

- 7. Subscriber Drop Cable

  200' per customer x 15,000 = 3,000,000

  $$\frac{3{,}000{,}000}{5280} \times \$194/\text{mile} = \$110{,}227$$

- 8. Power Supplies

  $139/mile x 350 miles x 2 = $97,300

  Total Equipment Cost (Items 1-8) = $3,085,065

- 9. Construction Cost 3" Asphalt

  (.750") 50 miles x $9658 = $ 482,900

  (.412") 300 miles x 7037 = $2,111,100

  $2,594,000

  plus Moving In Cost ($250) = $2,594,250

- 10. Amplifier Installation Cost (Includes Pedestal)

| | |
|---|---|
| (Trunk) 50 x 222.56 x 2 | = $ 22,256 |
| (Feeder) 300 x 514.80 x 2 | = $308,880 |
| (Bridger) 3.71 x 50 x 104 | = $ 15,292 |
| (Two Automatic Slope Amplifiers) 2 x $104 | = $ 208 |
| | $346,636 |

- 11. Drop Cable Installation (In PVC)

  Assume only 25' per subscriber is under asphalt.

  $$\frac{25' \times 15{,}000}{5280} \times \$9457 = \$671{,}636$$

Total Equipment and Installation Cost (Items 1-11) = $6,697,587

Table B-1

TOTAL PER MILE CABLE AND TRUNK AMPLIFIER COST: TRUNK CABLE

(Does Not Include Bridger Amps)

| Cable Type | Low-Capacity System: With AGC & ASC[a,b] | Low-Capacity System: All AGC | High-Capacity System: With AGC & ASC[a] | High-Capacity System: All AGC | Two-Way System: With AGC & ASC[a] | Two-Way System: All AGC |
|---|---|---|---|---|---|---|
| **0.500** | | | | | | |
| **Unjacketed** | | | | | | |
| Conventional Foam--small quantity | 2,283 | 2,526 | 3,085 | 3,275 | 3,343 | 3,595 |
| Conventional Foam--large quantity | 2,206 | 2,447 | 3,005 | 3,196 | 3,261 | 3,516 |
| Super Foam--small quantity | 2,059 | 2,253 | 2,700 | 2,852 | 2,9[illegible] | 3,109 |
| Super Foam--large quantity | 1,974 | 2,168 | 2,615 | 2,767 | [illegible],821 | 3,024 |
| **Jacketed** | | | | | | |
| Conventional Foam--small quantity | 2,412 | 2,654 | 3,212 | 3,402 | 3,470 | 3,723 |
| Conventional Foam--large quantity | 2,316 | 2,558 | 3,116 | 3,306 | 3,374 | 3,627 |
| Super Foam--small quantity | 2,169 | 2,363 | 2,810 | 2,962 | 3,016 | 3,218 |
| Super Foam--large quantity | 2,071 | 2,265 | 2,[illegible]12 | 2,864 | 2,918 | 3,120 |
| **Jacketed with Flooding** | | | | | | |
| Conventional Foam--small quantity | 2,447 | 2,689 | 3,[illegible]47 | 3,437 | [illegible],505 | 3,758 |
| Conventional Foam--large quantity | 2,316 | 2,614 | 3,172 | 3,362 | 3,430 | 3,683 |
| Super Foam--small quantity | 2,169 | 2,407 | 2,854 | 3,006 | 3,060 | 3,262 |
| Super Foam--large quantity | 2,071 | 2,308 | 2,755 | 2,907 | 2,961 | 3,163 |
| **Jacketed with Armour** | | | | | | |
| Conventional Foam--small quantity | 2,823 | 3,065 | 3,623 | 3,813 | 3,881 | 4,134 |
| Conventional Foam--large quantity | 2,723 | 2,965 | 3,523 | 3,713 | 3,781 | 4,034 |
| Super Foam--small quantity | 2,655 | 2,849 | 3,296 | 3,448 | 3,502 | 3,704 |
| Super Foam--large quantity | 2,523 | 2,717 | 3,164 | 3,316 | 3,370 | 3,572 |
| **0.750** | | | | | | |
| **Unjacketed** | | | | | | |
| Conventional Foam--small quantity | 2,457 | 2,632 | 3,038 | 3,177 | 3,226 | 3,410 |
| Conventional Foam--large quantity | 2,372 | 2,548 | 2,954 | 3,093 | 3,142 | 3,326 |
| Super Foam--small quantity | 2,331 | 2,461 | 2,763 | 2,865 | 2,903 | 3,039 |
| Super Foam--large quantity | 2,257 | 2,387 | 2,689 | 2,7[illegible]2 | 2,829 | 2,965 |
| **Jacketed** | | | | | | |
| Conventional Foam--small quantity | 2,617 | 2,793 | 3,199 | 3,337 | 3,[illegible]86 | 3,571 |
| Conventional Foam--large quantity | 2,484 | 2,660 | 3,066 | 3,204 | 3,253 | 3,438 |
| Super Foam--small quantity | 2,463 | 2,593 | 2,895 | 2,998 | 3,[illegible]34 | 3,171 |
| Super Foam--large quantity | 2,384 | 2,514 | 2,816 | 2,919 | 2,955 | 3,092 |
| **Jacketed with Flooding** | | | | | | |
| Conventional Foam--small quantity | 2,702 | 2,878 | 3,284 | 3,422 | 3,471 | 3,656 |
| Conventional Foam--large quantity | 2,597 | 2,773 | 3,179 | 3,317 | 3,366 | 3,551 |
| Super Foam--small quantity | 2,528 | 2,658 | 2,960 | 3,063 | 3,099 | 3,236 |
| Super Foam--large quantity | 2,419 | 2,549 | 2,851 | 2,954 | 2,990 | 3,127 |
| **Jacketed with Armour** | | | | | | |
| Conventional Foam--small quantity | 3,205 | 3,381 | 3,787 | 3,925 | 3,974 | 4,159 |
| Conventional Foam--large quantity | 3,079 | 3,255 | 3,661 | 3,799 | 3,848 | 4,033 |
| Super Foam--small quantity | 3,179 | 3,309 | 3,661 | 3,714 | 3,750 | 3,887 |
| Super Foam--large quantity | 3,109 | 3,239 | 3,541 | 3,644 | 3,680 | 3,817 |

a For a total of six trunk amplifiers, one is AGC and one is ASC.

b For low-capacity systems, ASC amplifiers are not available. Therefore, every third amplifier is AGC.

Table B-2

TOTAL PER MILE CABLE AND LINE EXTENDER COST: FEEDER CABLE

| Cable Type | Low Capacity[a] | High Capacity[a] | Two-Way[a] |
|---|---|---|---|
| 0.412 | | | |
| Unjacketed | | | |
| Conventional foam-- small quantity | 1,123 | 1,609 | 1,930 |
| Conventional foam-- large quantity | 1,075 | 1,561 | 1,882 |
| Super foam-- small quantity | 1,199 | 1,685 | 2,002 |
| Super foam-- large quantity | 1,149 | 1,635 | 1,956 |
| Jacketed | | | |
| Conventional foam - small quantity | 1,231 | 1,717 | 2,038 |
| Conventional foam - large quantity | 1,163 | 1,649 | 1,970 |
| Super foam - small quantity | 1,306 | 1,792 | 2,113 |
| Super foam - large quantity | 1,234 | 1,720 | 2,041 |
| Jacketed with Flooding | | | |
| Conventional foam - small quantity | 1,260 | 1,746 | 2,067 |
| Conventional foam - large quantity | 1,204 | 1,690 | 2,011 |
| Super foam - small quantity | 1,341 | 1,827 | 2,148 |
| Super foam - large quantity | 1,264 | 1,750 | 2,071 |
| Jacketed with Armour | | | |
| Conventional foam - small quantity | 1,572 | 2,058 | 2,379 |
| Conventional foam - large quantity | 1,508 | 1,994 | 2,315 |
| Super foam - small quantity | 1,663 | 2,179 | 2,500 |
| Super foam - large quantity | 1,566 | 2,052 | 2,373 |

a. Assumes 3 line extenders per 3,200 feet of drop cable.

Table B-3

TOTAL PER MILE CONSTRUCTION COSTS

| Alternatives<br>Type, Number and Size | Soil Type 1<br>Topsoil, Sand, Loam, Etc. | Soil Type 2<br>Clay or Mixture of | Soil Type 3<br>Small Rock, or Mixture of |
|---|---|---|---|
| **Direct Burial** | | | |
| 1 (.412 cable) | 3,785 | 4,207 | 4,735 |
| 2 (.412 cables) | 4,827 | 5,249 | 5,777 |
| 1 (.500 cable) | 4,167 | 4,589 | 5,117 |
| 2 (.500 cables) | 5,515 | 5,937 | 6,465 |
| 1 (.750 cable) | 5,241 | 5,663 | 6,191 |
| 2 (.750 cables) | 7,437 | 7,870 | 8,398 |
| **Conduit Burial** | | | |
| **Rigid Steel** | | | |
| 1 (.412 cable) | 14,083 | 14,505 | 15,033 |
| 2 (.412 cables) | 20,634 | 21,056 | 21,584 |
| 1 (.500 cable) | 14,364 | 14,786 | 15,314 |
| 2 (.500 cables) | 21,185 | 21,607 | 22,134 |
| 1 (.750 cable) | 15,591 | 16,013 | 16,541 |
| 2 (.750 cables) | 23,394 | 23,816 | 24,344 |
| 1 (Drop Cable) | 7,285 | 7,707 | 8,235 |
| 2 (Drop Cables) | 7,653 | 8,075 | 8,603 |
| **PVC** | | | |
| 1 (.412 cable) | 12,606 | 13,028 | 13,556 |
| 2 (.412 cables) | 17,846 | 18,268 | 18,796 |
| 1 (.500 cable) | 12,912 | 13,334 | 13,862 |
| 2 (.500 cables) | 18,397 | 18,819 | 19,347 |
| 1 (.750 cable) | 14,139 | 14,561 | 15,089 |
| 2 (.750 cables) | 20,606 | 21,028 | 21,556 |
| 1 (Drop cable) | 6,879 | 7,301 | 7,829 |
| 2 (Drop cables) | 7,247 | 7,669 | 8,197 |

Table B-4

TOTAL PER MILE CONSTRUCTION COSTS: CONCRETE

| Alternatives | Concrete Depth, Inches | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Type, Number and Size | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Direct Burial | | | | | | | | | | | |
| 1 (.412 cable) | 6,818 | 7,810 | 8,365 | 8,980 | 9,653 | 10,285 | 10,970 | 11,677 | 12,257 | 13,013 | 13,603 |
| 2 (.412 cables) | 7,860 | 8,852 | 9,407 | 10,022 | 10,695 | 11,327 | 12,012 | 12,709 | 13,299 | 14,055 | 14,645 |
| 1 (.500 cable) | 7,200 | 8,192 | 8,747 | 9,362 | 10,035 | 10,667 | 11,352 | 12,049 | 12,639 | 13,395 | 13,985 |
| 2 (.500 cables) | 8,548 | 9,540 | 10,095 | 10,710 | 11,383 | 12,015 | 12,700 | 13,397 | 13,987 | 14,743 | 15,333 |
| 1 (.750 cable) | 8,274 | 9,266 | 9,821 | 10,436 | 11,109 | 11,741 | 12,426 | 13,123 | 13,713 | 14,469 | 15,059 |
| 2 (.750 cables) | 10,481 | 11,473 | 12,028 | 12,643 | 13,316 | 13,948 | 14,633 | 15,330 | 15,920 | 16,676 | 17,266 |
| Conduit Burial | | | | | | | | | | | |
| Rigid Steel | | | | | | | | | | | |
| 1 (.412 cable) | 17,116 | 18,108 | 18,663 | 19,278 | 19,951 | 20,583 | 21,268 | 21,965 | 22,555 | 23,311 | 23,901 |
| 2 (.412 cables) | 23,667 | 24,659 | 25,214 | 25,829 | 26,502 | 27,134 | 27,819 | 28,516 | 29,106 | 29,862 | 30,452 |
| 1 (.500 cable) | 17,397 | 18,389 | 18,944 | 19,559 | 20,232 | 20,864 | 21,549 | 22,246 | 22,836 | 23,592 | 24,182 |
| 2 (.500 cables) | 24,218 | 25,210 | 25,765 | 26,280 | 27,053 | 27,685 | 28,370 | 29,067 | 29,657 | 30,413 | 31,003 |
| 1 (.750 cable) | 18,624 | 19,616 | 20,171 | 20,786 | 21,459 | 22,091 | 22,776 | 23,473 | 24,063 | 24,819 | 25,409 |
| 2 (.750 cables) | 26,427 | 27,419 | 27,974 | 28,589 | 29,262 | 29,894 | 30,579 | 31,276 | 31,866 | 32,622 | 33,212 |
| 1 (Drop cable) | 10,318 | 11,310 | 11,865 | 12,480 | 13,153 | 13,785 | 14,470 | 15,167 | 15,757 | 16,513 | 17,103 |
| 2 (Drop cables) | 10,686 | 11,678 | 12,233 | 12,848 | 13,521 | 14,153 | 14,838 | 15,535 | 16,125 | 16,881 | 17,471 |
| PVC | | | | | | | | | | | |
| 1 (.412 cable) | 15,639 | 16,631 | 17,186 | 17,801 | 18,474 | 19,106 | 19,791 | 20,488 | 21,078 | 21,834 | 22,424 |
| 2 (.412 cables) | 20,879 | 21,871 | 22,426 | 23,041 | 23,714 | 24,346 | 25,031 | 25,728 | 26,318 | 27,074 | 27,664 |
| 1 (.500 cable) | 15,945 | 16,937 | 17,492 | 18,107 | 18,780 | 19,412 | 20,097 | 20,794 | 21,384 | 22,140 | 22,730 |
| 2 (.500 cables) | 21,430 | 22,422 | 22,977 | 23,592 | 24,265 | 24,897 | 25,582 | 26,279 | 26,869 | 27,625 | 28,215 |
| 1 (.750 cable) | 17,172 | 18,164 | 18,719 | 19,334 | 20,007 | 20,639 | 21,324 | 22,021 | 22,611 | 23,367 | 23,957 |
| 2 (.750 cables) | 23,639 | 24,631 | 25,186 | 25,801 | 26,474 | 27,106 | 27,791 | 28,488 | 29,078 | 29,834 | 30,424 |
| 1 (Drop cable) | 9,912 | 10,904 | 11,459 | 12,074 | 12,747 | 13,379 | 14,064 | 14,761 | 15,351 | 16,107 | 16,697 |
| 2 (Drop cables) | 10,280 | 11,272 | 11,827 | 12,442 | 13,115 | 13,747 | 14,432 | 15,129 | 15,719 | 16,475 | 17,065 |

Table B-5

TOTAL PER MILE CONSTRUCTION COSTS: ASPHALT

| Alternatives | Asphalt Depth, Inches | | | | |
|---|---|---|---|---|---|
| Type, Number and Size | 2 | 3 | 4 | 5 | 6 |
| **Direct Burial** | | | | | |
| 1 (.412 cable) | 5,562 | 5,995 | 6,411 | 6,787 | 7,226 |
| 2 (.412 cables) | 6,604 | 7,037 | 7,453 | 7,829 | 8,268 |
| 1 (.500 cable) | 5,944 | 6,377 | 6,793 | 7,169 | 7,608 |
| 2 (.500 cables) | 7,292 | 7,725 | 8,141 | 8,517 | 8,956 |
| 1 (.750 cable) | 7,018 | 7,451 | 7,867 | 8,243 | 8,682 |
| 2 (.750 cables) | 9,225 | 9,658 | 10,074 | 10,450 | 10,889 |
| **Conduit Burial** | | | | | |
| Rigid Steel | | | | | |
| 1 (.412 cable) | 15,835 | 16,268 | 16,684 | 17,060 | 17,499 |
| 2 (.412 cables) | 22,411 | 22,844 | 23,260 | 23,636 | 24,075 |
| 1 (.500 cable) | 16,141 | 16,574 | 16,990 | 17,366 | 17,805 |
| 2 (.500 cables) | 22,962 | 23,395 | 23,811 | 24,187 | 24,626 |
| 1 (.750 cable) | 17,368 | 17,801 | 18,217 | 18,593 | 19,032 |
| 2 (.750 cables) | 25,171 | 25,604 | 26,020 | 26,396 | 26,835 |
| 1 (Drop cable) | 9,062 | 9,495 | 9,911 | 10,287 | 10,726 |
| 2 (Drop cables) | 9,430 | 9,863 | 10,279 | 10,655 | 11,094 |
| PVC | | | | | |
| 1 (.412 cable) | 14,383 | 14,816 | 15,232 | 15,608 | 16,047 |
| 2 (.412 cables) | 19,623 | 20,056 | 20,472 | 20,848 | 21,287 |
| 1 (.500 cable) | 14,689 | 15,122 | 15,538 | 15,914 | 16,353 |
| 2 (.500 cables) | 20,174 | 20,607 | 21,023 | 21,399 | 21,838 |
| 1 (.750 cable) | 15,916 | 16,349 | 16,765 | 17,141 | 17,580 |
| 2 (.750 cables) | 22,383 | 22,816 | 23,232 | 23,608 | 24,047 |
| 1 (Drop cable) | 8,656 | 9,089 | 9,505 | 9,881 | 10,320 |
| 2 (Drop cables) | 9,024 | 9,457 | 9,873 | 10,249 | 10,688 |

Table B-6

AMPLIFIER AND PEDESTAL INSTALLATION COST
(Per Mile)

(Does Not Include Bridger Amps)

| Cable Size | | Per Mile Cost | |
|---|---|---|---|
| .412 Conventional<br>.412 Super foam | Feeder Cable | $514.80 | (Assumes 3 Line Extenders per 3,200') |
| .500 Conventional | | $411.84 | |
| .500 Super foam | | $329.68 | |
| .750 Conventional | | $229.52 | |
| .750 Super foam | | $222.56 | |

APPENDIX C

## REPRESENTATIVE SYSTEM COSTS: OPERATING COSTS

To illustrate the use of these operating cost factor, a hypothetical example has been developed. This example examines operating costs over a ten-year period, beginning with the implementation of the system and continuing through level-off. The assumptions and parameters of the system are as follows:

Head end = $ 60,000
Cable = $2,025,000
Total Strand miles = 160

No Microwave Equipment
All underground cable - no aerial cable

| Year | New Subscribers | Cumulative Subscribers | Miles Added | Cum Miles | Service Revenues |
|---|---|---|---|---|---|
| 1 | 300 | 300 | 10 | 10 | $17,000 |
| 2 | 2300 | 2600 | 55 | 65 | 152,000 |
| 3 | 1700 | 4300 | 20 | 85 | 339,000 |
| 4 | 2000 | 6300 | 15 | 100 | 515,000 |
| 5 | 1700 | 8000 | 13 | 113 | 690,000 |
| 6 | 1200 | 9200 | 12 | 125 | 828,000 |
| 7 | 1500 | 10,700 | 10 | 135 | 951,000 |
| 8 | 1500 | 12,200 | 10 | 145 | 1,074,000 |
| 9 | 1000 | 13,200 | 10 | 155 | 1,181,000 |
| 10 | 1000 | 14,200 | 5 | 160 | $1,271,000 |

Note: Drop costs not included in example. Assume, for illustrative purposes, that all drop costs are included in cable cost.

I. Plant Operating Costs

A. Personnel

Manager

Year 1 $15,000

Year 2 15,000

Year 3 15,000 + 1,300 = $16,300 [$1300 for 1300 subscribers over base]

Year 4 16,300 + 2,000 = $18,300 [+ 2000 additional subscribers]

Year 5 18,300 + 1,700 = $20,000

Year 6 20,000 + 1,200 = $21,200

Year 7 21,200 + 1,500 = $22,700

Year 8 22,700 + 1,500 = $24,200

Year 9 24,200 + 1,000 = $25,000 [number is actually more than 25K but max is 25K]

Year 10 25,000

Chief Technician

Year 1 $12,000

Year 2 $12,000

Year 3 $12,000

Year 4 $12,000

Year 5 $12,000

Year 6 $12,000

Year 7 $12,000

Year 8 $12,000

Year 9 $12,000

Year 10 $12,000

Installers

| | | |
|---|---|---|
| Year 1 | 2 x $7000 = $14,000 | [Total = 2] |
| Year 2 | $14,000 | [Total = 2] |
| Year 3 | $14,000 | [Total = 2] |
| Year 4 | $14,000 | [Total = 2] |
| Year 5 | $14,000 | [Total = 2] |
| Year 6 | $14,000 | [Total = 2] |
| Year 7 | $14,000 | [Total = 2] |
| Year 8 | $14,000 | [Total = 2] |
| Year 9 | $14,000 | [Total = 2] |
| Year 10 | $14,000 | [Total = 2] |

Maintenance Technicians

| | | |
|---|---|---|
| Year 1 | 2 x $8000 = $16,000 | [Total = 2] |
| Year 2 | 16,000 | |
| Year 3 | 16,000 | |
| Year 4 | 16,000 | |
| Year 5 | 16,000 | |
| Year 6 | 16,000 + 8,000 = $24,000 | [Total = 3] |
| Year 7 | 24,000 | |
| Year 8 | 24,000 | |
| Year 9 | 24,000 | |
| Year 10 | 24,000 | |

Bench Technician

| | | |
|---|---|---|
| Year 1 | 0 | [Total = 0] |
| Year 2 | 0 | [Total = 0] |
| Year 3 | $8000 | [Total = 1] |
| Year 4 | $8000 | [Total = 1] |
| Year 5 | $8000 | [Total = 1] |
| Year 6 | $8000 | [Total = 1] |
| Year 7 | $8000 | [Total = 1] |
| Year 8 | $8000 | [Total = 1] |
| Year 9 | $8000 | [Total = 1] |
| Year 10 | $8000 | [Total = 1] |

Benefits

| | |
|---|---|
| Year 1 | (15,000 + 12,000 + 14,000 + 16,000 + 0) x .12 = $6,840 |
| Year 2 | (15,000 + 12,000 + 14,000 + 16,000 + 0) x .12 = $6,840 |
| Year 3 | (16,300 + 12,000 + 14,000 + 16,000 + 8,000) x .12 = $7,956 |
| Year 4 | (18,300 + 12,000 + 14,000 + 16,000 + 8,000) x .12 = $8,196 |
| Year 5 | (20,000 + 12,000 + 14,000 + 16,000 + 8,000) x .12 = $8,400 |
| Year 6 | (21,200 + 12,000 + 14,000 + 24,000 + 8,000) x .12 = $9,504 |
| Year 7 | (22,700 + 12,000 + 14,000 + 24,000 + 8,000) x .12 = $9,684 |
| Year 8 | (24,200 + 12,000 + 14,000 + 24,000 + 8,000) x .12 = $9,864 |
| Year 9 | (25,000 + 12,000 + 14,000 + 24,000 + 8,000) x .12 = $9,960 |
| Year 10 | (25,000 + 12,000 + 14,000 + 24,000 + 8,000) x .12 = $9,960 |

B. Repairs and Maintenance

Headend Repairs

Years 1 - 10 = $1,000 per year

Distribution System

Year 1 10 x 46 = $460

Year 2 10 x 46 + 55 x 46 = $2,990

Year 3 10 x 46 + 55 x 46 + 20 x 46 = $3,910

Year 4 10 x 66 + 55 x 46 + 20 x 46 + 15 x 46 = $4,800

Year 5 10 x 66 + 55 x 66 + 20 x 46 + 15 x 46 + 13 x 46 = $6,498

Year 6 10 x 66 + 55 x 66 + 20 x 66 + 15 x 46 + 13 x 46 + 12 x 46 = $7,450

Year 7 10 x 88 + 55 x 66 + 20 x 66 + 15 x 66 + 13 x 46 + 12 x 46
+ 10 x 46 = $8,430

Year 8 10 x 88 + 55 x 88 + 20 x 66 + 15 x 66 + 13 x 66 + 12 x 46
+ 10 x 46 + 10 x 46 = $10,360

Year 9 10 x 88 + 55 x 88 + 20 x 88 + 15 x 66 + 13 x 66 + 12 x 66
+ 10 x 46 + 10 x 46 + 10 x 46 = $11,500

Year 10 10 x 88 + 55 x 88 + 20 x 88 + 15 x 88 + 13 x 66 + 12 x 66
+ 10 x 66 + 10 x 46 + 10 x 46 + 5 x 46 = $12,260

C. Rental

Poles - not applicable

Tower Site

Years 1-10 = $600/year

D. Power

| | | |
|---|---|---|
| Year 1 | 700 + 28 x 10 | = $ 980 |
| Year 2 | 700 + 28 x 65 | = $2,520 |
| Year 3 | 700 + 28 x 85 | = $3,080 |
| Year 4 | 700 + 28 x 100 | = $3,500 |
| Year 5 | 700 + 28 x 113 | = $3,864 |
| Year 6 | 700 + 28 x 125 | = $4,200 |
| Year 7 | 700 + 28 x 135 | = $4,480 |
| Year 8 | 700 + 28 x 145 | = $4,760 |
| Year 9 | 700 + 28 x 155 | = $5,040 |
| Year 10 | 700 + 28 x 160 | = $5,180 |

E. Parts and Supplies

Inventory + Spare Parts

Year 1 .01 (2,085,000) + 25,000 = $45,850

Test Equipment

Year 1 .01 (2,085,000) = $20,850

Tools

Years 1-10 $1,500 per year

F. Truck Lease

| | |
|---|---|
| Year 1 | 6 x 2100 = $12,600 |
| Year 2 | 6 x 2100 = $12,600 |
| Year 3 | 6 x 2100 = $12,600 |
| Year 4 | 6 x 2100 = $12,600 |
| Year 5 | 6 x 2100 = $12,600 |
| Year 6 | 7 x 2100 = $14,700 |
| Year 7 | 7 x 2100 = $14,700 |
| Year 8 | 7 x 2100 = $14,700 |
| Year 9 | 7 x 2100 = $14,700 |
| Year 10 | 7 x 2100 = $14,700 |

2. Office Operating Expenses

A. Personnel

Bookkeeper/Office Manager

| | |
|---|---|
| Year 1 | $7000 |
| Year 2 | $7000 |
| Year 3 | $7000 |
| Year 4 | $7000 |
| Year 5 | $7000 |
| Year 6 | $7000 |
| Year 7 | $7000 |
| Year 8 | $7000 |
| Year 9 | $7000 |
| Year 10 | $7000 |

Secretary/Clerks

| | | |
|---|---|---|
| Year 1 | 0 | [Total = 0] |
| Year 2 | 0 | [Total = 0] |
| Year 3 | 1 x 5000 = $5000 | [Total = 1] |
| Year 4 | 5000 + 10,000 = $15,000 | [Total = 3] |
| Year 5 | 15,000 + 5000 = $20,000 | [Total = 4] |
| Year 6 | 20,000 + 5000 = $25,000 | [Total = 5] |
| Year 7 | 25,000 + 5000 = $30,000 | [Total = 6] |
| Year 8 | 30,000 + 5000 = $35,000 | [Total = 7] |
| Year 9 | $35,000 | [Total = 7] |
| Year 10 | 35,000 + 5000 = $40,000 | [Total = 8] |

Benefits

| | | |
|---|---|---|
| Year 1 | (7000) x .12 | = $ 840 |
| Year 2 | (7000) x .12 | = $ 840 |
| Year 3 | (7000 + 5000) x .12 | = $1,440 |
| Year 4 | (7000 + 15,000) x .12 | = $2,640 |
| Year 5 | (7000 + 20,000) x .12 | = $3,240 |
| Year 6 | (7000 + 25,000) x .12 | = $3,840 |
| Year 7 | (7000 + 30,000) x .12 | = $4,440 |
| Year 8 | (7000 + 35,000) x .12 | = $5,040 |
| Year 9 | (7000 + 35,000) x .12 | = $5,040 |
| Year 10 | (7000 + 40,000) x .12 | = $5,640 |

B. Office Rental

| | |
|---|---|
| Year 1 | $3,600 |
| Year 2 | $3,600 |
| Year 3 | $3,600 |
| Year 4 | $4,800 |
| Year 5 | $6,000 |
| Year 6 | $7,200 |
| Year 7 | $8,400 |
| Year 8 | $9,600 |
| Year 9 | $9,600 |
| Year 10 | $10,800 |

C. Office - Postage and Supplies

| | | |
|---|---|---|
| Year 1 | 1.35 x 300 | = $ 405 |
| Year 2 | 1.20 x 2600 | = $3,120 |
| Year 3 | .60 x 4300 | = $2,580 |
| Year 4 | .55 x 6300 | = $3,465 |
| Year 5 | .50 x 8000 | = $4,000 |
| Year 6 | .50 x 9200 | = $4,600 |
| Year 7 | .50 x 10,700 | = $5,350 |
| Year 8 | .50 x 12,200 | = $6,100 |
| Year 9 | .50 x 13,200 | = $6,600 |
| Year 10 | .50 x 14,200 | = $7,100 |

D. Furniture and Leasehold Improvements

Year 1 = 5000 + 1500 (14) = $26,000

E. Professional and Legal Services

| | |
|---|---|
| Year 1 | $4,000 |
| Year 2 | $4,000 |
| Year 3 | $4,000 |
| Year 4 | $4,000 |
| Year 5 | $4,000 |
| Year 6 | $4,000 |
| Year 7 | $5,000 |
| Year 8 | $5,000 |
| Year 9 | $5,000 |
| Year 10 | $5,000 |

F. Insurance

Property

Years 1-10 80 percent of 2,085,000 = $1,668,000
.35 per $100 = $5,838 per year

Note: As previously noted, this example does not consider capital drop costs. It assumes that drop costs are included in cable costs. In actual practice, this is not true and insurance costs would increase annually as more drops are made and capital costs increase.

Miscellaneous

| | |
|---|---|
| Years 1-6 | $500/year |
| Years 7-10 | $1000/year |

G. Taxes

Property Tax 1/2 percent (2,085,000) = $10,425

Years 1-10 = $10,425 per year

This example assumes that there is no depreciation.

## Franchise Fee

| | | |
|---|---|---|
| Year 1 | 17,000 x .03 | = $ 510 |
| Year 2 | 152,000 x .03 | = $ 4,560 |
| Year 3 | 339,000 x .03 | = $10,170 |
| Year 4 | 515,000 x .03 | = $15,450 |
| Year 5 | 690,000 x .03 | = $20,700 |
| Year 6 | 828,000 x .03 | = $24,840 |
| Year 7 | 951,000 x .03 | = $28,530 |
| Year 8 | 1,074,000 x .03 | = $32,220 |
| Year 9 | 1,181,000 x .03 | = $35,430 |
| Year 10 | 1,271,000 x .03 | = $38,130 |

## Sales Tax

| | | |
|---|---|---|
| Year 1 | 2 percent (2,085,000) | = $41,700 |

## Payroll

| | | |
|---|---|---|
| Year 1 | (57,000 (Plant) + 7,000 (Office)) x 5.5% | = $3,200 |
| Year 2 | (57,000 + 7,000) x 5.5% | = $3,200 |
| Year 3 | (66,300 + 12,000) x 5.5% | = $4,306 |
| Year 4 | (68,300 + 22,000) x 5.5% | = $4,966 |
| Year 5 | (70,000 + 27,000) x 5.5% | = $5,335 |
| Year 6 | (79,200 + 32,000) x 5.5% | = $6,110 |
| Year 7 | (90,700 + 37,000) x 5.5% | = $6,474 |
| Year 8 | (82,200 + 42,000) x 5.5% | = $6,831 |
| Year 9 | (83,000 + 42,000) x 5.5% | = $6,875 |
| Year 10 | (83,000 + 47,000) x 5.5% | = $7,150 |

## Licenses

| | |
|---|---|
| Years 1-6 | $200/year |
| Years 7-10 | $400/year |

H. Telephone, Utilities and Maintenance

Telephone

Years 1-10 $4000/year

Utilities and Maintenance

| | | |
|---|---|---|
| Year 1 | 3,600 x .5 | = $1,800 |
| Year 2 | 3,600 x .5 | = $1,800 |
| Year 3 | 3,600 x .5 | = $1,800 |
| Year 4 | 4,800 x .5 | = $2,400 |
| Year 5 | 6,000 x .5 | = $3,000 |
| Year 6 | 7,200 x .5 | = $3,600 |
| Year 7 | 8,400 x .5 | = $4,200 |
| Year 8 | 9,600 x .5 | = $4,800 |
| Year 9 | 9,600 x .5 | = $4,800 |
| Year 10 | 10,800 x .5 | $5,400 |

I. Billing and Bookkeeping

| | | |
|---|---|---|
| Year 1 | 300 x 1.75 | = $ 525 |
| Year 2 | 2,600 x 1.50 | = $ 3,900 |
| Year 3 | 4,300 x 1.50 | = $ 6,450 |
| Year 4 | 6,300 x 1.50 | = $ 9,450 |
| Year 5 | 8,000 x 1.50 | = $12,000 |
| Year 6 | 9,200 x 1.50 | = $13,800 |
| Year 7 | 10,700 x 1.50 | = $16,050 |
| Year 8 | 12,200 x 1.50 | = $18,300 |
| Year 9 | 13,200 x 1.50 | = $19,800 |
| Year 10 | 14,200 x 1.50 | = $21,300 |

J. Promotion and Sales

| | | |
|---|---|---|
| Year 1 | 300 x 10 | = $ 3,000 |
| Year 2 | 2,300 x 10 | = $23,000 |
| Year 3 | 1,700 x 10 | = $17,000 |
| Year 4 | 2,000 x 10 | = $20,000 |
| Year 5 | 1,700 x 10 | = $17,000 |
| Year 6 | 1,200 x 10 | = $12,000 |
| Year 7 | 1,500 x 10 | = $15,000 |
| Year 8 | 1,500 x 10 | = $15,000 |
| Year 9 | 1,000 x 10 | = $10,000 |
| Year 10 | 1,000 x 10 | = $10,000 |

K. Drop Replacement and Turnover

| | | |
|---|---|---|
| Year 1 | 0 | |
| Year 2 | 300 x .26 x 20 | = $ 1,560 |
| Year 3 | 2,600 x .26 x 20 | = $13,520 |
| Year 4 | 4,300 x .26 x 20 | = $22,360 |
| Year 5 | 6,300 x .26 x 20 | = $32,760 |
| Year 6 | 8,000 x .26 x 20 | = $41,600 |
| Year 7 | 9,200 x .26 x 20 | = $47,840 |
| Year 8 | 10,700 x .26 x 20 | = $55,640 |
| Year 9 | 12,200 x .26 x 20 | = $63,440 |
| Year 10 | 13,200 x .26 x 20 | = $68,640 |

L. Travel and Entertainment

| | | |
|---|---|---|
| Year 1 | 15,000 x .15 | = $2,250 |
| Year 2 | 15,900 x .15 | = $2,385 |
| Year 3 | 18,154 x .15 | = $2,723 |
| Year 4 | 21,243 x .15 | = $3,186 |
| Year 5 | 24,218 x .15 | = $3,633 |
| Years 6-10 | 25,000 x .15 | = $3,750 |

M. Membership and Dues

| | | |
|---|---|---|
| Year 1 | 630 | = $630 |
| Year 2 | 630 + 1,600 x .60 | = $1,590 |
| Year 3 | 630 + 3,300 x .60 | = $2,610 |
| Year 4 | 630 + 4,000 x .60 + 1,300 x .54 | = $3,732 |
| Year 5 | 630 + 4,000 x .60 + 3,000 x .54 | = $4,650 |
| Year 6 | 630 + 4,000 x .60 + 4,200 x .54 | = $5,298 |
| Year 7 | 630 + 4,000 x .60 + 5,000 x .54 + 700 x .48 = | = $6,066 |
| Year 8 | 630 + 4,000 x .60 + 5,000 x .54 + 2,200 x .48 | = $6,786 |
| Year 9 | 630 + 4,000 x .60 + 5,000 x .54 + 3,200 x .48 | = $7,266 |
| Year 10 | 630 + 4,000 x . 60+ 5,000 x .54 + 4,200 x .48 | = $7,746 |

N. Contributions

Years 1-10 = $600/year

O. Bad Debts

| | | |
|---|---|---|
| Year 1 | 17,000 x 1.5% | = $ 255 |
| Year 2 | 152,000 x 1.5% | = $ 2,280 |
| Year 3 | 339,000 x 1.5% | = $ 5,085 |
| Year 4 | 515,000 x 1.5% | = $ 7,725 |
| Year 5 | 690,000 x 1.5% | = $10,350 |
| Year 6 | 828,000 x 1.5% | = $12,420 |
| Year 7 | 951,000 x 1.5% | = $14,265 |
| Year 8 | 1,074,000 x 1.5% | = $16,110 |
| Year 9 | 1,181,000 x 1.5% | = $17,715 |
| Year 10 | 1,271,000 x 1.5% | = $19,065 |

P. Freight

Years 1-4 $200/year

Years 5-10 $700/year

Q. Sales Commission

| | | |
|---|---|---|
| Year 1 | 300 x 3 | = $ 900 |
| Year 2 | 2,300 x 3 | = $6,900 |
| Year 3 | 1,700 x 3 | = $5,100 |
| Year 4 | 2,000 x 3 | = $6,000 |
| Year 5 | 1,700 x 3 | = $5,100 |
| Year 6 | 1,200 x 3 | = $3,600 |
| Year 7 | 1,500 x 3 | = $4,500 |
| Year 8 | 1,500 x 3 | = $4,500 |
| Year 9 | 1,000 x 3 | = $3,000 |
| Year 10 | 1,000 x 3 | = $3,000 |

The total operating costs are displayed, on an annual basis, in Tables C-1 and C-2.

Table C-1

ANNUAL PLANT OPERATING COSTS

| Plant Operating Costs | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| A. Personnel | | | | | | | | | | |
| Manager | 15,000 | 15,000 | 16,300 | 18,300 | 20,000 | 21,200 | 22,700 | 24,200 | 25,000 | 25,000 |
| Chief Technician | 12,000 | 12,000 | 12,000 | 12,000 | 12,000 | 12,000 | 12,000 | 12,000 | 12,000 | 12,000 |
| Installers | 14,000 | 14,000 | 14,000 | 14,000 | 14,000 | 14,000 | 14,000 | 14,000 | 14,000 | 14,000 |
| Maintenance Technicians | 16,000 | 16,000 | 16,000 | 16,000 | 16,000 | 24,000 | 24,000 | 24,000 | 24,000 | 24,000 |
| Bench Technician | --- | --- | 8,000 | 8,000 | 8,000 | 8,000 | 8,000 | 8,000 | 8,000 | 8,000 |
| Benefits | 6,840 | 6,840 | 7,956 | 8,196 | 8,400 | 9,504 | 9,684 | 9,864 | 9,960 | 9,960 |
| B. Repair and Maintenance | | | | | | | | | | |
| Headend | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 |
| Distribution | 460 | 2,990 | 3,910 | 4,800 | 6,498 | 7,450 | 8,430 | 10,360 | 11,500 | 12,260 |
| C. Rental Costs | | | | | | | | | | |
| Tower Site | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 |
| D. Power | 980 | 2,520 | 3,080 | 3,500 | 3,864 | 4,200 | 4,480 | 4,760 | 5,040 | 5,180 |
| E. Parts and Supplies | | | | | | | | | | |
| Initial Inventory | 45,850 | | | | | | | | | |
| Test Equipment | 20,850 | | | | | | | | | |
| Tools | 1,500 | 1,500 | 1,500 | 1,500 | 1,500 | 1,500 | 1,500 | 1,500 | 1,500 | 1,500 |
| F. Truck Rental | 12,600 | 12,600 | 12,600 | 12,600 | 12,600 | 14,700 | 14,700 | 14,700 | 14,700 | 14,700 |
| (Total Plant Operating Costs) | (147,680) | (85,050) | (96,946) | (100,496) | (104,462) | (118,154) | (121,094) | (124,984) | (127,300) | (128,200) |

Table C-2

OFFICE OPERATING COSTS

| Office Operating Costs | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| A. Personnel | | | | | | | | | | |
| Bookkeeper/Officer Manager | 7,000 | 7,000 | 7,000 | 7,000 | 7,000 | 7,000 | 7,000 | 7,000 | 7,000 | 7,000 |
| Secretary/Clerks | --- | --- | 5,000 | 15,000 | 20,000 | 25,000 | 30,000 | 35,000 | 35,000 | 40,000 |
| Benefits | 840 | 840 | 1,440 | 2,640 | 3,240 | 3,840 | 4,440 | 5,040 | 5,040 | 5,640 |
| B. Office - Rental | 3,600 | 3,600 | 3,600 | 4,800 | 6,000 | 7,200 | 8,400 | 9,600 | 9,600 | 10,800 |
| C. Office - Postage and Supplies | 405 | 3,120 | 2,580 | 3,465 | 4,000 | 4,600 | 5,350 | 6,100 | 6,600 | 7,100 |
| D. Professional and Legal Services | 4,000 | 4,000 | 4,000 | 4,000 | 4,000 | 4,000 | 5,000 | 5,000 | 5,000 | 5,000 |
| E. Insurance | | | | | | | | | | |
| Property | 5,838 | 5,838 | 5,838 | 5,838 | 5,838 | 5,838 | 5,838 | 5,838 | 5,838 | 5,838 |
| Miscellaneous | 500 | 500 | 500 | 500 | 500 | 500 | 1,000 | 1,000 | 1,000 | 1,000 |
| F. Taxes and Licenses | | | | | | | | | | |
| Property | 10,425 | 10,425 | 10,425 | 10,425 | 10,425 | 10,425 | 10,425 | 10,425 | 10,425 | 10,425 |
| Franchise | 510 | 4,560 | 10,170 | 15,450 | 20,700 | 24,840 | 28,530 | 32,300 | 35,430 | 38,130 |
| Sales | 41,700 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Payroll | 3,200 | 3,200 | 4,306 | 4,966 | 5,335 | 6,116 | 6,474 | 6,831 | 6,875 | 7,150 |
| Licenses | 200 | 200 | 200 | 200 | 200 | 200 | 400 | 400 | 400 | 400 |
| G. Telephone, Utilities and Maintenance | | | | | | | | | | |
| Telephone | 4,000 | 4,000 | 4,000 | 4,000 | 4,000 | 4,000 | 4,000 | 4,000 | 4,000 | 4,000 |
| Utilities and Maintenance | 1,800 | 1,800 | 1,800 | 2,400 | 3,000 | 3,600 | 4,200 | 4,800 | 4,800 | 5,400 |
| H. Billing and Bookkeeping | 525 | 3,900 | 6,450 | 9,450 | 12,000 | 13,800 | 16,050 | 18,300 | 19,800 | 21,300 |
| I. Promotion and Sales | 3,000 | 23,000 | 17,000 | 20,000 | 17,000 | 12,000 | 15,000 | 15,000 | 10,000 | 10,000 |
| J. Drop Replacement and Turnover | --- | 1,560 | 13,520 | 22,360 | 32,760 | 41,600 | 47,840 | 55,640 | 63,440 | 68,640 |
| K. Travel and Entertainment | 2,250 | 2,385 | 2,723 | 3,186 | 3,633 | 3,750 | 3,750 | 3,750 | 3,750 | 3,750 |
| L. Membership and Dues | 630 | 1,590 | 2,610 | 3,732 | 4,650 | 5,298 | 6,066 | 6,786 | 7,266 | 7,746 |
| M. Contributions | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 |
| N. Bad Debts | 255 | 2,280 | 5,085 | 7,725 | 10,350 | 12,420 | 14,265 | 16,110 | 17,715 | 19,065 |
| O. Furniture and Leasehold Improvements | 26,000 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| P. Freight | 200 | 200 | 200 | 200 | 700 | 700 | 700 | 700 | 700 | 700 |
| Q. Sales Commission | 900 | 6,900 | 5,100 | 6,000 | 5,100 | 3,600 | 4,500 | 4,500 | 3,000 | 3,000 |
| (Total Office Operating Costs) | (118,378) | (91,498) | (114,147) | (153,937) | (181,031) | (200,927) | (229,828) | (254,620) | (263,279) | (282,684) |
| (Total Plant Operating Costs) | (147,680) | (85,050) | (96,946) | (100,496) | (104,462) | (118,154) | (121,094) | (124,984) | (127,300) | (128,200) |
| Total Operating Costs | 266,058 | 176,548 | 211,093 | 254,433 | 285,493 | 319,081 | 350,922 | 379,604 | 390,579 | 410,884 |

APPENDIX D

## NORMALIZED CONSTRUCTION COST EQUATIONS

The basic construction costs for underground cable systems as shown in Chapter 4 have been built up from the basic components illustrated in Table D-1. Based upon a series of specific assumptions regarding the size of the trench needed, the size and type of conduit, and crew composition, basic machine and labor rates for different types of jobs can be aggregated into per mile construction costs.

The basic trench for the underground cables was assumed to be one foot in width and eighteen inches in depth. These dimensions were fixed and did not vary when cable diameter or cable type changed or when conduit dimensions changed. Although construction costs are proportional to the trench cross section and a smaller trench could hold all of the cable and amplifiers, this larger area facilitates installation. This dimension was verified in discussions with a number of MSO's.

To derive the costs shown in Chapter 4, a Washington, D.C. labor rate was utilized. In addition, it was assumed that union workers were required. The following table illustrates the development of the basic labor rate and labor overhead rates. In a similar manner, the equivalent rate for construction personnel is \$7.00/hour and for general laborers the equivalent rate is \$6.50/hour.

Table D-1

LABOR RATE AND OVERHEAD

| | | | |
|---|---|---|---|
| Electrician Base Wage | | | $8.35 |
| Pension, Educational Fund, etc. | | | .55 |
| | | | $8.90 |
| Impact of Crew and Foreman--Five Man Crew | | | |
| | Percent of Hour | Rate | Cost Per Hour |
| Supervision | 20 | 9.90 | 1.98 |
| Electrician | 80 | 8.90 | 7.12 |
| | Equivalent Rate/Electrician Hour = | | $9.10 |
| Overhead Based upon Total Labor Cost | | | |
| (1) Unemployment Insurance, Workman's Compensation, Social Security, etc. | | | 13% |
| (2) Temporary Construction and Cleanup | | | 4% |
| (3) Small Tools, Consumables | | | 12% |
| (4) Field Supervision (excluding foreman) | | | 5% |
| (5) Home Office Costs | | | 11% |
| | Total Overhead = | | 45% |

The following sections will show how the costs of each of the elements of Table 4-14 have been derived. In addition, a series of normalized equations that are independent of labor rates will also be developed.

Trenching Costs

The basic trench is assumed to be 18 inches in depth and twelve inches in width. A single linear foot of trench has a volume of 18" x 12" x 12" or .056 cubic yards of material. The standard outputs of trenching machines are:

20.7 cubic yds/hour for Type 1 Soil (topsoil, sand, loam, or gravel)

16.7 cubic yds/hour for Type 2 Soil (clay or mixture of)

12.7 cubic yds/hour for Type 3 Soil (small rock or mixture of)

For Type 1 soil, this is the equivalent of:

$$\frac{20.7 \text{ cubic yds/hour}}{.056 \text{ cub yds/LF}} = 370 \text{ linear feet/hour.}$$

The total hourly rate including labor and machine is $35.00. Thus, the equivalent cost is = $\frac{370 \text{ LF/hour}}{35/\text{hour}}$ or approximately $.10 per linear foot or $528 per mile (see Table 4-17) for Type 1 soil. For Types 2 and 3 soil conditions, the following results are obtained:

<u>Type 2:</u>

$$\frac{16.7 \text{ cubic yds/hour}}{.056 \text{ cubic yds/linear foot}} = 298 \text{ linear feet/hour}$$

$$\frac{298 \text{ linear feet/hour}}{\$35/\text{hour}} = \$.12/\text{linear foot or } \$634 \text{ per mile}$$

<u>Type 3:</u>

$$\frac{12.7 \text{ cubic yds/hour}}{.056 \text{ cubic yds/LF}} = 227 \text{ linear feet/hour}$$

$$\frac{227 \text{ linear feet/hour}}{\$35/\text{hour}} = \$.15/\text{linear foot or } \$792 \text{ per mile.}$$

The equivalent hourly rate of $35/hour is composed of a machine cost per hour and a labor cost per hour. The labor component is about 72 percent of the total cost and implies a labor rate of $6.50/hour. The per mile cost for each type of soil condition can then be partitioned into an equipment cost and a labor cost. By dividing the labor cost by the equivalent hourly rate, an equation that relates trenching costs to labor rates on a per mile basis is derived. For Type 1 soil this becomes:

$$\$528 \text{ per mile} = \$147.84 \text{ (machines)} + \$380.16 \text{ (labor)}$$

or

$$\$147.84 + \left(\frac{380.16}{6.50}\right)\left(X_1\right)$$

or

$$\$147.84 + 58.61 \left(X_1\right)$$

where $X_1$ = equivalent hourly rate.

For Type 2 and Type 3 soil conditions the resultant equations are:

Type 2: $177.41 + 70.22 \left(X_1\right)$

Type 3: $221.76 + 87.65 \left(X_1\right)$

Backfilling Costs

A standard rate of backfilling by soil condition was used in deriving per mile backfilling costs. These rates are:

$3.50/cubic yard for Type 1 soil

$4.10/cubic yard for Type 2 soil

$4.70/cubic yard for Type 3 soil

Each of these rates are multiplied by the trench dimensions to obtain a cost per linear foot or per mile.

Type 1: $3.50/cubic yard x 0.056 cubic yd/LF = $.20/LF x 5280 = $1056 per mile

Type 2: $4.10/cubic yard x 0.056 cubic yd/LF = $.23/LF x 5280 = $1214 per mile

Type 3: $4.70/cubic yard x 0.056 cubic yd/LF = $.26/LF x 5280 = $1373 per mile

This operation is 100 percent labor and a normalized cost is obtained by dividing the per mile cost by $6.50.

Type 1: $\$1056/6.50 \bullet [X_1] = \$162.46 [X_1]$

Type 2: $\$1214/6.50 \bullet [X_1] = \$186.83 [X_1]$

Type 3: $\$1373/6.50 \bullet [X_1] = \$211.20 [X_1]$

Where $X_1$ = equivalent hourly rate.

## Compacting (with Pneumatic Tamper) Costs

Standard compacting rates by soil type were used in deriving per mile compacting costs. These rates are:

$3.05/cubic yard for Type 1 soil

$3.65/cubic yard for Type 2 soil

$4.25/cubic yard for Type 3 soil

Each of these rates are multiplied by the trench dimensions to obtain a per mile cost:

Type 1: $3.05/cubic yard x 0.056 cubic yard/LF = $.17/LF x 5280 = $ 898 per mile

Type 2: $3.65/cubic yard x 0.056 cubic yard/LF = $.20/LF x 5280 = $1056 per mile

Type 3: $4.25/cubic yard x 0.056 cubic yard/LF = $.24/LF x 5280 = $1267 per mile

The labor content of this operation is 53 percent of the total costs. By partitioning the per mile costs into equipment and labor cost components and dividing the labor component by the equivalent hour rate used in deriving these costs, a set of normalized equations are obtained.

Type 1: $\$\ 898 \text{ per mile} = \$421.87 \text{ (equipment)} + \frac{476.13}{6.50} [X_1] = \$421.87 + \$73.19 [X_1]$

Type 2: $\$1056 \text{ per mile} = \$496.32 \text{ (equipment)} + \frac{559.68}{6.50} [X_1] = \$496.32 + \$86.10 [X_1]$

Type 3: $\$1267 \text{ per mile} = \$595.58 \text{ (equipment)} + \frac{671.42}{6.50} [X_1] = \$595.58 + \$103.33 [X_1]$

## Total Trenching, Backfilling, and Compacting Costs

All of these operations are required for underground distribution systems. It is thus possible to add the individual costs by soil type to obtain a total trenching, filling, and compacting cost (either using D.C. labor rates or normalized). These results are shown in Table D-2.

Table D-2

TOTAL TRENCHING, BACKFILLING,
AND COMPACTING COSTS

| | Type 1 | | Type 2 | | Type 3 | |
|---|---|---|---|---|---|---|
| Operation | DC | Normalized | DC | Normalized | DC | Normalized |
| Trenching | 528 | 147.84 + 58.61 $[X_1]$ | 634 | 177.41 + 70.22 $[X_1]$ | 792 | 221.76 + 87.65 $[X_1]$ |
| Backfilling | 1056 | 162.46 $[X_1]$ | 1214 | 186.83 $[X_1]$ | 1373 | 211.20 $[X_1]$ |
| Compacting | 898 | 421.87 + 73.19 $[X_1]$ | 1056 | 496.32 + 86.10 $[X_1]$ | 1267 | 595.58 + 103.33 $[X_1]$ |
| Total (per mile) | \$2482 | 569.71 + 294.26 $[X_1]$ | \$2904 | 673.73 + 343.15 $[X_1]$ | \$3432 | 817.34 + 402.18 $[X_1]$ |

Breakup Concrete or Asphalt

The basic breakup cost for concrete or asphalt material is as follows:

| | |
|---|---|
| Concrete: | \$15/cy |
| Asphalt: | \$ 5/cy |

In order to apply these standards, a relationship between the depth of concrete or asphalt in the trench and the cubic yard dimensions of the trench must be determined. For example, a trench with 1" thick concrete has the following cubic yard dimensions (per linear foot):

$$12'' \times 12'' \times 1'' \text{ or } \left[\frac{1}{3} \times \frac{1}{3} \times \frac{1}{36}\right] \text{ cubic yards or .00308 cubic yards.}$$

Thus, each inch of material adds 0.00308 cubic yards.

The total breakup cost per mile is equal to:

$$0.00308 \times \text{thickness (inches)} \times 5280 \times \text{cost/cubic yard}$$

or

$$16.27\ (T) \times \text{cost/cubic yard} \qquad (1)$$

where $T$ = material thickness.

The labor content of this operation is 80 percent under a rate of \$6.50/hour. A normalized cost per cubic yard for concrete and asphalt can be derived as follows:

Concrete

$$\$15.00/\text{cubic yard} = 3.00 \text{ (equipment)} + 12.00 \text{ (labor)}$$

$$= 3.00 + \frac{12.00}{6.50}\ [X_1]$$

$$\text{Cost/cubic yard} = 3.00 + 1.85\ [X_1] \qquad (2)$$

Asphalt

$$\$5.00/\text{cubic yard} = 1.00 \text{ (equipment)} + 4.00 \text{ (labor)}$$

$$= 1.00 + \left(\frac{4.00}{6.50}\right)\ [X_1]$$

$$\text{Cost/cubic yard} = 1.00 + 0.62\ [X_1] \qquad (3)$$

Substituting equations (2) and (3) into equation (1) results in the following normalized equations:

$$\text{Concrete per mile breakup costs} = 16.27\,(T) \times [3 + 1.85\,(X_1)]$$

$$= 48.81\,(T_1) + 30.1\,(T_1)\,(X_1)$$

$$\text{Asphalt per mile breakup costs} = 16.27\,(T) \times \left[1. + 0.62\,[X_1]\right]$$

$$= 16.27\,(T_2) + 10.09\,(T_2)\,(X_1)$$

where $T_1$ = thickness of concrete (in inches)

$T_2$ = thickness of asphalt (in inches)

$X_1$ = equivalent hourly rate.

## Load, Haul, and Dump Costs

This cost is independent of material type. The standard rate is \$6.50/cubic yard of material. A relationship is derived using the methodology shown previously in the breakup cost section.

$$\text{Per mile load, haul, and dump cost} = (\text{standard rate/cy})\,(\text{amount of material cy/LF}) \times (\text{linear ft/mile})$$

$$= (\text{standard rate/cy}) \times [.00308 \times \text{thickness}] \times [5280]$$

$$= 16.27\,(T)\,(\text{standard rate/cy}) \qquad (4)$$

The standard rate is 70 percent labor intensive. Thus,

$$\$6.50/\text{cy} = 1.95\,(\text{equipment}) + 4.55\,(\text{labor})$$

$$\text{cost/cy} = 1.95 + \left(\frac{4.55}{6.50}\right)(X_1)$$

$$= 1.95 + 0.70\,(X_1) \qquad (5)$$

Substituting equation (5) into equation (4) results in the following normalized equation:

$$\text{Load, Haul, and Dump Cost} = 16.27\ (T) \times [1.95 + 0.70\ (X_1)]$$

$$= 31.73\ (T_1 \text{ or } T_2) + 11.39\ (T_1 \text{ or } T_2)\ (X_1)$$

where $T_1$ = thickness of concrete (in inches)

$T_2$ = thickness of asphalt (in inches)

$X_1$ = equivalent hourly rate.

Direct Burial of Cable

This procedure consists of two major operations

- Cable Reel set-up
- Pulling cable

The standard outputs for these operations (based upon 1500 linear feet of cable per reel) are:

| Cable Size (assumed armored cable) | Set-Up (M hrs. per LF) | Pulling (M hrs. per LF) | Total (M hrs. per LF) |
|---|---|---|---|
| 0.412 | 0.001 | 0.01604 | 0.01704 |
| 0.500 | 0.002 | 0.020 | 0.022 |
| 0.750 | 0.003 | 0.033 | 0.036 |

To calculate the per mile cost for this operation, the following steps are required:

(1) Multiply total M hrs per LF by 5280 and then by equivalent hourly rate for electricians

(2) Multiply result from (1) by 0.45 to obtain overhead

(3) Sum (1) and (2) and multiply by 10 percent to obtain fee.

(4) Total cost = (1) + (2) + (3) [single cable]

(5) For two cables multiply (4) by 1.8

Using a normalized labor rate, the results are:

One - 0.412" cable

Step (1) $0.01704$ M hrs/LF x 5280 x $[X_2]$

$= 89.97\ [X_2]$

Step (2) $89.97\ [X_2] \times 0.45 = 40.48\ [X_2]$ (overhead)

Step (3) $\left[89.97\ [X_2] + 40.48\ [X_2]\right] \times .10 =$ profit

$13.05\ [X_2] =$ profit

Step (4) Total cost per mile $= 89.97\ [X_2] + 40.48\ [X_2] + 13.05\ [X_2]$

$= 143.50\ [X_2]$

In a similar manner:

one - .500" Dia. Cable $= 185\ [X_2]$

one - .750" Dia. Cable $= 303\ [X_2]$

For two cables:

two - 0.412" cables $= 143.50\ [X_2] \times 1.8 = 258.30\ [X_2]$

two - 0.500" cables $= 185\ [X_2] \times 1.8 = 333\ [X_2]$

two - 0.750" cables $= 303\ [X_2] \times 1.8 = 545.50\ [X_2]$

Where $X_2$ = equivalent hourly rate (electrician)

Pulling Cable through Conduit

The procedures employed in pulling cable through a conduit are identical to those used in the direct burial of cable. Both alternatives require the setting up of a 1500-foot reel and the pulling of cable. The standards or man-hours per linear foot are higher in this case, which is as expected. These standards are:

| Cable Size | Set-Up | Pulling | Total |
|---|---|---|---|
| (non-armored cable) | (M hrs. per LF) | (M hrs. per LF) | (M hrs. per LF) |
| 0.412" | .001 | .01901 | .02001 |
| 0.500" | .001 | .023 | .024 |
| 0.750" | .003 | .037 | .040 |
| Drop Cable | NA | .006 | .006 |

Drop cables require no reel set-up. Pieces are cut when required.

Utilizing the same steps shown in the previous section, the following normalized results are obtained.

One - 0.412" cable

Step (1) $= 0.0200$ M hrs/LF x $5280 [X_2]$

$= 105.65 [X_2]$

Step (2) $= 105.65 [X_2] \times 0.45 = 47.54 [X_2]$ (overhead)

Step (3) $= (105.65 [X_2] + 47.54 [X_2]) \times 0.10 = 15.31 [X_2]$ (profit)

Step (4) = Total cost per mile $= 105.65 [X_2] + 47.54 [X_2] + 15.31 [X_2]$

$= 168.50 [X_2]$.

In a similar manner:

One - .500" ca le = $202 [X_2]$

One - .750" cable = $337 [X_2]$

One = drop cable = $50.50 [X_2]$

For two cables:

Two - 0.412" Dia. Cables = $168.50 [X_2] \times 1.8 = 303 [X_2]$

Two - 0.500" Dia. Cables = $202 [X_2] \times 1.8 = 363.50 [X_2]$

Two - 0.750" Dia. Cables = $337 [X_2] \times 1.8 = 606.50 [X_2]$

Two - drop cables $50.50 [X_2] \times 1.8 = 91.00 [X_2]$

Where $X_2$ = equivalent hourly rate (electrician)

Conduit Installation and Material

Two basic types of conduit have been examined during this study: rigid steel and PVC. For each type three sizes may be required. The size and specific use is shown below:

| Cable Diameter | Use |
|---|---|
| 2" | Single cable (any cable diameter) |
| 3" | Dual cable (any cable diameter) |
| ?/4" | Drop cable only(single or dual) |

The specifications and standards that apply to each conduit are as follows:

A. Rigid Steel Galvanized Conduit

Based upon 10' lengths, 1 coupling per length, straight runs

| Diameter | Material Cost (per LF) | Manhours/LF |
|---|---|---|
| 2" RS | 0.70 | 0.078 |
| 3" RS | 1.41 | 0.094 |
| 3/4" RS | .22 | 0.04 |

B. Rigid PVC Conduit

Based upon 10' length, one coupling per length, straight runs only.

| Diameter | Material Cost (per LF) | Manhours/LF |
|---|---|---|
| 2" PVC | 0.45 | 0.078 |
| 3" PVC | 0.93 | 0.094 |
| 3/4" PVC | 0.15 | 0.04 |

To calculate the per mile cost for this operation, the following steps are required:

(1) Multiply Material cost per LF by 5280

(2) Multiply Manhours per LF by 5280 and then by equivalent hourly rate for electricians

(3) Multiply result from (2) by 0.45 to obtain labor overhead

(4) Sum (1), (2) and (3) then multiply by 10 percent to obtain fee

(5) Total cost = (1) + (2) + (3) + (4).

For the 2" rigid steel case, the following normalized equation results:

Step (1) $0.70 \times 5280 = 3696$ (material cost)

Step (2) $0.078 \times 5280 \times [X_2] = 411.8\ [X_2]$ (direct labor)

Step (3) $411.8\ [X_2] \times 0.45 = 185.3\ [X_2]$ (labor overhead)

Step (4) $(3696 + 411.8\ [X_2] + 185.3\ [X_2]) \times .10 = 369.6 + 59.7\ [X_2]$ (fee)

Step (5) Total Cost $= 3696 + 411.8\ [X_2] + 185.3\ [X_2] + 369.6 + 59.7\ [X_2]$

$= 4066 + 657\ [X_2]$

The normalized equations for the other cases are:

| | |
|---|---|
| 3" Rigid Steel | $8190 + 791.5 [X_2]$ |
| 3/4" Rigid Steel | $1276 + 337 [X_2]$ |
| 2" PVC | $2612 + 657 [X_2]$ |
| 3" PVC | $5403 + 791.50 [X_2]$ |
| 3/4" PVC | $869 + 337 [X_2]$ |

Conduit Material and Installation and Cable Pulling Costs

Because the last two cases usually exist together[1], the normalized equations developed in the last two sections can be combined for user efficiency. For example, the costs associated with pulling two 1/2" cables through a three-inch rigid steel conduit can be estimated from the following equations:

A. Pulling two .500" Dia. Cables = $363.50 [X_2]$
+
B. 3" RS conduit (material and installation) = $8190 + 791.5 [X_2]$

or C. The combined equation = $8190 + 1155 [X_2]$

Combining all the realistic "options" the following set of normalized equations is obtained:

Table D-3

CONDUIT MATERIAL AND INSTALLATION PLUS PULLING CABLE

| | A. Single Cable | B. Two Cables |
|---|---|---|
| | Rigid Steel | |
| 0.412 | $4066 + 825.50 (X_2)$ | $8190 + 1094.50 (X_2)$ |
| 0.500 | $4066 + 859 (X_2)$ | $8190 + 1155 (X_2)$ |
| 0.750 | $4066 + 944 (X_2)$ | $8190 + 1398 (X_2)$ |
| Drop | $1276 + 387.50 (X_2)$ | $1276 + 428 (X_2)$ |
| | PVC | |
| 0.412 | $2612 + 825.50 (X_2)$ | $5403 + 1094.50 (X_2)$ |
| 0.500 | $2612 + 859 (X_2)$ | $5403 + 1155 (X_2)$ |
| 0.750 | $2612 + 994 (X_2)$ | $5403 + 1398 (X_2)$ |
| Drop | $869 + 387.50 (X_2)$ | $869 + 428 (X_2)$ |

1. The only exception to this is when the CATV system makes use of existing ducts and only cable pulling costs are needed.

## Amplifier Installation Cost

The amplifier installation standard is two manhours per amplifier. This includes the installation and balancing of the amplifier. This number is based upon industry averages and aggregates trunk amplifiers, bridger amplifiers, combined trunk and bridger amplifiers, and line extender amplifiers into one homogeneous grouping.

The procedure employed in developing a normalized equation for amplifier installation costs is as follows:

(1) Multiply standard by equivalent hourly rate for electricians

(2) Multiply (1) by 0.45 to determine labor overhead

(3) Add (1) + (2) and multiply by 10 percent for fee

(4) Add (1) + (2) + (3) for total amplifier installation cost.

| | |
|---|---|
| Step (1) | $2 \times [X_2]$ |
| Step (2) | $[2X_2] \times .45 = .90\ (X_2)$ (overhead) |
| Step (3) | $[\, 2(X_2) + .90\ (X_2)\, ]\ .1 = .29\ (X_2)$ (fee) |
| Step (4) | Total cost $= 2[X_2] + .9\ (X_2) + .29\ (X_2)$ |
| | $= 3.19\ [X_2]$ |

where $X_2$ = equivalent hourly rate - electrician.

## Pedestal Material and Installation

In underground systems, the electronics (amplifiers and taps) are usually contained in a vault or pedestal. This vault is adjacent to the cable and conduit and is designed so that the electronics can be replaced or adjusted without ripping up concrete or asphalt. It can be constructed of concrete or steel and is usually buried flush with the street or sidewalk. Because the concrete pedestals are less expensive than comparable steel versions, this study examined only concrete pedestals.

The average cost for such pedestals is $75.00. This is for the pedestal and complete installation. For the pedestal sizes required in a typical system, there is very little difference in cost between these sizes.

Eighty percent of the cost is labor and labor overhead and was based upon an equivalent rate of seven dollars per hour. This can be normalized in the following manner:

$$\text{Pedestal Material and Installation} = \$75 = 15 \text{ (material)} + \$60 \text{ (labor)}$$
$$= 15 + \frac{60}{7.00} [X_3]$$
$$= 15 + 8.57 [X_3]$$

Where $X_3$ = equivalent hourly rate.

Concrete Repaving

Concrete repaving standard costs are usually expressed in $/sq yard as a function of thickness. These costs, which are shown below, are average costs based upon bulk work. The dollars per square yard can be converted into dollars per square foot. This measure is actually a cost per linear foot since the width of the trench is assumed to be one foot.

Table D-4

CONCRETE REPAVING COSTS

| Thickness (inches) | $/Sq Yd | $/LF | $/Mile |
|---|---|---|---|
| 2 | 2.36 | .262 | 1382 |
| 3 | 3.45 | .383 | 2024 |
| 4 | 3.80 | .422 | 2229 |
| 5 | 4.25 | .472 | 2493 |
| 6 | 4.80 | .533 | 2816 |
| 7 | 5.23 | .587 | 3098 |
| 8 | 5.85 | .650 | 3432 |
| 9 | 6.43 | .714 | 3772 |
| 10 | 6.85 | .761 | 4019 |
| 11 | 7.54 | .838 | 4424 |
| 12 | 7.95 | .883 | 4664 |

Twenty-nine percent of the per mile cost is labor related. Thus, each total cost can be partitioned into a material cost and a labor related cost. If the labor component is divided by the Washington, D. C. hourly labor rate, a normalized series of equations can be derived.

For example, 2" thick concrete costs $1382 per mile

$$\$1382 = 981.22 \text{ (material)} + 400.78 \text{ (labor)}$$

$$\text{Cost per mile} = 981.22 + \frac{400.78}{7.00} [X_3]$$

$$= 981.22 + 57.25 [X_3]$$

The concrete per mile repaving costs can thus be expressed in the following form:

$$Y = A + B [X_3]$$

where $Y$ = repaving cost per mile

$A$ = material cost

$B$ = labor component cost

$X_3$ = equivalent hourly rate.

Table D-5 illustrates this format.

Table D-5

CONCRETE REPAVING COSTS

Concrete Repaving Costs (per mile) = A + B $[X_3]$

| Thickness (inches) | A | B |
|---|---|---|
| 2 | 981.22 | 57.25 |
| 3 | 1437.04 | 83.85 |
| 4 | 1582.59 | 92.34 |
| 5 | 1770.03 | 103.28 |
| 6 | 1999.36 | 116.66 |
| 7 | 2199.58 | 128.35 |
| 8 | 2436.72 | 142.18 |
| 9 | 2682.38 | 156.52 |
| 10 | 2853.49 | 166.50 |
| 11 | 3141.04 | 183.28 |
| 12 | 3311.44 | 193.22 |

## Asphalt Repaving Costs

Aspahlt repaving costs are developed in almost the identical manner as concrete repaving costs. The specific differences between the two arise because:

- Asphalt is not usually found in the same thickness as concrete.
- The cost per square yard is different (asphalt is cheaper).
- Asphalt is less labor intensive (15% versus 29% for concrete).
- Asphalt repaving requires a one-time equipment move-in charge of $250.00.

Table D-6 shows asphalt repaving costs as a function of thickness.

Table D-6

ASPHALT REPAVING COSTS

| Thickness (inches) | $/Sq Yd | $/LF | $/Mile |
|---|---|---|---|
| 2 | .77 | .086 | 452 |
| 3 | 1.19 | .132 | 698 |
| 4 | 1.58 | .176 | 927 |
| 5 | 1.91 | .212 | 1117 |
| 6 | 2.33 | .259 | 1367 |

Utilizing the 15 percent labor component of the total per mile costs and normalizing the labor rate, the total per mile asphalt repaving cost can be expressed in the following form:

$$\text{Asphalt repaving cost} = A + B\,[X_3]$$

where $A$ = material component cost

$B$ = labor component

$X_3$ = equivalent hourly rate.

Table D-7 illustrates this form.

Table D-7

ASPAHLT REPAVING COSTS (Per Mile)

Asphalt Repaving Costs (Per Mile) + A + B ($X_3$)

| Thickness (inches) | A | B |
|---|---|---|
| 2 | 384.20 | 9.69 |
| 3 | 593.30 | 14.96 |
| 4 | 787.95 | 19.86 |
| 5 | 946.90 | 23.87 |
| 6 | 1161.95 | 29.29 |

APPENDIX E

TIME-LIFE BROADCAST, INC.
CATV TECHNICAL STANDARDS

It is the interest of Time-Life Broadcast to plan, construct, and operate its existing and future systems to the highest level of technical standards achievable within the framework of current technology. To achieve this objective, the following detailed performance parameters and construction guidelines have been developed. Standards are herein established for initial layout of trunk and distribution system, headend and distribution hub design, and local studio facilities. Additionally, construction standards (both overhead and underground) have been specified.

Local conditions may occasionally require deviations from these standards to conform to specific needs, problems, codes, etc. of its community. Therefore, the specifications should be considered a general guide rather than an inflexible set of rules.

I. General Concept

All TLB systems constructed in the future, and existing systems to be rebuilt, or extended will be constructed with a dual outgoing plant as a minimum. Coaxial cable used will be capable of transporting the full spectrum to 300 mhz; amplifiers will be solid state push-pull output and passive equipment designed for two-way response between 10 and 300 mhz. Where required to transport a high quality video signal in the reverse direction, a third (reverse feed) cable will be used, such as would be needed to interconnect a local or remote CATV origination studio with the headend or distribution point.

Presently, the system capabilities for future two-way cable communication are not clearly defined, but in order to hold the risks of system obsolescence to a minimum, a basic (expandable) two way capability will be designed-in initially.

At future TLB systems, the basic system will include: 1) a separate (discrete) return coaxial cable running along main trunk routes to carry future return feeds from major community centers; 2) a plan whereby one of the two outgoing distribution cables can, in the future, be modified for two-way and cross connnected to the nearest return feed cable.

Wherever practical, a hub, or section distribution plan, will be employed. The main "hub" will be at or near the geographic center of the community with feeds emanating to major community sectors via discrete cable routes thereby permitting sector program distribution. The main tv station receiving site will be at an outlying location interconnected to the main hub by coaxial cable or LDS microwave. The tv receiving site will also be selected so as to serve as a distant signal or microwave or future satellite receiving station location.

Local origination facilities will be generally designed for color. The central studio will contain a minimum of two live color cameras, two color videotape machines and a color film chain, with multiplexer for 16 mm, 35 mm slides and adaptable for future super 8 mm film usage. Monochrome facilities will be provided for community studios where cost factors and lighting facilities, etc. preclude the use of color equipment.

II. Plant Specifications

1. Coaxial Cable -- the plant shall be constructed using a minimum of two discrete outgoing cables. Where not required for initial operation, unused cable ends shall be sealed and protected from moisture and other possible damage. A third discrete coaxial cable shall also be installed from neighborhood (community center) areas to the hub center (for local program carriage and future return data transmission.)

a. Trunk: (0.750"/0.500")conductor: solid copper insulation: Polyethylene cellular, extruded. Shield: Aluminum, seamless tubing. Jacket: Polyethylene.

Maximum attenuation as follows:

| Frequency | 0.750" | 0.500" |
|---|---|---|
| 50 mhz | 0.47 db/100 ft. | 0.64 db/100 |
| 216 " | 0.95 " | 1.35 " |
| 240 " | 1.00 " | 1.43 " |
| 300 " | 1.13 " | 1.60 " |

Return loss: 30 db or better, 50 - 300 mhz.

b. Distribution: (0.412") conductor: solid copper insulation; Polyethylene, cellular, extruded. Shield: Aluminum, seamless tubing. Jacket: Polyethylene. Maximum attenuation as follows:

| | |
|---|---|
| 50 mhz | 0.75 db/100 ft. |
| 216 " | 1.65 " |
| 240 " | 1.75 " |
| 300 " | 1.95 " |

Return loss: 30 db or better. 50-300 mhz

Underground Cable

The above specifications apply; however, where cable is installed in buried conduit, the cable shall contain an additional moisture barrier in the form of a flooding compound interspersed between the outer Polyethylene jacket and the aluminum tubing.

No trunk or distribution cable shall be directly buried unless it contains a protective steel outer covering (spiral wrap or corrugated), a second Polyethylene jacket protecting the steel from corrosion, plus a moisture barrier flooding compound inside both the inner and outer jackets.

Subscriber Drop Cables

Overhead drop cables should preferably be dual type to present a clean appearance; underground installations may be separate cables, however, in either case, 100% shielded type cable is required. Where a dual drop is installed underground, it should either be in plastic conduit or a cable type specifically designed for direct burial for the soil conditions indigenous to the area. In any event, direct burial drop cables should be preferably a dual jacket type with steel outer wrap and moisture protective flooding compound. General subscriber drop cable characteristics are:

| Dielectric | 54 mhz | 216 mhz |
|---|---|---|
| cellular Polyethylene (foam) | 1.9 db/100 | 4.2 db/100 |
| natural Polyethylene (solid) | 2.70 db/100 | 5.50 db/100 |

2. Amplifiers (trunk and distribution)

All amplifying equipment installed shall be push-pull output type capable or normal operation between 50 and 260 mhz. In locations where wide temperature variations are anticipated a dual pilot AGC system will be required with AGC amplifiers located at every third location, as a minimum.

To prevent power line (or cable induced) surges from causing component failure, individual 60 hz power transformers shall be an integral part of each amplifier's internal power supply. This transformer shall be wired so that it serves as an effective isolation device between the coaxial cable and the power supply rectifying, regulatory and filtering components. Additional power surge protective devices should be designed into input and output circuits to protect amplifier components.

General specifications for amplifiers in TLB systems are as follows:

| | Trunk | Distribution | Extender |
|---|---|---|---|
| Gain (min) | 26 db (AGC)<br>23 db (man) | 46 db | 25 db |
| Response | ± 0.25 db | ± 0.75 db | ± 1.0 db |
| AGC Comp. | + 0.6 db for Tnput change of ± 4 db | - | - |
| Hum level (min) | - 60 db | -60 db | - 60 db |
| Impedence match return loss | 16 db | 16 db | 16 db |
| Noise figure (max) | 10 db | 10 db | 14 db |
| Cross Modulation at operating levels, 20 chan operation | -90 db | -60 db | -60 db |

3. Passive Electronic Devices (splitters, couplers, taps, etc.)

All passive equipment utilized in TLB systems should be capable of response between 10 and 300 mhz and designed for two-way operation (i.e., reverse feed of frequencies below 35 mhz). All taps shall be of the directional coupler type. Minimum isolation between desired and undesired signal paths should be 30 db. Mechanically, the device should be appropriately designed for the service intended application (i.e., indoor,outdoor,underground,etc.) Fitting should be mechanically and electrically secure, preferably of the center conductor screw-down type. General specifications are:

| | |
|---|---|
| Impedence Match return loss | 20 db |
| Bandwidth | 10-300 mhz |

Subscriber installation material (i.e. cable fittings, grounding blocks) should be a general good quality to provide secure and safe construction. Where grounding wire, rod, clamps, etc. are used they shall be selected to conform to pertinent National Electric Code and local electrical safety specifications. Subscriber terminal 75/300 ohm balum shall have an insertion loss of 0.7 db or less over a spectrum of 50 to 260 mhz.

Cable A-B switches should be designed to: 1) electrically insert a terminating 75 ohm resistor or the output of the unused cable and 2) provide a minimum of 60 db of isolation between the desired and undesired cable signal.

4. Head End Equipment

a. Antennas - Each antenna shall be of sufficient gain and directivity to provide adequate reserve of signal to noise ratio and suppression of adjacent channel interference. Co-channel interference levels shall be computed, and each antenna selected and oriented for a theorectical minimum of 55 db suppression of the undesired co-channel station. If necessary, the antenna height may be reduced to achieve required ratios. Except where specific needs dictate, all

VHF antennas shall be of log periodic design. More than one station may be received on an individual antenna, providing all specifications can be achieved, including co-channel suppression. The following specifications shall apply:

1) Antennas shall be ruggedized in construction with heavy duty cross arms and welded joints.

2) All exposed metallic parts shall be adequately protected from corrosion.

b. Converters and Preamplifiers - All active tower mounted devices shall be designed to operate continuously and meet full specifications under the most adverse weather and temperature conditions anticipated. Converters shall be frequency stabilized to conform to ± 25 khz tolerance (see Section III Performance).

c. Hetrodyne Processing Devices - All processing amplifiers shall be solid state and of modular design. The following specifications shall apply.

| | |
|---|---|
| Response: | ± 1 db max over desired channel |
| Sensitivity: | - 20 dbmv input level for + 60 dbmv output |
| Adjacent Carrier Rejection: | 50 db |
| Image Rejection | 60 db |
| Output Level | Adjustable to ± 60 dbmv |
| AGC Range | + 0.5 dbv output level variation for input levels of -20 dbmv to +30. |
| Ambient Temperature Range: | -20°F to 120°F |
| Frequency Stability: | On channel: phase locked to tv station. Off channel: ± 25 khz of assigned frequency. |

d. Combining Network - The single channel headend processing amplifier outputs shall be combined in a network which will result maximum isolation between channels. The network should be designed so that a correct impedence match to each signal processed is maintained regardless of the condition of other processers in the system. A maximum return loss of 18 db should be maintained at all times at any input port of the network, and the networks' output driving impedence (feed to cable) shall be 75 ohms with a maximum return loss of 18 db.

III. Performance Specifications

The following technical performance specifications are for the purpose of covering specified transmissions regardless of location or distance. The specifications that follow relate to factors affecting picture quality in the carriage of NTSC-TV signals within standard 6 mhz bandwidth channels, as designated by FCC in Sec. 73.682 (a) either in the frequency bands designated in Sec. 73.603 (a) or any other designation deemed appropriate.

1. Headend

This section covers performance of those portions of the system designed to process and transmit a single TV channel (visual and aural) from the source (off-air or origination) to the multiplex combiner located at the distribution hub.

The various input terminals are defined for relevant specifications as follows:

a) Terminals to which the antenna is connected for broadcast signals received over the air.

b) Video and audio input terminals of any TV channel modulator located anywhere within the system including neighborhoods, and mobile origination studios at any or all possible points of insertion into the transmission system, but not including inter-city common carrier or CARS microwave.

a. Signal-to-noise-ratio is not specified separately but included in the overall system data.

b. Multiburst frequency response of single channel equipment (at the head-end or origination points) shall conform with Sec. 73.687 (a) of FCC Rules, as follows:

| White Level | 0 db Reference |
|---|---|
| 0.5 mhz | +0, -2db |
| 1.5 | +0, -2 |
| 2.0 - 3.0 | +0, -2 |
| 3.58 | +0, -2 |
| 4.18 | +0, -6* |

* Not more than 4 db below the level of the 3.58 mhz burst.

c. Video Modulation - TV channel modulators used either as part of the system or as test instruments, shall be adjusted to 87.5% ± 2.5% downward modulation at reference white level with FCC standard composite video waveform as indicated in Sec. 73.699, Figure 6 or 7, as applicable. (FCC Rules)

d. Transfer linearity shall be adjusted for optimum practicable performance at 10%, 50%, and 90% of APL, but in any case differential gain shall not exceed 2 db; differential phase shall not exceed 5° for R-F input, or 10° for video input.

e. Transient Response to a 2T sine-squared pulse (HAD 0.250 microseconds) shall fall within the limits indicated by a 5 K-rating.

f. Chrominance delay relative to luminance, as indicated by response to t modulated 20T pulse, shall not exceed ± 150 nano-seconds for RF input or -170 ± 120 nano seconds for video input. Measurement accuracy shall be ± 20 nano-seconds or better.

g. Low and mid frequency distortions, as indicated by response to the 60 hz "window" signal, with a 2T transitions, shall not exceed 5 IRE units in tilt, rounding or overshoot.

h. The frequency of each visual carrier shall be 1.25 ± .025 mhz above the lower boundary of nominal channel assignment.

i. The center frequency of all FM radio carriers shall be maintained within ± 10 khz of the nominal center.

j. FM Aural signals shall meet all the requirements of FCC Rules Sec. 73.687 (b) for signals associated with tv channels; with Sec. 73.317 (a) subparagraphs (1) through (5) for FM radio monauralsignals; and with Sec. 73.322

stereophonic signals.

k. <u>Best engineering effort</u> within the restrictions imposed by the state of the art (including economic and zoning limitations) shall be exercised in antenna system design, to avoid or minimize co-channel interference; electrical noise interference, multipath signals, or excessive fading.

2. <u>Distribution System</u>

a. <u>Signal level of the visual carrier</u> at the 75-ohm service drop termination at any subscriber's TV (or at the drop terminal serving multiple dwellings with distribution system) on any channel at 70°F shall not be less than +6 dbmv level to each TV set installed. Levels below 6 dbmv, but not less than 0 dbmv will be acceptable providing direct pick-up interference or excessive noise resulting from low levels are corrected.

b. <u>The difference in level</u> between any two channels at any particular subscriber terminals shall not exceed 10 db at 70°F.

c. <u>The difference in level</u> between visual carriers in any two TV channels contiguous in frequency at any particular subscriber terminals shall not exceed 2 db, at 70° F.

d. <u>Signal level of the aural carrier</u> in any TV channel shall be at least 13 db and not more than 17 db below the level of the associated visual carrier.

e. <u>Signal level of FM radio carrier</u> shall be between -14 dbmv and 0 dbmv, provided that FM carriers between 88 and 90 mhz shall be at least 10 db below the Channel 6 visual carrier, if any.

f. <u>Visual carrier to rms thermal noise power</u> ratio on any channel, overall, with the antenna or video input terminals terminated, shall be no less than 40 db (4 mhz noise bandwidth) at any location, measured at approximately 70° F. Note: If the limitations of site location and permissible tower height make it impossible in spite of best engineering efforts to receive signals in excess of -5 dbmv at the antenna terminals from any station authorized for carriage on the system, the requirements of this paragraph shall be waived with respect to that station only

g. Cross-modulation ratio on the visual carrier in any TV channel shall not exceed -40 db (0.325) as defined by NCTA 002.0267, at any location, measured at approximately 70°F. The generation of spurious signals, particularly inter-modulation products and harmonics, shall be maintained as low as the state of the art permits, but in no case greater than -60 db at approximately 70°F unless it can be shown that a particular spurious signal at higher level is not perceptible on a commercial TV set.

There shall be no visible cross-modulation or inter-modulation products generated within the cable system on any channel carried on the system at any location, time or temperature.

h. Hum Modulation shall be no more than 2% at any time, location, supply voltage between 105 and 135 volts, or temperature. (Note: hum modulation is the ratio of one-half the peak-to-peak hum to the average carrier envelope.)

i. The peak-to-valley radio frequency amplitude frequency response of the trunk distribution system measured at the output of any trunk amplifier shall not exceed 3 db between 54 and 252 mhz, at any temperature between 0° and 100°F.

j. AGC shall be installed at not fewer than one trunk location in every three in cascade. AGC stiffness ratio shall be not less than 6 to 1.

k. Direct pick-up causing leading ghosts or blanking bars shall not be visible on a thoroughly shielded test receiver or converter connected to any service drop. Ghosts, ringing, or reflections of any sort shall be eliminated, or minimized as much as possible, subject to limitations imposed by the technical state of the art. The design, construction, and operation of the entire system from antenna or video input to service drops shall be such as to minimize reflections and all unused taps shall be terminated.

l. All specifications shall be met for any primary supply voltage between 105 and 135 volts.

m. Isolation between any two TV sets, on the same or different premises, shall exceed 18 db with either set tuned to any channel on the system, except that isolation up to but not exceeding 30 db, may be required to prevent interaction in exceptional cases.

n. Dual cable switches located at subscriber TV terminals shall provide isolation between cables of at least 65 db, and shall have 75 ohm return loss of 18 db or greater. No evidence of cross-coupling between the two cables shall be visible on any subscriber's TV set.

o. Compliance with all relevant FCC technical performance rules shall be provided. Where there is a conflict between FCC rules and the foregoing specifications or between any of these specifications, the more restrictive shall be controlling.

p. Incidental Radiation from any part of the system or service outlets shall conform with Subpart D of Part 15 of FCC Rules, or such modifications thereof as may subsequently be adopted.

IV Measurement Methods

1. Signal level measurements shall be made with a properly adjusted and accurately calibrated selector R.F. voltmeter, or signal level meter.

2. Video Testing shall be performed in accordance with NCTA or IEEE standard methods, where available, or by methods generally accepted in the TV and CATV industries. Video tests may be made at the input to the IF amplifier of the heterrodyne processor unless evidence exists indicating defective performance of preamps, converters, strip amplifiers, or tuners.

3. Noise levels shall be measured in accordance with NCTA Standard No. 005-0669.

4. Cross Modulation may be tested by substituting a CW carrier for each of the normally carried visual carrier in turn and inspecting the raster of a TV receiver connected to the cable. Measurements made in accordance with NCTA Standard 002-0267 shall be considered to be more reliable, but need not

be performed unless the foregoing method produces results inconsistent with subscriber complaints or direct viewing in homes.

5. Spurious Signals may be detected and measured with a spectrum analyzer or other suitable instrument.

6. Frequency shall be measured with suitable equipment having overall accuracy of $10^{-6}$ (1 ppm) or better.

V. Construction Standards

1. Overhead - The installation shall conform to the requirements applicable to urban districts in the National Electrical Safety Code and shall apply to all streets, alleys, roads, and drives. All aerial coaxial cables shall be laced with lashing wire to messenger cables by means of a suitable lashing machine. Lashing wire shall be 0.045-inch stainless steel of the type used to lash aerial telephone cables. The pitch of lashing wire may be from 10 to 15 inches but shall be consistent throughout the system. Construction shall be in accordance with pole attachment drawings. Fig. 1-6.

2. Underground - Under paved areas and roadways, the cables shall be installed in conduit not less than two inches in size. Conduit shall be zinc-coated rigid steel. Conduit shall be extended not less than two feet beyond pavements and roadways, when such roadway is utilized for vehicular traffic.

Trenches in which direct burial cables are placed shall have a minimum depth of 18 inches below grade, shall be not less than six inches wide, and shall generally be in straight lines between cable connections, except as otherwise necessary. Bends in trenches shall have a radius of not less than 36 inches.

Rock, where encountered, shall be removed to a depth of not less than three inches below the cable depth and the space filled with sand or clean earth, free from particles that would be retained on a quarter inch sieve. Cables shall be unreeled in place at the bottom of the trench. Cables normally shall not be unreeled and pulled into the trench from one end. Cables shall be in one piece without splices between connections except where the distance exceeds the length in which the cable is manufactured.

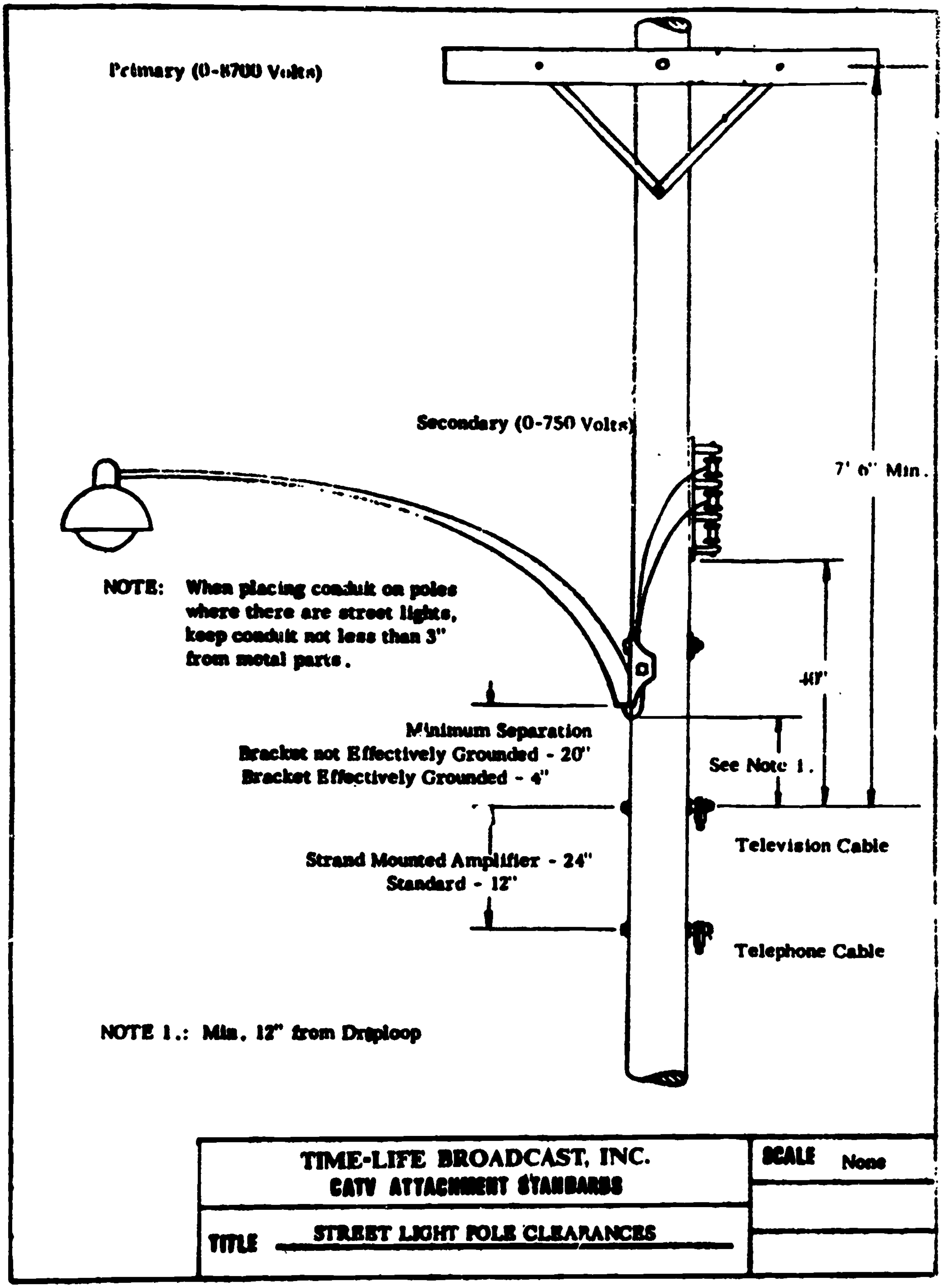
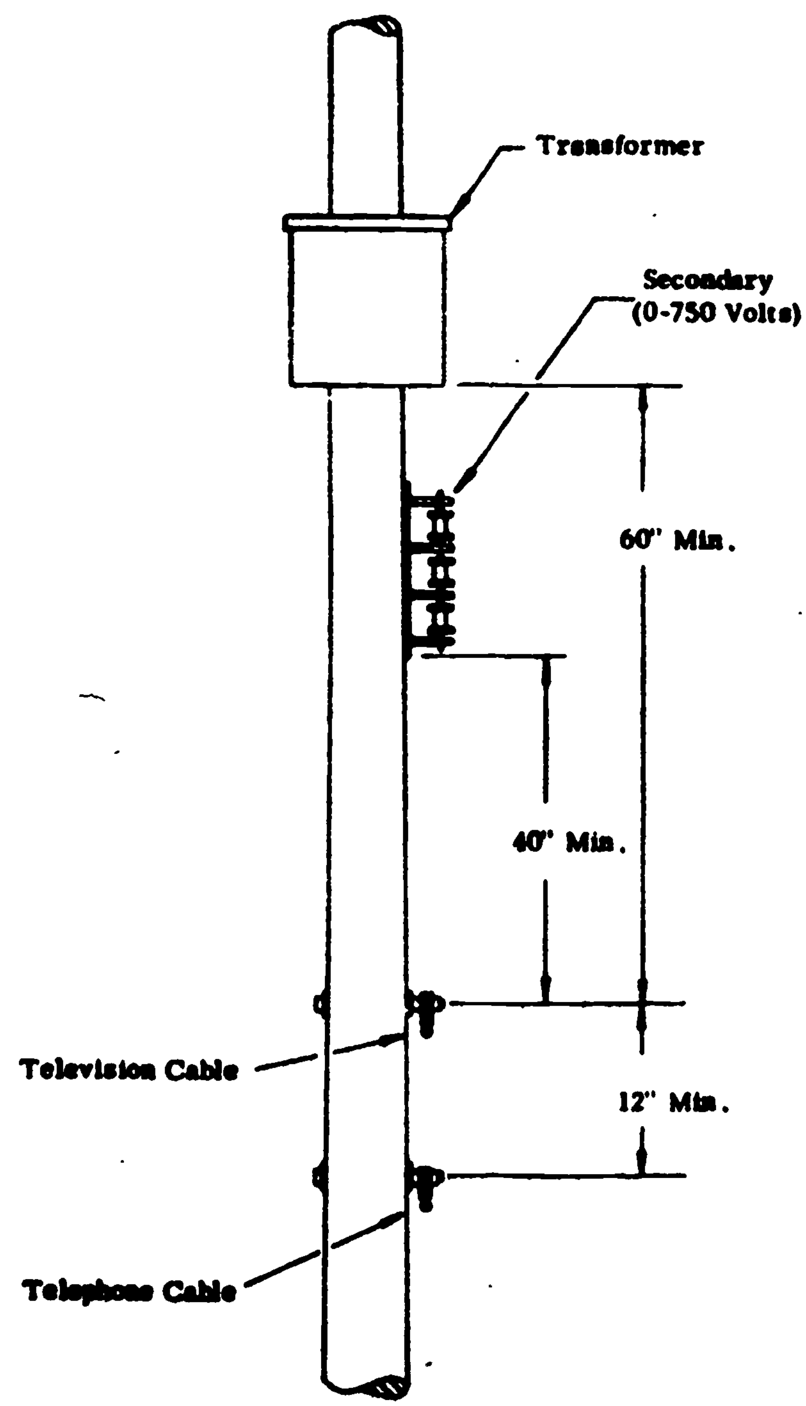
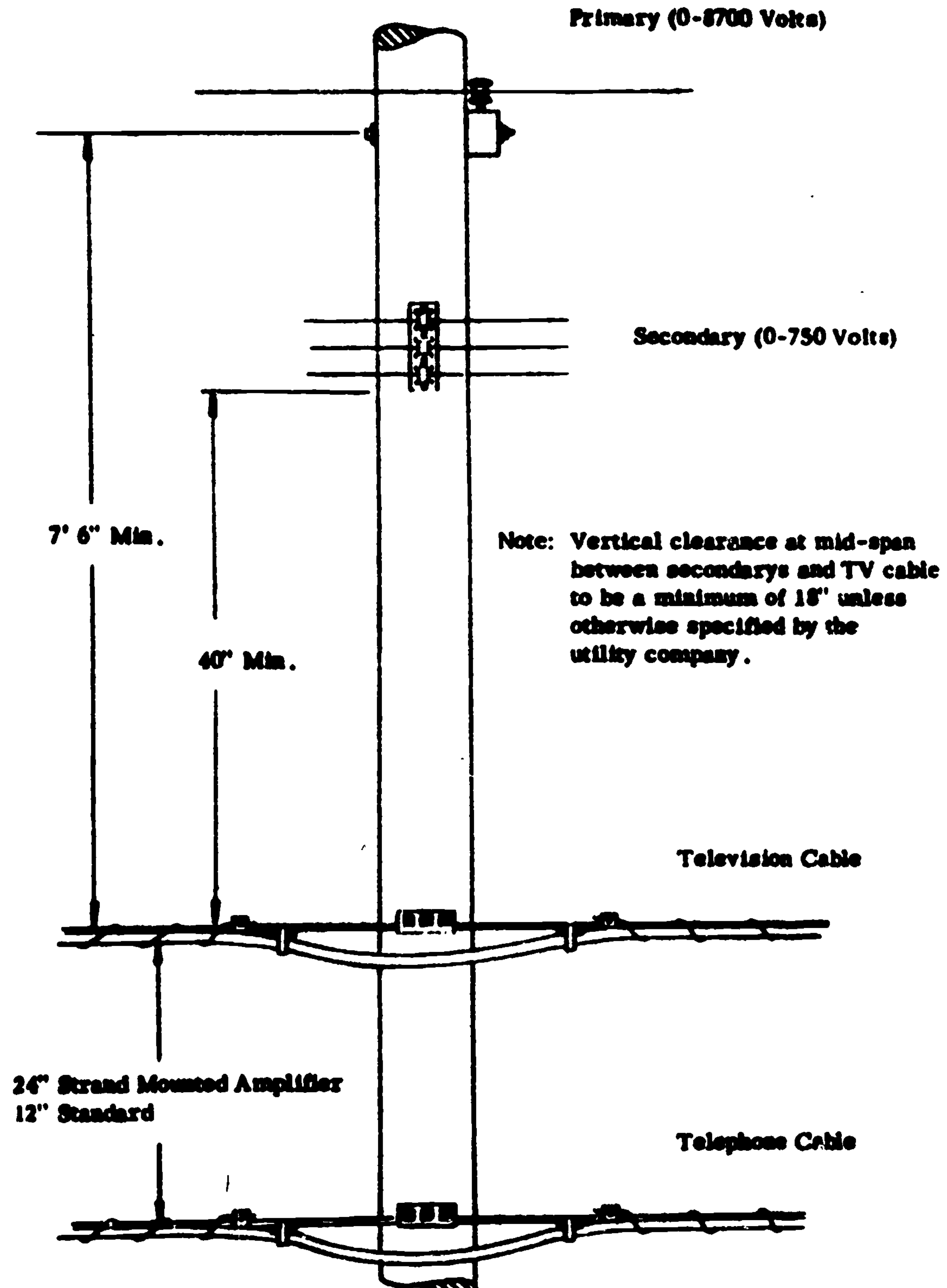

Primary (0-8700 Volts)
Secondary (0-750 Volts)
7' 6" Min.
40"
NOTE: When placing conduit on poles where there are street lights, keep conduit not less than 3" from metal parts.
Minimum Separation
Bracket not Effectively Grounded - 20"
Bracket Effectively Grounded - 4"
See Note 1.
Television Cable
Strand Mounted Amplifier - 24"
Standard - 12"
Telephone Cable
NOTE 1.: Min. 12" from Driploop
TIME-LIFE BROADCAST, INC.
CATV ATTACHMENT STANDARDS
SCALE None
TITLE STREET LIGHT POLE CLEARANCES



Figure 1



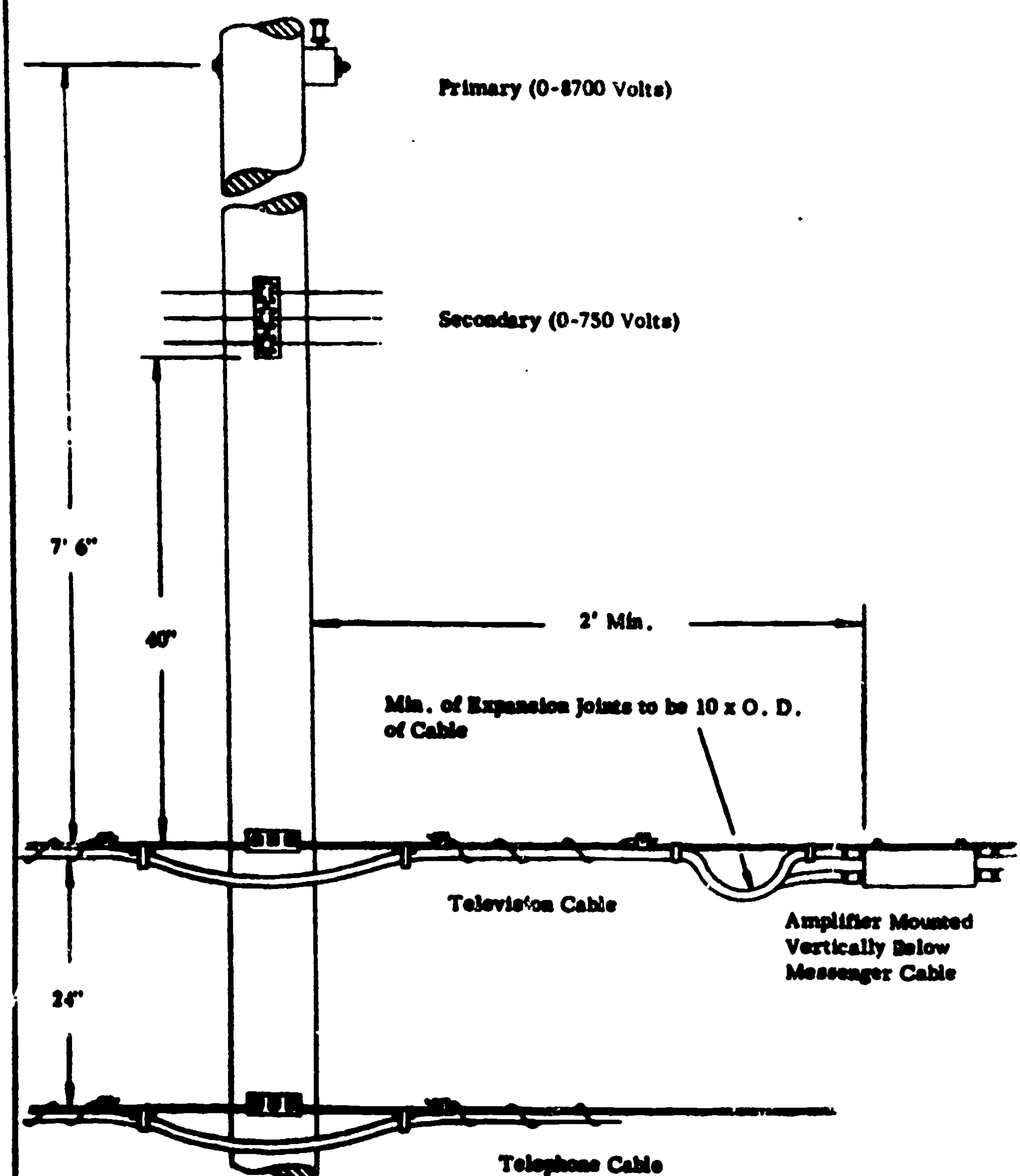

| | |
|---|---|
| TIME-LIFE BROADCAST, INC.<br>CATV ATTACHMENT STANDARDS | SCALE None |
| TITLE TRANSFORMER POLE CLEARANCES | |




| | |
|---|---|
| TIME-LIFE BROADCAST, INC.<br>CATV ATTACHMENT STANDARDS | SCALE None |
| TITLE LINE POLE CLEARANCES | |



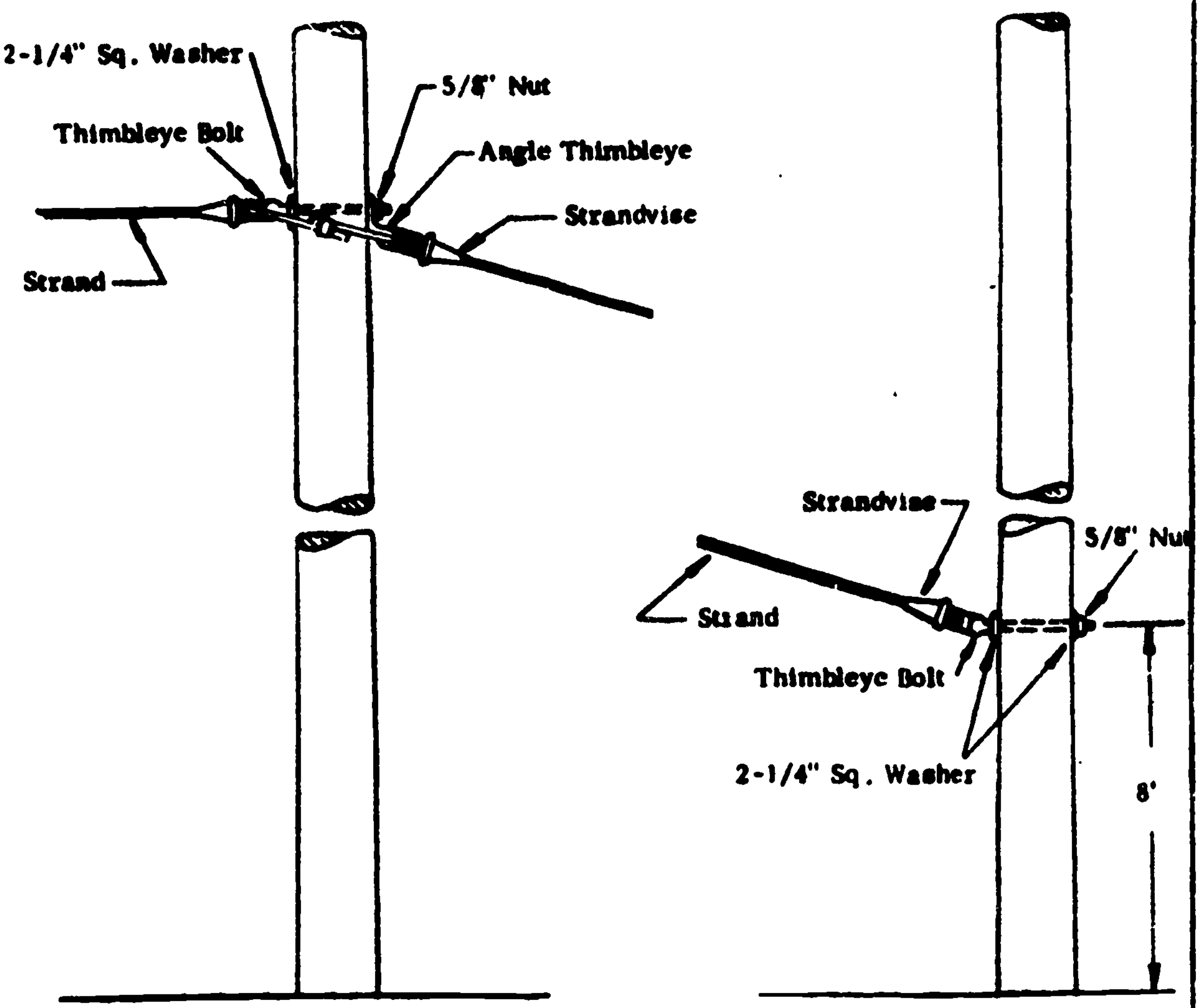
Figure 3




| | |
|---|---|
| TIME-LIFE BROADCAST, INC.<br>CATV ATTACHMENT STANDARDS | SCALE None |
| TITLE POLE CLEARANCES FOR STRAND MOUNTED AMPLIFIER LOCATION | |

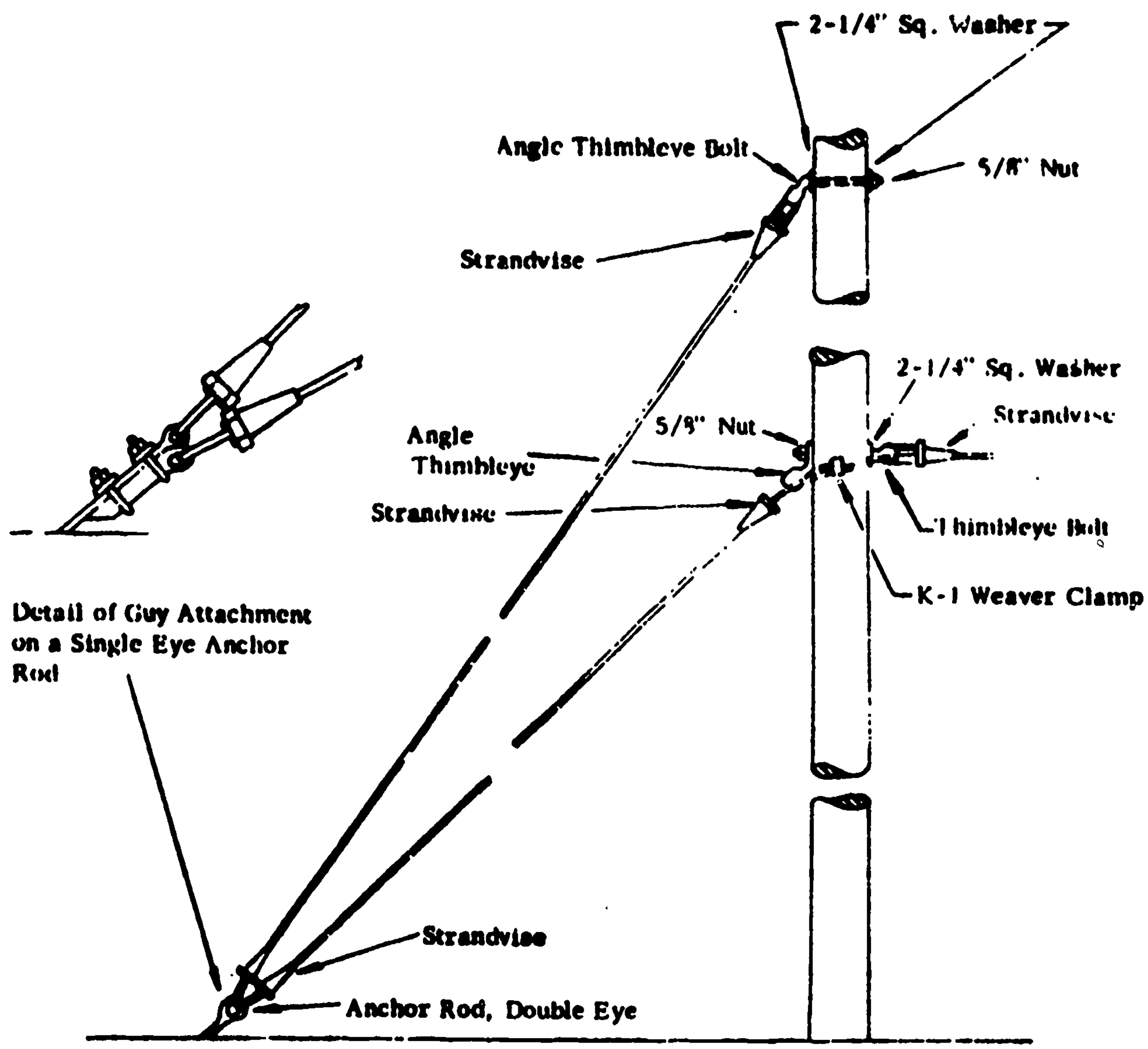


Figure 4




NOTE: The CATV pole to pole guy shall be anchored on a separate bolt at least 6" from any existing anchor bolt.

| | |
|---|---|
| TIME-LIFE BROADCAST, INC.<br>CATV ATTACHMENT STANDARDS | SCALE None |
| | REV. |
| TITLE POLE TO POLE GUY | |




NOTE: The CATV Company will supply a guy guard at locations specified by owner of pole.

| | |
|---|---|
| TIME-LIFE BROADCAST, INC.<br>CATV ATTACHMENT STANDARDS | SCALE None |
| | REV. |
| TITLE GUY ATTACHMENTS (DOUBLE & SINGLE EYE ROD) | |



Figure 6

APPENDIX F

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Atlanta, Georgia

- Antenna Systems
- Signal Processors
- Modulators/Demodulators
- Preamplifiers, converters, filters, and passive devices
- Single Channel microwave systems

B. Jerrold Corp.
Philadelphia, Pennsylvania

- Antenna Systems
- Signal Processors
- Modulators/Demodulators
- Preamplifiers, converters, filters, and passive devices
- Coaxial Cable
- Trunk, Bridger and Line Extender Amplifiers
- Test equipment
- Origination Equipment
- Subscriber Material
- Connectors, etc.

C. Kaiser CATV
Phoenix, Arizona

- Coaxial Cable
- Trunk, Bridger and Line Extender Amplifiers
- Splitters and Taps
- Pilot Carrier Generator
- Cable Powering Units
- Cable Fittings

D. Essex International, Inc.
Chicago, Illinois

- Coaxial Cable

E. GTE - Sylvania
Seneca Falls, New York

- Trunk, Bridger and Line Extender Amplifiers
- Power Supplies
- Filters, Splitters, and Directional Couplers

F. AEL Communications Corp.
Landsdale, Pennsylvania

- Power Supplies
- Trunk, Bridger and Line Extender Amps
- Pilot Carrier Generators
- Splitters
- Converters
- Handbook

G. Entron Corp.
Silver Spring, Maryland

- Amplifiers
- Attenuators, Filters, and Mixers
- Power Supplies
- Taps, Cable Connectors

H. Theta-Com.
Los Angeles, California

- AML Multichannel Microwave System