METRO RAIL TRANSIT CONSULTANTS

August 31, 1983

Mr. Robert J. Murray
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Subject: Communications Alternatives Analyses Study, WBS 14CAC

File : P001Z410 14CAC

Dear Mr. Murray:

Attached are four (4) copies of the Communications Alternatives Analyses Study, a preliminary version of which was submitted with a January 17, 1983 letter from P. M. Burgess to W. J. Rhine and commented on in Mr. Rhine's February 22, 1983 memo to Mr. Burgess. The frequency allocation study addressed in the February 22 memo, and being carried out by T. J. Collins Associates, will address the vehicle radio configuration and, as such, is not being undertaken at this time. The telephone description in the Executive Summary now has been clarified, deleting references to the emergency telephone system. The DeLeuw Cather study on cable transmission alternatives was transmitted separately on May 16, 1983 as Chapter V for District comments. We have not received any comments and are including this as Chapter V of the 14CAC deliverable.

This fulfills our requirements for deliverable under WBS 14CAC.

METRO RAIL TRANSIT CONSULTANTS

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Final Report

COMMUNICATIONS ALTERNATIVES ANALYSES

WBS 14CAC

KE Job 81152-403

Prepared for the
Southern California Rapid Transit District
by
Kaiser Engineers California

August 1983

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EXECUTIVE SUMMARY

The purpose of this work element is to enable the Metro Rail Project staff to select preferred design alternatives for the communications system and its major components. This report includes analyses of the alternatives and recommendations for vehicle radio service, telephone service, closed circuit television (CCTV), and cable transmission service (CTS).

Originally, two other analyses were to be included: an analysis of lease-vs.-buy telephone equipment, and an analysis of TV camera aperture control vs. higher levels of illumination.

Analysis of the lease-vs.-buy alternative was discontinued after Pacific Telephone representatives informed us that a recent court ruling precludes any guarantee that the telephone company will be in the leasing business when telephone services and equipment are being procured for the Metro Rail System (see Appendix H). The evaluation of TV camera aperture control was discontinued after a technology assessment showed that moderately priced cameras meeting the video requirements with relatively wide-range automatic aperture control have recently become available. Thus, one camera design is suitable for all station requirements, without the need for extra illumination (see Appendix G).

The methodology used in the analyses compares the total annual costs of each alternative, including capital, maintenance, and operating costs. Annualized capital costs were developed on the assumption that money can be borrowed for 32 years at 12% annual interest. All costs are in 1982 dollars.

The results of these alternatives analyses are expected to advance the design of the communications system toward a configuration that will optimize economy, performance, and reliability. Table A and the paragraphs below summarize the results of each alternative analysis.

PASSENGER VEHICLE RADIO SERVICE

The analysis of vehicle radios evaluates three alternatives: nonremovable radio, removable nonoperable radio, and removable operable radio. For the first two alternatives a portable radio is needed for each train so that the operator can communicate while away from the train. The annual equivalent cost ($74,153) of the removable operable radio is the lowest. The additional handling risk during check-in and check-out and mounting and dismounting from the vehicle raises concerns that need to be addressed in detailed design. The removable nonoperable radio has the same risks and has an annual equivalent cost of $90,327. The nonremovable radio, with an annual equivalent cost of $100,350, is the most expensive of the 3 alternatives. The removable operable radio is recommended for the Metro

Rail System at this time. However, it is also recommended that the current PATCO system, which is similar to the removable operable radio analyzed in this chapter, be considered during final design.

TELEPHONE SERVICE

The telephone service covers administrative calling, maintenance calling, and emergency calling. This analysis evaluates three alternatives: three separate exchanges, two combined exchanges, and one combined exchange. The one combined exchange configuration has a 24% savings in annual equivalent costs over three separate exchanges, and a 15% savings over the two combined exchanges configuration. Thus, the one combined exchange configuration is recommended for the Metro Rail System.

CLOSED CIRCUIT TELEVISION (CCTV) MONITORS

The analysis of monitoring techniques evaluates three alternatives to dedicated monitoring. (Dedicated monitoring was eliminated due to the high cost of providing such a system.) Multiple camera sequencing, split-screen projection, and split-screen sequencing are analyzed. Although multiple camera sequencing is not the least expensive, it is only 5% more than split-screen sequencing and has a proven track record in the rail rapid transit industry. It also has the lowest equipment cost of all three alternatives and implements the fullest potential of a single TV screen.

It is recommended that this alternative be implemented. However, during detailed design certain cameras may be appropriately sequenced in monitors, while other scenes may require continual surveillance. Thus, a combination of multiple camera sequencing and dedicated monitoring might be most effective.

CABLE TRANSMISSION SYSTEM

This analysis evaluates three alternatives for use as the back bone communications facility: 1) an audio frequency copper wire system using physical copper pairs for each telephone and audio circuit back to central control (with coaxial cable for CCTV), 2) a multiplexed coaxial cable system for both audio and video circuits and 3) an optical fiber cable system using digitized audio and video multiplexing (TDM).

To enhance future expansion capabilities and to realize expected future cost reductions and performance capability of the optical fiber cable system its implementation is recommended even though its present annual equivalent cost is highest.

Table A

COST SUMMARY OF COMMUNICATION ANALYSES*

VEHICLE RADIO SERVICE			
Nonremovable Radio			100,350
Removavle Nonoperable Radio		90,327	
Removable Operable Radio	74,153		
TELEPHONE SERVICE			
Three Separate Exchanges			166,400
Two Combined Exchanges		140,900	
One Combined Exchange	126,600		
CCVT MONITORS			
Multiple Camera Sequencing		962,907	
Split-Screen Projection			1,503,435
Split-Screen Sequencing	923,218		
CABLE TRANSMISSION SYSTEM			
Copper Wire (Video on Coax)	805,142		
Coaxial Cable		891,544	
Optical Fiber Cables			1,179,669

*Annual equivalent cost in 1982 dollars

Chapter 1

INTRODUCTION

1.1 BACKGROUND

In WBS element 14CAC, Kaiser Engineers' contractual responsibility was to develop engineering analyses, conclusions, and recommendations on the alternative characteristics of the communications system where several options are available. KE was to analyze the alternatives, reporting on the following:

- The most cost-effective components
- Differences in performance characteristics and operating experience
- Any problem areas for SCRTD application

It was recognized that some design options would have a major impact on the Metro Rail System's and the communication system's effectiveness, while others would have only minor impact, or no impact at all. KE was to analyze only those items that would have a major impact on the communication system and/or the Metro Rail System.

KE prepared a list of candidate design alternatives which was influenced by the District-furnished list of Metro Rail Project Alternatives, dated December 30, 1981. At a meeting on March 1, 1982 with the Metro Rail Project staff, the proposed list was presented and discussed. At that time the following six items were selected for analysis:

- Vehicle radios
- Telephone service configuration
- Closed circuit television monitors
- Cable transmission system
- Controlled aperture cameras
- Lease or purchase of telephone system

The first four of these items became the framework for KE's work effort in WBS 14CAC, and are discussed in Chapters 2 through 5 of this report. The last two items are covered in Appendices G and H.

1.2 PURPOSE/OBJECTIVES

Kaiser Engineers' primary task in WBS 14CAC was to develop engineering analyses, conclusions, and recommendations on the communication system alternatives in sufficient detail to enable the District to make the most beneficial choice from among the alternatives.

The output of WBS 14CAC leads directly into later communication work elements, and the development of information in this work element will be used to establish the design criteria called for by WBS 16CAC.

1.3 SCOPE

The following paragraphs summarize the general scope of the alternative analyses covered in Chapters 2 through 5.

1.3.1 Passenger Vehicle Radio Service Analysis

Alternatives studied:

- o Nonremovable vehicle radio with portable operator's radio
- o Removable nonoperable radio with portable operator's radio
- o Removable operable radio

The analysis was based on a fleet size of 142 vheicles made into 71 dependent pairs. The functional requirements of the service are to provide the train operator with continuous communication with Central Control, communication capability when not onboard the vehicle, and communication with yard control when entering or leaving the yard.

1.3.2 Telephone Service Analysis

This analysis studied methods which could be used to provide the three telephone functions: administrative calling, maintenance calling, and emergency calling. The following alternatives were studied:

- o Three separate exchanges
- o Two combined exchanges
- o One combined exchange

1.3.3 Closed Circuit Television (CCTV) Monitor Analysis

Alternatives to be studied:

- o Multiple camera sequencing
- o Split-screen projection
- o Sequential split-screen projection

Initial screening of the alternatives determined that the "dedicated monitoring" alternative, which requires one TV monitor for each camera, would be too expensive.

1.3.4 Cable Transmission Service CTS) Analysis

This analysis will be submitted under separate cover in January 1983.

1.4 METHODOLOGY

KE made an analysis of the alternatives under consideration. The following list was developed to define those areas which would show critical differences between the alternatives:

- o Capital Costs
- o Operating Costs
- o Maintenance Costs
- o Annual Equivalent Costs
- o Technical Risk
- o Availability

In some instances, other qualitative factors which showed major differences between the alternatives were also included. The methodology section of each chapter details the addition or deletion of any evaluation factor.

1.4.1 Design Assumptions

Design assumptions for the purpose of this report were made by Kaiser Engineers on the basis of the following:

- o SCRTD Metro Rail Project Architectural Standards for Communication
- o SCRTD Metro Rail Preliminary Operating Plan and Design Criteria

The particular design assumptions used for each analysis are listed in each chapter.

1.4.2 Pertinent Literature

In order to obtain the latest information on communication systems, a literature search was made. Vendors were contacted and applicable reports, papers, and equipment specifications obtained and reviewed. Kaiser Engineers' reports on other transit systems were reviewed for any data that would apply to the Metro Rail System. For details, see Appendix A, Bibliography.

1.4.3 Vendors, Users, and Associates

Interviews were also conducted with the following:

- o Equipment manufacturers
- o Personnel at existing rail rapid transit systems
- o Telephone company personnel
- o Engineering associates in the rail rapid transit field

For a complete listing of users, vendors, and associates, see Appendix B, List of Sources.

1.4.4 Calculations

Cost comparisons were based on preliminary estimates; these costs will be further developed in later work elements. The cost analyses include annualized capital cost, based on borrowing money at 12% interest for 32 years at an annual payment schedule of $123.28 per $1,000.00 borrowed.

Other cost values used in calculations were:

- Energy cost - \$0.07/kWh
- Operating labor rate - \$18.00/hr
- Maintenance labor rate - \$19.30/hr

For more details regarding calculations, see Appendix C, Calculations.

1.4.5 Appendices

Backup data for the analyses is presented in Appendices D, E, F, I, J, and K. Information on two analyses that were discontinued is included in Appendices G and H.

Chapter 2

PASSENGER VEHICLE RADIO SERVICE ANALYSIS

2.1 INTRODUCTION

The purpose of this study is to determine the optimum configuration for the passenger vehicle radio service equipment to be used on the Metro Rail System. The functional requirements of the service are to provide the train operator with the ability to maintain continuous communications with Central Control on the mainline during revenue operation and with yard control when entering or leaving the yard and operating within the yard limits. Additionally, the vehicle radio service will be required to provide communications capability at any other location on or near the train.

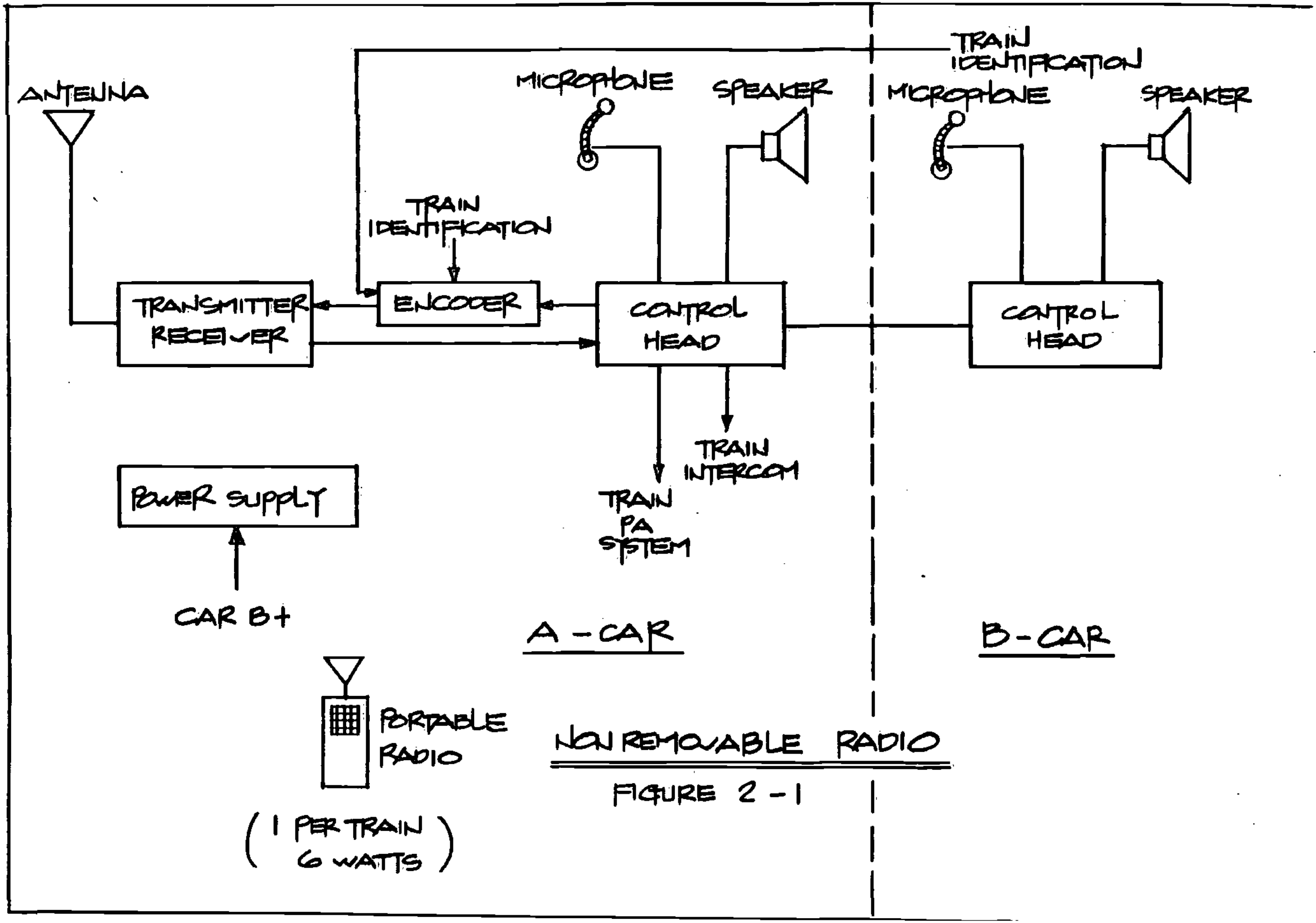
2.2 DESCRIPTION OF ALTERNATIVES

In all three alternatives the control head allows the cab speaker and microphone to be used with the train PA and intercommunications apparatus. Also, the train number can be set manually by the train operator.

2.2.1 Nonremovable Radio (Alternative 1)

In this alternative all radio equipment is permanently installed on each dependent pair of cars. Figure 2-1 shows the configuration for a dependent pair. The train operator is issued a portable radio unit to provide communications while away from the cab. The following equipment is required:

- A-Car: Transmitter/receiver, quarter-wave antenna installed on top of the car, encoder, control head, power supply, microphone, and speaker.
- B-Car: Control head, microphone, and speaker.
- Portable Equipment: One handheld-type radio per train.



NON REMOVABLE RADIO

FIGURE 2 - 1

2.2.2 Removable Nonoperable Radio (Alternative 2)

In this alternative, the transmitter/receiver unit is removable. All other radio equipment is permanently installed, as shown in Figure 2-2, on each dependent pair of cars. As with the first alternative, the train operator is issued a portable radio unit to provide communication capability while away from the cab. The following equipment is required:

- A-Car: Quarter-wave antenna installed on top of the car, encoder, control head, power supply, microphone, and speaker.
- B-Car: Same as A-car except no power supply.
- Portable Equipment: One handheld-type radio per train and one removable transmitter/receiver per train.

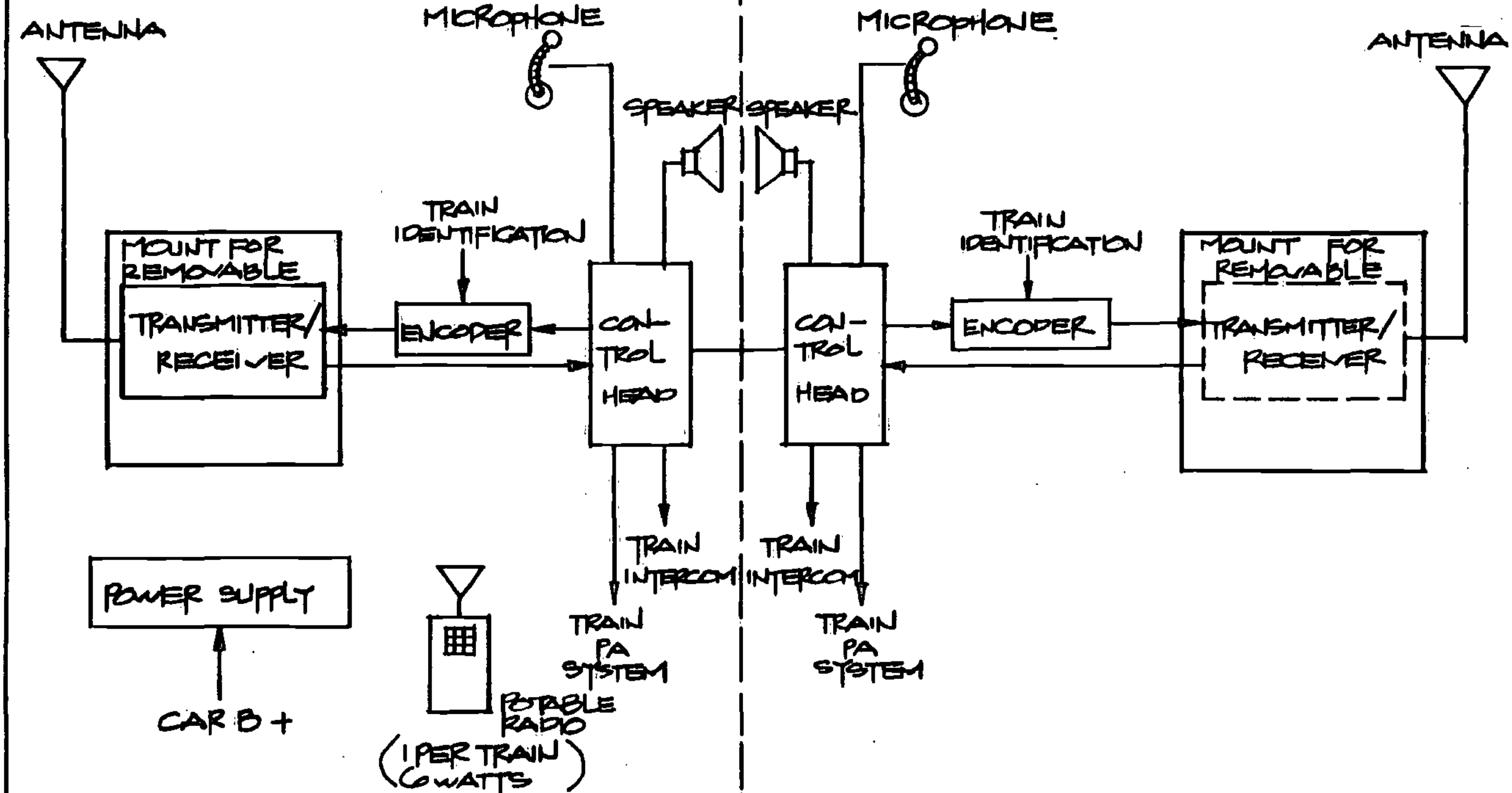
2.2.3 Removable Operable Radio (Alternative 3)

In this alternative, the radio transmitter/receiver is removable and, since it is fully operable outside the train, it can be used by the operator to provide communication while away from the cab. The control head charges the battery in the removable radio unit whenever it is installed in the operator's console. The following equipment, as shown on Figure 2-3, is required:

- A-Car: Quarter-wave antenna installed on top of the car, encoder, control head, battery charger, power supply, 60-watt linear amplifier, microphone, and speaker.
- B-Car: Same as A-car except no power supply.
- Portable Equipment: One hand-held type removable operable radio per train.

2.3 APPLICATION HISTORY

WMATA, BART, and MARTA use a nonremovable vehicle radio for train operator communications and Baltimore and Miami plan to do the same. Transit systems in Philadelphia, New York, and Chicago use a removable nonoperable radio for train operator communications on the train. CONRAIL and the San Diego trolley use a removable operable radio service for train operator communication. PATCO recently modified their existing fleet to have a removable operable radio in each car of each dependent pair.

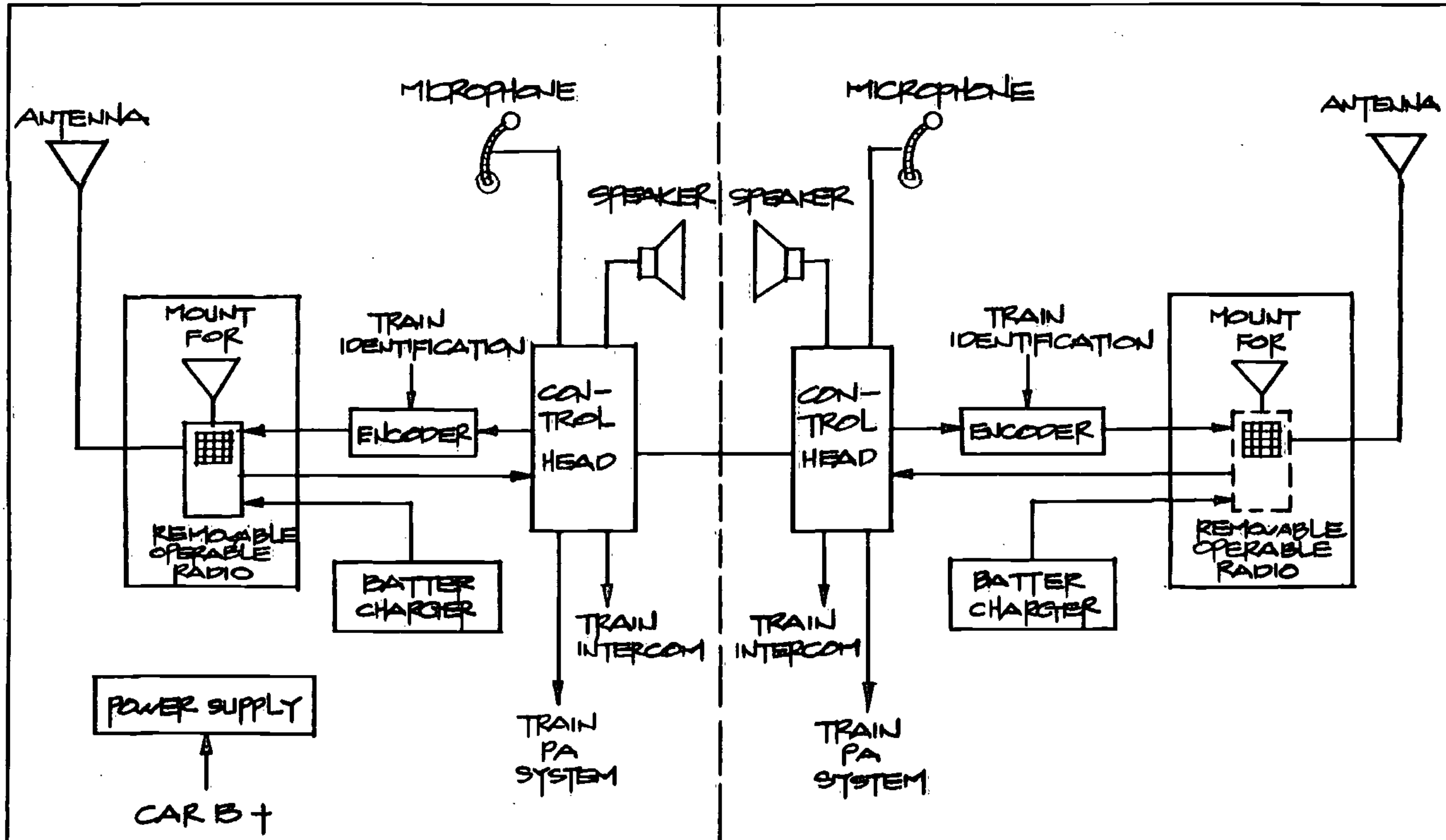


A-CAR

REMOVABLE NON OPERABLE RADIO

FIGURE 2-2

B-CAR



REMOVABLE OPERABLE RADIO

FIGURE 2-3

2.4 METHODOLOGY

The basic quantitative and qualitative evaluation factors discussed in Chapter 1, Section 1.4, are used in this analysis.

2.4.1 Design Assumptions

For the purpose of this analysis, Kaiser Engineers made the following assumptions:

- Alternatives 1 and 2 have 6-channel capacity with a rated power output of 60 watts.
- The handheld radio has 6-channel capaicty with a rated power output of 6 watts.
- The radio operates in the FCC allocated frequency range of 150 to 176 MHz.
- No coaxial antenna leads would be routed between the cars. Therefore, an antenna must be installed on each car that has a transmitter.
- Fleet size is 142 vehicles made into 71 dependent pairs.
- A maximum of 19 6-car trains (114 cars total) will be operating during peak hours.
- The remainder of the fleet (28 cars) will be on standby or undergoing maintenance.
- Annual Metro Rail operating time is 20 hours/day x 365 days = 7,300 hours.
- Portable transmitter/receivers and radios will be checked in and out of a secured storeroom once each day.
- 25 portable units will be required to support a peak of 19 revenue trains.
- The operator inserts removable equipment in the cab area of only the headend car of the train.

2.5 RESULTS

2.5.1 Capital Costs

The capital costs are systemwide. Three battery chargers ($360 each) are required for the portable units in Alternatives 1 and 2. These chargers will charge the batteries in the portable units while they are in the store room between assignments to a train operator. One charger is required for Alternative 3 to charge the portable units which are not assigned to train operators. Those assigned to train operators are charged while they are plugged into the train units.

A. Fixed radio. Permanently installed radios will be required for each married pair; a total of 71 units at $2,515 each or $178,565. Also 25 portable units at $2,595 or a total of $64,875 are required.

B. Removable nonoperable radio. A removable transmitter/receiver will be required for each operating train, 25 units at $2,136 each or $53,400. One hundred forty-two of the permanently installed section of the radio are required at $445 each or $63,190. Also 25 portable units at $2,595 or a total of $64,875 are required.

C. Removable operable radio. Removable operable radios will be required for each operating train, 25 units at $2,595 each or $64,875. One hundred forty-two of the permanently installed section of the radio are required at $455 each or $63,190.

Table 2-1

CAPITAL COSTS*

Equipment	(1) Nonremovable Radio	(2) Removable Nonoperable Radio	(3) Removable Operable Radio
Permanently installed radio equipment	178,565	63,190	63,190
Portable radio unit	64,875	64,875	64,875
Portable nonoperable transmitter/receiver	-	53,400	
Battery charger (3 units for complete system)	1,080	1,080	360
TOTAL CAPITAL COSTS	$244,520	$182,545	$128,425
ANNUALIZED CAPITAL COSTS	$ 30,144	$ 22,504	$ 15,832

* Installation costs of permanently mounted equipment are essentially equal for each alternative and are therefore not included.

2.5.2 Operating Costs

Operating costs are shown in Table 2-2.

A. Energy. There are 59,830 annual operating train hours for the Metro Rail System.[1] A 110% factor is assumed to allow for gap trains and wait time before and after runs (59,830 x 1.1 = 65,813).

1. Nonremovable radio. Based on manufacturers' information, the power consumption for each 60 watt radio will be 480 watts (0.48 kW). This gives a total annual energy cost of:

   $0.07 per kWh x 65,813 hr x 0.48 kW = $2,211

2. Removable nonoperable radio. Based on manufacturers' information, the power consumption for each 60 watt radio is 480 watts (0.48 kW). This gives a total annual energy cost of:

   $0.07 per kWh x 65,813 hr x 0.48 kW = $ 2,211

3. Removable operable radio. To approximate the power consumption for the 6 watt radios, 60 watts were subtracted from the 60 watt radio power consumption to give a net of 420 watts (.42 kW). This gives a total annual energy cost of:

   $0.07 per kWh x 65,813 hr x 0.42 kW = $ 1,935

B. Labor. Since train operators will, as part of their routine duties, operate the radio equipment no matter which alternative is selected, the labor costs are the same for all and have not been included in this study. There is, however, labor involved with checking out the portable transmitter/receivers and radio units. The estimated (by KE) average time to check a unit in-and-out on a daily basis is 2 hours total per unit per week. Therefore, this annual labor cost would be:

2 hours/week x 52 weeks x 19 units x $19.30/hr = $38,137

For option 2 the operator has 2 units to check in and out. An additional time equal to 10% of the time for the first unit has been allocated to the second unit.

$38,137 x .10 = $3,814

[1] See Table 3-8 in the Preliminary Operating Plan, WBS 13 DAA.

Table 2-2
ANNUAL OPERATING COSTS

	(1) Nonremovable Radio	(2) Removable Nonoperable Radio	(3) Removable Operable Radio
Energy*	2,211	2,211	1,935
Administration (check-in and check-out)			
Removable nonoperable transmitter/receiver	-	3,814	-
Removable operable radio	-	-	38,137
Portable radio	38,137	38,137	-
ANNUAL OPERATING COSTS	$40,348	$44,162	$40,072

2.5.3 Maintenance Costs

For the purposes of evaluating the three alternatives, the cost of an annual maintenance contract for parts and labor was calculated. General Electric stated that 10% of the equipment capital costs are normally asked for parts and labor on an annual maintenance contract.** Maintenance costs are shown in Table 2-3.

Table 2-3
ANNUAL MAINTENANCE COSTS

	(1) Nonremovable Radio	(2) Removable Nonoperable Radio	(3) Removable Operable Radio
Service contract with radio vendor[1]	$24,452	$18,255	$12,843
Replacement of portable radios (1/12/yr.)	5,406	5,406	5,406
ANNUAL MAINTENANCE COSTS	29,858	23,661	18,249

* The energy costs for the permanently installed radio equipment (control head, microphone, and speaker) are included with the train PA system, are very low, are virtually identical for the 3 alternatives, and are therefore not considered here.

**See Appendix D, Radio Service Data, Meeting Minutes with General Electric, May 25, 1982.

[1] Service contract with vendor includes all labor and spare parts costs, therefore, there are no spare parts shown separately in the Radio Cost Analysis.

2.5.4 Annual Equivalent Costs

Table 2-4 summarizes the above three costs, and, using the formula shown in Appendix D, shows the annual equivalent costs.

Table 2-4

RADIO COST ANALYSIS

	(1) Nonremovable Radio	(2) Removable Nonoperable Radio	(3) Removable Operable Radio
Capital Cost (installed)	244,520	182,545	128,425
Operating Cost (annual)	40,348	44,162	40,072
Maintenance Cost (annual)	29,858	23,661	18,249
Total Operating and Maintenance Costs	$ 70,206	$ 67,823	$ 58,321
Annualized Capital Cost	$ 30,144	$ 22,504	$ 15,832
ANNUAL EQUIVALENT COST	$100,350	$ 90,327	$ 74,153

2.5.5 Technical Risk

All three alternatives utilize off-the-shelf equipment that has been used in rail rapid transit service. The radio equipment will be furnished with solid-state components that provide a long life expectancy, instantaneous operation, and very low failure rates. The technical risk with the radio is more associated with having correct interfaces between the various system elements on the vehicle, in Central Control, and in the portable usage than in the equipment itself. The removable radio alternatives have the disadvantage of additional handling risk during the check-out/check-in procedure and mounting and dismounting from cars. Both require repeated installation and removal of equipment with connectors. Such connectors are subject to malfunction due to vibration, dirt accumulation, and physical damage. Removable equipment is also subject to loss and damage while being handled and carried by train operators.

2.5.6 Availability

Equipment for all three alternatives is readily available. During final design the availability of equipment required for the selected alternative will be determined.

2.6 CONCLUSION

On a cost basis, the removable operable radio (Alternative 3) is the least expensive. However, the risks (as discussed in Section 2.5.5) associated with the constant removal and replacement of the radio raises concerns that would need to be addressed in detailed design. Alternative 2 also has the same risks. Therefore, the removable operable radio (Alternative 3) is best suited to the Metro Rail requirements.

2.7 RECOMMENDATION

It is recommended that Alternative 3 be selected for the passenger vehicle radio service for the Metro Rail system. Is is also recommended that the current PATCO system, which is similar to Alternative 3 except that a removable, operable radio is installed in each car, be considered during final design. This PATCO configuration eliminates the administrative costs of a constant check-in/check-out activity, minimizes the reliability/loss/damage problems associated with frequent insertion into the mounting, but does not, however, realize the capital cost savings due to fewer transmitters/receivers fleet wide. Because of these factors the cost effectiveness of this additional alternative should be examined more closely.

Chapter 3

TELEPHONE SERVICE ANALYSIS

3.1 INTRODUCTION

The telephone facilities may be broken down into three categories for analysis:

- Telephone instruments
- Cable transmission system (outside cable)
- Central switching equipment (PBX)

The first category of equipment includes telephone sets, terminal blocks, distribution panels, and the corresponding interconnecting wiring. The second category, outside cable, provides the conductive connection for carrying signals to and from the telephone instruments. The third category is the PBX* equipment, which makes the connection between the calling- and called-telephone lines.

This chapter of the report is concerned with the cost of installation and maintenance of the first and third categories of equipment, including telephone plant, telephone instruments, and PBX equipment. The second category or outside cable is the subject of a separate section of this report (see Chapter 5).

3.1.1 Functional Requirements

The telephone service will provide a means of communication to serve the following three functions:

A. Administrative calling. This function will be provided by telephones located in Metro Rail offices, stations, shops, and Central Control. They will be used for placing calls to and receiving calls from other Metro Rail telephones, exchange telephones in the Los Angeles extended area, and telephones reached over the toll telephone and state private-line networks.

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*Stands for private branch exchange; sometimes also referred to as PABX for private automatic branch exchange.

B. Maintenance calling. This function will be provided by telephone sets located in shops and equipment rooms, and by telephone test sets which plug into weatherproof jacks located in signal bungalows, on wayside signals, in the fare collection areas, ventilation shafts, and in traction power substations. These telephones will be used for communication between maintenance personnel.

C. Emergency calling. This function will be provided by telephones located on station platforms and other critical locations. They will be used for calling Central Control. These telephones will have no pushbuttons or dials but will be provided with automatic ringdown sent by removing the handset from its cradle.

If administrative and maintenance telephones also have the capability for emergency calling to Central Control, they will have ringdown sent by pressing only one dual-tone multifrequency (DTMF) key on the instrument.

3.2 DESCRIPTION OF ALTERNATIVES

The following paragraphs describe the options studied for telephone service:

3.2.1 Alternative 1: Three Separate Exchanges

The three telephone services may be provided by installing separate exchanges for each function including separate instruments, lines, channels, and switching arrangements for their interconnection.

3.2.2 Alternative 2: Two Combined Exchanges

Two services, administrative and maintenance, combine calling on one exchange with emergency calling on another exchange. Separate instruments, lines, channels, and switching apparatus are supplied for each exchange.

3.2.3 Alternative 3: One Combined Exchange

All three services are combined into one exchange with all telephone calling with common lines, channels, and switching apparatus. Instruments for emergency phones are separate.

3.3 APPLICATION HISTORY

Recently constructed heavy-rail transit properties have similar telephone service needs as those required for Metro Rail. Table 3-1 provides a comparison of the facilities installed on BART, MARTA, and WMATA.

Table 3-1

COMPARISON OF TELEPHONE FACILITIES

	BART	MARTA	WMATA
EMERGENCY TELEPHONE			
Type	Automatic ringdown	Automatic ringdown	Press "*" pushbutton
Ability to Call	Central Control	Central Control	Central Control
Central Office Switching	None--telephones from each station appear on a separate "press-and-hold" button on console	None--calls are handled by one-way ringdown apparatus and appear on console communications panel	Combined PBX
MAINTENANCE TELEPHONES			
Type	Plug-in	Plug-in	Plug-in
Able to Communicate with	Party on own line	Party on own line	Party on own line
Central Office Switching	None	None	None
ADMINISTRATIVE TELEPHONES			
Type	DTMF pushbutton	DTMF pushbutton	DTMF pushbutton
Ability to Call	Any admin. telephone	Any admin. telephone	Any admin. telephone
Central Office Switching	Separate PBX	Separate PBX	Combined PBX

3.4 METHODOLOGY

The evaluation factors discussed in Chapter 1, Section 1.4. were used in the analysis of the alternatives. The primary evaluation factor in the study of the telephone service alternatives is the annual equivalent cost. This cost is composed of two components--the annual capital cost of the installed equipment plus the maintenance expense of the installed equipment.

Cost estimates for the telephone equipment are based on averaging data obtained from various suppliers of telephone equipment. The annual maintenance expense is calculated from expense ratios applied to the cost of corresponding categories of telephone equipment. These ratios are based on the experience of typical small telephone utilities operating in Southern California.

3.4.1 Design Assumptions

Under all alternatives, the telephone service will provide the following functions and facilities:

A. Emergency telephones. Separate emergency telephones will be installed at public locations where required. These telephones will be without dials and will be provided with automatic ringdown to Central Control activated by removing the handset from its cradle. A separate line or channel will connect each telephone to the PBX at Central Control, which will have access to the required number of answering lines at the attendant's console.

B. Administrative and maintenance telephones. Administrative and maintenance telephones with maintenance jacks will be installed, where required, with DTMF dialing and access to all other administrative and maintenance telephones. Call waiting, call forwarding, and call conferencing capabilities will be included. Access to Central Control for emergency calling would be possible by pressing a single "*" pushbutton. Each telephone or jack location will have a separate line or channel to the PBX at Central Control.

Table 3-2 shows the distribution and function of the telephone apparatus assumed for the alternatives studied. It shows the number of telephones and jack locations that would be required if separate exchanges were to be provided for each function, and the number required for the alternatives which combine more than one function into a single exchange. The chart also shows the total number of circuits, including the allowance for trunk circuits which are required for calls made to telephones served by other exchanges.

Table 3-2

DISTRIBUTION OF TELEPHONES

	Separate Exchanges (1)				Combined Exchanges (2 & 3)		
	Emerg. Ringdown Telephones	Admin. Telephones	Maintenance Telephones	Jacks	Emerg. Ringdown Telephones	Admin. and Maintenance Telephones	Admin. and Maintenance Jacks
Each Passenger Station							
Platform	6	-	-	3	6	-	3
Ventilation shaft	1	-	-	2	1	-	2
Fare collection area	2	-	-	2	2	-	2
Equipment room	1	2	2	2	-	2	2
Attendant's booth	1	1	-	-	-	1	-
Power substation	1	1	2	4	-	2	4
Tunnel cross-passages	12	-	-	-	12	-	-
TOTAL/station	24	4	4	13	21	5	13
TOTAL/16 stations	384	64	64	208	336	80	208
Wayside Locations							
Signals	-	-	-	28	-	-	28
Switch machines	-	-	-	38	-	-	38
Central Control							
Control room	-	65	2	12	-	65	12
Equipment room	-	5	2	32	-	5	32
Yards and Shops							
Signal bungalows	-	-	-	20	-	-	20
Yard signals	-	-	-	35	-	-	35
Signal towers	3	12	3	25	-	12	25
S.& I. Shop	-	32	12	-	-	32	-
Maintenance shops	-	50	18	-	-	50	-
TOTAL Telephones & Jacks	387	228	101	398	336	244	398
Required PBX Lines & Trunks*	387	274	599		336	770	

*Figures include an allowance for outside trunks of approximately 20% of the number of telephone lines connected exce for the emergency telephone service where outside calls are not anticipated.

3.5 RESULTS

3.5.1 Capital Costs

The capital costs are the total of the procurement and installation costs. Table 3-3 provides the unit costs which are used in developing the total capital costs for each option.

Table 3-3

COST DEVELOPMENT DATA*

Material	
Telephone instrument, DTMF pushbutton	$ 55.00
Telephone instrument, wall-mounted, without dial for automatic ringdown	36.00
Telephone jack	16.00
Electronic PBX:	
100-400 line capacity, per line	450.00
400-800 line capacity, per line	400.00
800-1600 line capacity, per line	350.00
Labor	
Install telephone instrument, each	50.00
Install PBX equipment, per line	40.00

Table 3-4 shows the capital cost for each alternative based on the material and labor costs given in Table 3-3.

*See Appendix E, Telephone Service Data, for backup costs.

Table 3-4

CAPITAL COSTS

	Alternative 1			Alternative 2			Alternative 3		
	Number Required	Unit Cost	Amount	Number Required	Unit Cost	Amount	Number Required	Unit Cost	Amount
MATERIAL									
Emergency Exchange									
Ringdown instruments	387	$ 36	$ 13,932	336	$ 36	$ 12,096	336	$ 36	$12,096
PBX line equipment	400	450	180,000	350	450	157,500	-	-	-
Admin. Exchange									
Telephone instruments	228	55	12,540	-	-	-	-	-	-
PBX line equipment	300	450	135,000	-	-	-	-	-	-
Main./Combined Ex.									
Telephone instruments	101	55	5,555	244	55	13,420	244	55	13,420
Telephone jacks	499	16	7,984	398	16	6,368	398	16	6,368
PBX line equipment	600	400	240,000	800	400	320,000	1200	350	420,000
TOTAL MATERIAL			$595,011			$509,384			$451,884
INSTALLATION									
Telephone instruments and jacks	1215	50	60,750	978	50	48,900	978	50	48,900
PBX equipment, per line	1300	40	52,000	1150	40	46,000	1200	40	48,000
TOTAL INSTALLATION			$112,750			$ 94,900			$ 96,900
TOTAL Material and Installation			707,761			604,284			548,784
ROUNDED CAPITAL COST			$710,000			$600,000			$550,000

3.5.2 Operating Costs

A. Labor. The cost of operating personnel is not included because all the equipment operates unattended. Any "operator assistance" which may be required would be performed by the same Central Control personnel, irrespective of the alternative selected.

B. Energy. The cost of electrical energy used in electronic telephone systems is very low compared to other types of electrical power loads. The largest telephone exchange considered in this study would have a power requirement of only 2,000 watts. Supplying this load on an annual basis would represent an insignificant amount in the overall cost of the alternatives (approximately 1%).

3.5.3 Maintenance Costs

A. Labor. Unless telephone service is obtained from The Pacific Telephone and Telegraph Company on a monthly-charge basis, maintenance will be performed by Metro Rail technicians. The same crews will maintain other electrical and electronic apparatus in addition to the telephone apparatus. It is necessary, therefore, to estimate the amount of time and and material that will be used in the maintenance of the telephone equipment.

As an approximation of this cost, the expense ratios were derived from the experience of public utilities engaged in providing similar telephone service.* Data obtained from the files of the California Public Utilities Commission have shown that, for the telephone companies examined, the ratio of expense of instrument repairs to the plant value of telephone instruments ranges from 17.8 to 18.7 percent. Similar ratios for expense of repair central office equipment (PBX) to the plant value of central office equipment ranges from 9.9 to 10.3 percent.

The values judged appropriate for use in this study and the resulting maintenance expense estimates are shown in Table 3-5.

*See Appendix E, Telephone Service Data, for backup costs.

Table 3-5

ANNUAL MAINTENANCE EXPENSE

	Alternative 1	Alternative 2	Alternative 3
Telephone instruments	$101,000	$ 80,800	$ 80,800
Maintenance (18% of capital cost)	18,200	14,500	14,500
PBX equipment	607,000	524,000	468,000
Maintenance expense (10% of capital cost)	60,700	52,400	46,800
TOTAL ESTIMATED MAINTENANCE	$ 78,900	$ 66,900	$ 61,300

3.5.4 Annual Equivalent Costs

For the analysis of the telephone service, the total annual equivalent cost consists of the annualized capital cost plus the estimated annual maintenance expense. Table 3-6 shows the combination of the capital costs from Table 3-4 as modified to obtain the annual cost, and the estimated maintenance from Table 3-5 to obtain the annual equivalent cost for all three options.

Table 3-6

TELEPHONE ALTERNATIVES COST ANALYSIS

	Alternative 1	Alternative 2	Alternative 3
Capital Cost (Table 3-4)	$710,000	$600,000	$530,000
Annualized Capital Cost	87,500	74,000	65,300
Estimated Annual Maintenance (Table 3-5)	78,900	66,900	61,300
ANNUAL EQUIVALENT COST	$166,400	$140,900	$126,600
SAVINGS (compared to highest cost)	-	15%	24%

3.5.5 Reliability

The central switching equipment (PBX) used in this comparative analysis comprises small electronic switching systems (ESS). Experience with ESS equipment has shown that it is more reliable and requires less maintenance than the electromechanical PBX equipment used previously, and its reliability may be further increased for larger electronic PBX installations. For units of 1,000 lines or more, it is possible to add a redundant central processing unit (CPU) to the PBX apparatus to assume operation in case of malfunction of the primary CPU. This can be obtained without appreciable increase in the cost per line.

For many years telephone instruments have been considered fairly rugged and reliable. Their reliability has also been increased by replacing the rotary dial, which is susceptible to dirt contamination and to mechanical maladjustment, with touch-tone dialing.

Overall, the only option which offers an advantage in reliability is the option that will be able to profit by the redundant features offered in the larger PBX units; that is, Alternative 3.

3.5.6 Technical Risk

The telephone instrument is a standard electromechanical device including a receiver, transmitter, hybrid coil, ringer, switchhook, and DTMF dial. The basic apparatus has been in general use for over 30 years and the touch-tone feature has been in general use on telephone company exchanges in California for over 15 years.

Electronic PBX installations began replacing electromechanical PBX plants approximately 12 years ago and have since become standard. For these reasons there is little technical risk with any of the telephone service altenatives considered.

3.5.7 Availability

The availability of telephone equipment is very broad. Telephone instruments and PBXs are available from many vendors offering apparatus manufactured in a number of European countries, Japan, Canada, and the United States. The equipment for any of the alternatives should therefore be obtainable with little difficulty.

3.6 CONCLUSION

This analysis concludes that the alternative offering the lowest annual equivalent cost is that which combines into one exchange all telephone calling with common lines and switching apparatus. The analysis showed that this configuration offers a 24% savings in annual equivalent costs over the separate exchange alternative, and a 15% savings over the partially combined exchange alternative. These savings are obtained by minimizing the quantity of telephone instruments and PBX line equipment required, as well as by taking advantage of the lower cost per line available with larger PBX equipment.

Additional savings will be realized in the CTS through the use of a combined exchange, because fewer telephone lines will be required to carry signals to and from Central Control. Under the combined exchange configuration, emergency telephone service would be provided in public areas by separate wall-mounted telephones without dials, arranged to ring at Central Control when the handset is removed from the switchhook.

All telephones in this analysis are single party line units. Each telephone has a dedicated circuit to the central PBX. In this way, there would be no interference caused by a telephone line being shared by maintenance or administrative personnel.

3.7 RECOMMENDATION

The recommendation is to combine all telephone requirements into one exchange using common switching apparatus and lines (Alternative 3). Emergency phone instruments are separate. This installation would offer the lowest equivalent annual cost and fully meet the requirements of the Metro Rail System telephone service.

Chapter 4

CLOSED-CIRCUIT TELEVISION MONITOR ANALYSIS

4.1 INTRODUCTION

The use of closed-circuit television (CCTV) surveillance on transit systems as a deterrent to crime has been an accepted practice for many years. All of the newer operating rail systems (BART, MARTA, WMATA, and PATCO) employ some form of CCTV surveillance. Systems under construction or in the design stage, such as Miami, Baltimore, and Houston, are including CCTV for their future operation. The extent to which each of these systems use CCTV varies from property to property and is based upon the uniqueness of each property.

An example of factors which influence the extent of CCTV usage on a system are: the operating environment through which the system traverses, physical constraints of the system, manned or unmanned stations, budget limitations, and others. Once a decision is reached to use CCTV on a system, several critical issues must be addressed, such as: areas of system to be monitored, the monitoring technique to be used, and local or remote monitoring. All of these issues must be addressed early in the design as they greatly impact the design of facilities.

This analysis of monitoring techniques reviews the advantages and disadvantages of three viable alternatives to dedicated monitors for each camera, and provides sufficient cost data to enable an economic comparison of alternatives.

4.2 DESCRIPTION OF ALTERNATIVES

Several techniques for CCTV monitoring are available in the marketplace, each with advantages and disadvantages. These techniques include:

- o Dedicated monitoring
- o Multiple camera sequencing
- o Split-screen projection
- o Sequential split-screen projection

The initial screening of the alternatives eliminated dedicated monitoring as a further consideration as a result of the high cost of providing such a system. Dedicated monitoring for the SCRTD system would require an array of 216 CCTV monitors with a large monitoring staff. Elimination of this alternative is consistent with the transit industry trend toward providing an effective system at a reasonable cost. The three remaining alternatives, which are described below, will be analyzed.

4.2.1 Multiple Camera Sequencing (Alternative 1)

Multiple camera sequencing is a method in which several scenes are projected on one monitor in automated sequential order. The normal range of scenes is from 2 to 5. For this alternative, the system is designed to sequence 4 cameras on each monitor. Large or small monitors can be used. This method, which requires 3 monitor screens per station, additionally allows the viewer to select and hold a specific scene desired, and can be likened to changing a channel on a television set. Normally, the sequencing rate can be adjusted from 2 seconds to 3 minutes of viewing time. A block diagram of Alternative 1 is shown in Figure 4-1.

4.2.2 Split-Screen Projection (Alternative 2)

Split-screen projection is a method whereby 2 or more scenes are projected on a single monitor via a splitter. Two scenes per monitor were selected as the basis for the study of this alternative. This method would require 6 monitor screens per station. A block diagram of Alternative 2 is shown in Figure 4-2.

4.2.3 Split-Screen Sequencing (Alternative 3)

The split screen sequencing method would use a combination of apparatus to permit three camera images to be sequenced in rotation on a split screen showing two displays. Two monitors per station would be required. A block diagram of Alternative 3 is shown in Figure 4-3.

4.3 APPLICATION HISTORY

In the transportation industry CCTV is being used for monitoring activities at passenger stations and facilities. The Illinois Central Gulf Railroad uses Alternative 1, multiple camera sequencing. Each monitor is dedicated to 5 fixed cameras which are sequenced every seven seconds. Port Authority Transit Corporation (PATCO) uses one monitor screen per camera, as does the Washington Metropolitan Area Transit Authority (WMATA) and the Port Authority of New York and New Jersey. A review of the above properties and BART, Baltimore, Miami, and MARTA determined that the Metro Rail System will monitor by far the largest number of cameras in a single Central Control center.

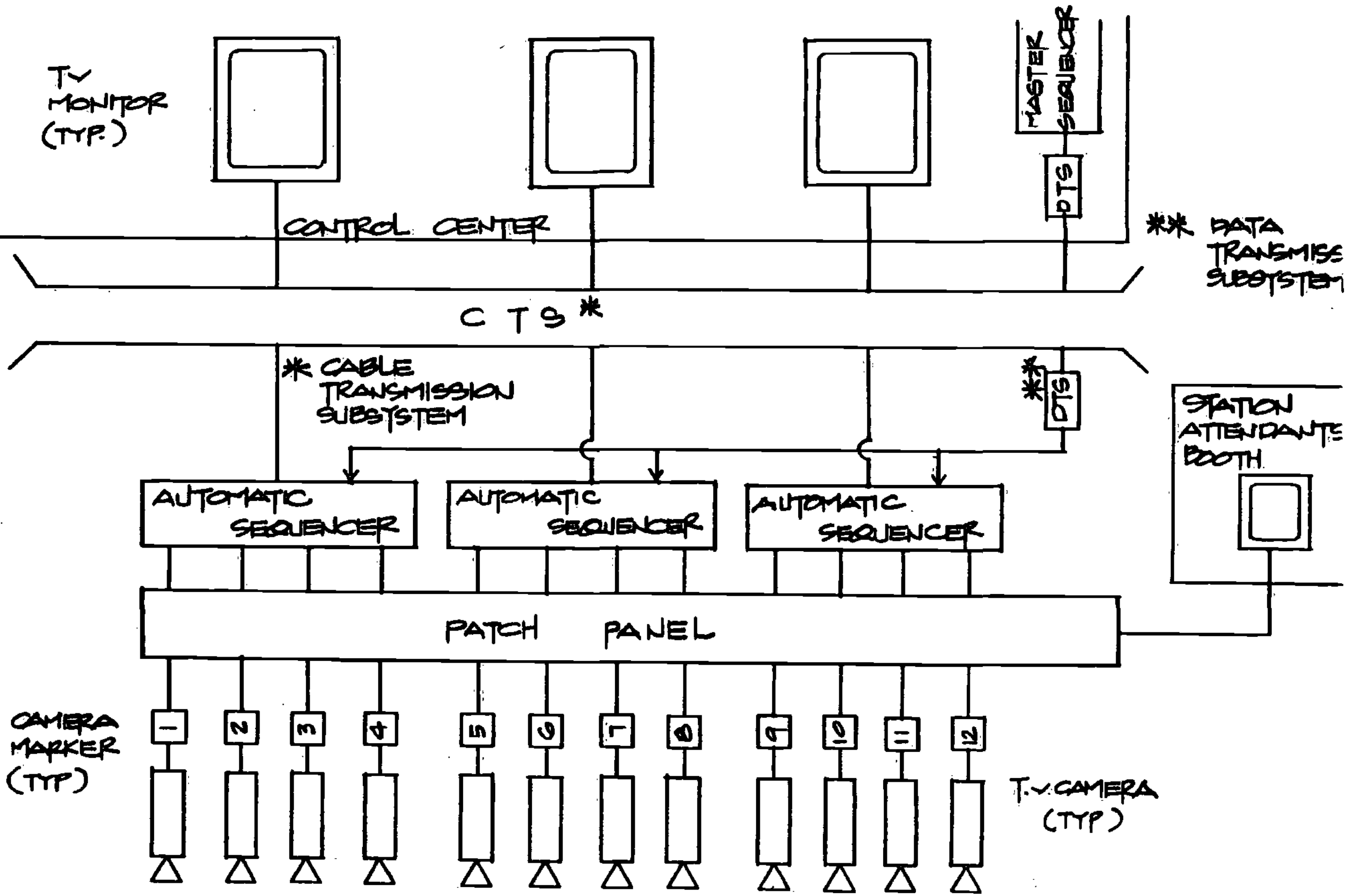

FIGURE 4-1. ALTERNATIVE #1 MULTIPLE CAMERA SEQUENCING

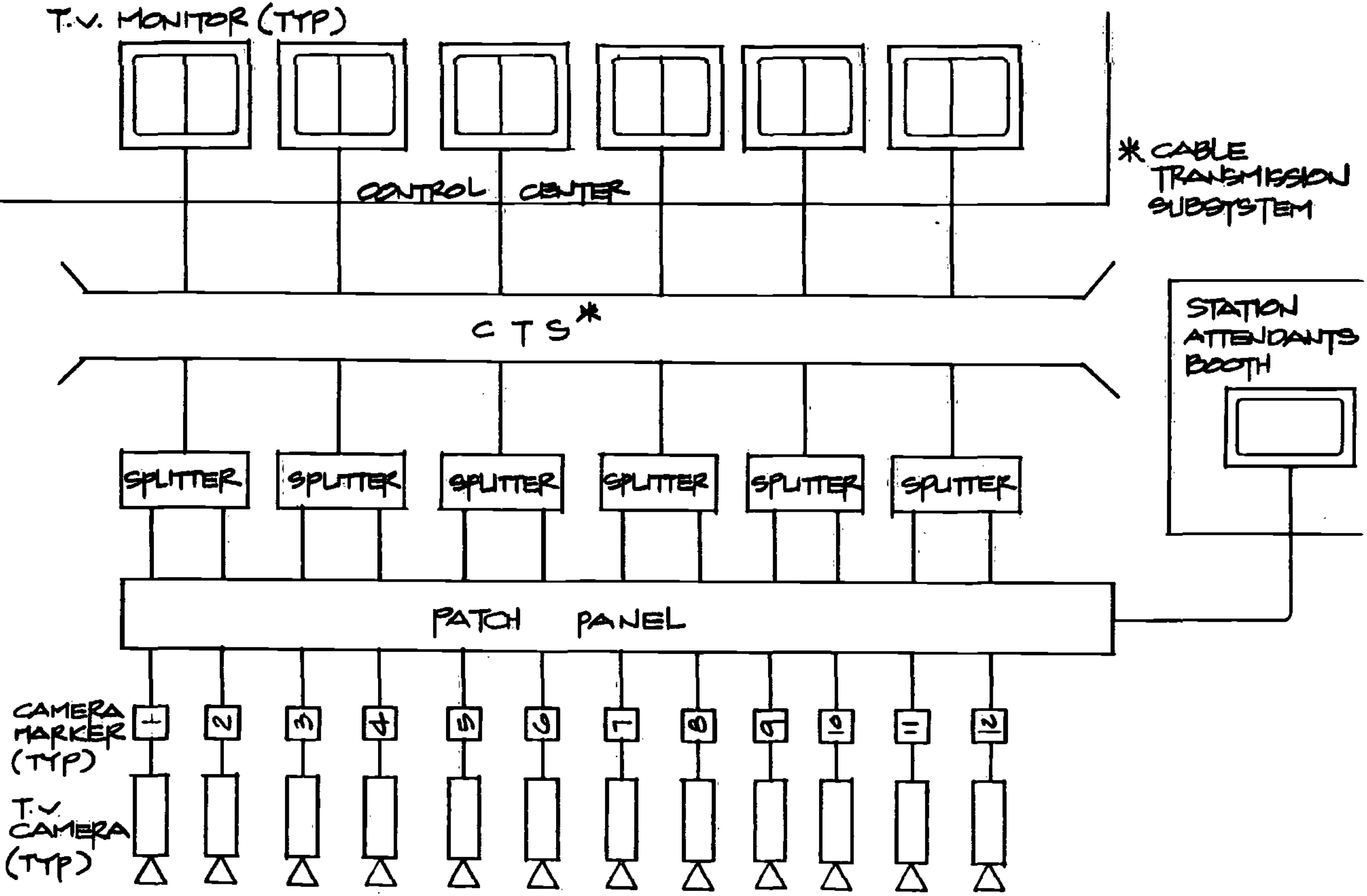

FIGURE 4-2. ALTERNATIVE #2 SPLIT-SCREEN PROJECTION

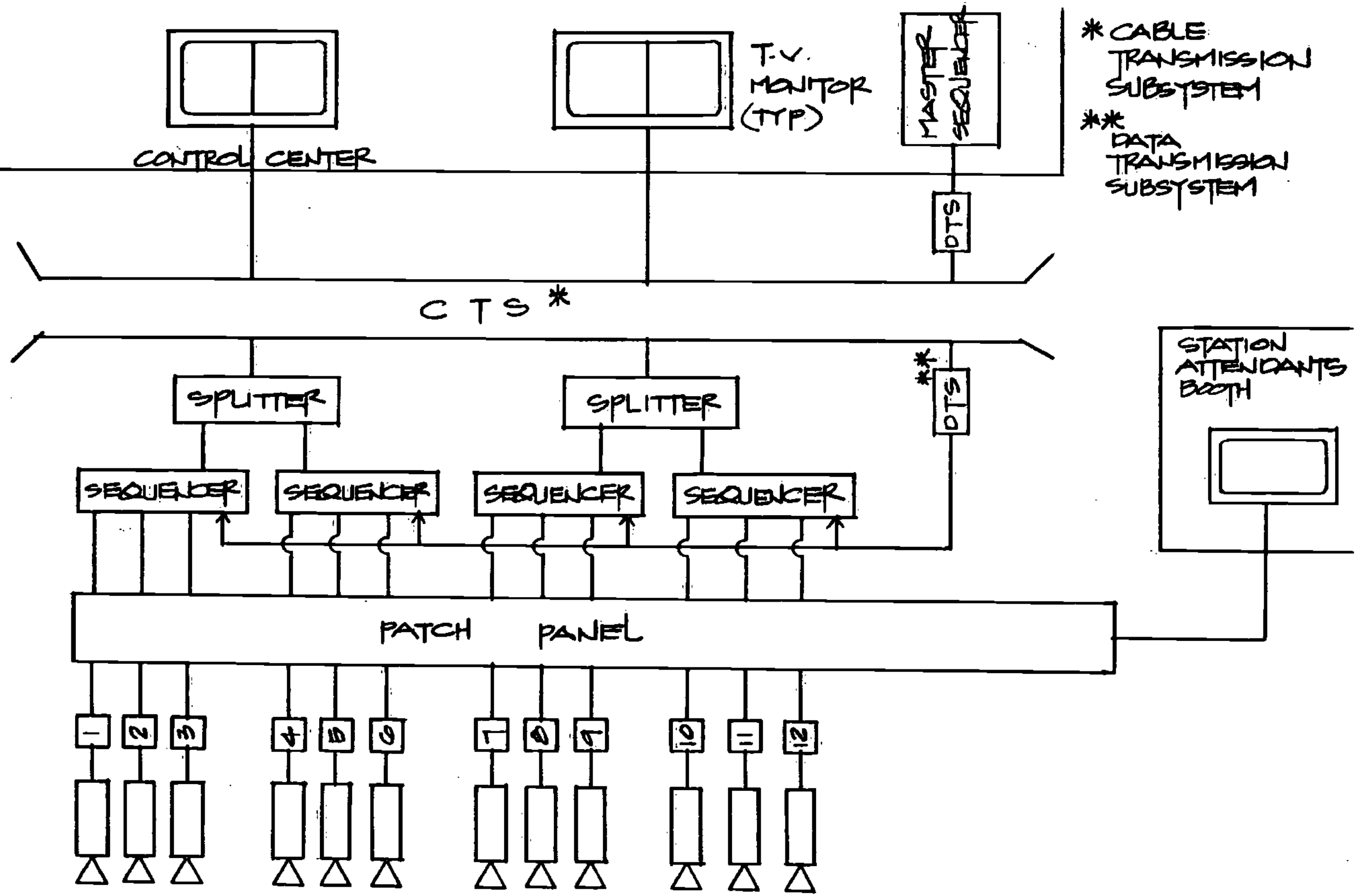

FIGURE 4-3 ALTERNATIVE #3 SPLIT-SCREEN SEQUENCING

4.4 METHODOLOGY

The alternatives are analyzed using the evaluation factors described in Chapter 1, Section 1.4. Additional qualitative factors, observation continuity and TV monitor personnel work load, are discussed in Sections 4.5.5 and 4.5.6. The SCRTD Architectural Standards for Communications and the APTA Guidelines for Transit Security were reviewed, and a possible configuration was developed for the Metro Rail System.

4.4.1 Design Assumptions

The following assumptions were made for the purpose of this analysis:

- o Closed circuit television surveillance of stations shall be required on a 24-hour a day basis.
- o Two TV surveillance sites are added for the purpose of monitoring two storage yards.
- o The primary location for monitoring the CCTV system is the Central Control facility.
- o CCTV monitoring personnel are also responsible for answering the public assistance telephones.
- o Twelve fixed TV cameras will be provided at each passenger station and at each shop/yard.
- o No CCTV coverage of a central revenue-counting facility is considered because of its specialized function and separate monitoring location.
- o Areas subject to CCTV surveillance include: fare collection, handicapped/service entrance and egress, security telephones, fire emergency telephones, patron assistance telephones, toilet room entrances, stairs at terminations, escalators at terminations, station platforms at termination of vertical circulation elements and at platform ends and at corridors, and pedestrian bridges and underpasses within stations.
- o No video recorders are included in the analysis since the costs would be similar for all three alternatives.

4.4.2 Operational Assumptions

The SCRTD operational concept for CCTV surveillance established to date requires that Central Control will have the primary responsibility for monitoring the CCTV surveillance system. Each station will be provided with twelve fixed cameras which will send images of various areas within each station to Central Control. An array of monitoring equipment combined with dedicated monitoring personnel will be located at this facility. Additional TV monitors will be provided for the surveillance of two vehicle storage yards located at each end of the operating line.

Provisions for one additional monitor in each station will be included in the design of stations. It is expected that if stations are manned, CCTV monitoring will not be a primary duty of the station agent. Central Control will advise the station agent of any situation which is occurring at his/her station which may necessitate further investigation or assistance. The station agent may then switch a single video monitor to the appropriate image for further viewing.

Both of these policies are in accordance with the recommendations of Closed Circuit Television in Transit Stations: Application Guidelines.*

4.5 RESULTS

4.5.1 Capital Costs

The capital costs for equipment for each of the three alternatives are shown in Table 4-1. These costs have been obtained from the manufacturers and include only the cost of the basic equipment.** The costs associated with the installation of equipment and the procurement and installation of cabling from stations and yards to Central Control have not been included in this analysis. For Alternatives 1 and 3, no cost was included for the master sequencer function since it is anticipated that the timing will be established at each station and no additional hardware is required. The detailed cost data for capital equipment is shown in Appendix F.

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* See Appendix F, CCTV Backup Data, for more information.

**Component costs were obtained from Panasonic CCTV Products and GE, with the Panasonic data used as the baseline. See Appendix F, CCTV Backup Data, for more information.

Table 4-1

CAPITAL COSTS

	Qty	(1) Multiple Camera Sequencing	Qty	(2) Split-Screen Projection	Qty	(3) Combination Split-Screen Sequencing
TV cameras at each station, automatic light compensation lens, scanner control ($1,260 ea.)	12	15,120	12	15,120	12	15,120
Camera sequencers at each station ($280 ea.)						
a) Four image	3	840	-		-	
b) Three image	-				4	1,120
TV monitors, 12", automatic control ($360 ea.)						
a) Central Control	3	1,080	6	2,160	2	720
b) Each station	1	360	1	360	1	360
Camera splitters at each station ($360 ea.)						
a) Two image	-		6	2,160	-	
b) Three image	-		-		4	1,440
TOTAL STATION COST		$ 17,400		$ 19,800		$ 18,760
TOTAL SYSTEM COST*		$313,200		$356,400		$337,680
ANNUALIZED CAPITAL COST		$ 38,611		$ 43,937		$ 41,602

*16 at passenger stations and 2 for the yards.

Closed Circuit Television in Transit Stations: Application Guidelines was published by UMTA in August 1980. This report discussed life-cycle costs of CCTV installations. The report stated that "Depending on size, pricing policies, construction requirements, and many other factors, a CCTV transit station security system can have a purchase cost of anywhere from $1,500 to $20,000 per camera/monitor installed." This was for a one camera to one monitor system. This indicates that there is a large tolerance on the anticipated cost of CCTV installations. The costs shown above are within this range but on the low side since combined monitoring, minimum functional requirements, and a competitive bid process are anticipated. Also, the data transmission equipment is not included.

4.5.2 Operating Costs

The labor cost associated with monitoring a CCTV system is inevitably a major factor in the selection of a surveillance system. The only cost item in this category consists of personnel to monitor the televisions at Central Control. Table 4-2 shows the total quantity of monitor screens required in Central Control for each alternative, and the number of employees needed for each operating period and the number of monitors each employee would watch.

Table 4-2

Employees Required in Central Control

	Alternative 1	Alternative 2	Alternative 3
TV Monitors at Central			
Screens per station	3	6	2
Total screens	54	108	36
Off-Hours Period			
10 pm-6 am, 7 days/week	1	1	1
Sunday Base Period			
6 am-10 pm, 1 day/week	2	3	2
Peak Periods			
6-10 am & 2-6 pm, 5 days/week	2	2	1
Base Period			
6 am-10pm, 6 days/week	3	6	3
Total employees in Central during peak period	5	8	4
TV Monitors			
per employee during peak periods	11	13.5	9

The number of employees per shift is based upon a review of related transit property studies and actual experience of Kaiser Engineers personnel. The calculations used to determine the number of personnel required are shown in Appendix C, Calculations. The following factors determine the number of employees required:

- o Sequencing or nonsequencing
- o Other employee duties
- o Distance employee is from TV screens
- o Configuration of TV screens
- o Level of activity on the display screens

Closed Circuit Television in Transit Stations: Application Guidelines discussed, in Section 3.3, the number of monitors which can be viewed by each "operator." It concludes that 9 to 16 is the reasonable range of monitors for each employee.

These numbers of employees convert to a total staff level and annual operating costs for the three alternatives as shown in Table 4-3. Only labor costs are included because a cost comparison of energy costs between all these alternatives showed only a slight cost difference. The labor costs are based on 2,080 total paid work hours per year and 1,920 total productive work hours per year.

The staff levels are established around four system operating time zones. The base period consists of two eight-hour shifts: 6 am to 2 pm and 2 pm to 10 pm, six days/week. The peak period consists of two four-hour periods: 6 am to 10 am and 2 pm to 6 pm. The off-hour period consists of the eight-hour period from 10 pm to 6 am, seven days/week. The Sunday base period consists of two eight-hour shifts: 6 am to 2 pm and 2 pm to 10 pm.

Table 4-3

ANNUAL OPERATING COSTS (LABOR)

	(1) Multiple Camera Sequencing	(2) Split-Screen Projection	(3) Combination Split-Screen Sequencing
Peak Periods 6-10 am & 2-6 pm, 5 days/week, 8 hours/day	112,320	112,320	74,880
Employees/yr	(3)	(3)	(2)
Base Periods 6 am-10 pm, 6 days/week, 16 hours/day	299,520	599,040	299,520
Employees/yr	(8)	(16)	(8)
Off-Hours Period 10 pm-6 am, 7 days/week, 8 hours/day	74,880	74,880	74,880
Employees/yr	(2)	(2)	(2)
Sunday Base Period 7 am-10 pm, 1 day/week, 16 hours/day	37,440	74,880	37,440
Employees/yr	(1)	(2)	(1)
TOTAL EMPLOYEES	14	23	13
TOTAL OPERATING COSTS	$524,160	$861,120	$486,720

4.5.3 Maintenance Costs

Table 4-4 shows the maintenance costs for all three alternatives.

A. Labor. The labor costs are established around two time zones: the Monday to Saturday (6 day) coverage over a 24-hour period and the Sunday only 24-hour period. For Alternatives 1 and 3, during the 6-day period at least one technician would be stationed at Central Control and one other technician would be available for on-site maintenance at the stations. During the 24-hour Sunday period, one technician would cover the complete system. For Alternative 2, because twice the number of monitors are required, the number of technicians has been appropriately increased as shown. The backup data is shown in Appendix F.

B. Spares. The cost of spares is based upon 10% of the base equipment cost for each alternative as recommended by both Panasonic and GE. The backup data is shown in Appendix F.

Table 4-4

ANNUAL MAINTENANCE COSTS

	(1) Multiple Camera Sequencing	(2) Split-Screen Projection	(3) Combination Split-Screen Sequencing
Labor			
a) CCTV Technicians 24 hrs/day 6 days/week	321,152	481,728	321,152
Technicians	8	12	8
b) CCTV Technicians 24 hrs/day Sunday	40,144	80,288	40,144
Technicians	1	2	1
Spares	38,840	36,360	33,600
TOTAL MAINTENANCE COSTS	$400,136	$598,376	$394,896

4.5.4 Annual Equivalent Costs

Table 4-5 provides the annual equivalent cost comparison data for the three configurations. The annual equivalent costs are computed using the formula shown in Appendix C, Calculations.

Table 4-5

CCTV COST ANALYSIS

	(1) Multiple Camera Sequencing	(2) Split-Screen Projection	(3) Combination Split-Screen Sequencing
Capital Costs	313,200	356,400	337,680
Operating Costs (annual)	524,160	861,120	486,720
Maintenance Costs (annual)	400,136	598,376	394,896
Total Operating and Maintenance Costs	$924,296	$1,459,496	$806,736
Annualized Capital Costs	$ 38,611	$ 43,937	$ 41,602
ANNUAL EQUIVALENT COST	$962,907	$1,503,435	$923,218

4.5.5 Observation Continuity

All 12 TV cameras at each station are energized 24 hours a day. Patrons are not aware of whether the image seen by the camera is being observed by a Metro Rail employee. It is therefore possible to achieve the crime deterrent affect without having an employee actually look at each camera scene 24 hours a day. The operating scenarios for each alternative are discussed below:

A. Multiple Camera Sequencing (Alternative 1). With this alternative the scene from each camera is shown on the TV monitor only 25% of the time. If the scenes are sequenced every 6 seconds, then each area being monitored would appear on the monitor for 6 seconds, then be off for 18 seconds. In the event that a TV monitor or sequencer failed, the scenes from 4 cameras would be lost until repairs were made.

B. Split-Screen Projection (Alternative 2). With this alternative each scene from each camera is shown 100% of the time on one-half of the monitor screen. The images are therefore one-half the size of those available for observation using Alternative 1. In the event that a TV monitor or splitter fails, then scenes from 2 cameras would be lost until repairs were made.

C. Split-Screen Sequencing (Alternative 3). With this alternative each scene from each camera is shown one-third of the time. If the scenes are sequenced every 6 seconds, each area being monitored would appear on one-half the monitor for 6 seconds and then be off for 12 seconds. In the event that a sequencer failed, scenes from 3 cameras would be lost. If a splitter or monitor failed, scenes from 6 cameras would be lost until repairs were made.

A potential solution for monitor failures for any of the alternatives would be to provide redundant monitoring capability. The plan would require an additional number of spare monitors which would permit monitoring personnel to switch the images normally seen on the failed monitors to the spare monitors. Equipment which would permit this redundancy has not been developed at this time, but the possibility should be analyzed upon selection of the alternative. In general, the best continuity is provided by Alternative 2, followed by Alternative 1 and then 3.

4.5.6 TV Monitor Personnel Workload

Closed Circuit Television in Transit Stations addresses personnel work schedules, including the number of TV screens each employee can effectively monitor. The report concludes that if a lot of activity were present one person could monitor 9 screens. If there were little activity then one person could monitor up to 16 screens. In the report's discussion of constant

U.S. sequential monitoring modes, the constant monitoring mode is the preferred method. However, the report does state that sequential monitoring would be acceptable for unusually low activity areas and in areas where there were extreme limitations on space. The number of employees has been adjusted for an equal work load (see Table 4-2) for each alternative, thus the labor costs reflect any variation in work load.

4.5.7 Technical Risk

The use of splitters (Alternatives 2 and 3) is a somewhat new technology for widespread commercial use and must be considered a greater risk than the sequencing mode (Alternative 1).

4.5.8 Availability

Based on conversations with both G.E. and Panasonic, splitters are not as commercially available as sequencers. This limitation may not be a factor by the time of the procurement stage.

4.6 CONCLUSION

Alternative 1 requires the least amount of equipment, which is reflected in the total equipment dollar value. This is a direct result of sequencing four images onto one monitor, significantly reducing the number of monitor screens required. This method requires 3 TV monitor screens per passenger station. Sequencing has a proven track record in the transit industry, with off-the-shelf hardware available from most vendors. However, due to the sequencing feature, periods of unobserved time are a characteristic of this method; the condition could be compensated for by providing the operator with a device to stop and hold a particular scene.

Alternative 2 is not an attractive alternative due to the intensive labor requirements. A total of 37 employees makes this plan the most labor intensive, because the split screen showing only 2 images per monitor significantly increases the number of monitors required per station, which increases the labor force. The plan also has the highest equipment cost due to the increased number of units required.

Alternative 3 has the lowest labor requirement of all three alternatives, due to the optimum use of a single TV screen by splitting the screen and sequencing the projected images. These features require less monitoring personnel. A disadvantage is that combining all these features results in a "busy" TV screen and could possibly result in operator monotony and fatigue. Equipment cost ranks second when compared to the other plans. This alternative has no track record and is not conveniently available from vendors.

4.7 RECOMMENDATION

It is recommended that Alternative 1 be implemented. Although this plan is not the least expensive overall (ranked second), it is only 5% more than Alternative 3, its proven track record and availability makes it the best alternative. It has the least equipment cost of the three alternatives, and effectively implements the fullest potential of a single TV screen. Once the final decision to have or not to have a station attendant is made, the final criteria for CCTV can be established. Further analysis at that time would determine the optimum CCTV configuration.

During detailed design, certain cameras (scenes) may be appropriately sequenced in monitors while other scenes may require continual surveillance. Thus, a combination of Alternative 1 and the "one camera-one monitor" approach may be logical. Also, slow scan transmission, as described in Closed Circuit Television in Transit Stations in Section 4.6.2 may also be an alternative for certain scenes (see Appendix F).

CHAPTER 5

CABLE TRANSMISSION SUBSYSTEM ANALYSIS

5.1 INTRODUCTION

On October 26, 1982, Kaiser Engineers Corporation of California issued a letter of intent to enter into a contract with De Leuw, Cather & Company to perform certain preliminary engineering studies and tasks associated with the Cable Transmission Subsystem which will be the basic backbone communications subsystem which ties passenger stations to Central Control in the Los Angeles rapid rail line.

Task I of the work involved performing a comparative evaluation of three alternative methods of configuration for the cable transmission subsystem. These three alternatives were stipulated by Kaiser Engineers and are briefly described as follows:

1. Alternative I - All voice, data and control functions would be connected between Central control and each passenger station via copper wire pairs without repeaters. Video signals would utilize coaxial cables and repeaters where necessary.

2. Alternative II - Voice, data, control circuits and video would be connected from Central Control to the passenger stations via coaxial cable. Either frequency division or time-division multiplex techniques could be used. The cable transmission subsystem must provide for ringing, supervision and all signaling for the circuits carried.

3. Alternative III - The communications signals all may be transmitted by light waves over optical fiber cables with appropriate terminal equipment and repeaters.

The factors to be considered in the evaluation were specified to be:

1. Cost Factors

    a. Capital Costs
    b. Operating Costs
    c. Maintenance Costs

2. Quantitative Factors

    a. Technical Risk
    b. Hardware Availability
    c. Relevant Judgemental Factors

Task II of the work involved preparation of detailed subsystem description, preliminary specifications and drawings, and definition of interfaces.

The following material pertains to the evaluation of the alternative subsystems.

5.2 DESCRIPTION OF ALTERNATIVES

Figure 1 is a composite of the system which has been constructed from information contained in the scope of services pertaining to the number of circuits for each terminal location, from the recommended alignment drawings dated 9-16-82, and from Kaiser supplied Figure 5-1 entitled "Cable Alignment."

5.2.1 Alternative #1

Alternative 1 utilizes dedicated copper pairs for each telephone, voice or data circuit between the central control facility and each terminal location. In addition, each passenger station is equipped to transmit a minimum of four video signals to the central control facility at which location certain areas of each passenger station will be monitored on closed circuit television (CCTV) monitors.

This alternative contains only CTS cabling between Central Control and the terminal points. It does not include any cabling between PABX or other subsystems and the CTS, nor does it include station circuits at the terminal locations.

Most PABX equipment can tolerate a loop resistance of 1,200 to 1,500 ohms where subscriber equipment is connected directly by copper wire pairs. The PABX to be used in the Los Angeles RTD system is not yet specified. Therefore, a loop resistance of 1,500 will be assumed.

The loop resistance is a function of the wire guage and the temperature, and is the sum of the resistance of both conductors for the length of the circuit. Telephone cable with large pair counts can be obtained in standard wire gauges, AWG 26, AWG 24, AWG 22 and AWG 19. Where circuits must be extended for great distances, economics dictate that the smallest wire gauge that can satisfy the requirements be used. Because of the environment which exists along a rapid transit wayside, wire gauges smaller than AWG 22 are not considered adequate.

Because the cost of copper cable increases rapidly with increases in wire gauge, devices have been developed which effectively increase the loop resistance that can be handled by a PABX or central office. Such devices are called long line adaptors or loop extenders. These devices are used to overcome the resistance to direct current flow.

MADE BY TLG DATE 11-8-82 CHECKED BY ______ DATE ______

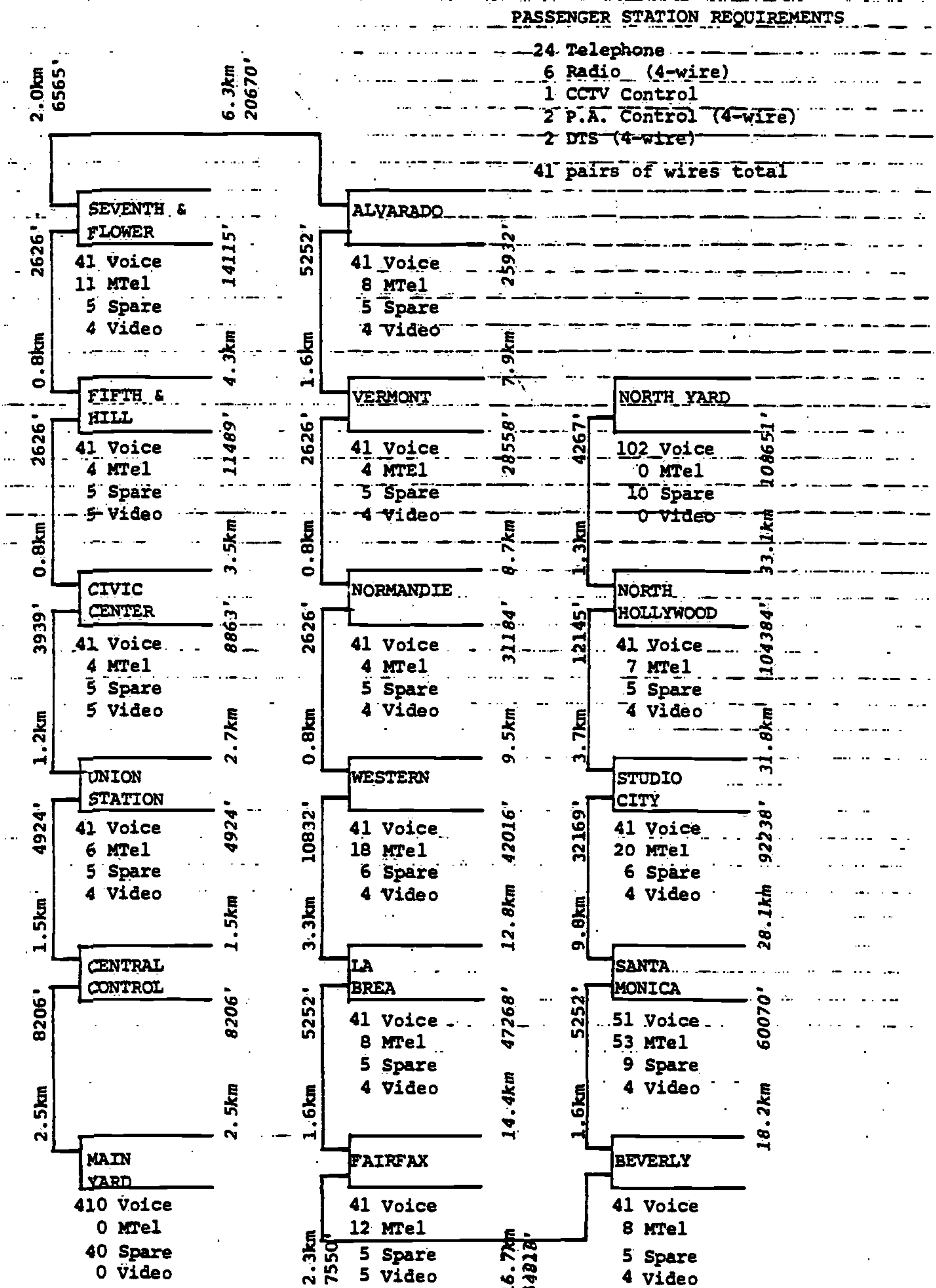


FIGURE 1

In voice circuits, there are other losses that must be considered. One of these is the audio attenuation in the cable. Telephone circuits are considered to have a band pass ranging between 180 Hz and 4,000 Hz. Between the conductors of a pair of wires in a multiconductor cable, there exists mutual capacitance. Techniques of cable construction have been developed such that the capacitance is minimized and is approximately 0.083 microfarads per mile. However, in every long circuit, there is sufficient capacity between conductors to cause nonlinear attenuation of a complex voice signal. Higher frequencies in the voice signal are attenuated at a higher rate than are the lower frequencies.

The least expensive method of treating a cable to improve its frequency response is to load the cable with lumped inductance for each pair at periodic intervals. One standard loading scheme allows the addition of 88 mh coils at intervals of 6,000 fet +0%, -6%. This treatment results in a fairly flat response between 200 Hz and 3,200 Hz with a cutoff frequency of about 3,600 Hz. Each added coil will increase the loop resistance by about 8.5 ohms. For this study, H-88 loading will be considered. When AWG #19 or AWG #22 wire is used, the maximum length of a telephone circuit without loading is 18,000 feet.

Finally, even with loop extenders and loading on the cables, some circuits in the RTD starter line are of sufficient length to require amplifiers to overcome the effects of overall signal attenuation.

If we assume that the conduits from the guideway to the communications equipment areas are to be standard 4" pipes, the maximum size cable that can be put into the cableway for the cable transmission subsystem can have a diameter of not more than 2.5 inches for 40% fill of the conduit.

AWG #19 communications cable suitable for direct burial or duct installation can be procured in pair counts of up to 300 pairs with the diameter less than 2.5 inches. A standard reel length is 1,000 feet for this pair count.

AWG #22 communications cable suitable for direct burial or duct installation can be procured in pair counts of up to 600 pair count is 1000 feet.

Cables with smaller pair counts in both gauges can be procured in longer reel lengths. Jumbo reels that hold 6,000 feet can be obtained in either gauge in a 75 pair count.

The cables which make up the various circuits for Alternative 1 in this study will utilize AWG #22, where possible, to reduce the cost. Composite cables utilizing lengths of #22 and #19 gauge wire have been calculated to produce loop resistances which can be used with the loop extenders and loading plans.

For each cable, where entrance is made to a passenger station to drop circuits, all circuits which terminate at the station will be wired to protector blocks. Through-circuits will be wired to standard terminals and jumpered through to continue to the next station. All circuits at Central Control will be terminated on protector blocks.

The material immediately following will describe each of the separate circuits which make up the Cable Transmission Subsystem in Alternative I. Each circuit is accompanied by a figure showing the terminal points, distances and circuit requirements.

5.2.1.1 Circuit #1 - Central Control to Main Yard

This circuit provides for 400 telephone subscriber circuits and ten voice grade circuits for other purposes between Central Control and the Yard. The 10 percent spare requirement raises the total pair count requirement to 450 pairs.

Two separate cables will be installed for the primary circuits. One cable of #22 AWG gauge wire will contain 300 pairs, and the second cable of #22 AWG gauge wire will contain 150 pairs.

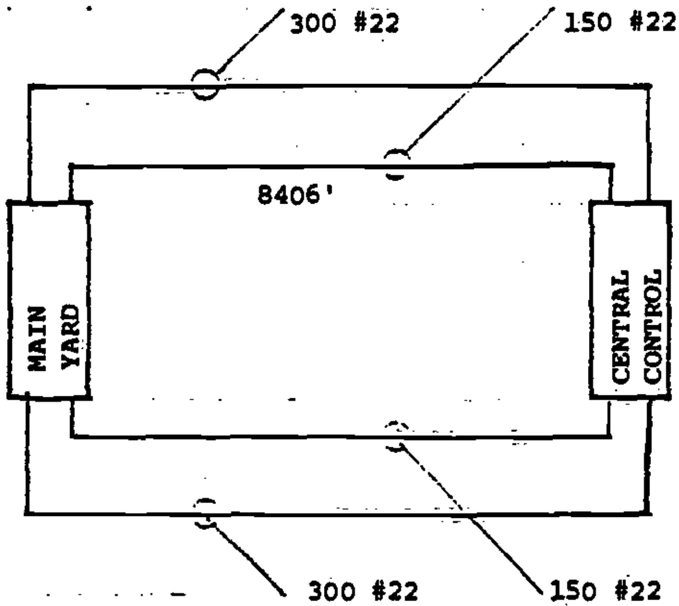
No loading, long line adaptors or other special treatment is required on any of the pairs in this circuit.

The redundant cirucit will be identical to the primary circuit.

5.2.1.2 Circuit #2 - Central Control to Seventh & Flower

This cable circuit provides for 209 voice grade circuits to be dropped at Union Station, Civic Center, Fifth & Hill and Seventh and Flower stations. Requirements for each station are as shown on Figure 3. A 300 pair, #22 AWG cable will be installed between Central Control and Union Station. Leaving Union Station, a 200 pair #22 cable will continue to the Civic Center Station. Between Civic Center and Fifth and Hill, a 150 pair #22 AWG cable will be installed. Seventy-five pairs of #22 wire will be required between Fifth and Hill and Seventh and Flower.

The cables require no loading, long line adaptors or special conditionaing. Because of reel length restrictions, splices will be required.



410 Voice
0 MTel
40 Spare
0 Video

Figure 2

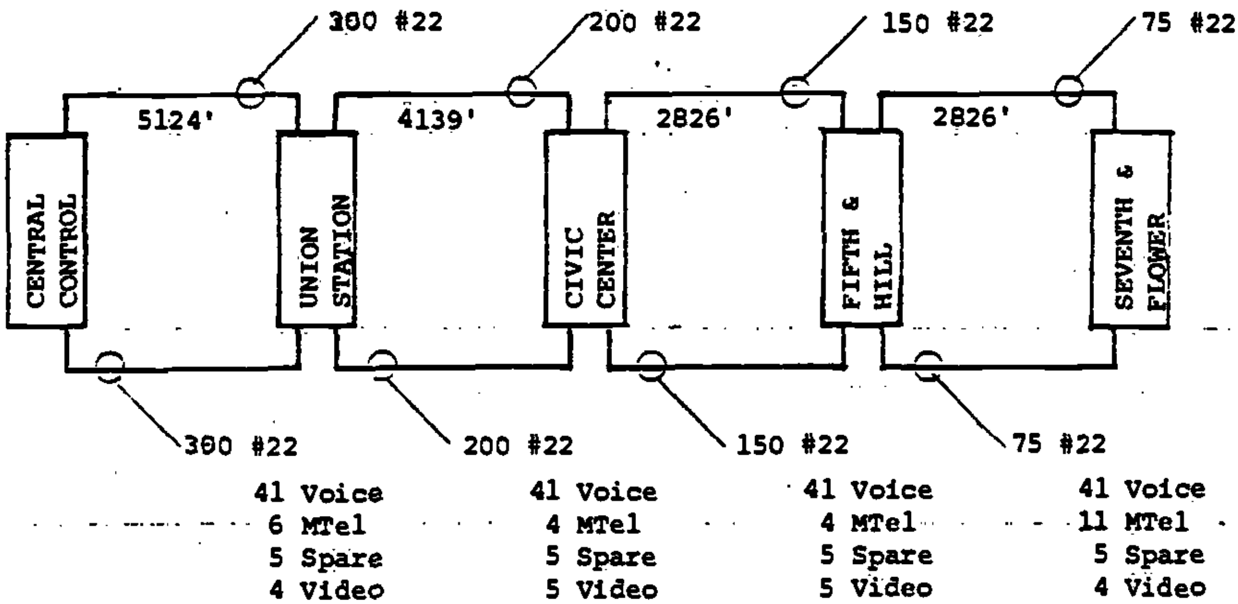

300 #22
200 #22
150 #22
75 #22
5124'
4139'
2826'
2826'
CENTRAL CONTROL
UNION STATION
CIVIC CENTER
FIFTH & HILL
SEVENTH & FLOWER
300 #22
200 #22
150 #22
75 #22
41 Voice
6 MTel
5 Spare
4 Video
41 Voice
4 MTel
5 Spare
5 Video
41 Voice
4 MTel
5 Spare
5 Video
41 Voice
11 MTel
5 Spare
4 Video

Figure 3

LEUW, CATHER & COMPANY
ENGINEERS
WASHINGTON, D.C.

CIRCUIT 3 - CENTRAL CTL TO LA BREA ______ SHEET NO.______ OF______

MADE BY______ DATE______ CHECKED BY______ DATE______

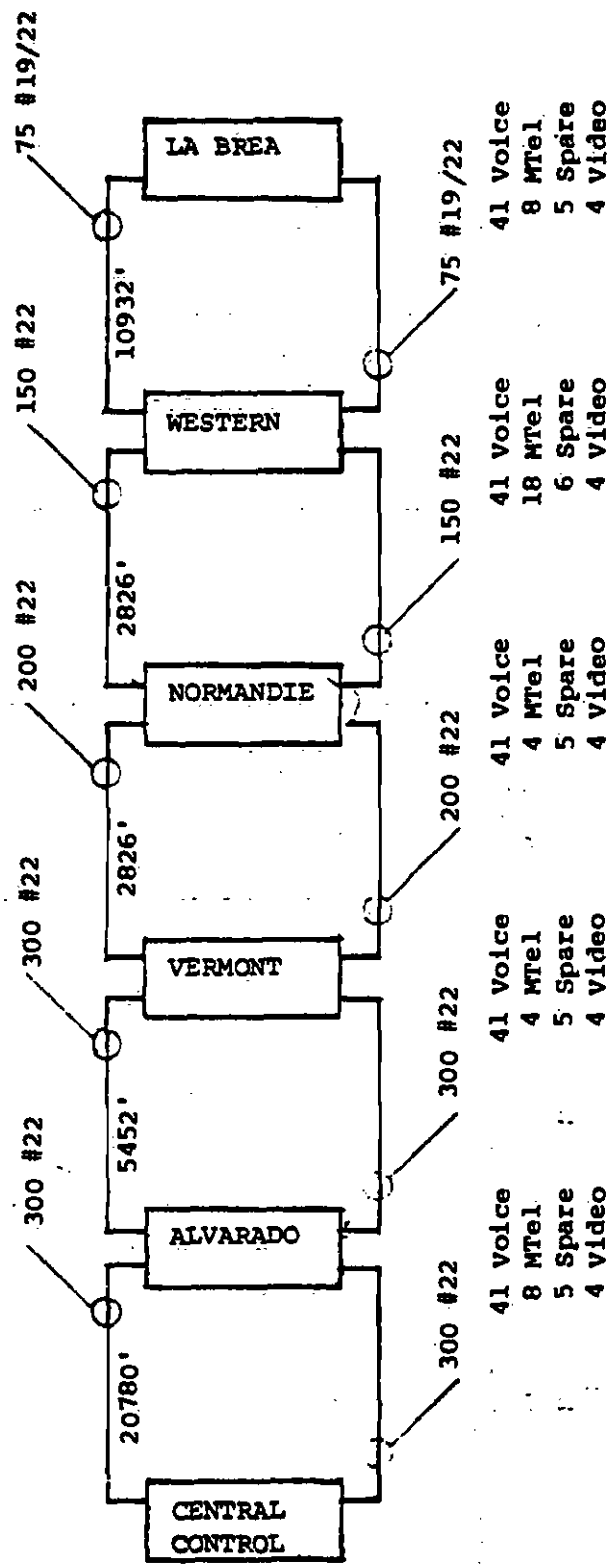


FIGURE 4

5.2.1.3 Circuit #3 - Central Control to La Brea

The distance for each of the drop points on this circuit is greater than can be handled with an unloaded circuit. However, with proper selection of cable size and splice points, the loop resistance, including the loading coil resistance, can be held to 1,500 ohms. The PABX can work with this loop resistance without long line adaptors or amplifiers.

For this circuit, #22 AWG gauge is used between Central and Western. Between Western and La Brea, approximately 5,000 feet of #22 will be installed, and approximately 6,000 feet of #19 cable will be used. With this arrangement, the total loop resistance to the farthest point will be very close to 1,500 ohms.

A 300 pair cable will be installed between Central Control and the Alvarado station, and also between Alvarado and Vermont. Between Vermont and Normandie, only 200 pairs will be required, and a 150 pair cable can satisfy the needs between Normandie and Western. The composite #22/19 cable between Western and La Brea need only be 75 pairs.

5.2.1.4 Circuit #4 - Central Control to Studio City

This circuit is a total of 92.839 kilofeet. A cable of #22 AWG would result in a total loop resistance of 3,360 ohms not including loading coils. Even with #19 AWG wire, the total loop resistance minus loading coils would exceed the 1,500 ohm capability of the PABX equipment. Thus, it will be necessary to use long line adaptor techniques which will provide the capacity for the PABX to work with as much as 3,500 ohms total loop resistance. The cable will require 14 loading points. Each coil will add 8.5 ohms of resistance. The total loaded loop resistance for the farthest circuit will be 3,479 ohms which is within the capacity of the loop extenders. Voice frequency amplifiers will also be required.

A 300 pair cable will be required between Central Control and Fairfax, extending on to the Beverly station. Between Beverly and Santa Monica, a 200 pair cable will be required. Between Santa Monica and Studio City, a 75 pair cable can satisfy all requirements.

5.2.1.5 Circuit #5 - Central Control to the North Yard

This circuit is a total of 109.05 kilofeet. It will require loading at 17 points with H-88 loading coils. Therefore, the total wire resistance which can be tolerated while remaining within the 3,500 ohm capability of the loop extenders would be 3,356 ohms. The circuit must be a mixture of #22 and #19 AWG wire. The most economic arrangement utilizes

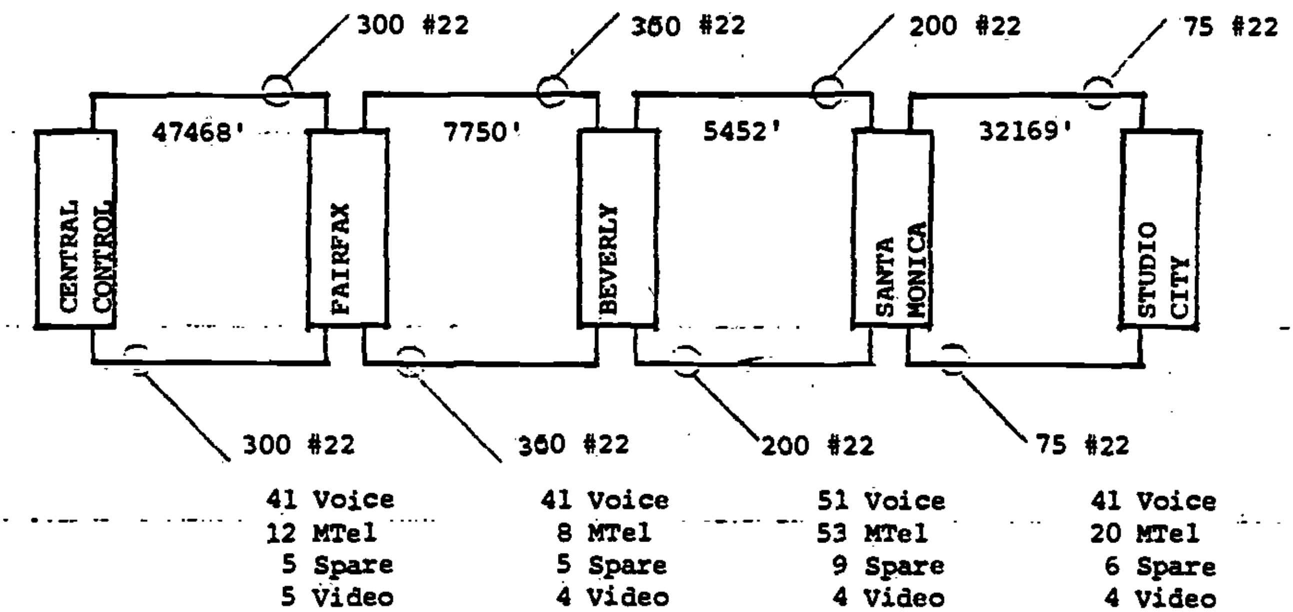
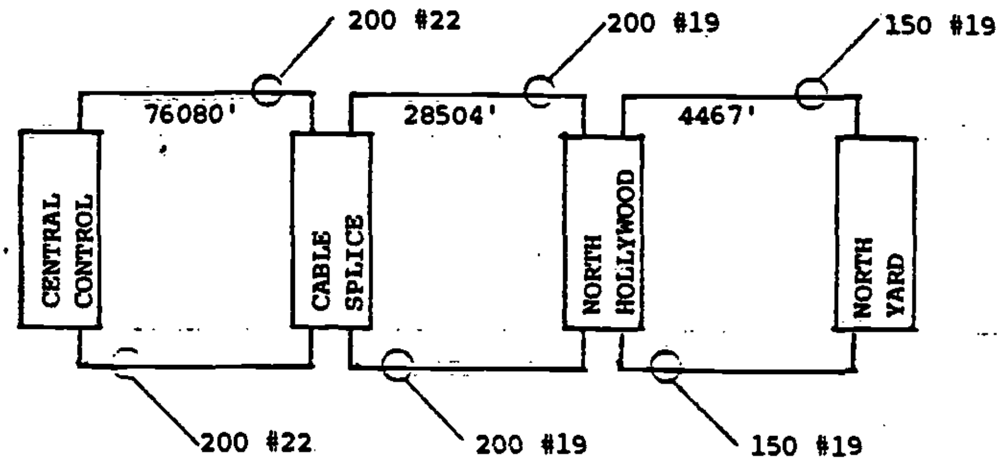

300 #22
360 #22
200 #22
75 #22
47468'
7750'
5452'
32169'
CENTRAL CONTROL
FAIRFAX
BEVERLY
SANTA MONICA
STUDIO CITY
300 #22
360 #22
200 #22
75 #22
41 Voice
12 MTel
5 Spare
5 Video
41 Voice
8 MTel
5 Spare
4 Video
51 Voice
53 MTel
9 Spare
4 Video
41 Voice
20 MTel
6 Spare
4 Video

FIGURE 5



41 Voice	102 Voice
7 MTel	0 MTel
5 Spare	10 Spare
4 Video	0 Video

FIGURE 6

76,080 feet of #22 gauge wire, and 28,504 feet of #19 wire to reach the North Hollywood station. This much of the circuit will require 200 pairs in the cable. From the North Hollywood Station to the North Yard, a 150 pair cable of #19 AWG gauge will be required. Voice frequency amplifiers will be required.

5.2.1.6 Video Transmission - Alternatives 1 and 2

By agreement, the video transmission techniques and elements were established as being the same for the wireline subsystem -Alternative 1 - and the coaxial cable subsystem - Alternative 2.

The video circuits discussed in this and succeeding paragraphs in Section 5.2 are applicable to Alternative 2 as well as Alternative 1.

Because of the noise environment inherent in electrical rail transit, frequency modulation techniques have been selected for this alternative subsystem study. Despite the requirement for additional bandwidth when FM is used rather than the Vestigial Sideband AM modulation technique normally employed in CATV systems, the 10 dB signal to noise ratio improvement over AM modulation in the same carrier-to-noise enviornment is sufficient to warrant utilizing FM modulation. In addition, FM systems display a very high immunity to impulse noise because of the inherent discrimination against AM signals.

The choice of cable size wil materially affect the overall subsystem costs. CATEL applications engineers have stated that the twenty-mile starter line can be operated with a coaxial cable of 1/2 diameter. While this will result in a greater number of trunk amplifiers, the larger diameter cables would increase the total cost were they to be used. There are, however, some practical limits on the number of amplifiers which can be cascaded on a common circuit.

In the Los Angeles CTS subsystem, trunk amplifiers must be placed where they can be serviced. This will mean installation of amplifiers in the cross passages in the subway areas, and these cross passages will occur every 600 feet along the rail system. Getting out of the cable tray and into the cross passage will involve cable length in addition to the normal linear run length. If we assume that each trunk amplifier installation will add 50 feet to the cable length, and that each pair of connectors will add 1 dB of loss, the 400 MHz loss of a 1/2 inch cable will dictate that amplifiers be located every 1,200 feet (every other cross passage).

The subsystem will be designed for a 27 dB loss maximum in each span to the extent that this possible with the cross passage spacing of the rail system. The higher frequency carrier assignments will be allocated to stations closest to Central Control. In this manner, as the cable gets farther from Centrol Control, the modulator frequencies will continue to decrease. Since Cable losses are calculated on the basis of the highest frequency in use, greater spacing may be possible between amplifiers in the sections of cable where the frequencies are lower than 400 MHz.

Video will be transmitted within the 50 to 400 MHz band with video channels on 14 MHz spacings. Within this band, 25 video channels can be multiplexed on a single cable via freqency-division techniques.

Because the attenuation of the video signals is greater at the higher radio frequencies, it will be necessary to introduce equalizers at each amplifier location. These devices serve to equalize the signal levels across the total spectrum prior to introducing the signals into the trunk amplifiers. Thus, the amplified signals enter the cable following each amplifier at equal levels.

Figure 7 shows a typical station arrangement for CCTV. Video from each camera (or sequencer, if employed) is fed into an FM modulator. Each modulator operates on a different RF frequency. The signals are combined in a "splitter" network, and are introduced into the cable via a dirctional coupler where they join signals from passenger stations more distant from Central Control and share the same cable path.

Figure 8 shows a typical section of coaxial cable passing through several passenger stations. Figure 9 depicts a typical setup for receiving and demodulating video signals from a passenger station.

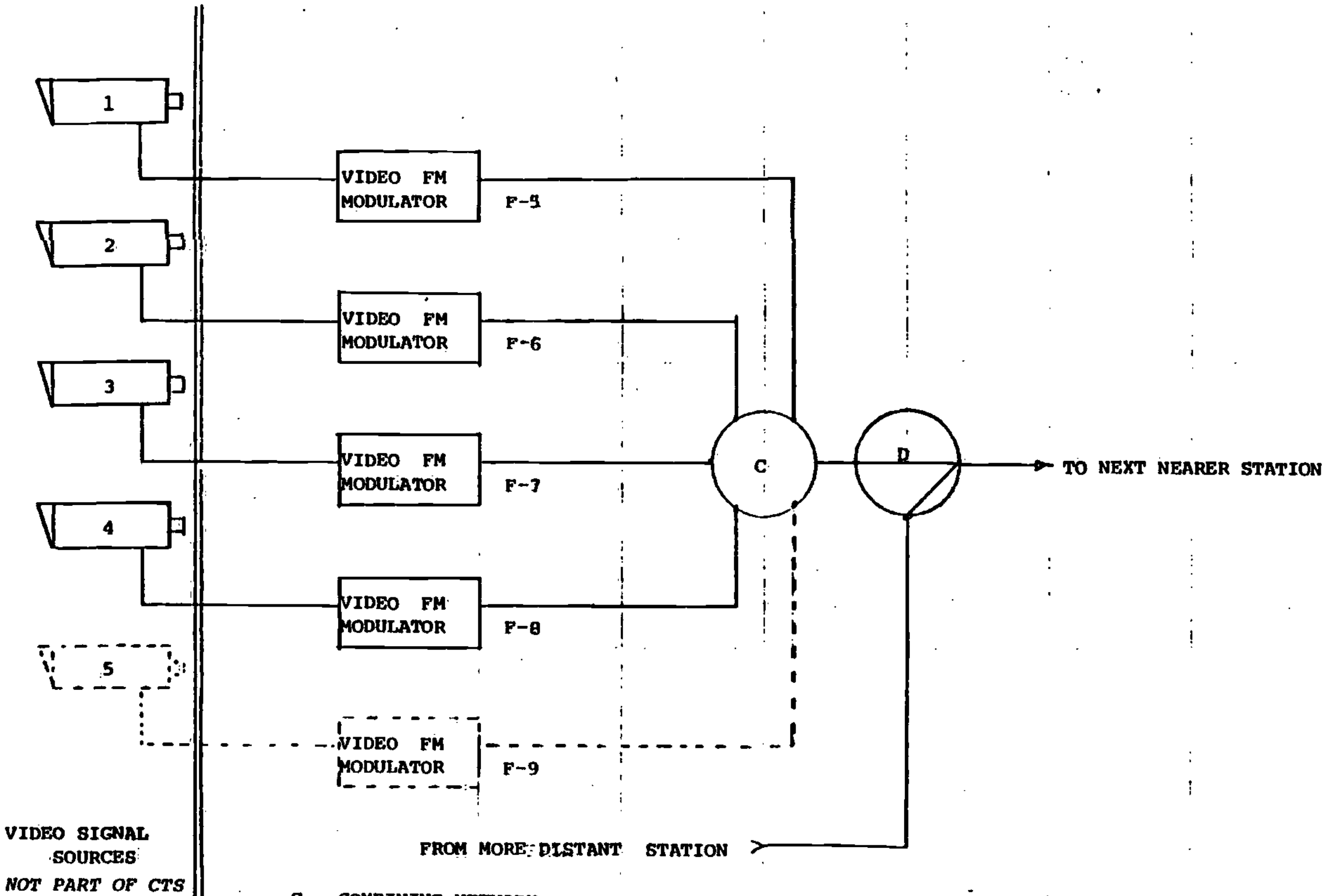
Redundancy in the CCTV transmission facility will be through an arrangement where two separate cables are fed from the same source material toward the terminal point. At the terminal point, the carriers on each cable will be monitored. Loss of any single carrier should result in an alarm condition. Loss of all carriers on a cable should cause an alarm condition and switch all service to the redundant cable.

The redundant cable will be monitored in the same manner as the main cable. Should a failure occur in the redundant cable while the main is in use, an alarm should be sounded, and switching to the failed facility should be inhibited.

Figures 10, 11, and 12 show the cable circuits and typical frequency plans for the inbound video service.

ENGINEERS
WASHINGTON, D.C.

STATION TRANSMISSION EQUIPMENT   SHEET NO. 1 OF 1
MADE BY TJG   DATE ____   CHECKED BY ____   DATE ____



C = COMBINING NETWORK
D = DIRECTIONAL COUPLER

TYPICAL STATION CCTV TRANSMISSION SCHEME

FIGURE 7

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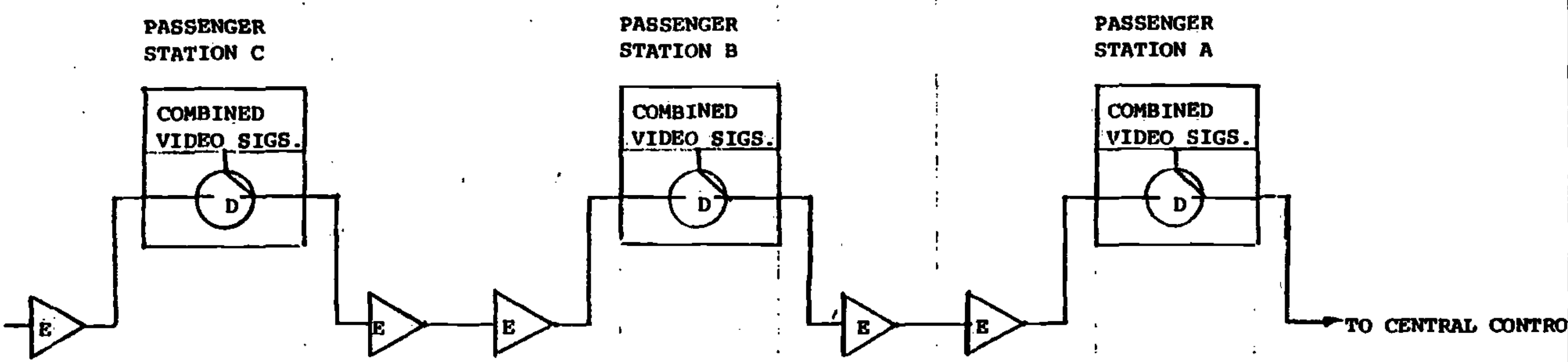
ALTERNATIVES 1 AND 2 COAXIAL CABLE SHEET NO.____ OF____

MADE BY____ DATE____ CHECKED BY____ DATE____

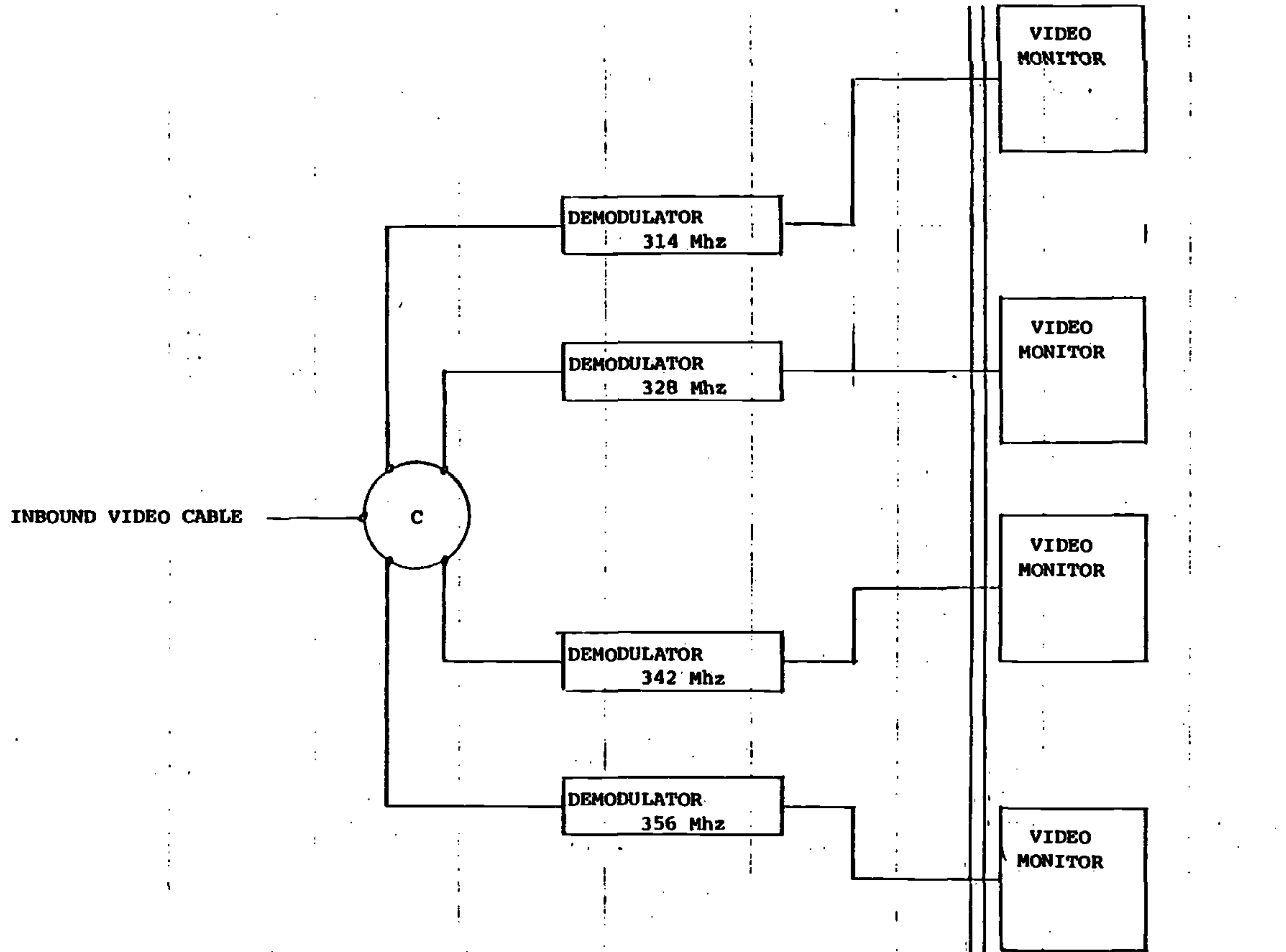


D = DIRECTIONAL COUPLER

E = EQUALIZER AND AMPLIFIER (INSTALLED IN CROSS PASSAGE SPACES IN TUNNELS AS REQUIRED)

TYPICAL CABLE PLAN FOR CCTV TRANSMISSION

FIGURE 8



TYPICAL ARRANGEMENT FOR CENTRAL CONTROL VIDEO RACK - UNION STATION DEPICTED

FIGURE 9

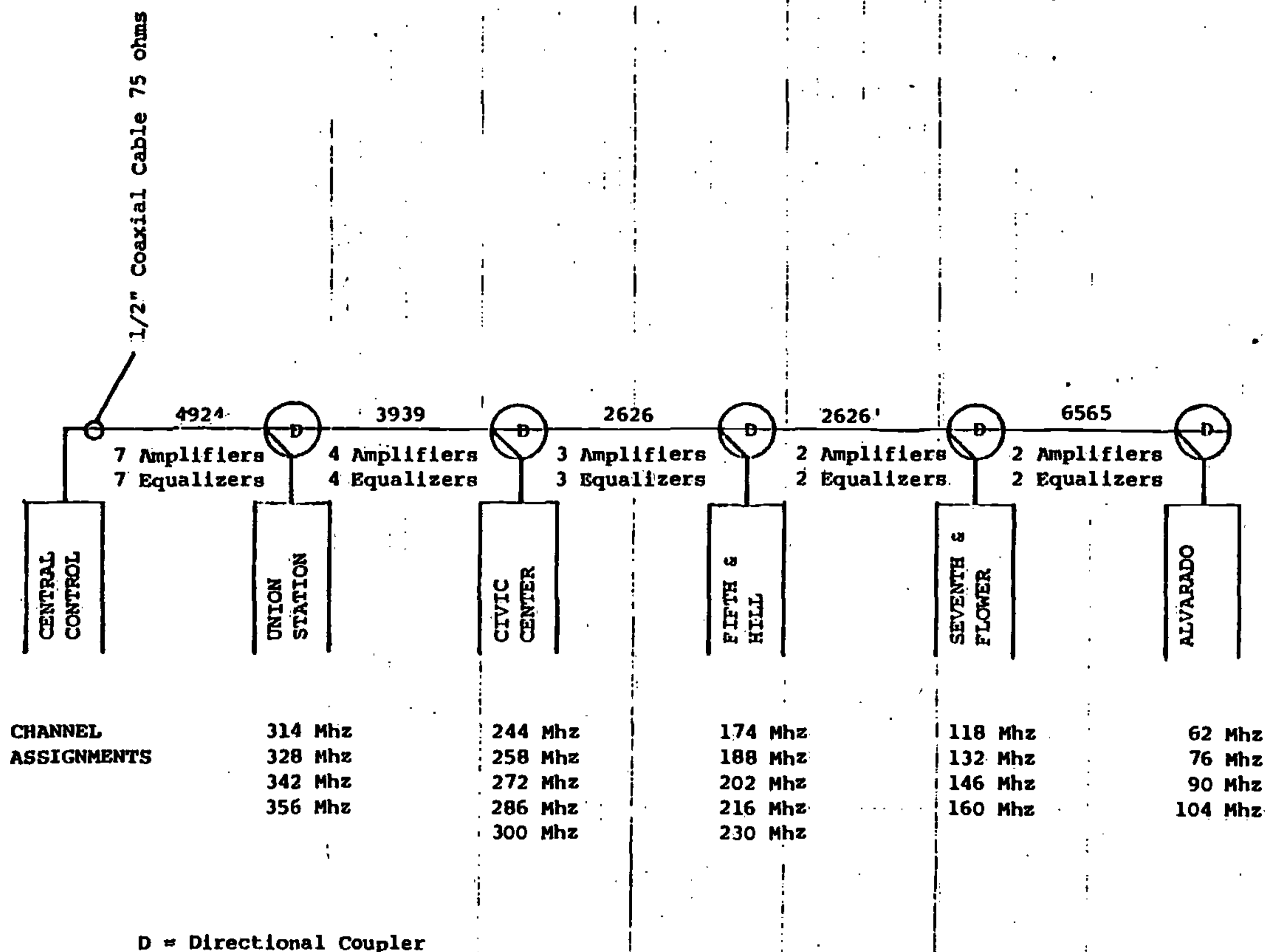
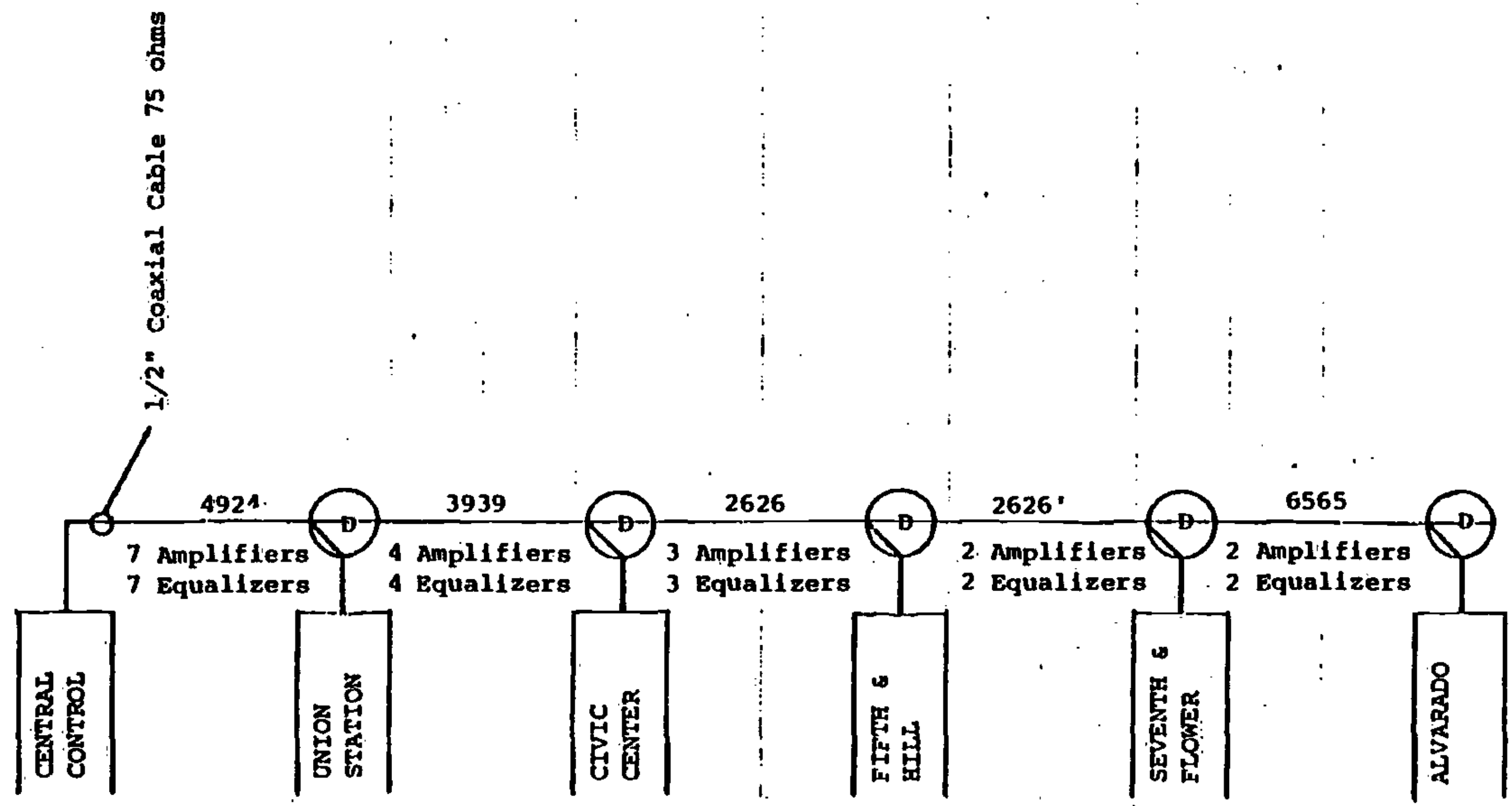

1/2" Coaxial Cable 75 ohms
4924
3939
2626
2626'
6565
D
7 Amplifiers
7 Equalizers
4 Amplifiers
4 Equalizers
3 Amplifiers
3 Equalizers
2 Amplifiers
2 Equalizers
2 Amplifiers
2 Equalizers
CENTRAL CONTROL
UNION STATION
CIVIC CENTER
FIFTH & HILL
SEVENTH & FLOWER
ALVARADO
CHANNEL ASSIGNMENTS
314 Mhz
328 Mhz
342 Mhz
356 Mhz
244 Mhz
258 Mhz
272 Mhz
286 Mhz
300 Mhz
174 Mhz
188 Mhz
202 Mhz
216 Mhz
230 Mhz
118 Mhz
132 Mhz
146 Mhz
160 Mhz
62 Mhz
76 Mhz
90 Mhz
104 Mhz
D = Directional Coupler

Figure 10



CHANNEL ASSIGNMENTS					
	314 Mhz	244 Mhz	174 Mhz	118 Mhz	62 Mhz
	328 Mhz	258 Mhz	188 Mhz	132 Mhz	76 Mhz
	342 Mhz	272 Mhz	202 Mhz	146 Mhz	90 Mhz
	356 Mhz	286 Mhz	216 Mhz	160 Mhz	104 Mhz
		300 Mhz	230 Mhz		

D = Directional Coupler

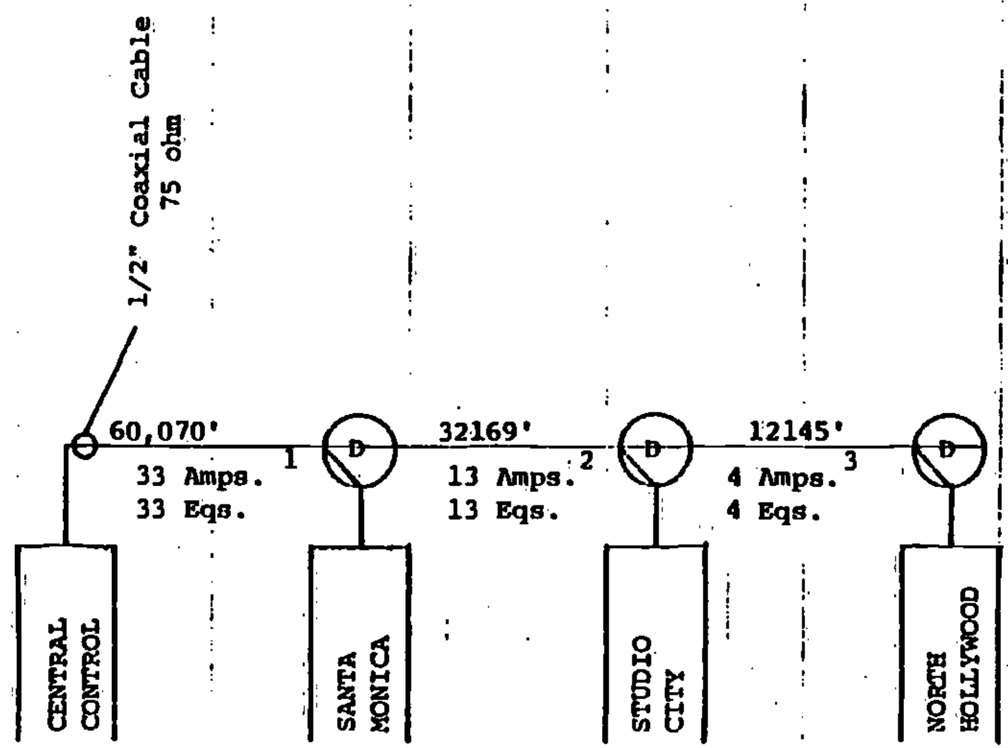
Figure 11

ENGINEERS
WASHINGTON, D.C.

CCTV COAXIAL CIRCUIT #3

SHEET NO.____ OF____

MADE BY____ DATE____ CHECKED BY____ DATE____



CHANNEL ASSIGNMENTS	SANTA MONICA	STUDIO CITY	NORTH HOLLYWOOD
	174 Mhz	118 Mhz	62 Mhz
	188 Mhz	132 Mhz	76 Mhz
	202 Mhz	146 Mhz	90 Mhz
	216 Mhz	160 Mhz	104 Mhz

D = Directional Coupler

1 = Spacing of amplifiers 3000 feet. Highest frequency 104 Mhz.
2 = Spacing of amplifiers 2400 feet. Highest frequency 160 Mhz.
3 = Spacing of Amplifiers 1800 feet. Highest Frequency 216 Mhz.

Figure 12

5.2.2 Alternative #2 - Coaxial Cable for Voice/Telephone/Data

For Alternative 2, the video transmission system will be identical to that shown for Alternative 1.

For voice circuits, Pulse Coded Modulation of the FM carriers will be used rather than frequency-division multiplexing. With hardware that is available today, PCM will likely be somewhate less expensive, and will provide the added benefit of increasing the immunity of the voice and data to the noise environment prevalent along an electrified railway. PCM modulation on FM carrier equipment should provide extremely good immunity from noise.

VIDAR has successfully used a 12-port multiplexer which it offers as an off-the-shelf hardware item to combine three T-2 carriers at 6.3 Mbps into a 19 Mbps bit stream to transmit 288 voice channels over one 16 MHz wide carrier channel.

There is a requirement to transmit 979 voice channels from Central Control toward the North Yard. By utilizing a scheme in which up to 288 channels may be multiplexed on a single carrier, the number of carrier frequencies needed is reduced.

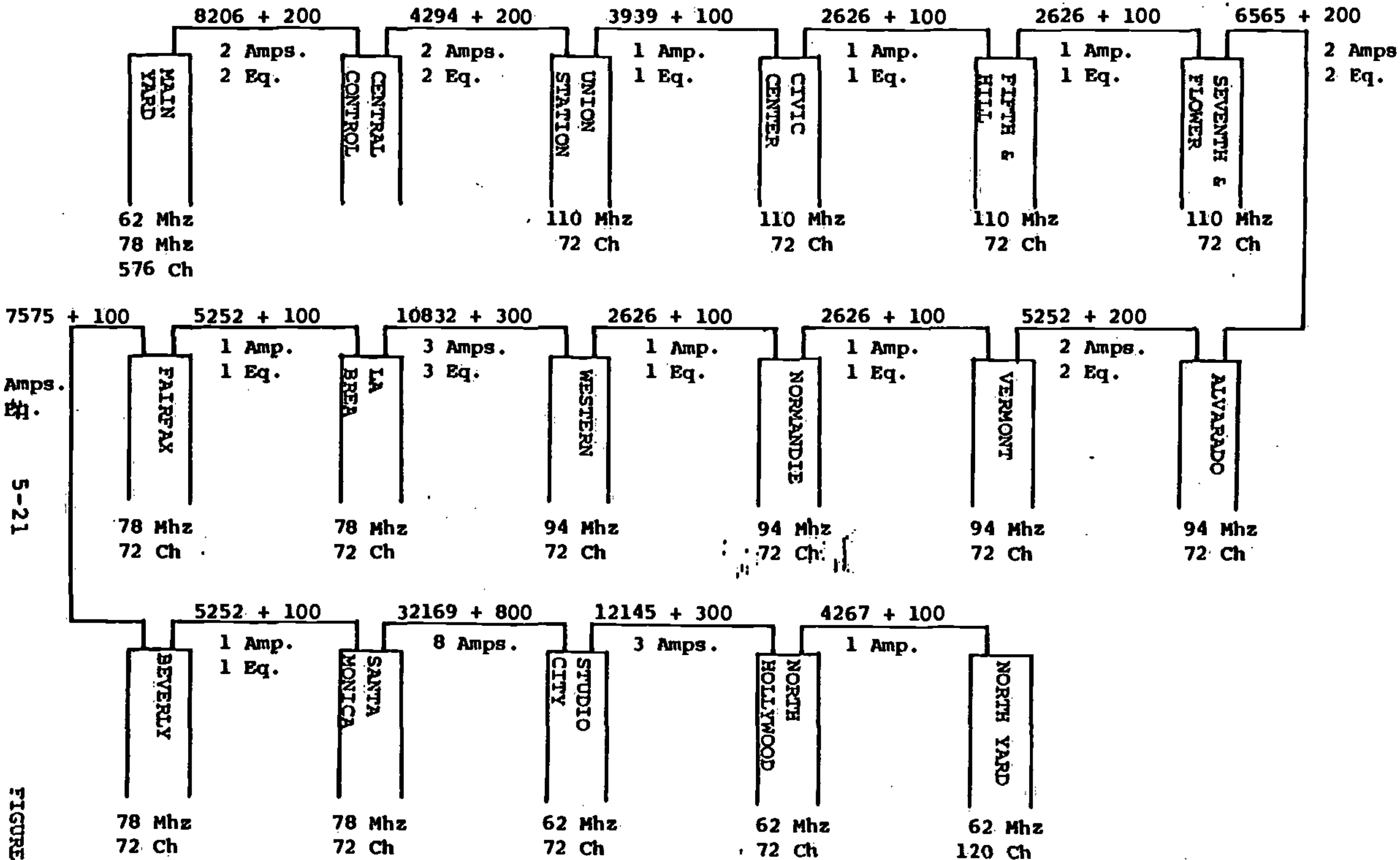
Figure 13 is a simplified schematic of the outbound cable for coaxial voice and data subsystem. In this scheme, the same radio frequency channel is monitored at several suceeding stations. At each location, the 12-port multiplexer demodulates the bit stream and feeds the time-division multiplexed signals to the appropriate T-1 carrier terminals. By employing this scheme, only the four lower frequency channels are used on the outbound cable. This allows trunk amplifier spacing to be maximum and reduces the costs.

Figure 14 is a simplified schematic showing the arrangement for connecting T-1 carrier terminals at Central Control into the 12-port multiplexer for transmission on the coaxial cable. Figure 15 shows the station arrangement for demodulation.

Figure 16 is a simplified schematic of the inbound cable for coaxial voice and data. In this scheme, each passenger station is assigned its own carrier channel. As was done in the CATV cable, the coaxial cable enters each passenger station where that station's carrier is injected into the cable via a directioal coupler. At Central Control, carriers are separated by frequency division multiplex techniques, and each carrier is demodulated via a 12 port multiplexer which, in turn, feeds its assigned T-1 carrier units.

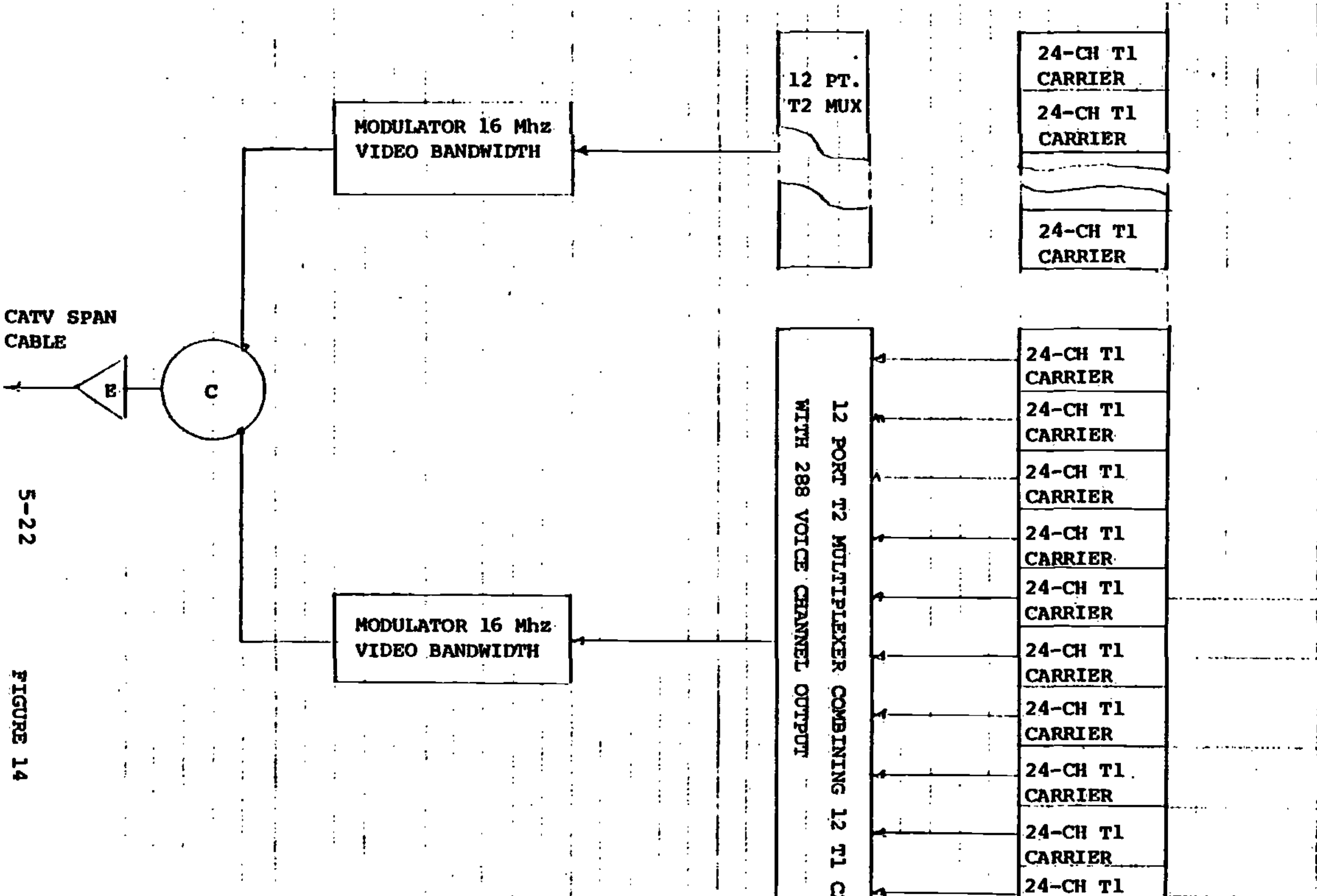
DeLEUW CATHER
De Leuw, Cather & Company
Consulting Engineers and Planners

SUBJECT ALTERNATIVE #2 COAXIAL CABLE
OVERALL PLAN OUTBOUND VOICE CABLE
JOB NO. 3469-00
SHEET NO. ____ OF ____
MADE BY ____ DATE ____ CHECKED BY ____ DATE ____



OUTBOUND COAXIAL CABLE PLAN FOR VOICE FREQUENCY CABLE TRANSMISSION LINK

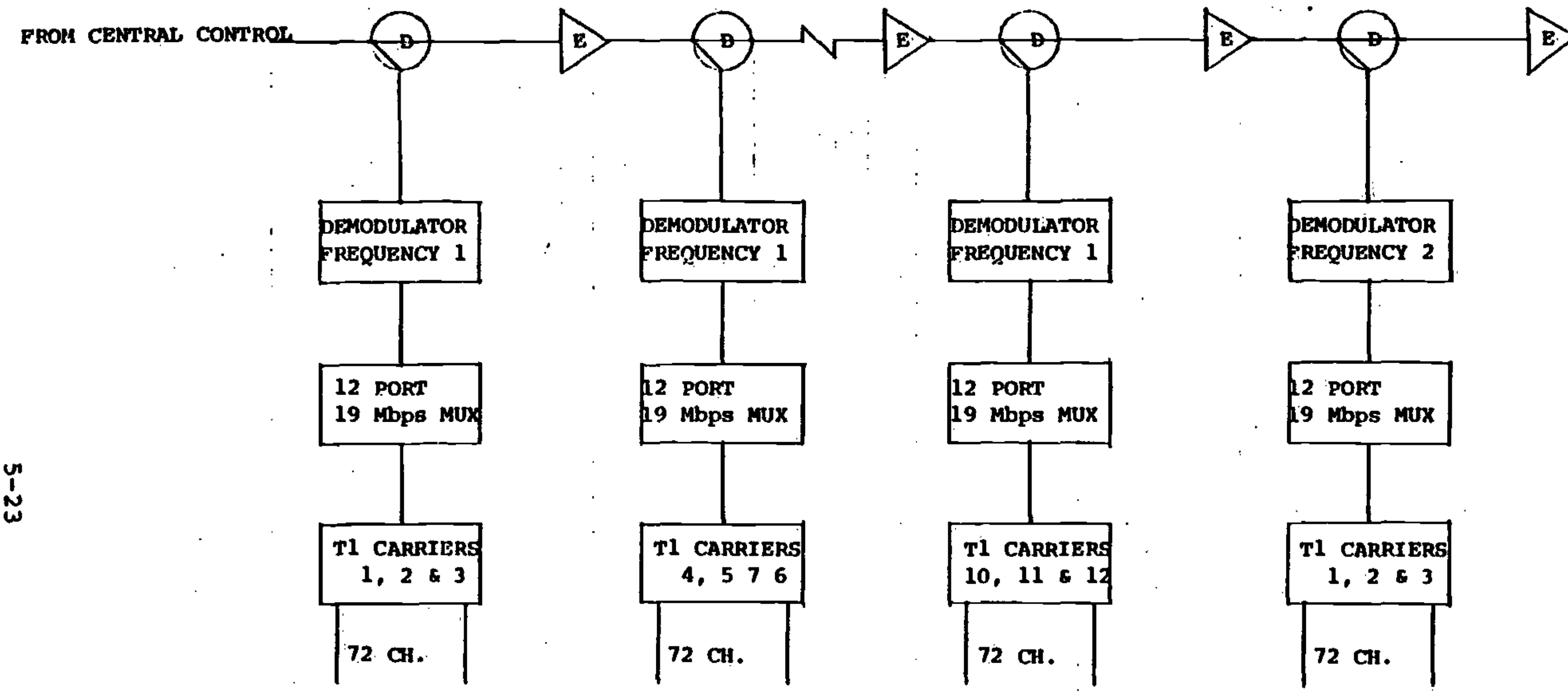
FIGURE 13



SIMPLIFIED BLOCK DIAGRAM CENTRAL CONTROL

TYPICAL VOICE & TELEPHONE CHANNEL ARRANGEMENT

FIGURE 14



SIMPLIFIED BLOCK DIAGRAM
ALTERNATIVE #2 VOICE
FM/PCM DIGITAL OUTBOUND

FIGURE 15

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WASHINGTON, D.C.

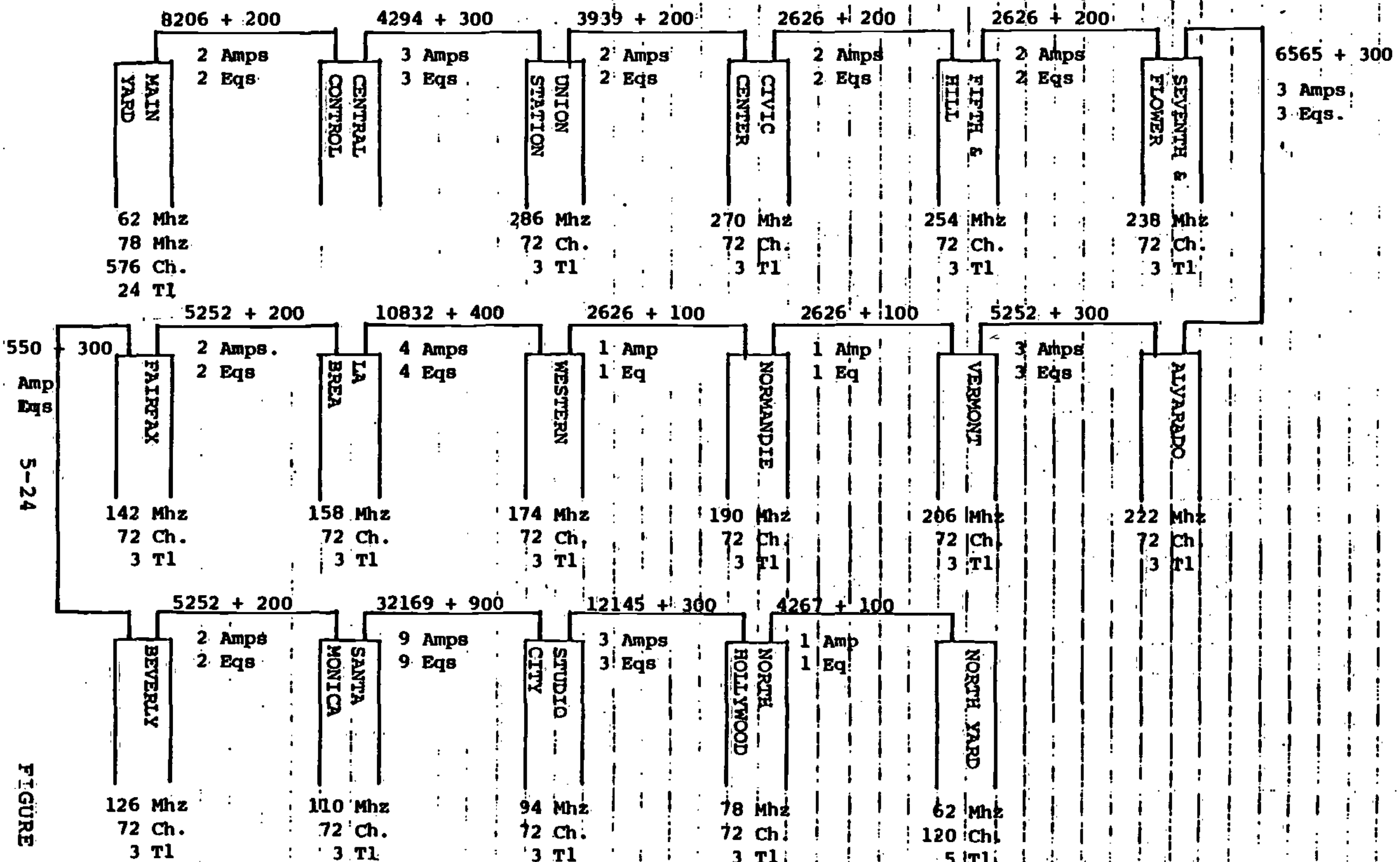
MADE BY____ DATE____ CHECKED BY____ DATE____

SHEET NO.____ OF____

De Leuw, Cather & Company
Consulting Engineers and Planners

INBOUND COAXIAL VOICE CABLE

MADE BY ____ DATE ____ CHECKED BY ____ DATE ____ SHEET NO. ____ OF ____



INBOUND COAXIAL CABLE PLAN FOR VOICE FREQUENCY CABLE TRANSMISSION LINK

FIGURE 16

Redundancy in this scheme is achieved in the same manner as in the CCTV coaxial cable scheme. The data will be fed into both the primary and the redundant cable for both the inbound and outbound cable paths. At the receiving end, the carriers will be monitored, and loss of the carriers will cause a switch to the redundant cable.

5.2.3 Alternative 3 - Fiber Optics

As described in the Scope of Services, Alternative 3 will utilize a pair of fibers for each voice link between Central Control and a terminal point. In addition, one fiber will be required between each passenger station and Central Control for each television circuit. As a minimum, then, six fibers are required for each passenger station, with seven being the minimum required for three of the stations. A pair of fibers will satisfy the requirements for the Main Yard and the North Yard.

For the purpose of this study, we will assume a cable with high quality, graded index, fiber having losses of not more than 3.5 dB per kilometer due to attenuation. Repeater spacing will be about 10 kilometers (see design assumptions 5.4.1).

ITT reports that it has supplied fiber cables with up to 35 fibers for its customers. A single cable to carry all of the circuits in the first link of the rail starter line would require 89 fibers between Central Control and Union Station. Because there is a lack of information concerning the tensile strength and pulling problems with a cable of almost 90 fibers, this study will be based on cables with a maximum of 38 fibers.

Full motion television can be transmitted at a 6.3 Mbps rate (T-2 carrier with 96 channel capacity). The equipment to allow this is designed to interleave television and voice signals into a common bit stream, and it is quite expensive. Since the fiber optic alternative described in the Scope of Services stipulates a separate fiber for each television signal, this study will utilize the T-3 carrier television encoder and transmission rate of 44.7 Mbps.

Voice signals will be transmitted at the standard T-2 rate for 96 channels - 6.3 Mbps - over a separate pair of fibers. One fiber will carry the outbound signals, and the second fiber will carry the inbound signals.

Figures 17, 18 and 19 show the cable arrangements for each of the fiber optics circuits. Because fiber cables are made-to-order, each leg of the circuit contains only those fibers which are required for stations beyond.

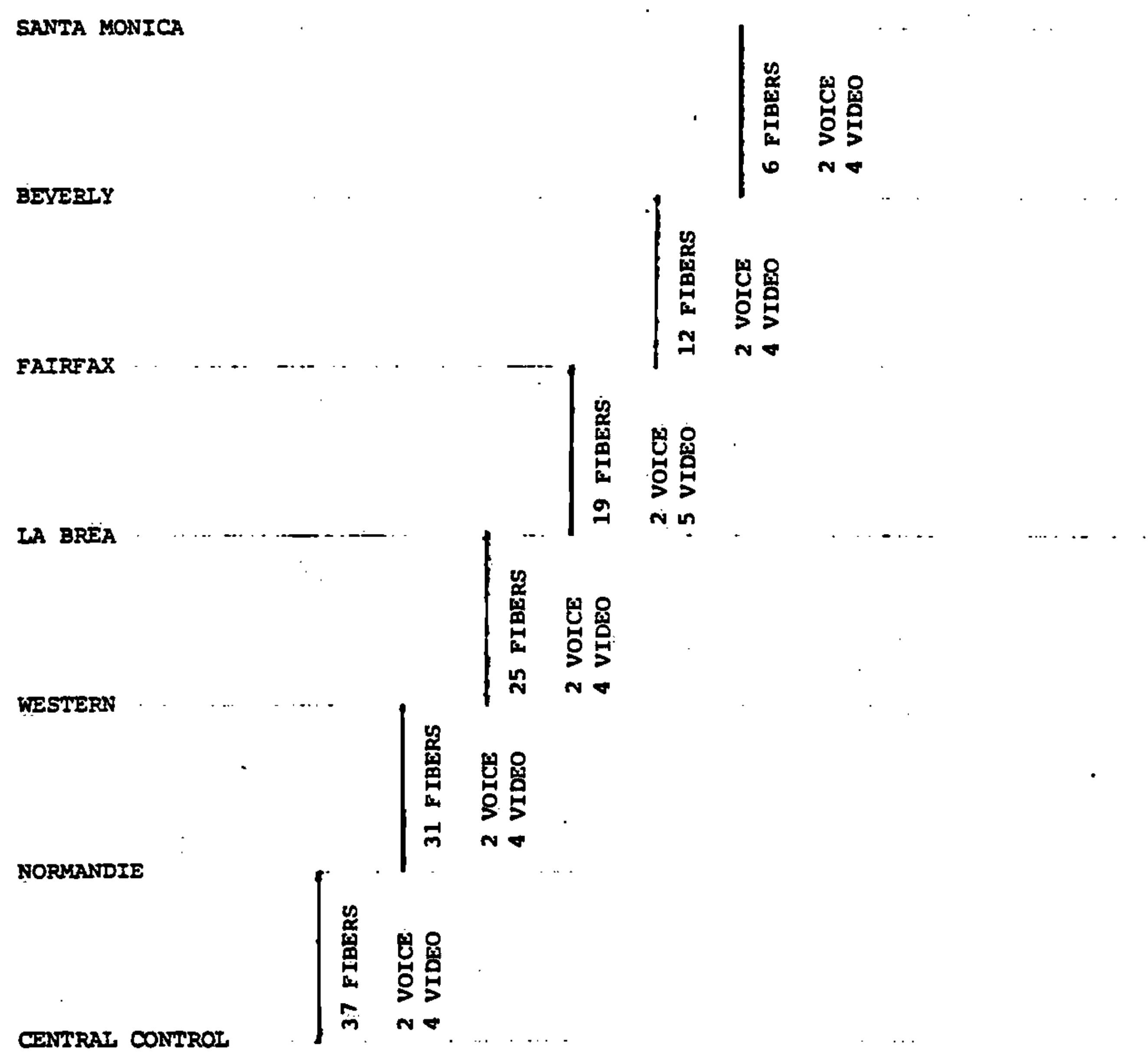

SANTA MONICA
BEVERLY
FAIRFAX
LA BREA
WESTERN
NORMANDIE
CENTRAL CONTROL
37 FIBERS
2 VOICE
4 VIDEO
31 FIBERS
2 VOICE
4 VIDEO
25 FIBERS
2 VOICE
4 VIDEO
19 FIBERS
2 VOICE
5 VIDEO
12 FIBERS
2 VOICE
4 VIDEO
6 FIBERS
2 VOICE
4 VIDEO

FIGURE 17

FIBER OPTICS - ALTERNATIVE 3 - CIRCUIT 1 SHEET NO.____ OF____

MADE BY______ DATE______ CHECKED BY______ DATE______

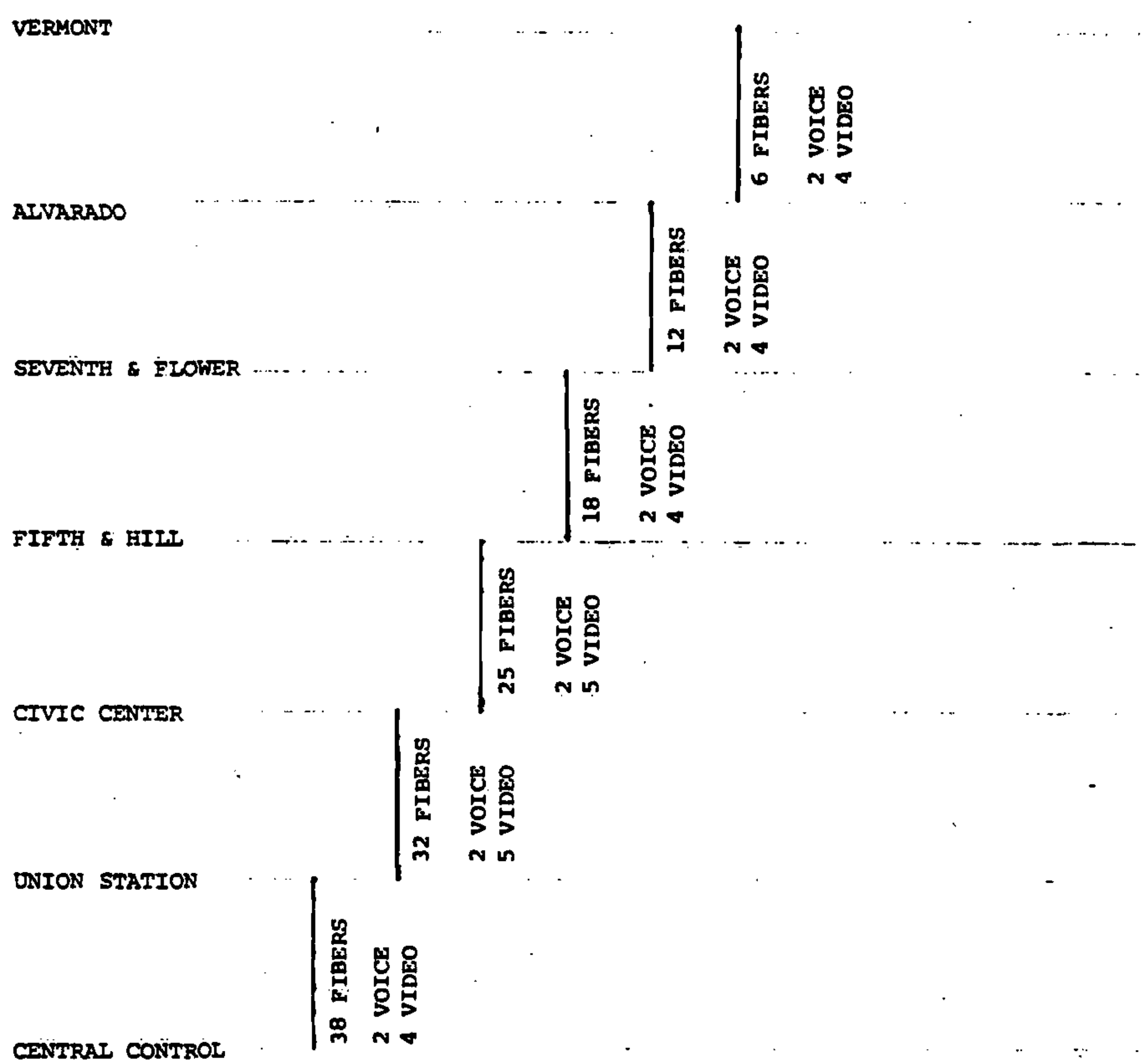


FIGURE 18

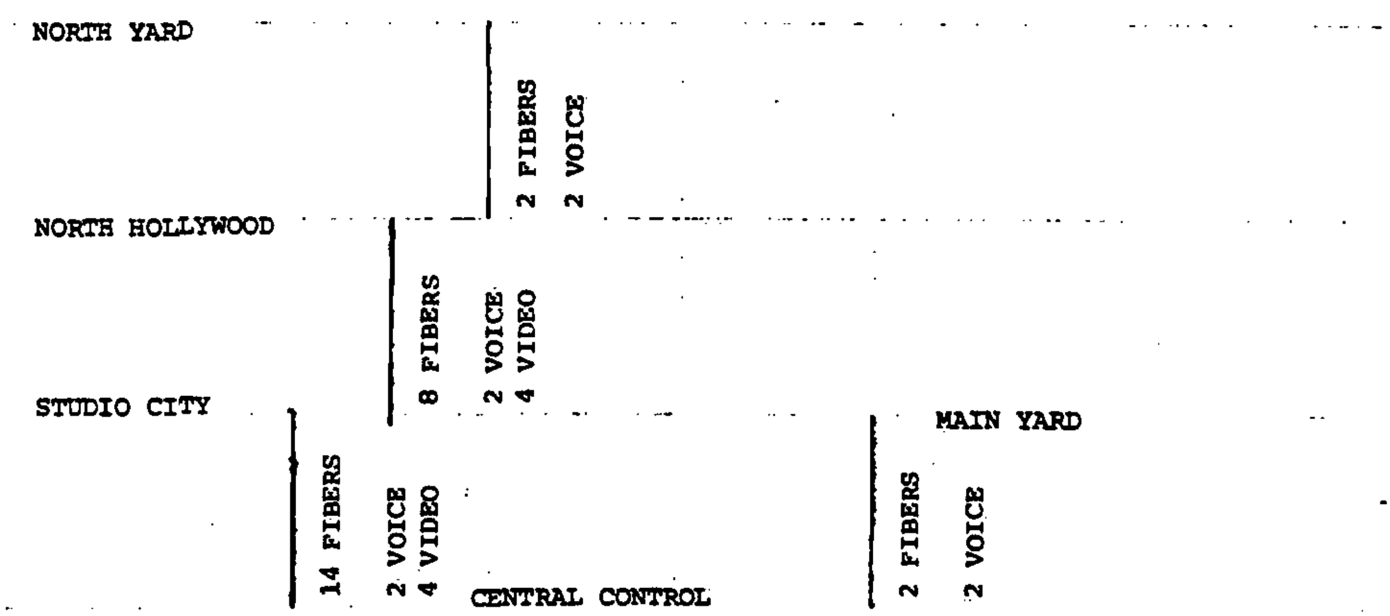
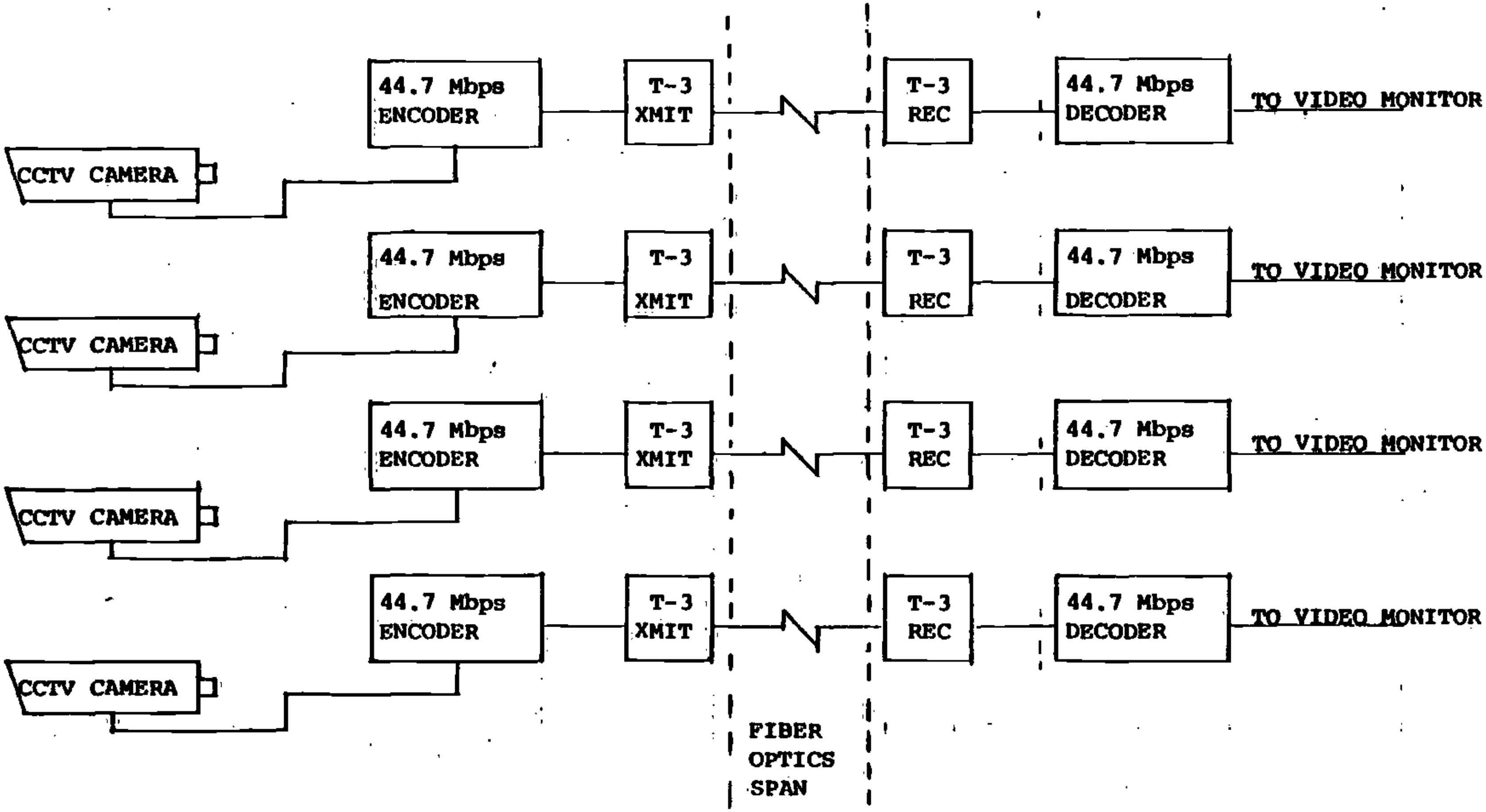
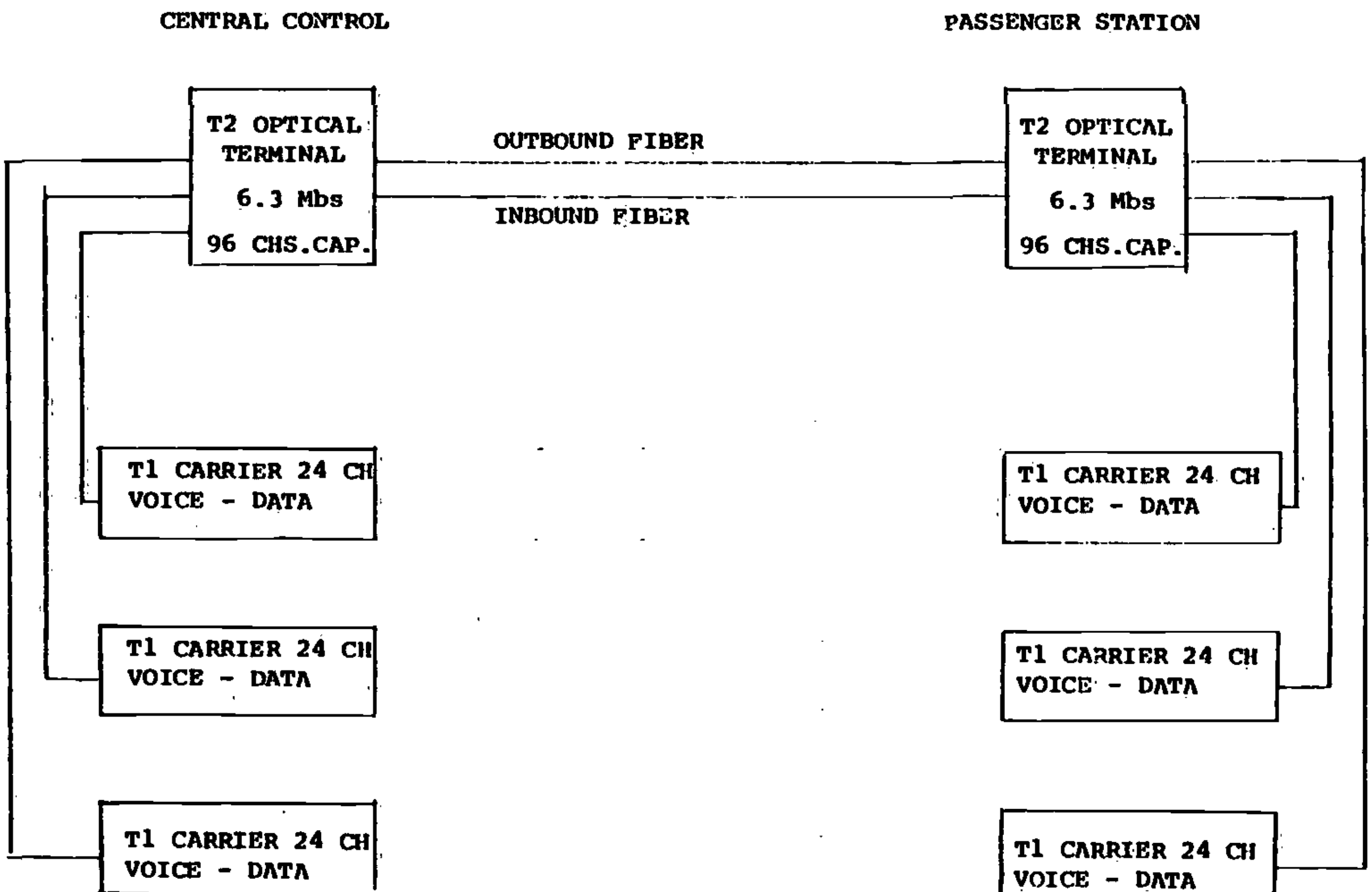

NORTH YARD
2 FIBERS
2 VOICE
NORTH HOLLYWOOD
8 FIBERS
2 VOICE
4 VIDEO
STUDIO CITY
14 FIBERS
2 VOICE
4 VIDEO
CENTRAL CONTROL
MAIN YARD
2 FIBERS
2 VOICE

FIGURE 19



SIMPLIFIED BLOCK DIAGRAM - FIBER OPTICS
VIDEO TRANSMISSION SCHEME

FIGURE 20



SIMPLIFIED BLOCK DIAGRAM - VOICE TRANSMISSION SCHEME FIBER OPTICS

FIGURE 21

5.3 APPLICATION HISTORY

Of the three technologies involved in the three alternatives under study, the utilization of wire pairs - Alternative 1 -is the oldest and most mature. Largely because of the Bell Telephone System, the standards for telephone performance are such that all of the hardware required for the first alternative is available from a large number of suppliers. However, circuits of the length required in the RTD starter line are generally avoided because of noise problems.

CATV techniques which are recommended for the video transmission in both Alternatives 1 and 2, and for the voice, data and control circuits in the second alternative are quite mature, and video modulators, trunk amplifiers, combining circuits and directional couplers are available from a number of suppliers. The number of sources for FM modulators and demodulators is not as numerous as for AM hardware.

The Pulse Coded Modulation equipment which is used to translate the voice, data and control signals from an analog signal to a binary bitstream is avaible from a number of telephone equipment manufacturers. Perhaps as many as 200,000 T-1 carrier systems are in use in interexchange service for trunking in telephone systems in this country alone.

It has only been within the last year or so that fiber optics systems have begun to be designed and installed in system applications which are not, to some degree, experimental. Prior to that time, most of the system, applications were largely experimental or test applications between telephone exchanges in this county. The crowded conditions of many existing cable ducts within metropolitan areas makes the small fiber cable size and the inherent very wide bandwidth of the fibers extremely attractive for telephone service expansion and for cable replacement.

Fiber optic technology is maturing rapidly, and standard hardware is now available from a number of manufacturers. There are several sources for the type of hardware postulated in Alternative 3.

By the time when a CTS subsystem might be specified, procured and installed, lasers and photodiodes will be available which operate in the longer wavelength region of 1.3 micrometers will be as readily available as those now available for operation in the 0.850 micrometer wavelength.

5.4 METHODOLOGY

The methodology which led to the development of the individual subsystem configurations which were studied as Alternatives 1, 2, and 3 in this report is largely explained in the portions of this report which describe the three basic configurations. There are, however, some assumptions which were made, and some calculations to support the basic study designs which will be presented here.

5.4.1 Design Assumptions

1. The PABX equipment will handle a loop resistance of 1,500 ohms for a subscriber line.

2. The maximum temperature in a ductline or cableway will not exceed 50 degrees Celsius or 122 degrees Farenheit.

3. The resistivity of annealed copper is 10.371 ohms for one foot of wire having an area of one circular mil.

4. Each station entrance adds 100 feet to the cable length. Each station exit adds 100 feet to the cable length.

5. Telephone circuits will be two-wire.

6. Emergency telephones are to be located at cross passages at intervals of 600 feet. At each cross passage, two telephones will be located. Each phone will be a part of a separate system. These two telephones will constitute the redundancy for emergency telephones along the guideway.

7. Emergency telephones within the passenger station are included in the 24 telephone channels stipulated for each passenger station.

8. Emergency telephone circuits will be fully supervised by equipment which is a part of the emergency telephone subsystem, and any such supervisory signals inherent in the subsystem can be used to switch CTS circuits upon failure.

9. DTS circuits will be four-wire because of the full-duplex requirement. DTS equipment will be self-supervising with automatic switchover.

10. Redundancy with automatic switchover for the Radio and P.A. control will require that those circuits be four-wire.

11. Complete redundancy, as stipulated in 3.12.1.E of the Design Criteria implies that there will be redundant, physically separated, cable facilities connecting Central Control to the passenger stations and to the yard areas.

12. Within each separate cable facility, certain channels will have independent redundancy at the channel level.

13. Each cable should have a minimum 10% spare pairs terminated at each location.

14. Cables with standard pair counts will be used. AWG #22 wire cable can be procured in pair counts of 6, 12, 18, 25, 50, 75, 100, 150, 200, 300, 400 and 600 pairs. AWG #19 wire cable is not put up in the 600 pair configuration, but can be obtained in the other pair counts as shown for AWG #22.

15. Video Frequency Modulation has a 7.4 dB advantage in signal-to-noise over Vestigial Sideband Amplitude Modulation when standard to five times the number of cascaded amplifiers in a trunk cable over that possible with AM. (See "A Frequency Modulation System for Cable Transmission of Video or Other Wideband Signals," Court, Patrick R. J., et al, April 1720, 1977.)

16. High quality, graded index, fibers will be used, and these can be procured cabled in lengths up to one mile without splices.

5.4.2 Calculations

Repeater spacing in the fiber optics subsystem configuration is based on the following:

Type of Light Source:	Injection Laser 850 nm - 5mw = 7 dBm
Coupling Loss into Fiber:	3 dB per source
Connector Loss:	1 dB
Splice Losses:	0.25 dB splice (Assume 1 mile = 0.155/km)
Type of Detector:	Avalanche Photo Diode
Required Bit Error Rate:	45 Mbps
Required Receive Power:	-53 dBm
System Margin for Aging:	10 dB
Allowable Link Loss	39 dB
Cable Attenuation:	3.5 dB/km
Link Attenuation Limit:	39/(3.5 + .155) = 10.67 km

The system bandwidth for the fiber optics link is a function of the link rise time, and has been calculated using the following parameters:

COMPONENT	RISETIME	$RISETIME^2$
Light Source	1.5 ns	2.25 ns^2
Fiber Dispersion	5.0 ns	25.0 ns^2
Receiver	3.0 ns	9.0 ns^2
	SUM OF SQUARES	36.26 ns^2

Link Rise Time = 1.1 $(\text{sum of squares})^{1/2}$ 6.2 ns

System Bandwidth = $\frac{.35}{6.2 \times 10^{-9}}$ 56.4 MHz

5.5 RESULTS

5.5.1 Capital Costs

The capital costs for the three alternative CTS subsystem concepts were developed on the basis of the cost estimate sheets contained in Appendix iii. Copper wire costs were obtained from Okonite for the part numbers shown, and are current quotations. Similarly, many of the hardware items were priced on the basis of telephone quotations for specific items. Coaxial cable costs were based on 1981 catalogue price lists which were escalated 15 percent. Where necessary, other catalogue prices were escalated to reflect more nearly current pricing.

All of the costs contained in this analysis were developed on the basis of preliminary configurations of hardware items. As such, they are quite suitable for comparison purposes. Detailed engineering of the various alternatives would almost certainly result in somewhat higher costs for each, but would not result in reversal of the relative positions of each of the alternatives.

5.5.1.1 Alternative 1 Cost Summary

Circuit #1 - Wireline Voice Central Control to Main Yard	67,371	
Circuit #2 - Wireline Voice Central Control to Seventh & Flower	67,362	
Circuit #3 - Wireline Voice Central Control to La Brea	325,909	
Circuit #4 - Wireline Voice Central Control to Studio City	512,918	
Circuit #5 - Wireline Voice Central Control to North Yard	612,829	
TOTAL WIRELINE		1,586,389

Video Circuit #1 Central Control to Avlarado	246,907	
Video Circuit #2 Central Control to Beverly	408,101	
Video Circuit #3 Central Control to North Hollywood	506,982	
TOTAL VIDEO		1,161,990
Redundant Wireline	1,586,389	
Redundant Video	784,394	
TOTAL COSTS - ALTERNATIVE #1		5,119,162

5.5.1.2 Alternative #2 Cost Summary

Outbound Coaxial Voice Cable	476,578	
Inbound Coaxial Voice Cable	518,636	
Central Control RF Hardware	68,753	
PCM Multiplexers & T-1 Carrier	1,392,288	
COAXIAL VOICE CABLE		2,456,255
Video Circuits		1,161,990
Redundant Coaxial Voice		920,913
Redundant Video Cable		784,394
TOTAL ALTERNATIVE #2		5,322,552

5.5.1.3 Alternative #3 Cost Summary

Circuit #1 Fiber Cable Installed	181,547	
Circuit #2 Fiber Cable Installed	891,586	
Circuit #3 Fiber Cable Installed	676,029	
Circuit #4 Fiber Cable Installed	21,081	
TOTAL FIBER CABLE COST		1,770,243

Voice Circuit Optical Hardware	201,267	
Voice Digital Carrier Hardware	1,104,795	
CCTV Optical Hardware	2,398,704	
TOTAL HARDWARE COSTS		5,273,742
Redundant Fiber Cable Circuits	1,770,243	
TOTAL ALTERNATIVE #3 COSTS		7,043,985

5.5.2 Operating Costs

Operating costs pertaining to the overall communications system have been defined elsewhere by Kaiser Engineers as consisting of:

a. Labor for Operators
b. Off-hour surveillance labor
c. Energy

5.5.2.1 Labor Costs

The CTS subsystem will be operating 365 days a year, 24-hours per day. The choice of subsystem type is not likely to effect the quantity or quality of the operators. Thus, all three subsystem configurations are considered to be equal in terms of operating labor requirements.

Similarly, there appears to be no requirement for a different amount of off-hour surveillance for either of the alternatives considered. All of the systems will be equipped with failure alarms.

5.5.2.2 Energy Costs

At this preliminary level of engineering, estimates of power consumption for each alternative subsystem would only represent the roughest order of energy requirements for one subsystem as opposed to another. The CCTV transmission subsystems are precisely the same for Alternatives 1 and 2, and the requirements for transmission of information in one alternative subsystem do not change from those of the others.

For purposes of this study, we consider the energy requirements equal for all three alternatives.

5.5.3 Maintenance Costs

Based on historical information relative to the maintenance of small public telephone systems, it is estimated that the annual costs for maintaining the subsystem configured as Alternative #1 would equal approximately 3.4 percent of the capital cost.

Recognizing that a significant amount of the hardware requirements in Alternative #1 are met by the PABX equipment, it is estimated that the maintenance for Alternatives 2 and 3 would likely be at least 30% greater than for Alternative 1.

Utilizing these factors as a basis for estimating the maintenance and spare parts costs for the three alternatives, the costs are as follows:

Alternative #1	174,052 per year
Alternative #2	235,257 per year
Alternative #3	311,344 per year

5.5.4 ANNUAL EQUIVALENT COSTS

The annual equivalent costs for the three alternative subsystems are those capital costs for subsystem acquisition annualized over the system lifetime at some time value for the capital dollars plus annual operating and annual maintenance costs.

For purposes of this analysis the system lifetimes are considered to be a period of 32 years, and the time value for the investment is considered 12% annually.

5.5.4.1 Annualized Capital Costs

Annualized capital costs have been defined by Kaiser Engineers as follows:

$$ACC = \text{Capital Costs} \times \frac{i(1 + i)^n}{(1 + i)^n - 1}$$

Where i = interest rate
n = subsystem lifetime

For the parameters previously cited concerning lifetime and annual percentage rate for money, this formula yields the following multiplier:

$$ACC = \text{Capital Costs} \times \frac{.12(1 + 0.12)^{32}}{(1 + 0.12)^{32} - 1} = 0.123280$$

The annualized capital costs for each of the three alternatives are as follows:

Alternative #1	5,119,162 x 0.123280 = $631,090
Alternative #2	5,323,552 x 0.123280 = $656,287
Alternative #3	7,043,522 x 0.123280 = $868,325

5.5.4.2 Relative Standings of Alternatives

The relative standings of the alternatives based on cost factors can be found by adding the annualized capital costs for each alternative to the annual operating and maintenance costs. Since the operating costs are considered equal for all alternatives, the annual equivalent costs for the three alternatives are:

Alternative #1 631,090 + 174,052 = $ 805,142

Alternative #2 621,945 + 235,257 = $ 891,544

Alternative #3 868,325 + 311,344 = $1,179,669

5.5.5 RELIABILITY

This alternative study has been based on very preliminary engineering. Therefore, there will be no attempt to assess the reliabilities of the subsystem configurations in a quantitative manner.

From a relative standpoint, Alternative #1 utilizes very mature technology, and hardware to implement that configuration is highly standardized and has been in use for a very long time. Based on these facts, it would appear that Alternative #1 should experience fewer failures per unit time that could be expected in Alternatives 2 and 3.

Since Alternatives 2 and 3 both utilize digital carrier techniques to transmit the voice signals, much of the hardware for this purpose is common to both subsystems. It does not appear that either of these two alternative subsystems has a reliability advantage over the other.

5.5.6 TECHNICAL RISK

5.5.6.1 Alternative #1

The technology involved in Alternative #1 is that of the telephone industry. As such, it is very mature, and little technical risk would be involved provided that the subsystem were within normal operating limits for the technology.

Many of the circuits in the Alternative #1 configuration are sufficiently long to require specialized treatment of the telephone pairs that make up the circuits. The Scope of Services which sets forth the various subsystem alternative stipulated that the circuits utilize no repeaters. All of the circuits beyond LaBrea will require voice frequency amplifiers or repeaters.

In the environment which will exist along the electrified rapid rail system, Alternative #1 involves technical risks in that the voice circuits which extend beyond the LaBrea station are likely to be very noisy. The amplifiers necessary to make the circuits workable will also amplify any induced noise.

Certainly expansion beyond the North Yard location would worsen this problem, and there are finite limits beyond which a subsystem configured as Alternative #1 will not work.

5.5.6.2 Alternative #2

The technology involved in Alternative 2 is basically that of the CATV industry. Hundreds of systems with thousands of miles of trunks are in daily operation. The majority of these systems utilize Vestigial Sidband AM modulation because the narrower bandwidth requirements will allow a larger number of channels to be transmitted on a single cable. The noise environment inherent in electrified rapid rail transit is such that there is a high risk of inducing hum and noise impulses into a trunk cable which utilizes AM modulation techniques. The FM modulators utilized in this Alternative should provide a large measure of protection against noise. The reduced bandwidth capabilities when FM is used will limit the number of channels on a common cable to less than that available with AM. However, utilizing separate cables for voice and video will provide a measure of protection from interference to the video from digital signals in the voice system.

The hardware necessary to implement Alternative #2 is readily available, although theere are not so many suppliers of the FM modulators as there are of the AM modulator equipment.

5.5.6.3 Alternative #3

The technology involved in Alternative #3 is relatively new. However, the techniques for transmitting both voice and video information over fiber cables are quite mature in terms of multiplexing techniques. Developmental work has continued in the manufacture of glass fibers, and in improving the transmitting and receiving equipment. Manufacturers are now delivering transmitters and receivers which operate in the 1.2 to 1.3 micrometer region at which today's glass fibers have a very low attenuation rate.

Telephone companies in this country and abroad are now beginning to construct new interexchange trunking facilities utilizing fiber optics. In locations where wireline duct capacity has limited growth, wire pairs are being replaced with fibers which vastly increase the bandwidth and consequently the number of voice circuits which can be handled in the physical space occupied by the cables.

By the time that the CTS subsystem is constructed for the RTD starter line, the technical risks associatd with a relatively new technology will have been minimized.

5.5.7 AVAILABILITY

5.5.7.1 Alternative #1

Hardware with which to construct a subsystem such as described in this alternative is readily available from numerous manufacturers and suppliers of equipment to the telephone industry. The equipment is generally very standardized because most telephone companies specify that hardware be compatible with and meet the Bell System Standards.

5.5.7.2 Alternative #2

Hardware to construct a CATV distribution system is readily available from a number of sources. All CATV sources have AM modulators available. Not every supplier can provide the FM modulators specified for Alternative #2.

5.5.7.3 Alternative #3

Hardware to construct a fiber optics subsystem is available from several manufacturers. Not only is the number of manufacturers of fiber optics hardware more limited than Alternative 1, not every item utilized in Alternative #3 as specified herein is available from every manufacturer. However, there are sufficient sources to assure that competitive procurement can be undertaken.

5.6 CONCLUSION AND RECOMMENDATION

The circuits in Alternative #1 are stretched to the maximum for direct operation from a PABX. On the longer runs, amplifiers will be required enroute, and any noise accumulated between Central Control and the terminal points will be amplified along with the voice signals. Because of the Electromagnetic Interference (EMI) associated with signal and communications circuits along an electrified railway, Alternative #1 is not recommended for further consideration.

Alternative #2 is a feasible approach to the Cable Transmission Subsystem design for the RTD starter system. There are some limiting considerations. The basic design which was considered in this study uses a 1/2 inch coaxial cable. Were the basic starter line to be lengthened, or if longer rail segments are later constructed, a larger copaxial cable would be required. Increasing the diameter of the coaxial cable with a RULON low smoke jacket from 1/2 inch to 7/8 inch would increase the cable cost per foot from 2.02 to about 5.00. While not all of this would be increased costs for the system - the lower attenuation would mean fewer trunk amplifiers - the costs for a CTS subsystem along a longer transit line would be more expensive on a per mile basis than the optimum system discussed in this report. it is not possible to continue adding CCTV trunk amplifiers without limit to meet the requirements of longer circuits. As the rail segments get longer, the costs per mile for CATV techniques are going to more nearly approach those for the third alternative.

Alternative #3 is a feasible approach to the Cable Transmission Subsystem. From a noise environment standpoint, the fibers themselves are immune to the types of EMI normally associated with cable systems along an electrified railway. However, the transmitters and receivers associated with the optical system are not designed to be specifically immune to the effects of induced or impulse noise. ITT recommends that these devices be installed in shielded enclosures when systems are operated in heavy EMI environments.

High speed operation on fiber cables generally requires that a laser diode be used as a light source. Laser diodes are somewhat more pure in spectral output than are the Light Emitting Diodes (LEDS), and the pulse stretching that occurs with broader spectrum light sources is minimized when lasers are used. Lasers, however, must be cooled, and lifetimes are quoted on the basis of accelerated tests at which the laser diodes have been operated at higher than recommended temperatures. On the basis of accelerated testes, lifetimes of 100,000 hours are projected.

5.6.1 Recommendation

Alternative #3 is recommended for implementation because it will provide the greatest flexibility for growth and change within the CTS subsystem. Were a rail system longer than the RTD starter line considered for Alternative #2, larger cable would be required, and Alternative #2 Annual Equaivalent Costs would more nearly equal those for Alternative #3.

Once the fiber cables have been installed along the starter line, they will represent a fixed facility which cannot readily be discarded. As such, it might be difficult to retrofit the starter line should a new and dramatic breakthrough in fiber technology occur within the lifetime of the system. However, on the basis of the known requirements, there should be no reason to consider replacement of the fibers during the system lifetime.

Future rail extensions will not be bound by existing fiber optics hardware and fiber technology. Improved transmitter/-receiver and fiber technology can be utilized on each new rail segment when the CTS for that segment is designed.

It is recommended that the fiber optics approach be pursued, but that the design incorporate available hardware and techniques which can promise to reduce the acquisition cost. The CTS system need not necessarily employ a dedicated fiber for every function at every terminal. Utilizing existing technology, the number of fibers in the cables can be reduced. This would materially reduce the cost for this alternative subsystem.

APPENDIX A

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UMTA	Closed Circuit Television in Transit Stations: Application Guidelines. August 1980.
Westinghouse	Westinghouse Lighting Handbook. 1981.

APPENDIX B

LIST OF SOURCES

Kaiser Engineers contacted various vendors, users, and associates in the process of the communications system alternatives analyses. This appendix details the organization or company and, where applicable, the person contacted.

VENDORS

Radio Service:

- General Electric Company, Mobile Radio Communications Division: Hank Williams, Glen Gelineau, Jack Miller, and William Nye
- Motorola Electronics and Communications Division: Larry Hamilton and Kristine White

Telephone Service:

- Frontier Electronics (CSC): Tim Moses
- General Dynamics (Stromberg-Carlson)
- General Telephone & Electronics: Frank Jett
- Pacific Telephone: William K. Hendley, Jr. and Jim Picker
- ROLM Telecommunications: Phil Mackey and D. Miller

Closed Circuit Television:

- COHU Closed Circuit TV: Julian J. Peck and G. Kuntz
- General Electric: William Nye
- Javelin Electronics: David Gibbs
- Pacific International Corporation: J. T. Booth
- Progress Research Organization (Panasonic): R. E. Johnson

Cable Transmission Service:

- Anaconda Telecommunications: R. Glisson
- Anixter-Pruzan: Roland Watkins and Guy Stuart
- Artel Communications Division: Richard Cerny
- ITT, Electro-Optical Products Division: Dale, G. McBride
- Leeds & Northrup: Peter Kraus
- Pirelli Communications Products Division: Michael Salisbury and J. W. Johnston
- RFL Industries: Pete Tarbell
- Wescom: H. L. Robinson

USERS

American Natural Resources, Detroit, Michigan: W. L. Johnson
Bay Area Rapid Transit District (BART): G. Austin, J. Schiro, and J. Allen
Chicago Transit Authority (CTA): J. Stewart
Grumman Aerospace Engineering and Manufacturing, Bethpage, Long Island: J. Mooney
Mass Transit Administration (MTA): D. Wellington
Metropolitan Atlanta Rapid Transit Authority (MARTA): J. Tucker and R. Miller
Metropolitan Dade County Transportation Rapid Transit System: J. Abbas, R. Maguire, and W. Brownson
Naval Ocean Systems Center, San Diego, California: R. A. Greenwell and D. N. Williams
Naval Submarine Base, Kings Bay, Georgia: E. J. Clarke
Navy Public Works Center, San Diego, California: Ed Murdock and Jack McClanahan
New York City Transit Authority (NYCTA): C. Kalkhof
San Francisco Municipal Transit Authority, San Francisco, California: T. E. Hopkins

ASSOCIATES

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Jan Van Buuren
Roy Yamada

APPENDIX C

CALCULATIONS

ECONOMIC ANALYSIS PARAMETERS

In the tables, all costs are based on 1982 dollars.

Annualized Capital Cost (ACC)

$$ACC = \text{Annualized Capital Cost} = CC \times \frac{i\ (1 + i)^N}{(1 + i)^N - 1} = CC \times 0.12328$$

CC = Capital Cost
i = Interest Rate (12%)
N = Economic Life (32 years)

Annual Operating Cost (AOC)

Communications equipment installed in stations and central control will operate for 365 days/year based on 24 hour operation for a total of 8760 hours a year. Vehicle radios will operate for 365 days/year based on 20 hours operation.

Labor (cost for operators)	= 18.00/hour
Off-hour surveillance labor cost	= 15.00/hour
Energy (cost of electricity)	= 0.07/kWH

Operating costs shown in this report are based on equipment data power consumption required to perform its intended function.

Annual Maintenance Cost (AMC)

Based on service contracts offered by the manufacturer of radio equipment, 10% of capital cost will be the annual maintenance cost, including labor and parts. Maintenance for other communication services will be by the Metro Rail Project personnel with the following rate:

Labor (cost for technicians) = $19.30/hour

Annual Equivalent Cost (AEC)

The annual total cost can be obtained from the following equation:

AEC = Annual Equivalent Cost = ACC + AOC+ AMC

APPENDIX D

RADIO SERVICE DATA

GENERAL ELECTRIC

April 5, 1982

Kaiser Engineers
300 Lakeside Drive
P.O. Box 23210
Oakland, CA 94623

Attention: AP (Jun) Adela Jr.

Dear Jun:

As per you request please find the attached budgetary pricing for the equipment in your consideration for use by SCRTD PROJECT. If you should have any further questions regarding this equipment please do not hesitate to call me.

Sincerely,

Glenn W. Gelineau
Major Account Sales Agent
560 San Antonio Road, #201
Palo Alto California 94306

GWG:rac

Encl

GENERAL ELECTRIC

Kaiser Engineers
April 5, 1982

Item	Qty	Description	Unit Price
1	1	CP2BKK66KEN 6 watt VHF MPR Portable Radio, equipped with GE STAR toggle switch encoder. 6 Frequency capability equipped to operate on 1 frequency with Channel Guard.	$ 2,595.00
2	1	354C3AIK MPR VHF Vehicular Charger, includes MNTG accessories, speaker and microphone.	$ 350.00
2A	1	P3AK6AG Power Master. 60 watt UHF power amplifier for use with MPR Vehicular Charger.	$ 510.00

GENERAL ELECTRIC

Kaiser Engineers
April 5, 1982

Item	Qty	Description	Unit Total
1	1	MC66KAU66A Mastr II Mobile Radio 65 watts VHF, 8 frequency capability. Equipped for single frequecy operation, Channel Guard, and GE-Star encoder, includes speaker, microphone 1/4 wave antenna, and MNTG hardware.	$ 2,285.00

KAISER ENGINEERS

JOB No. 8142-403
SHEET 1 OF 3

MEETING WITH GENERAL ELECTRIC
— RADIO —

DESIGNED BY [initials] DATE 5/24
CHECKED BY DATE

ATTENDEES:

RTD	G.E.	K.E.
MIKE BERTOK	HANK WILLIAMS	JUN ADELA
JIM TRANI	GLENN GELINEAU	V. KIERNAN

TRANI: — DISCUSSED THE PROJECT, METHODS OF HOW EQUIPMENT WILL BE PURCHASED AND INFORMATION FLOW BETWEEN VENDORS TO RTD, COPY ONLY TO K.E. PURPOSE OF THE MEETING IS TO PRESENT ALTERNATIVE ANALYSIS TO BE PERFORMED BY K.E.

WILLIAMS — DISCUSSED AND PRESENTED THE ROUTING SYSTEM BEING USED BY RTD ON THE BUS SYSTEM. THE UNITS INSTALLED ON THE BUS ARE EQUIPPED WITH A KEYED RADIO TRANSCEIVER SECTION, ALTHOUGH THE KEYS ARE NOT PROVIDED TO THE DRIVERS.

OPEN DISCUSSION:

G.E. WAS ASKED BY J. ADELA TO PROVIDE MTTR AND MTBF FOR THE RADIOS, EITHER THE PORTABLE OR TRAIN MOUNTED UNITS. WILLIAMS INDICATED THAT THESE INFO ARE NOT AVAILABLE FOR THE DESIGNED PROJECT STANDARDS, THESE INFO ARE BASED ON EXISTING UNITS INSTALLED; HE INDICATED THAT HE WILL SEND THEM TO RTD.

GE WAS ALSO REQUESTED TO PROVIDE COST COMPARISON FOR MAINTENANCE OF THE EQUIPMENT. WILLIAMS AND GELINEAU INDICATED THAT IT WOULD BE CHEAPER ON RTD's PART (METRO RAIL) TO HIRE OR GET INTO A SERVICE CONTRACT RATHER THAN MAINTAINING THE RADIOS BECAUSE:

1. METRO RAIL HAS TO STOCK SPARE PARTS, AND TEST EQUIPMENT.
2. METRO RAIL PERSONNEL HAS TO BE TRAINED AND LICENSED TO PERFORM TRANSCEIVER /FREQUENCY ADJUSTMENT
3. SPARE PARTS ARE READILY AVAILABLE AT SERVICE CONTRACTORS AND TIME SPENT AT SERVICING THEM ARE FASTER.
4. ALTHOUGH RTD HAVE PERSONNEL QUALIFIED TO SERVICE THESE UNITS, THE PRIORITY SEQUENCES APPLIES TO ANY DEPARTMENTS RTD HAVE WHICH WILL INCLUDE METRO RAIL EQUIPMENT.

6. GELINEAU INDICATED THAT SERVICE CONTRACTS WITH TRAINED AND PRESENTLY CONNECTED WITH G.E., NORMALLY ASK FOR 10% OF THE TOTAL EQUIPMENT COST, WHICH WILL INCLUDE SERVICE PERSONNEL AND PARTS.

KAISER ENGINEERS

JOB NO. 81152

SHEET 3 OF 3

DESIGNED BY ______ DATE ______

CHECKED BY ______ DATE ______

WHETHER THE SERVICING IS CONTRACTED OR NOT, GE INDICATED THAT THEY NORMALLY RECOMMEND 10% OF EACH REPLACEABLE PARTS TO BE INCLUDED AS SPARE PARTS ON INITIAL PURCHASE OF EQUIPMENT.

C. GELINEAU (G.E.) SUPPLIED THE EQUIPMENT FOR BART - SAID - BART PERSONNEL INDICATED THAT ONLY 2-5% FAILURE HAS BEEN EXPERIENCED ON THE PORTABLE RADIOS - 1 OUT OF 10 FAILS ON THE FIXED UNITS INSTALLED ON THE TRAIN CABS.

COST QUOTED BY G.E. (GELINEAU) ON APRIL 5, 1982 STILL STANDS AND CAN BE USED FOR BUDGETARY PURPOSES. ACTUAL PRICES CAN ONLY BE PROPOSED WITH COMPLETE SPECIFICATIONS.

CALCULATIONS KE Form No. E-6 Rev. 10-71

KIRK RUMMEL

E REP JIM TWITTY
619-565-8220

Telecon with Pete Tereshuk 12/22/82
SAN Diego Trolley 619-239-6054

Ref: Carbourne Communications

Their system has portable hand-held units. 35 units used:

10 transportation — { 5 operators on trains, 2 standby oper, 1 yard, 2 supervisors }
10 Maintenance
10 misc — fare checkers, etc

car does not have charging provisions (big problem — battery goes dead)

check-out is minor effort — S/N logged by clerk

Pete estimated on a big system (LA - 140 cars, 17 operators @ a time)

the administrative effort would be 1/4 of a person's time at all times 3 shift × 1/4 = 3/4 of a person's time = 30 hours per week

30/17 = 1.8 manhours/radio = say 2 hr/radio

Raymond Kaiser Engineers

JOB No. ______ SHEET 1 OF 1

VEHICLE RADIO CACULATION
CAPITAL COSTS.

DESIGNED BY C FISHER DATE 1-6-8
CHECKED BY DATE

OPTION A 71 MARRIED PAIRS.

XMIT/REC	71 × 2515 = 178 565 (PER 4-8-82 TELECON)	=	178,565
PORT	25 × 2595 = 64 875	=	64,875
BATT. CHG.	3 × 360 = 1 080	=	1,080
	244,520		244,520
~~INSTALLATION (10% OF FIXED EQP)~~			~~17964~~
			~~262,48~~

OPTION B 142 CAR ENDS

CAR EQP.	142 × [445 = (350 + 95)] = 63,190 (PER 4-8-82 TELECON)	63,19
XMIT/REC	25 × 2136 (PER 4-8-82 TELECON)	53,40
PORT.	25 × 2595 = 64,875	64,87
BATT CHG.	3 × 360 = 1,080	1,08
		182545
~~INSTALLATION (10% OF FIXED EQP.)~~		~~11,767~~
		~~194,312~~

OPTION C 142 CAR ENDS

~~CAR EQP 142 × [445 = (350 + 95)] =~~

CAR EQP	142 × [955 = (350+95+510)] = 135,610		135,610
PORT	25 × 2595	= 64,875	64,875
BAT. CHG.	1 × 360	= 360	360
			200,845
~~INSTALLATION (10% OF FIXED EQP.)~~			~~13599~~
			~~214,44~~

Raymond
Kaiser Engineers

JOB No. ______
SHEET 1 OF 1

REPLACEMENT COST OF PORT. RADIOS FOR TRAIN OPERATION

DESIGNED BY C. FISHER DATE 1-6-
CHECKED BY DATE

NOMINAL LIFE OF PORTABLE RADIOS IS ASSUMED TO BE 12 YEARS.

THUS ON THE AVERAGE WITH 25 RADIOS THERE WILL BE $25/12$ = 2.08 RADIOS REPLACED PER YEAR. AT $ 2595/ RADIO THIS IS AN ANNUAL REPLACEMENT COST OF 5406 / YR.

CALCULATIONS KE Form No. E-6 Rev. 10-71

NOTES RE: TEL CONV. W/ G GELINEAU 4/8/82
CHANGES ON PRICES

1. CHANGE FROM $2285.00 COST OF MC 66 KAU66A TO $2515.00 TO INCLUDE: 6-CHANNELS INSTEAD OF SINGLE FREQ.
CONTROL HEAD FOR CAB MOUNTING AND ACC

2. ADD COST FOR PORTABLE BATTERY CHARGER ~ $360.00/UNIT - RAPID 3-HOUR CHARGER

3. POWER AMPLIFIER PDAK6AG COST CHANGE FROM $510.00 TO $605.00 WHICH INCLUDES THE FOLLOWING ACCESSORIES:

a) ANTENNA FOR TRAIN ROOF MOUNTING 1/4 WAVE TYPE

b) COAX CABLE & MOUNTING ACC.

4. THE COST FOR A REMOVABLE TRANSCEIVER SECTION COSTS 20% MORE WHEN BOUGHT SEPARATELY. KEYED TRANSCEIVER SECTION COST $2136.00/UNIT WITH KEYS WHILE THE FIXED PORTION (RADIO COMPARTMENT) INCLUDING THE CONTROL HEADS, MIC., SPEAKER AND ACCESS. COSTS $890.00/MARRIED PAIR (CARS 1-11-83) FOR A TOTAL OF $3026.00 BUT WHEN BOUGHT AS A UNIT IT WILL COST $2515.00

APPENDIX E

TELEPHONE SERVICE DATA

CAPITAL COSTS

Unit costs were obtained from the sources indicated below:

Push-button telephone instrument: The Pacific Telephone and Telegraph Company inventory price list mailed to customers of record in Southern California, November 1982.

Wall-mounted instrument without dial and test set jack: GTE Automatic Electric Company, Milbrae, California estimating prices provided by sales representative.

Electronic PBX: This item of cost presented the most difficulty in obtaining. Most PBX apparatus is sold by communication consultants or contractors who freely quote approximate turnkey estimates of $1,000 per line. Two suppliers, however, were willing to quote approximate costs of PBX equipment only. The figures used in this report were obtained from a representative of Northern Telecom in Pomona, California. The prices quoted were as follows:

Size of PBX	Cost Range
400 lines	$150 to $200,000
1400 lines	550 to 600,000
1400 lines	650 to 700,000

Substantiation was obtained from a sales representative of GTE Business Communications Systems in Reseda, California who quoted an equipment only price for a 400 line PBX at $500 per line.

Labor to install: GTE Business Communications Systems in Reseda, California, sales representative stated that $80 per line was appropriate. Universal Communications Systems, Culver City, California, sales engineer indicated cost to install each line was $100.

MAINTENANCE COSTS

Maintenance expense data were derived from information in the annual reports of telephone companies on file with the State of California Public Utilities Commission. Reported data was obtained from two smaller telephone companies which serve Southern California. The two companies are CP National Corporation and Continential Telephone Company of California. The date of the annual reports are December 31, 1981. Data from plant accounts for central office equipment and station apparatus provided the base for which corresponding expense accounts, repairs to central office equipment, and repairs to station apparatus were compared. The ratios developed are as follow:

	Central Office Equipment Ratio	Station Apparatus Ratio
CP National Corporation	10.3%	17.7%
Continential Telephone Co	9.9%	18.7%

APPENDIX F

CCTV BACKUP DATA

MULTIPLE CAMERA SEQUENCING

(ALTERNATIVE 1)

OPERATING COST (LABOR)

CCTV Monitoring Personnel (Central Control)

Base Period

6 am-10 pm, 6 days/week, 16 hours/day
3 monitors/hr x 16 hours/day x 312 days/year ÷ 1,920 work hours/year = 7.8
say 8 television monitor employees.

Peak Period

6-10 am & 2-6 pm, 5 days/week, 8 hours/day
2 monitors/hr x 8 hours/day x 260 days/year ÷ 1,920 work hours/year = 2.1
say 3 television monitor employees.

Off-Hours Period

10 pm-6 am, 7 days/week, 8 hours/day
1 monitor/hr x 8 hours/day x 365 days/year ÷ 1,920 work hours/year = 1.5
say 2 television monitor employees.

Sunday Base Period

6 am-10 pm, 1 day/week, 16 hours/day
2 monitors/hr x 16 hours/day x 52 days/year ÷ 1,920 work hours/year = .8
say 1 television monitor employee.

TOTAL MONITORING PERSONNEL	14

Annual CCTV Operating Personnel Cost

14 employees x 2,080 paid work hours/year x $18/hr

TOTAL OPERATING COST	$524,160

MAINTENANCE COSTS

Spare Parts

22 TV cameras @ $1,260/camera	$ 27,720
8 Sequencers @ $1,120/sequencer	8,960
6 12-inch TV monitors @ $360/monitor	2,160
TOTAL SPARE PARTS	$ 38,840

Labor

CCTV Maintenance Personnel

2 CCTV technicians/hr x 24 hrs/day x 312 days/year ÷ 1,920 productive work hrs/year = 7.8 say 8 technicians

1 CCTV technician/hr x 24 hrs/day x 52 days/year ÷ 1,920 productive work hrs/year = .65 say 1 technician

TOTAL MAINTENANCE PERSONNEL	9

Annual CCTV MAINTENANCE Personnel Cost

9 CCTV Technicians x 2,080 paid work hrs/year x $19.30/hr

TOTAL MAINTENANCE PERSONNEL	$361,296
TOTAL MAINTENANCE COST	$400,136

SPLIT-SCREEN PROJECTION

(Alternative 2)

OPERATING COST (LABOR, INCLUDES FRINGE BENEFITS)

CCTV Monitoring Personnel (Central Control)

Base Period

6 am-10 pm, 6 days/week, 16 hours/day
6 monitors/hr x 16 hours/day x 312 days/year ÷ 1,920 work hrs/year = 15.6 say 16 TV monitor employees.

Peak Period

6-10 am & 2-6 pm, 5 days/week, 8 hours/day
2 monitors/hr x 8 hours/day x 260 days/year ÷ 1,920 productive work hours/year = 2.1 say 3 TV monitor employees.

Off-Hours Period

10 pm-6 am, 7 days/week, 8 hours/day
1 monitor/hr x 8 hours/day x 365 days/year ÷ 1,920 productive work hours/year = 1.5 say 2 TV monitor employees.

Sunday Base Period

6 am-10 pm, 1 day/week, 16 hours
3 monitors/hr x 16 hours/day x 52 days/year ÷ 1,920 work hours/year = 1.3 say 2 TV monitor employees.

TOTAL MONITORING PERSONNEL 23

Annual CCTV Operating Personnel Cost

23 employees x 2,080 paid work hours/year x $18/hr

TOTAL OPERATING COST $861,120

MAINTENANCE COSTS

Spare Parts

22 TV cameras @ $1,260/camera	$ 27,720
11 2-image camera splitters @ $360/splitter	3,960
11 12-inch TV monitors @ $360/monitor	3,960
2 12-inch TV monitors @ $360/monitor	720
TOTAL SPARE PARTS COST	$ 36,360

Labor

CCTV Maintenance Personnel

3 CCTV technicians/hr x 24 hrs/day x 312 days/year ÷ 1,920 productive work hrs/year = 11.7 say 12 technicians

2 CCTV technician/hr x 24 hrs/day x 52 days/year ÷ 1,920 productive work hrs/year = 1.3 say 2 technicians

TOTAL MAINTENANCE PERSONNEL	14

Annual CCTV MAINTENANCE Personnel Cost

14 CCTV Technicians x 2,080 paid work hrs/year x $19.30/hr

TOTAL MAINTENANCE PERSONNEL	$562,016
TOTAL MAINTENANCE COST	$598,376

COMBINATION SPLIT-SCREEN SEQUENCING
(ALTERNATIVE 3)

OPERATING COST (LABOR, INCLUDES FRINGE BENEFITS)

CCTV Monitoring Personnel (Central Control)

Base Period

6 am-10 pm, 6 days/week, 16 hours/day
3 monitors/hr x 16 hours/day x 312 days/year ÷ 1,920 work hours/year = 7.8
say 8 TV monitor employees.

Peak Period

6-10 am & 2-6 pm, 5 days/week, 8 hours/day
1 monitor/hr x 8 hours/day x 260 days/year ÷ 1,920 work hours/year = 1.08
say 2 TV monitor employees.

Off-Hours Period

10 pm-6 am, 7 days/week, 8 hours/day
1 monitor/hr x 8 hours/day x 365 days/year ÷ 1,920 work hours/year = 1.5
say 2 television monitor employees.

Sunday Base Period

6 am-10 pm, 1 day/week, 16 hours/day
2 monitors/hr x 16 hours/day x 52 days/year ÷ 1,920 work hours/year = .8
say 1 TV monitor employee.

TOTAL MONITORING PERSONNEL	13

Annual CCTV Operating Personnel Cost

13 employees x 2,080 paid work hours/year x $18/hr

TOTAL OPERATING COST	$486,720

MAINTENANCE COSTS

Spare Parts

22 12-inch TV cameras @ $1,260/camera	$ 27,720
8 3-image camera splitters @ $360/splitter	2,880
8 3-image camera sequencers @ $280/sequencer	840
4 12-inch TV monitors @ $360/monitor	1,440
2 12-inch TV monitors @ $360/monitor	720
TOTAL SPARE PARTS COST	$ 33,600

Labor

CCTV Maintenance Personnel

2 CCTV technicians/hr x 24 hrs/day x 312 days/year ÷ 1,920 productive work hrs/year = 7.8 say 8 technicians

1 CCTV technician/hr x 24 hrs/day x 52 days/year ÷ 1,920 productive work hrs/year = .65 say 1 technician

TOTAL MAINTENANCE PERSONNEL	9

Annual CCTV MAINTENANCE Personnel Cost

9 CCTV Technicians x 2,080 paid work hrs/year x $19.30/hr

TOTAL MAINTENANCE PERSONNEL	$361,296
TOTAL MAINTENANCE COST	$394,986

(1

MAY 16, 198
10:35 A

TELEPHONE CONVERSATION NOTES: -

WITH MR. JOHN T. BOOTH OF
PACIFIC INTERNATIONAL CORPORATION
REPRESENTING: JAVELIN ELECTRONICS AND
PANASONIC CCTV PRODUC

DISCUSSED THE SCRTD METRO RAIL PROJECT AND REASON FOR CCT REQUIREMENTS AND ALTERNATIVE ANALYSIS K.E. IS PREPARING.

BOOTH: SEQUENCERS ARE COMMERCIALLY AVAILABLE AND BEING USED BY NEARLY ALL SECURED ENVIRONMENT.

SPLITTERS ARE COMMONLY USED AT CASH REGISTERS AND STUDIO OR COMMERCIAL T BUT NOT YET READILY AVAILABLE TO CONSUMERS.

CAMERAS FOR ALL TYPES OF ENVIRONMENT ARE AVAILABLE FROM VIRTUALLY NO LIGHT TO DIRECT SUNLIGHT WITH AUTOMATIC COMPENSATION TYPE LENSES.

ADELA: REQUESTED INFORMATION ON COST/UNI
F-8 AND EXPERIENCES ON FAILURES/.

RATES OF REPAIR AND NATURE OF MAINTENANCE REQUIREMENTS.

			/UNIT
COST:	1.	CAMERA WITH AUTO-LIGHT LENS AND SCANNER	— 1260-
	2.	6-CAMERA SEQUENCER	— 280-
	3.	12" TV MONITOR WITH AUTOMATIC CONTROLS	— 360
	4.	2 CAMERA SPLITTER	— 360.00

(A) FAILURES: 1/YR: ARE:

1. LENSES — REPLACEMENT ~~FIRST TO FAIL~~ —
   - WIDE ANGLE LENS f 1.8 — 245.00
   - MOTORIZED IRIS LENS ~~[illegible]~~ 12.5mm — 299.00
   - 12.5mm f 1.4 WIDE ANGLE — 179.50
2. CAMERA TUBES
   - 1" VIDICON HIGH SENSITIVITY — 65.00
   - 1" SEPARATE MESH VIDICON w/ HIGH RESOLUTION — 150.00
3. PAN AND TILTS AND AUTO SCAN
   - AUTO SCANNER UNIT —— 265.00
   - 0 - 360 DEGREES

(B) 1/5 YEARS

1. CONTROLS, SEQUENCERS OR SPLITTERS
2. MONITORS

MAINTENANCE: 10% - OF REPLACEABLE COMPONENTS
BASED ON TOTAL EQUIPMENT COST

POWER CONSUMPTIONS:

1. 12" TV MONITORS — 30 W
2. CONTINUOUS SCANNERS — 34 W
3. SPLITTERS — 3 W
4. CAMERAS — 11 W

RECORDED: BY JUAN ADELA

MAY 27, 1982

TELEPHONE CONVERSATION W/ BILL NYE OF G.E.
G.E. - CCTV CAMERAS AND ACC.

DISCUSSED THE ANALYSIS WE IS PREPARING AND ENVIRONMENT THE TV'S WILL BE INSTALLED, SOME CAMERAS WILL BE INSTALLED ON BOTH LOW LIGHTED AREAS AND WELL LIGHTED.

CAMERAS G.E. PROPOSES AN INTENSIFIED SILICON VIDICON TUBE CAMERA WITH CAPABILITY TO SEE OBJECTS IN LESS THAN 1 FT. CANDLE OF ILLUMINATION.

G.E. DOES NOT HAVE SPLITTER AVAILABLE IN MARKET, BUT QUOTED THE FOLLOWING ITEMS

SEQUENCER (UP TO 8 CAMERAS)	- 840.—
VIDEO TAPE RECORDER W/ 60 MIN TAPE CASE AND TIME/DATE GENERATOR	— 3700—
MOTION DETECTOR	— 735—
10" VIDEO MONITOR	- 315—

17" VIDEO MONITOR — 525 —
VIDEO SWITCH — 152 —

G.E. WILL SERVICE THEIR OWN EQUIPMENT WITH SERVICE CONTRACTOR USUALLY 10% OF EQUIPMENT COST.

FAILURES ARE MINIMAL EXCEPT FOR CAMERA TUBES, LENSES AND SCANNING UNITS.

for file
JIM [illegible]

KUMPEL

marta

ASSESSMENT

OF

FUNCTIONAL, OPERATIONAL

AND RELATED SUPPORT REQUIREMENTS

FOR THE

MARTA RAIL TRANSIT SYSTEM

CCTV ZONE SURVEILLANCE CENTERS

Parsons, Brinckerhoff, Quade and Douglas, Inc./
Tudor Engineering Company General Engineering
Consultants to the Metropolitan Atlanta Rapid Transit Authority

4.4 Monitor Display Technique

Since the indicated camera quantities reflect presently anticipated requirements, the monitor display board must be large enough to accommodate the monitors required for initial use as well as the future potential growth. There are four basic methods that may be employed individually or possibly as a combination of two or more, namely:

1. Individually dedicated large screen monitors, one for each camera,
2. Individually dedicated small screen monitors, one for each camera,
3. Split-screen projection on a large screen monitor, viewing two, three or four cameras, or,
4. Sequencing of several cameras (2 to 5 max.) on each large or small monitor.

4.4.1 Dedicated Monitors

Three of the four transit authorities currently employing the CCTV surveillance technique, reference 3, favor employing one monitor dedicated to each camera. One of these authorities use 8 inch and 19 inch monitors (at different zone centers) while the other two employ 9 and 10 inch monitors respectively.

Each authority felt that the size of monitor they employed adequately revealed the degree of surveillance desired. Although the larger screen (19 inch) projected a larger picture than did that of the small screens, each had equal resolution (624 lines). In general, the small screens displayed a sharper picture, however, this was partially due to the use of more advanced equipment. Based on the CCTV camera and monitor display and ensuing discussion with an equipment supplier, arranged by Bechtel, the lack of clear display by 19" screens was attributed to the fact that they provided only 624 lines of resolution reflecting old equipment. The recommendation was made to employ 21 inch monitors having 1200 + lines of resolution (the current suitable monitor for the application under consideration).

4.4.2 Split-Screen Projection

Split-screen projection, employing large screen monitors is another technique for effectively accomplishing multiple camera viewing within a limited space. Although this approach may at first be considered undesirable since the requirement for additional equipment means added cost, the savings that will be realized in requiring less monitors may more than compensate. This technique will enable the projection of 1, 2, 3 or 4 pictures on one monitor. By employing the recommended 21 inch monitor, the diagonal viewing display achievable would be 10.5 inch picture when 4 pictures are projected. In areas where a camera is required to view a wide area and a corresponding wide monitoring area is desired, a two picture split-screen projection (horizontal or vertical) may be employed resulting in a viewing display of 7.4 inches x 14.85 inches. Single picture projection may be employed when desiring better definition and/or video taping.

4.4.3 Sequencing Multiple Cameras

Sequencing is yet another method that may be employed to minimize the quantity of monitors in the zone center. Although other authorities have considered the application, Illinois Central Gulf was found to be the only authority currently employing sequencing of camera coverage, and found it to be acceptable. The sequencing rate is adjustable from two seconds to three minutes of viewing time. The one major drawback to this approach is that during the period after a camera transmission has been terminated and until it is once more transmitting on screen, dependent upon the sequencing rate and number of cameras dedicated to a given monitor, the activity within the purview of the camera will go unnoticed. When more than two cameras are sequenced, this situation then involves all but one camera dedicated to a particular monitor. As related in the trip report, reference 3, such an occurrence was detected during one evening of observance.

This technique should not be considered for the MARTA system. With the Avondale Zone Center initially responsible for observing 33 cameras, the sequencing of two cameras per monitor would reduce the quantity of monitors to 17. Sequencing four cameras per monitor would result in a need of nine monitors. If a three second sequencing rate were employed, the first consideration would result in an unobserved period of three seconds with the second consideration resulting in a nine second unobserved period.

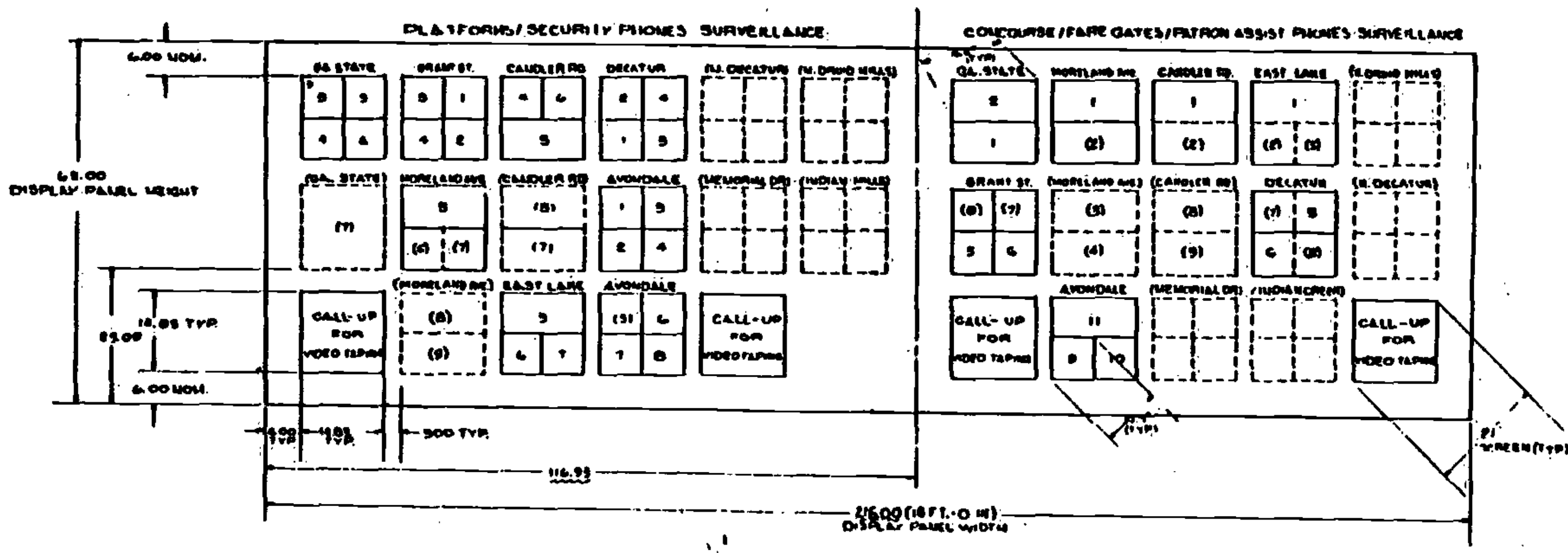
Increasing the sequencing time period would result in a correspondingly longer unobserved period of time, which would permit undesirable activity to ensue.

4.5 Monitor Arrangement Rationale

There are several possible monitor arrangements that may be employed for effective surveillance. An assessment, also considering maximization of effectiveness and minimization of quantity on the part of observers, indicates that the arrangement should be based on the overall surveillance requirements and intensity of activity that may occur. By arranging the monitors in two major groups, namely platform and concourse, the optimal balance can be achieved relative to operational activity. The group containing platform viewing camera monitors will be greater in number since more cameras are so located. Since communications will also be a major activity of the zone centers, and the patron assistance calls are anticipated to comprise the greatest activity of communications, the combination of a lesser quantity of monitors to view in the concourse group plus the involvement with patron assistance should approximately balance the effort of observing the greater number of platform dedicated monitors and the associated communications involving public address and security telephones.

The proposed monitor application and arrangements for the Avondale and West Lake zone centers, as considered necessary to satisfy the four zone center concept, are shown on drawings CMX110 and CMX210. Since the West Lake zone center will have interim jurisdiction for four stations and later have other stations added, a rearrangement of the monitors will be required as shown on drawing CMX220. By arranging the monitors and cameras as shown on the drawings, the observers can achieve and maintain orientation of the assigned sector.

Two major factors were considered in establishing the rationale for arranging the monitors for stations and their respective cameras. In most cases, the station monitors were arranged such that at the Avondale center, the extreme upper left monitor would be assigned to the extreme west station (Georgia State) and extend to the right, reflecting adjacent stations to the east. However, when a station requires two or more monitors, the desired arrangement must be compromised. The West Lake center arrangement is reversed such that the upper right monitor is assigned to the eastern most station (Five Points), then progressing to the left for stations progressively west. This format is duplicated, to the extent possible, for both concourse and platform sections of the display board. The second factor involved is specific camera/split-screen assignment. The monitors will display an arrangement based on the type of camera(s) dedicated. Cameras having

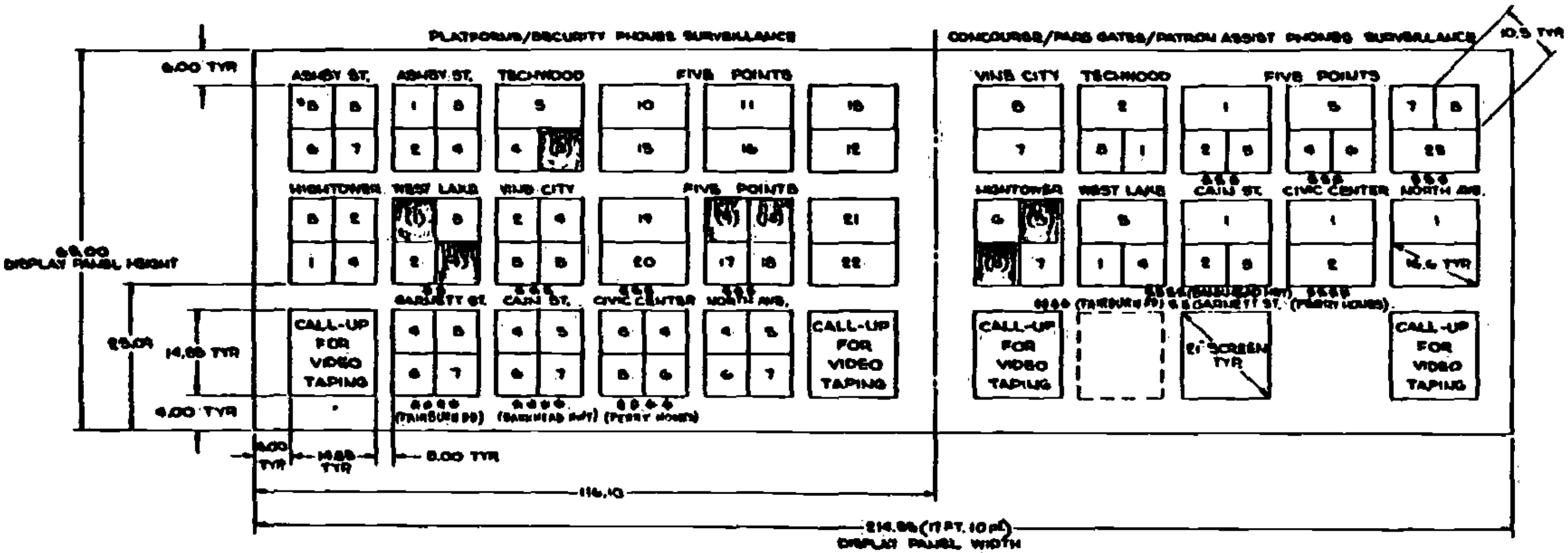


NOTE: (NAME) OR (NUMBER) DENOTES FUTURE REQUIREMENT # DENOTES CAMERA I.D.

METROPOLITAN ATLANTA RAPID TRANSIT AUTHORITY

MONITOR ARRANGEMENT
AVONDALE ZONE CENTER

1/10



NOTE: (NAME) OR (NUMBER) DENOTES FUTURE REQUIREMENTS
- 5 DENOTE CAMERA I.D.
- 55 INTERIM LOCATION-ULTIMATE LOCATION AT LAKEWOOD
- 555 INTERIM LOCATION-ULTIMATE LOCATION AT LINDBERGH/PIEDMONT
- 5555 FUTURE LOCATION

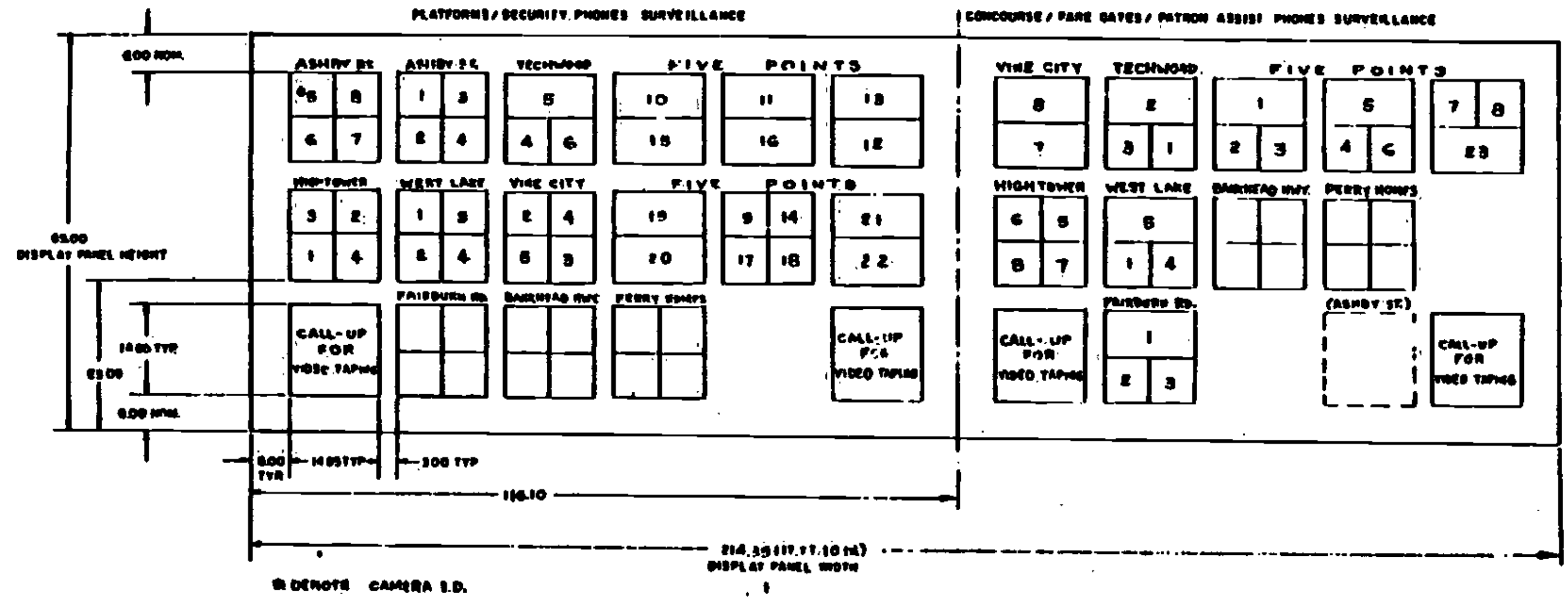
F-20

METROPOLITAN ATLANTA RAPID TRANSIT AUTHORITY

MONITOR ARRANGEMENT
WESTLAKE ZONE CENTER
(FOUR ZONE - PHASE 'A' CONCEPT)

1/10

F-21



METROPOLITAN ATLANTA RAPID TRANSIT AUTHORITY

MONITOR ARRANGEMENT

WESTLAKE ZONE CENTER

UMTA-MA-06-0048-80-5

CLOSED CIRCUIT TELEVISION IN TRANSIT STATIONS: APPLICATION GUIDELINES

AUGUST 1980

AUTOMATED GUIDEWAY TRANSIT TECHNOLOGY PROGRAM

U.S. DEPARTMENT OF TRANSPORTATION
Urban Mass Transportation Administration
Office of Technology Development and Deployment
Washington DC 20590

DOCUMENT IS AVAILABLE TO THE PUBLIC THROUGH THE NATIONAL TECHNICAL INFORMATION SERVICE, SPRINGFIELD, VIRGINIA 22161

US GOVERNMENT PRINTING OFFICE: 1980—601-397/181

Chapter 6, but are referenced here so that the designer can plan for them in the layout of operator workplaces. It is important to have an appropriate location for storing those documents, and flat surfaces for using them. In addition, space should be made available for storing expendable items like writing supplies, new and used cassettes, labels, bulbs, and other articles that are necessary for day-to-day operations.

3.3 PERSONNEL AND WORK SCHEDULES

The questions to be addressed when planning for personnel in the monitoring center include: (1) how many monitor screens can an operator view effectively; (2) what hourly, weekly and monthly shifts are best; (3) how many operators, supervisors and other personnel are needed on each shift; and (4) which other jobs can operators be expected to perform? To answer these questions, current practice and the research literature have been reviewed. As a result, it is possible to provide some general guidelines, but each transit security system must also accommodate its own sets of resource constraints and variations among its own personnel when considering those generalities. For instance, it may be ideal to use trained young police officers, working in 6-hour shifts of 1/2 hour on - 1 hour off, viewing no more than 8 video monitors, with no duties other than interacting with the passengers under surveillance and the responding units, but this ideal option could require ingenious planning or be prohibitively expensive to implement. One then needs to know what kinds of compromises with the ideal are reasonable. It is the intent of this section to provide a sense of operating ranges around the ideal design parameters.

3.3.1 Number of Monitors Viewed per Operator

The practical upper goal that is most frequently established by CCTV transit security personnel contacted during the preparation of this document is 16 video monitors per operator. However, the actual number at which performance (detection and interpretation capability) becomes unacceptable depends upon many factors, including: (1) how crowded the scene is and how much activity is taking place; (2) whether or not multiple cameras are sequentially scanned on individual video monitors; (3) how far into the work shift the operator is; (4) what other duties the operator must perform; and (5) operator experience. (10)

Of over a dozen existing CCTV security systems examined, the number of monitors in the control center ranged from 2 to 55, and the number of operators ranged from 1 to 3. In some of these systems, the number of operators varied during the day as a function of predictable peak activity levels. As a representative example, the second largest system examined has 38 monitor screens (no sequencing) and employs 2 civilian operators most of the time, going up to 3 operators during rush hours in the morning (7:00-8:45 AM) and afternoon (4:00-6:30 PM), and dropping to 1 operator after 10:00 PM. This particular system is "shut down" from 12:30-5:30 AM, but a police duty officer is present and can observe the screens during that period. The operator's responsibilities, other than the video monitors, include patron assistance telephones, police telephone and radio, remotely controlled access to rest rooms, intrusion alarms, elevator telephones and the public address system. Sequential switching of 2 to 3 cameras per monitor screen was tried and rejected when it was found to degrade operator attention. To help reduce fatigue, operators receive a 10-minute break about every 1 to 1-1/2 hours.

Relatively few researchers have conducted relevant scientific studies on the number of video monitors one operator can view effectively. Target numerosity studies on air traffic control type displays have demonstrated the degradation of detection and recognition as the number of significant targets, or even the number of irrelevant forms, increases. More applicable studies involving outdoor television scenes of people and vehicles showed that police officers were better than civilians at detecting critical incidents; near incidents were detected more reliably than distant incidents; and learning what to look for masked fatigue effects (even after 4 hours). (5, 24, 26, 28)

The most relevant research studies involved the problems of monitoring numerous video displays for one or two hours. In one study, 16 and 24 television displays showing little movement were observed. In the other, 16 displays showing a great deal of movement were observed. Both required the detection of incidents in prison environments, by civilians and police officers. The video display monitors were 40 x 30 mm (about 19 inches diagonal) in size, and typically arranged in a 4 x 4 or wider 4 x 6 array at a distance of 13 feet from the observer. In some parts of the tests only 1, 4, 8 or 9 of the video monitors were used, but the array was maintained. It was found that, for scenes involving a great deal of movement, a 100% likelihood of detecting incidents requires viewing only one monitor display. If it is necessary to watch more than 1 screen with a great deal of movement, then no more than 9 should be viewed by one person. The likelihood of detecting incidents on 9 monitors was 83%, and on 4 monitors it was 84%—no significant improvement by going from 9 to 4 monitor screens. However, for 16 monitors that figure dropped to 64%. If very little movement is present in the viewed scenes, then 16 monitors is the recommended maximum number by the authors, When 24 monitors with very little movement were viewed. the likelihood of detection dropped from 97% (for the 16) to 88% (for the 24). It is recommended that these same guidelines of a maximum of 9 or 16 monitor screens per operator be followed by transit systems as well, for the high and low movement conditions, respectively. (25, 27)

3.3.2 Viewing Time and Shifts

Where security of busy transit stations is the primary mission, eyes should be kept on the screens virtually full time; non-viewing activities increase the probability of missing the detection of a brief critical incident and lengthen reaction time generally. In one large department store examined, detective-operators only attend the monitor screens for just one hour at a time, rotating duties with other roving store detectives throughout the full workday. The tendency among existing CCTV transit security organizations is to maintain the conventional, non-rotating work shift of about eight hours' duration. However, these organizations recognize the need for breaks from the routine of watching monitor screens. Such breaks are provided in more or less formal ways, by either scheduling an actual relief (e.g., for about 2 to 10 minutes per 1/2 to 1 hour) or by designing the operator's job to include non-viewing activities such as found in the role of communicator or police desk officer. For many systems, the shift assignments are determined and specified through terms negotiated with a transit workers' union. In the 38-monitor system referred to in the previous section, for instance, the agreement permits from one to three operators to be present during the operating period of 19 hours per day. A 30-minute lunch break is required and approximately 5-10 minutes per hour or so are provided for a rest break. (22)

The research on optimum viewing time indicates that vigilance can be maintained for about one hour, and then begins to degrade noticeably. This one-hour criterion is borne out by objective measures of missed incidents and by subjective preferences reported by viewers. For example, the previously cited research study involving eight monitor screens and a great deal of movement showed a 71% likelihood of detecting incidents during the first hour, dropping to 62% in the second hour. The authors concluded that the maximum desirable length of watch is about one hour. Two hours is certainly too long. Half an hour gives us advantage over one hour. In the research study involving 16 monitor screens showing little movement, no objective time comparisons were made, but interviews with the viewers revealed that 50 out of 65 considered that 1 hour was not too long a viewing period; 7 considered 1 hour to be about the maximum, while 8 felt it to be too long. Opinions about the length of a regular viewing period included durations from 1/2 to 3 hours, and 55 observers considered that it should not be more than 1 hour. (22, 27)

In summary, the maximum recommended viewing time is about 1 hour. When longer shifts are used, it is recommended that viewer personnel be provided with 5- to 10-minute rest periods each hour, or rotate jobs with other non-viewer personnel each hour.

When operators work in shifts, usually of eight hours each, the issue of changing or rotating shifts must be considered. Typical shifts run from 8 AM - 4 PM, 4 PM - 12 M, and 12 M - 8 AM, give or take an hour and some overlap. While most police and transit departments have experience with shift changing, it may be helpful to consider some of the research findings on this subject. Biological rhythms and personality attributes have been found to be associated with the ability to adjust successfully to shift changes. Certain types of people adjust more easily than others to shift changes and night work. Since those adjustments can take up to two or three weeks for some people, frequent (e.g., weekly, biweekly) reassignment of an individual's work shift is not appropriate under ordinary circumstances. Several studies of individual circadian rhythms have shown that evening-type people adjust better than morning types to night work. Studies of personality have shown that extroverts adjust better than introverts, especially if those extroverts have certain neurotic tendencies. The ability to sleep at unusual times of day, and to overcome drowsiness, is likewise characteristic of those who adapt better among the general population. Interestingly, the indications are that most people, if given the opportunity, will tend to choose the shifts that best fit their combined biological, psychological and social situation. "Permanent" or long-term shift assignments have met with great success in such cases. Finally, there is some early research underway which is investigating the use of drugs to alter biological cycles and possibly aid adaptation to shift

4.6 TRANSMISSION LINKS

4.6.1 Methods of Transmitting Video Signals

The Direct Wire system is the most common and economical approach for CCTV signal transmission. In this method, the video signal is carried directly from the camera to the monitoring center by coaxial cable. No license is necessary, but one may have to obtain rights of way to cross certain properties. This method is limited in distance of transmission, unless equalization and amplification are used. It is also quite susceptible to interference, especially over long distances.

The other methods of transmission generally make use of radio frequency (RF) carrier signals onto which the video signal is placed electronically through a process known as modulation. The modulated carrier signal can be transmitted on a coaxial cable, in which case the method can be referred to as an RF (Wire) transmission system. Several separate video signals (e.g., 12 or more) can be transmitted on a single coaxial cable by this method. Like the direct wire method, no license is necessary, but rights of way may need to be obtained. When the modulated carrier is transmitted over a wireless, RF (Microwave) system, a license is required from the Federal Communications Commission (FCC), but rights of way become unnecessary. These radio links are limited to line-of-sight arrangements, so that repeater stations may be necessary if long distances or terrain obstacles are to be traversed. Although the RF (Microwave) link is typically limited to a single channel (or camera signal), multiple channels (or camera signals) can be transmitted on the UHF (Ultra-High-Frequency) system. The UHF system is like the RF (Microwave) system in the other noted characteristics. Finally, the Optical Transmission system is one of newest techniques for transmitting video signals. One method does so over a modulated laser or light beam. Unfortunately, this method is presently subject to weather variations such as precipitation and fog. It requires line-of-sight clearance (though mirror relays are possible) but may have an all-weather limitation of about 1,000 feet. This method is convenient for traversing railroad yards, parking lots and other locations where cable installation may be a problem. No license or rights of way are required. Development is currently continuing on optical fiber transmission systems which have relatively unlimited distance capabilities for multiple channels carried in cables of optical fiber bundles. Satellite Transmission, now in its infancy, will probably become available in the next several years for those willing to pay the price for it. (8,9)

4.6.2 Slow Scan Television Transmission

Standard telephone lines, ordinary paired wires or other existing "narrow-band" transmission systems can be used to transmit "frozen frame" video images. These special systems typically provide a sequence of still pictures with rates varying from one frame every 0.5 to 300 seconds. To speed up the process, some systems may also reduce resolution from the normal 525 lines to less than half that number. Under favorable conditions, transmissions up to a mile are practical with some individual devices and repeaters can be used to increase that distance to the extent that noise or resolution levels become objectionable. These systems are useful only where brief or high speed events are not anticipated and where some picture degradation can be tolerated. An extreme version of this slow transmission method would be to make an "instant" photograph of the CCTV monitor screen and then place the photograph on a facsimile scanner for transmission to another location. (6)

6. OPERATOR MONITORING AND RESPONSE PATTERNS

6.1 GENERAL

It is the expressed belief of many security officials that any crime countermeasure or safety system must be perceived by those served as providing rapid and certain response, or its credibility will be questioned, confidence will falter and the consequent value of that system will be seriously diminished. The purpose of this chapter is to provide the reader with information about appropriate operating procedures and action sequences that typical transit CCTV monitor personnel employ in the course of their day-to-day activities. These activities include routine monitoring of displays, response sequences to representative incidents, communications procedures in working with related services and the public, the use of automatic capabilities and the keeping of records. The information presented in this chapter is a further development of the operator issues addressed in Chapter 5. (Personnel Practices). It is considerably more specific, however, about step-by-step procedures employed when detections are made on the monitor displays.

6.2 ROUTINE MONITORING

6.2.1 General

The continuous, routine human activity most associated with CCTV station security operators is the monitoring of television screens for the purpose of detecting events requiring a response. This activity is an essential part of maintaining an overall awareness of the security and safety status at each location. Typically, the function of routine monitoring is carried out entirely by the human operator, although there are certain conditions which permit the use of automatic detection devices which can alert operators by distinct alarms when conditions change. This section on Routine Monitoring addresses only the continuous monitoring of conditions by the human operator. Automatic monitoring and detection capabilities are the subject of a subsequent section in this chapter. The response sequence following the detection of a significant security or safety event is also treated in a subsequent section.

6.2.2 Patterns of Station Activity

After the system has been operating for some period of time, monitor operators will begin to notice the existence of certain trends or patterns which are characteristics of each station and its various surveillance zones. Each station will usually have some cameras that observe an abundance of activity while others may show activity only during certain time periods of the day. At certain times, there may be a predominance of particular types of passengers (e.g., school children, elderly, shoppers, office workers, etc.), so that other types stand out as different from the majority. Some of these routine patterns may contribute to reduced vigilance or even boredom.

6.2.3 Maintaining Vigilance

The administrator's continuing challenge is to help the operators overcome those tendencies toward degraded monitoring performance created by routine and boring activity patterns. Overall alertness and awareness must be maintained so that threats to security of safety are readily and reliably recognized. The operator's ability to detect significant events can be sustained even when facing routine and boring patterns by sensitizing him/her to expect such events and to be accountable for recognizing them. One way such sensitization is accomplished in certain CCTV security systems is to inform operators that periodic training and testing of the entire system (including operators) will be carried out using unannounced events staged before the cameras at random times. These events are actually carried out, operators are later informed of their occurrence and response patterns are reviewed.

6.2.4 Adherence to Geometrical and Numerical Guidelines

Routine monitoring is influenced by the degree to which the operator's physical, perceptual and cognitive capacities are respected. Found elsewhere in this document are guidelines for the geometrical arrangement of CCTV displays before the monitor operator and the number of monitors one person can monitor effectively. Should those guidelines be violated, the reliability of routine monitoring and detection can be degraded because of resulting fatigue, task overloading, eyestrain or other consequences of the mismatch between operators and equipment under the given conditions.

6.2.5 Redeployment of Police Surveillance Patrols

To the extent that the CCTV surveillance system accomplishes its function, the use of police patrols for broad surveillance in all areas of the transit stations can be reduced. Those police officers should be deployed instead to other locations where CCTV surveillance is not as effective, or from where they can make more rapid responses and more certain apprehensions (such as near exit gates). It is not recommended that police patrol activity be stopped, but rather that the emphasis be shifted if CCTV surveillance is effective. Implicit in this guideline is the need for good communications between the CCTV monitor operators and the police patrol units. Police patrol units can even visit the monitoring center to gain a perspective on station and system status prior to initiating their patrol tour.

6.2.6 Local Monitoring and Central Monitoring

Some systems which are staffed by people (e.g., police officers, ticket agents, change-makers) at each station, may encounter technical or administrative circumstances which necessitate that monitoring functions be shared or otherwise divided between those local individuals and personnel in a central monitoring location. If such a compromise is necessary, it could be executed on the basis of relative workloads at given times of day (or week) or the relative hours of operation for certain positions or functions. In the event that routine monitoring and detection functions are so shared, it is essential that appropriate equipment and procedures be provided to insure effective monitoring performance.

For example, it may be necessary to locate small CCTV monitors and a videotape recorder in an agent's booth, along with an audio capability for communicating with other system personnel or with the public. As protection for such an agent, it is also possible to keep an open audio link to another agent, in a form of "buddy" systems, thus making the source of detection and alarm ambiguous to a potential assailant. In local station security booths, one-way mirrors facing the station can provide a similar sense of ambiguity, whereby a potential offender or fare evader will remain uncertain if a police officer or other official is present in the booth.

6.2.7 Combined Audio and Visual Remote Surveillance

To help overcome the tedium that sometimes occurs in visual CCTV surveillance alone, generally quiet stations can also be monitored by an audio system. In this case, the control center operator would be alerted to observe some significant events on the CCTV monitor upon hearing unusual sounds or commotion over the speaker system. Typically, this approach does not insure that all types of incidents will be detected and it is really limited to use on one or, at most, a few stations having unusually low background noise levels. Once the background noise becomes annoying, the operator is likely to turn off the audio monitor until it is needed. (2)

6.2.8 Attention to Vulnerable Passengers

The CCTV monitor operator should usually be alert to the types of people, numbers of people and kinds of movements seen on the monitor screen. For example, handicapped, elderly and infirm passengers are highly vulnerable targets for criminals and may require extra attention. Sleeping passengers awaiting the arrival of their train are vulnerable, as are lone passengers in isolated areas and intoxicated passengers. Accelerated activity at the time of boarding and unboarding of vehicles may provide special opportunities for certain kinds of crimes (e.g., purse or necklace snatching, fare evasion). Each geographical area and transit system has its own segments of the population and types of circumstances that may require special attention because of an increased likelihood of people being victimized or hurt. The local police unit is usually in the best position to train monitor operators in recognizing those higher risk passengers and circumstances as well as the types of individuals who are likely to commit offenses.

6.2.9 Constant vs. Sequential Monitoring Modes

Most operators interviewed during the preparation of this guidebook expressed a strong preference for one constant, individual camera's pictures on each CCTV monitor, rather than sequentially switching from one camera to another on a single screen. In special circumstances, the sequentially switched cameras viewed on a single monitor are acceptable. These circumstances include extreme limitations of space, unusually low activity levels being monitored and a high likelihood that the events requiring a response would take place over long enough periods of time so as not to be missed by the sequential monitoring process. A typical sequential mode could include as many as six cameras, with about three seconds of monitoring on each one in succession. Of course, the operator must have the capability to stop the sequencer and display only the picture from any one camera at will, when necessary. Obviously, the other cameras may be going unattended at that time, unless the system is designed to continue the sequential display on one monitor screen while using a second monitor screen to dwell on the one selected camera. As noted elsewhere in this guidebook, the disadvantage of sequential switching of cameras on a single monitor screen is that it virtually eliminates the possibility for an operator to make good use of movement on the screen as a cue to be more attentive to what is happening at the station.

6.2.10 Experienced vs. Inexperienced Observers

There is some air-defense research which indicates a difference in the way skilled and unskilled observers view television-type situation displays. Unsophisticated viewers tend to be stimulus oriented rather than response oriented. That is, the unskilled observers tend to make judgments in terms of stimulus characteristics rather than in terms of what the situation requires of them. Certain characteristics of complex situations tend to be selectively ignored, and the observer concentrates on only one or two characteristics. While no simple guidelines can be presented at this time, it may be helpful to the system designer and trainer to be aware that there are complex relationships between the characteristics of a display (number and forms of things seen) and the individual's perceptual style (how things are scanned, discriminated and assessed and cognitive style (how perceptions are integrated and processed for a response). (3,7,8)

6.3 RESPONSE SEQUENCES

6.3.1 General Sequence of Events

The generalized response sequence for the CCTV monitor operator begins when he/she detects a suspicious activity or event on the display. Usually the operator will immediately start the videotape recorder for the appropriate camera (and audiotape, if available) while attempting to further recog[illegible]nd identify what is actually taking place. Based upon this determination [illegible]at is occurring, the operator next evaluates the need for a response based up[illegible]her knowledge of available options. Those options range from minimal respo[illegible].g., doing nothing, making a brief announcement over the public address sys[illegible] to complex responses involving coordination with personnel of other departm[illegible] (e.g., police, fire, train operations, medical, etc.). Often the detection, identifi[illegible]ion and evaluation functions occur almost simultaneously. The operator next c[illegible]ies out the response, taking responsibility for its completion unless that respo[illegible]bility is legitimately assumed by another authority. After the crisis period is [illegible]ver, the operator must frequently follow-up the incident with the preparation of [illegible] written notation or report. In more complex situations, the operator's follow-up responsibilities may also include the preservation of videotape evidence and possible court appearances as a witness to, or even a participant in, the incident.

6.3.2 Incident Recognition and Identification

Upon detecting an event that must be further examined, the operator should start the videotape recorder (and audio recorder, if used). A time and date generator should be overlaying its information on the upper or lower edge of the image at the same time. The operator must determine where the incident is occurring, its nature and scope, who appears to be involved, and how it is developing. To aid in this function, the image should be switched to the largest available monitor. Often, that is the one which monitors whatever is being recorded on the videotape recorder. To help identify what is occurring, the operator should also make use of any additional information available, such as alarms, prior knowledge from the supervisor, and verbal reports from passengers or other system employees. At this time, the operator should also take advantage of any special capabilities available, such as camera pan, tilt and zoom features. In unclear situations, an officer or other individual may need to be dispatched to the incident location in order to make a final determination of what is taking place.

6.3.3 Incident Evaluation

One of the first assessments to be made by the operator is whether the identified situation is a life-endangering one. If it is, an immediate call for police response is usually appropriate. In some systems, the police will then initiate and coordinate contacts with all other outside organizations like fire or emergency medical services. In other systems, the operator or his/her supervisor must initiate those contacts. If no life is endangered, the operator may still determine that a police response is needed, especially if the incident is criminal in nature. Other responses, which the operator could determine a need for, include notification of transit system personnel or direct contact with the passengers with no other departments involved. The implication of all these evaluation options for response to an incident is that pre-determined response procedures and communications link to related services and passengers are essential if the response is to be most effective. For systems with small monitors (e.g., 12 inches or less), the identification and evaluation functions can usually be aided if the scene can be switched to a larger monitor (e.g., 19 inches) such as one used in conjunction with the videotape recorder. CCTV systems having pan, tilt and zoom capabilities on its cameras can make use of those capabilities to carry out these functions. (6)

6.3.4 Planned Responses and Job Aids

The more structured and pre-planned the response procedures are for each kind of incident, the less likelihood there is of an inappropriate response by the operator. It is helpful to have a book of prepared instructions describing the special actions to be taken for the different kinds of incidents that could be encountered. It is also helpful to have a readily available list of telephone numbers of persons to call in different types of emergencies. For certain kinds of incidents the operator should also have maps of the station, showing all access features, camera surveillance zones, and other important facts. Responding police officers also require these handy facts and should have them readily available (e.g., as part of the small loose-leaf notebooks they carry with them at all times).

6.3.5 Response Authority

In some monitoring systems, especially those staffed by civilian rather than police operators, it may be necessary to notify a higher level supervisor or sworn police officer of the incident. As a result the operator may either relay response instructions or may hand over management of the incident to that higher authority.

6.3.6 Response to Suspected Criminal Activity

The videotape and audio recorders should be in continuous operation during every significant event, especially if a criminal incident is taking place. The operator should be recording the event using the camera that shows the clearest image of the suspect, the victim, the suspected criminal activity, the responding officers or civilians and the apprehension or escape process. Police procedures and control center capabilities will dictate particular steps to be taken, such as calling a second officer if an apprehension is taking place, using automatic gate-locking devices to contain the suspect, stopping of elevators and escalators, closing (or opening) of selected doors/gates, re-directing of vehicles in the system and using existing contingency plans (e.g., for station evacuation, bomb threats, hostage-taking). In the events of system failures, all automatic locking devices should have reliable (but secure) methods for manually bypassing such locks. Many transit systems are inherently designed to make apprehensions relatively easy, since they typically restrict escape to the exit gates or to tracks and guideways. Direct communication between the CCTV operator, or someone (like a desk officer) with the same monitor coverage as the operator, and the responding police officer is essential if accurate information for apprehension is to be made available rapidly and if escape is to be prevented. (6)

6.3.7 Availability of Responding Officers

When an officer is on patrol at the station, the operator (or superior official) must establish radio, telephone or public address contact with him/her and direct that officer to the incident location. When the station is part of a multi-station patrol area for the officer, a more difficult and slower sequence may result. Good communication facilities are essential, and the contacted officer must then use his own resources in getting to the scene as quickly as possible. In some systems, where the transit vehicles are used to conduct the patrol and long headways are sometimes in effect, it may take considerable time (20-30 minutes) to reach the scene. Often, the use of a radio patrol car (or even a helicopter) traveling between stations can reduce that response time significantly. This may or may not be adequate, depending upon the incident in progress (e.g., rape vs. purse snatching). The operator should know vehicle schedules and the location of all police officers and transit personnel in the system. More or less complex and sophisticated techniques are available to accomplish that purpose (from simple phone-in to costly, automatic radio transponder tracking). Considering the countermeasures potential of the CCTV surveillance system and rapid communications techniques, everything possible should be done to shorten the time required to get a police office to the scene. Once a suspect escapes from the transit property and is on the streets outside, local police usually must be called with a description to aid in the apprehension.

6.3.8 Inhibiting Effect of CCTV on Responding Officers

With the prevailing concern over charges of "police brutality," some police officers making an apprehension in a criminal incident hesitate to use necessary force to subdue a resisting suspect, if those officers know they are being observed on camera and being videotaped for possible evidence purposes. This could result in injury to officers and others. Police administrators should remind police officers of their right to use whatever force is necessary to arrest the resisting suspect.

6.3.9 Direct Contact Responses Between Operators and Passengers

In cases where the operator is to respond directly with passengers or suspects, the use of a one-way or two-way audio system is generally necessary. This can be one that is non-private (e.g., the Public Address System) or it can be private (e.g., the Passenger Assistance Telephone). One way of establishing contact with a specific passenger is to use the public address system to direct that individual to go over and pick up the passenger assistance telephone (e.g., "That man in the leather jacket who just cocked the turnstile, please go to the wall on your right and pick up the yellow telephone"). A firm, but polite discussion can then be carried out to find out what the problem is and to direct subsequent proper action. In other cases, such as if a person goes onto the tracks or guideway, the one-way public system may provide the only immediate response capability. The public address system can also be used to signal police officers (using codes or calls to the telephone) if no radio is available for that purpose.

Depending on the transit system design and the purpose of the CCTV operation, many other interactions can take place between operators and passengers. Some of these interactions would have more to do with passenger convenience services than with security or safety. For example, passengers may call to request directions for reaching their destination or to report a lost child. Pre-planned procedures may be necessary for some of these types of inquiries or services. (3)

6.3.10 Response Failures Due to Lack of Confidence

It is essential that operators develop confidence in the surveillance systems and the organizations responding to it. That confidence can be seriously diminished by excessive equipment failures, false alarms, undependable individuals needed to aid the response, inadequate support and follow-up resources or other reasons. For example, a major department store in a very large Eastern city recently suffered an unrecognized after-hours burglary in its jewelry department, despite its CCTV monitoring system. The perpetrators had simply turned the cameras to look at the ceiling. The security force assumed that this was just a continuation of a recent series of camera malfunctions and chose to do nothing about the inappropriate images on the television monitors. Even the best system is likely to suffer similar costly consequences if the attitude and confidence of its operators is poor.

8. COSTS

8.1 LIFE-CYCLE COSTS

8.1.1 General

To aid the reader in calculating the costs of a potential CCTV transit station security system, this chapter identifies typical categories of costs and provides some representative dollar figures of possible items for which one must pay. It is concerned only with economic costs. In the earlier chapter on system evaluation, non-economic (e.g., social and political) costs were addressed, and those also should be kept in mind.

Depending on size, pricing policies, construction requirements and many other factors, a CCTV transit station security system can have a purchase cost of anywhere from $1,500 to $20,000 per camera/monitor installed. For example, a very low cost, recently installed system covering a single platform, a waiting room and a ramp area, using eight monochrome cameras and eight 10-inch monitors, an automatic sequential switcher, a videotape recorder and 17-inch monitor, a two-way audio system, and no special installation problems, at low prices based on authorized Federal supply schedules (General Services Administration), actually was purchased for about $12,000 ($1,500 per camera/monitor). This is considered an unusually low cost, and should not be the expected purchase cost of most systems. It is also essential to note that many other development, operation, and maintenance costs are incurred, which could easily and rapidly exceed the purchased equipment costs. This chapter provides some perspective on all of those cost components.

8.1.2 Cost of Ownership

To establish a comprehensive framework for estimating all economic costs, the life cycle of a transit system can be used to define a series of stages, and then costs can be computed for each stage. The life cycle of a transportation system has been classified by others, and is depicted in Table 8-1. Most "advanced" transit systems will go through all of these phases. "Conventional" systems will require little, if any, RD&D, and "revolutionary" systems generally will be confined to RD&D until they probably become "advanced" systems. The CCTV security system planner must determine which stages of the life cycle are relevant to his/her cost computations. In most instances, it is expected that the Acquisition and Use periods would include the applicable cost categories. (3, 5, 6)

TABLE 8-1. LIFE CYCLE OF A TRANSIT SYSTEM

Period	Phase	Stage
Research, Design and Development (RD&D)	Novel System Development	Concept Formulation and Definition
		Technology Development and Demonstration
Acquisition	Revenue System Engineering	Concept Selection
		System Definition and Planning
		Detail Design and Development
	Property Development	Construction, Fabrication, Assembly, Test and Checkout
Use	Operation	Operation, Maintenance, Modification, and Removal

Within each category one must consider the costs of purchased items (equipment and materials), labor (designers, operators, technicians, and other system employees), travel expenses (transportation, per diem, etc.), outside services (consultants, etc.), and any other miscellaneous expenses (e.g., leased items). One possible way of classifying those costs is in terms such as shown in Table 8-2. Obviously, each planner or designer will be subject to the general planning and budgeting practices followed in his/her agency.

TABLE 8-2. COST FACTORS IN EACH STAGE OF THE LIFE CYCLE

1. One-time costs, such as purchased equipment. These costs can often be depreciated or amortized over the useful life, in accordance with generally accepted accounting principles. They include office equipment as well as CCTV apparatus. Upon system removal, a scrap value credit may be realized.
2. Fixed costs, such as needed to maintain and operate the activities at any stage of the life cycle. They include wages, employee benefits (holidays, insurance, etc.), utilities, insurance, leasing and renting costs. These costs can increase if the gross activity level requires more permanent personnel.
3. Variable costs, which are incurred in accordance with activity level at any stage. They include repair and replacement costs, office supplies, etc.
4. General and administrative expenses, which are allocable to the system activity in accordance with generally accepted accounting principles.

APPENDIX G

CONTROLLED APERTURE EVALUATION

Kaiser Engineers California

Kaiser Engineers (California) Corporation
A Subsidiary of Raymond Kaiser Engineers Inc.
425 South Main Street 6th Floor
Los Angeles, California 90013
(213) 972-6033

Job #: 81152-403
WBS #: 14 CAC

DECEMBER 21, 1982

MEMORANDUM TO: W. J. Rhine

FROM: P. M. Burgess

RE: ALTERNATIVE ANALYSIS -- COMMUNICATION SYSTEM

This is in response to a December 20, 1982 request by your staff to write you a memo to be inserted in the appendix of our revised WBS #14 CAC report. The desired purpose of the memorandum is to confirm that alternative analysis work, on the subject of controlled aperture CCTV for dimly-lit areas versus higher illumination, was suspended after the technology assessment phase of the alternative analysis showed that moderately priced cameras are available with aperture control range that precludes the need for extra illumination.

On March 17, 1982 we confirmed, by memo, that we would evaluate six communications alternatives under task WBS #14 CAC. On June 14, 1982, we included the controlled aperture CCTV alternative in a composite list of alternative analysis subjects that we had analyzed or were continuing to analyze.

On April 27, 1982, we discussed with Metro Rail staff summarized results of the analysis work completed to that date. Our May 28, 1982 memo to you advised that we had suspended the TV camera aperture control alternative analysis because we had verified that a readily available, reasonably priced, general purpose camera with automatic light compensation would accommodate the range of minimum emergency lighting to maximum illumination for passenger station application.

Our July 19, 1982 WBS #14 CAC draft report summarized the analysis work that had been done and the significant results and conclusions.

As requested, we will append these written communications to our WBS #14 CAC final report, including a copy of Chapter VII of our draft report.

cc: C. Fisher
D. Wellington
A. Adela
D. Schuler

PMB/lm

KAISER ENGINEERS

KAISER ENGINEERS, INC.
425 SOUTH MAIN STREET
8th FLOOR
LOS ANGELES, CALIFORNIA 90013
TELEPHONE: (213) 972-6033

June 14, 1982

File: 81152-100
WBS: 11DAF A/2439

MEMO TO: W. J. Rhine

FROM: P. M. Burgess *P.M. Burgess/cmc*

SUBJECT: <u>Composite List of WBS 14 Alternatives*</u>

Following is a list combining the eight separate lists of alternatives that I forwarded to you with eight memoranda all dated ~~June 4~~ *March 17*, 1982. This composite list is being prepared as a convenient reference document for use in keeping track of alternatives that have been deferred or eliminated during the alternative analysis work and for keeping track of changes in terminology.

* This is a Basic Data Subject

PMB:mea

RECEIVED
JUL 12 1982
TRANSIT POLICE

Loaned to WJR; & returned on 7/13/82

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Invest.	
Serv. Inspc.	
Support	

RECEIVED
SCRTD
JUL 13 1982
OFFICE OF
MGR/CHIEF ENGINEER
METRO RAIL PROJECT

ALTERNATIVES

Passenger Vehicle — **WBS: 14CAA** — Date Delivered March 17, 1982

1. Vehicle Configuration
   - A. Semi-permanent dependent pairs (shared equipment).
   - B. Quick separable dependent pairs (shared equipment).
   - C. Double-ended single cars (controls each end).
   - D. Single-ended single cars (controls one end only).

2. AC (60Hz and 400 Hz) vs. DC Auxiliaries.

3. Chopper vs. Cam Controller.

4. Disc vs. Tread Brakes (or both).

5. Wheel Diameter (28 inch minimum to 34 inch maximum).

6. Roof Vs. Undercar Airconditioning.

7. Material and Structural (steel, aluminum, or combination).

Train Control — **WBS: 14CAB** — March 17, 1982

1. Reverse Running:
   - A. Full protection for close following moves.
   - B. Headblock to headblock with no following moves between interlockings.

2. Automatic Vehicle Identification:
   - A. Passive - intermittent (only reads labels for vehicle and train information).
   - B. Active - Also intermittent but can be used for:
     1. Automatic track switching.
     2. Control of station destination signs.
     3. Control of train arrival and boarding location indicators.

3. Central Control:
   - A. Mimic Panel vs. banked CRT display.
   - B. Operator interface via CRT vs. control console.

4. Platform Train Destination Signs:
   - A. Signs triggered by wayside AVI.
   - B. Signs controlled by Central CPU (possibility of having equipment cost underwritten by advertising).
   - C. No platform destination signs.

5. Scope of Starter Line ATO:
   - A. Automatic speed regulation.
   - B. Programmed station stops.
   - C. Automatic station dispatching.
   - D. Automatic door closing.

Communications WBS: 14CAC March 17, 1982

1. Vehicle radios fixed or removable, as in a combination having an installed handset.

2. PABX, maintenance and emergency telephone systems, separate or combined employing common equipment.

3. Lease vs. purchase of telephone systems.

4. Controlled aperture CCTV, for dimly lighted areas, vs. higher illumination.

5. TV monitors sequenced or split screen, or combination.

6. Cable transmission via fiber optics, vs. multi-conductor cable, vs. coaxial cable.

Electrification System WBS: 14CAD11 March 17, 1982

Traction Power

1. Substation configuration single unit vs. double unit.

2. Substation spacing and location at passenger station vs. intermediate other locations.

3. Substation cooling system, self-cooling vs. forced cooling, dry vs. liquid.

4. Contact rail, aluminum with stainless steel cap vs. steel rail with extruded aluminum sides.

5. Switchgear overload protection, breakers vs. fuses.

6. Cable and raceway system in tunnel exposed conduit vs. embedded.

Auxiliary Power WBS: 14CAD12 March 17, 1982

1. Primary power supply integration with traction power vs. separate feeders from utility company.

2. Secondary power distribution, radial vs. dual selective.

3. Emergency standby power supply, DG/UPS vs. turbine-generator/UPS.

4. Tunnel lighting fixture, fluorescent vs. incandescent or high intensity discharge.

5. Secondary distribution equipment panelboards vs. switchgear.

6. Secondary distribution transformer, liquid vs. dry, self-cooling vs. forced cooling.

7. Low voltage switching system, large ACB vs. fuses, insulated case vs. fuses, molded case vs. fuses, drawout vs. fixed.

Fare Collection **WBS: 14CAE11** **March 17, 1982**

1. Self service vs. barrier.

2. Flat fare structure vs. graduated.

3. Bus fare compatibility.

4. Special fares capability.

Auxiliary Vehicles **WBS: 14CAE13** **March 17, 1982**

1. Self propelled maintenance and service vehicles vs. locomotive and unpowered vehicles. (Types of self-propulsion might be 3rd rail, diesel or both).

2. Rail grinding and track alignment equipment procured during construction or deferred. (Equipment could be purchased or leased; it will be needed before start of revenue operations and again after approximately two to five years of operation).

Escalators and Elevators **WBS: 14BAG** **March 17, 1982**

Escalators

1. One standardized width for all stations vs. sized according to projected patronage.

2. Treadle operated vs. supervised starting and stopping.

3. Long escalators vs. segmented design.

4. Inclined moving sidewalk vs. escalator for short rise.

Elevators

1. No laternative developed in WBS 14BAG.

Vehicle Maintenance Shop Equipment **WBS: 14AAG11** **March 17, 1982**

1. In-floor vehicle hoists vs. portable jacks for lifting vehicles.

2. Shop stinger system vs. self-propelled car switcher.

3. Shop lubrication system vs. portable lub carts.

4. Shop air system vs. electric powered tools.

5. Lathe vs. milling method for wheel truing.

KAISER ENGINEERS

INTEROFFICE MEMORANDUM

TO	P. M. Burgess	DATE	March 22, 1982
AT		FROM	A. P. Adela, Jr.
COPIES TO		AT	OB 601 - Oakland
		JOB NO.	81152-403

RECEIVED
MAR 24 1982
KAISER ENGINEERS
LOS ANGELES

SUBJECT RTD METRO RAIL PROJECT
COMMUNICATION SYSTEM

Attached is an outline for WBS 14CAC Deliverable to be prepared. This outline will be used unless a standard format has been prepared. I also would like to amend the alternatives previously sumitted to delete the following:

1. 1 footcandle level of lighting as against aperture control of TV cameras for higher FC light level.

   There is no operational and cost difference involved. The type of camera with automatic light compensation applicable for 1 FC and 2 FC or more is the same. General purpose cameras will be used with options. The ranges are as follows:

Type of Camera	Sensitivity
General Purpose	1FC - 100 FC SHOULD READ (1FC - 1000FC) CORRECTION PER TELE CONV W/JUW
Normal Light Range	0.1FC - 1FC
Low Light Level	0.01FC - 0.1FC
Very Low Light Level	0.001FC - 0.01FC

2. Masterclock programmable against non-programmable control unit. There is no considerable difference in the functions required. Programmable control units are more complex and expensive as against a non-programmable. The following features envisioned to be required for the Masterclock System are standard to both types.

   1. Central reset
   2. Hourly correction
   3. Instant reset after power failure
   4. Pre-set timer for standard and daylight savings time
   5. 12-hour correction

Please advise if you or the clients disagree with this motion, otherwise, we will proceed as outlined.

/spt
attachment

KAISER ENGINEERS

INTEROFFICE MEMORANDUM

TO P. M. Burgess
AT KE - Los Angeles

COPIES TO Ed Freeman, UII

DATE April 27, 1982
FROM A. P. Adela, Jr.
AT OB-601
JOB NO. 81152-403

SUBJECT COMMUNICATIONS SYSTEM
WBS 14 CAC DESIGN ALTERNATIVES

This is to confirm our recent meeting with the client regarding the various design alternatives to be evaluated.

1. Radio Service - Passenger Vehicle

   a. Fixed
   b. Removable
      1. Non-operable
      2. Operable

2. Telephone Service
   Equipment Configuration

   a. PABX, PAX and Emergency Telephones as separate equipment.
   b. Combine two or three services in one common equipment or instrument

   Method of Acquisition:

   a. Lease
   b. Buy

3. Closed Circuit Television (CCTV)

   a. Sequencer
   b. Split Screen
   c. Combination

4. Cable Transmission Service (CTS)

   a. Fiber Optics
   b. Paired Cables
   c. Coaxial Cables

The following criteria has been evaluated to further enlighten the reasons for dropping the alternative for CCTV on the aperture control as against the light level.

1. The requirements for emergency lighting are primarily established by NEC and Section 5 of the Life Safety Code (NFPA 101), which states that the light level shall not be less than 1.0 foot candle measured at the floor.

2. The locomotive headlights classified by the Federal Railroad Administration are classified as road service giving 800 ft. object visibility. Each lamp projects a beam about 5 degrees wide of 300,000 candelas.

   Using a 10 ft. distance from the light to camera lens, with direct exposure, the vertical illumination level will be;

$$FC = \frac{\text{Candlepower} \times \sin \theta}{\text{Distance Squared}} = \frac{300{,}000 \times \sin 5^{\circ}}{10^2} = \frac{26147}{100} = 261 \text{ FC}$$

3. Although the calculated illumination level is high, the camera lens won't be directly exposed to the headlight. The actual light level will just be a spill from the 261 FC.

4. As previously mentioned in my memo of March 22, 1982, the general purpose camera with automatic light compensation will be able to handle the minimum emergency lighting level of 1.0 FC and a maximum of 1000 FC.

APA/jln

KAISER
ENGINEERS

1 copy to Dorothy
→ PMB

KAISER ENGINEERS, INC.
425 SOUTH MAIN STREET
8th FLOOR
LOS ANGELES, CALIFORNIA 90013
TELEPHONE: (213) 972-4033

May 28, 1982

File: 81152-403
WBS: 14CAC A/2439

MEMO TO: W. J. Rhine

FROM: P. M. Burgess

SUBJECT: WBS 14CAC Telephone Lease vs Buy Alternatives Analysis

A meeting was held June 25 between representatives of Pacific Telephone, Kaiser Engineers and your staff to obtain telephone leasing information for our lease vs buy alternatives analysis.

We were informed by the telephone representatives that a recent anti-turst court ruling against the telephone company precludes any gurantee that Pacific Telephone will be in the leasing business during the time we will be procuring telephone services or equipment. Therefore, as discussed with Jim Trani and Mike Becher, we have discontinued the analysis of the lease versus buy alternative.

We plan to address the lease vs buy subject again in WBS 16CAC work when we expect to have more definite information regarding the possible deregulation of communication utilities and its effect on leasing vs owning options.

Our WBS 14CAC Alternatives Analysis report will include a narrative of the previous work that was done on this alternative subject.

Coincidentally the report will briefly address the subject of T.V. Camera aperture control versus increased illumination on which we suspended the analysis because our technology assessment showed that moderately priced cameras have recently become available with aperture control range that precludes the need for extra illumination.

PMB:mea

CHAPTER 7

CLOSED CIRCUIT TELEVISION APERTURE CONTROL EVALUATION

7.1 INTRODUCTION

The intent of this analysis was to assess the capabilities of current CCTV camers lens technology for providing good TV coverage of areas where illumination levels differ widely, as they do in transit system stations and yards. The analysis was suspended after the initial technology assessment showed that moderately priced cameras have recently become available with aperture control range wide enough to accommodate the entire range. Following are details of the information obtained and the results concluded.

7.2 DESCRIPTION OF ALTERNATIVES

7.2.1 1.0 Footcandle of Lighting

According to the Life Safety Code, 1.0 footcandle should be the minimum level of lighting for emergency purposes. Camera lenses should conform to this lighting level to provide clear and usable images.

7.2.2 Higher Level of Lighting

Normal lighting in stations and concourse areas is maintained at a level of 100 to 200 footcandle. The cameras intended for these areas do not require highly sophisticated control functions as long as the lighting levels are maintained.

7.3 RESULTS

The requirements for emergency lighting are primarily established by NEC and Section 5 of the Life Safety Code (NFPA101), which states that the light level shall not be less than 1.0 foot footcandle measured at the floor.

The greatest amount of localized light intensity that can be expected in a transit trainway is that of a locomotive headlight. These are classified by the Federal Railroad Administration as road service headlights giving 800-ft object visibility. Each lamp projects a beam about 5 degrees wide of 300,000 candles, which converts to 261 footcandle as shown below.

Using a 10-ft distance from the light to camera lens, with direct exposure, the vertical illumination level will be:

$$fc = \frac{\text{candlepower x sin (theta)}}{\text{distance squared}}$$

$$= \frac{300{,}000 \text{ x } \sin 5^\circ}{10^2} = \frac{26147}{100} = 261$$

Although the calculated illumination level is high, the camera lens will not be directly exposed to the headlight; the actual light level will just be a spill from the 261 footcandle.

The type of camera with automatic light compensation applicable for 1 footcandle and 2 footcandle or more is the same. General purpose cameras, with options, will be used. The ranges are as follows:

Type of Camera	Sensitivity
General purpose	1 fc - 1000 fc
Normal light range	0.1 fc - 1 fc
Low light level	0.01 fc - 0.1 fc
Very low light level	0.001 fc - 0.01 fc

APPENDIX H

TELEPHONE LEASE VS. BUY EVALUATION

KAISER
ENGINEERS

KAISER ENGINEERS, INC.
425 SOUTH MAIN STREET
8th FLOOR
LOS ANGELES, CALIFORNIA 90013
TELEPHONE (213) 972-6000

1 Eq → Donovan
→ PMB

May 28, 1982

File: 81152-403
WBS: 14CAC A/2439

MEMO TO: W. J. Rhine

FROM: P. M. Burgess

SUBJECT: WBS 14CAC Telephone Lease vs Buy Alternatives Analysis

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We were informed by the telephone representatives that a recent anti-turst court ruling against the telephone company precludes any gurantee that Pacific Telephone will be in the leasing business during the time we will be procuring telephone services or equipment. Therefore, as discussed with Jim Trani and Mike Becher, we have discontinued the analysis of the lease versus buy alternative.

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PMB:mea

CHAPTER 6

TELEPHONE SERVICE

LEASE vs. BUY EVALUATION

6.1 INTRODUCTION

In this alternative, Kaiser Engineers was to analyze leasing and purchasing options for the telephone equipment.

6.2 DESCRIPTION OF ALTERNATIVES

6.2.1 Lease

Leasing the PABX and PAX main frames, including lines and telephone instruments, is the current trend of major business industries. This equipment, installed on the Metro Rail premises according to the Metro Rail system specifications, will be furnished and maintained by the local telephone company.

6.2.2 Buy

This alternative presents an advantage to the Metro Rail system in purchasing the telephone system, because it could be precisely engineered and specified to meet specific requirements.

6.3 RESULTS

A preliminary functional specification was prepared by Kaiser Engineers and presented to the telephone company for a lease quotation. A meeting was held at the Metro Rail project premises and was attended by representatives of Pacific Telephone, Kaiser Engineers, and the Metro Rail Project staff.

A recent antitrust court ruling against the telephone company precludes any guarantee that Pacific Telephone will be in the leasing business when the telephone system for the Metro Rail project is installed. As a result of this discussion, the analysis of this alternative will not be included in this report until more definite information is gathered.

APPENDIX I

MANUFACTURER'S CUT SHEETS

HEAVY DUTY OPTICAL FIBER CABLE

These optical fiber cables are especially suited for employment in voice, video and data transmission applications which require ruggedized cables. High cable strength, crush and abrasion resistance, and moisture protection characterize the rugged nature of these cables. (See Installation Suitability Table)

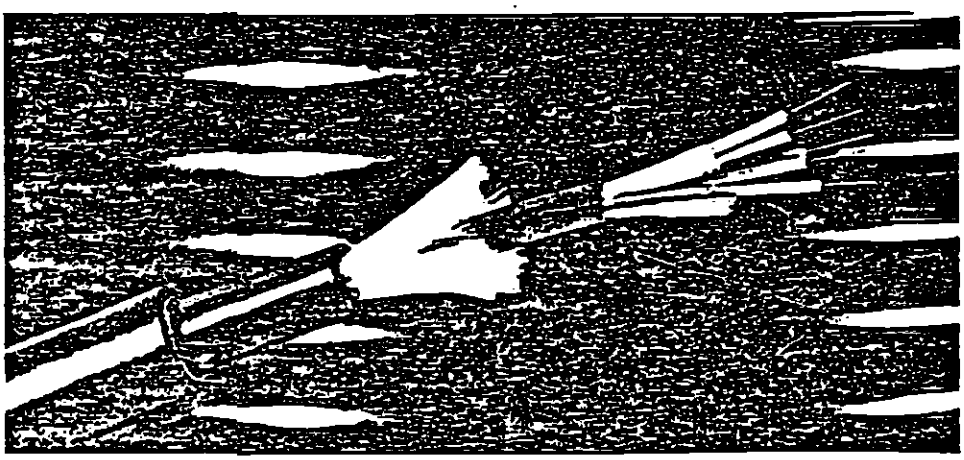
The optical fiber cables are available in two types which are described as General Purpose and Heavy Duty. The General Purpose cables incorporate standard ITT optical fibers which have 0.5 millimeter outer jacket diameters. These cables are generally intended for installation in ducts, cable trays, or similar applications. The Heavy Duty cables incorporate ITT optical fibers having outer jacket diameters of 0.95 millimeter. The additional buffering material on the fibers provides an additional measure of ruggedness which makes these cables well suited for direct burial or aerial installations. Both cable types are characterized by high cable strength and excellent abrasion resistance. Either cable type can incorporate up to nineteen optical fibers.

Both cable types are comprised of an inner core of optical fibers over which is extruded a black polyurethane jacket. This inner jacket is surrounded by helically laid Kevlar® strength members over which the outer jacket of polyurethane is extruded.

The Heavy Duty cable is designed for aerial installation by lashing to a messenger wire. It is also suitable for duct installation using standard duct-pulling techniques. This cable is available with an optional void-filling compound applied within the inner cable jacket as well as an aluminum tape armor with an outer polyethelene jacket. This cable complies with the "REA General Guidelines for Fiber Optic Communication Cables, Issue 2." With the addition of these options, the cable is suitable for direct burial by plowing or trenching.

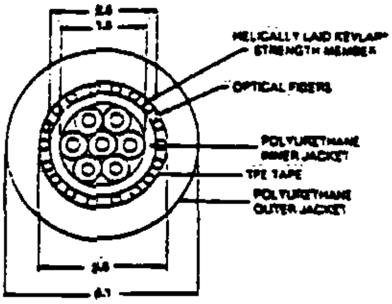
Since the optical fibers used in these cables are inherently strong (continuous proof tested at 100 kpsi loads) and special attention has been paid to increased cable strength in cable designs, standard cable installation techniques can be used without damaging the optical fibers in the cable. Additionally, termination of the strength member and optical fiber is enhanced by the flexibility and internal structure of the cables.

These cables can be ordered with any ITT multimode optical fibers. Fibers in a wide range of attenuation and dispersion are available. As an option, the fibers can be color-coded in accordance with "REA General Guidelines for Fiber Optic Communication Cables, Issue 2." These cables are available in lengths up to one kilometer. Longer continuous lengths can also be provided on special order.

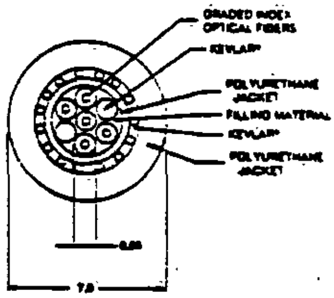


ITT

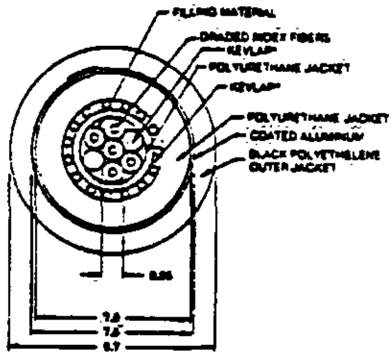
GENERAL PURPOSE OPTICAL FIBER CABLE



AERIAL OPTICAL FIBER CABLE



DIRECT BURIAL OPTICAL FIBER CABLE



ALL DIMENSIONS IN MILLIMETERS

INSTALLATION SUITABILITY

CABLE TYPE	Intrabuilding	Aerial	Duct/wet	Duct/dry	Direct Burial
Heavy Duty					
Unfilled, unsheathed		•		•	
Filled, unsheathed			•		
Filled, sheathed					•
General Purpose	•			•	

CABLE SPECIFICATIONS

OPTICAL

Numerical Aperture	Refer to Optical Fiber Data Sheets
Attenuation @ 0.85 μm	Refer to Optical Fiber Data Sheets
Dispersion (−3dB Intermodal)	Refer to Optical Fiber Data Sheets

MECHANICAL

	GENERAL PURPOSE	HEAVY DUTY Unsheathed	HEAVY DUTY Sheathed
Jacketed Fiber Diameter	0.5 mm	1.0 mm	1.0 mm
Cable Diameter	6.1 mm	7.0 mm	9.7 mm
Weight	30 kg/km	39 kg/km	58 kg/km
Minimum Bend Radius	4 cm	5 cm	10 cm
Short-Term Tensile Strength	150 kgf	150 kgf	150 kgf
Number of Fibers	1 to 7*	1 to 7*	1 to 7*

*Eight to nineteen fibers can be specified on special order.

CABLE ORDERING INFORMATION

(Cable Part Number is prefixed by the letter "T", followed by a three-element number as follows: T-XXXX-YY-ZZZZ - see below.)

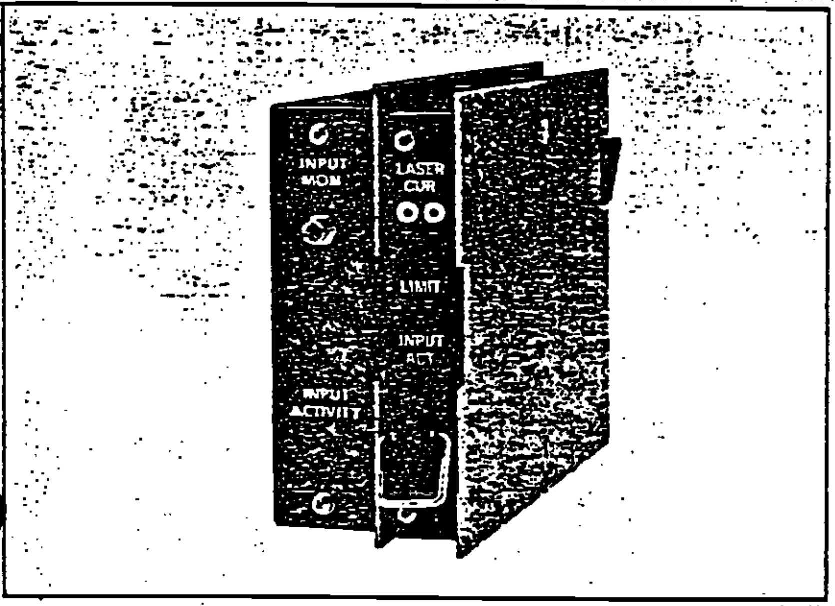
	XXXX Cable Type	YY Number of Working Fibers	ZZZZ Fiber Type Number***
Heavy Duty†			
Filled, unsheathed	2500	Specify 01 to 19	See Optical Fiber Data Sheet**
Unfilled, unsheathed	2501	Specify 01 to 19	See Optical Fiber Data Sheet**
Filled, sheathed	2502	Specify 01 to 19	See Optical Fiber Data Sheet**
General Purpose††	3500	Specify 01 to 19	See Optical Fiber Data Sheet**

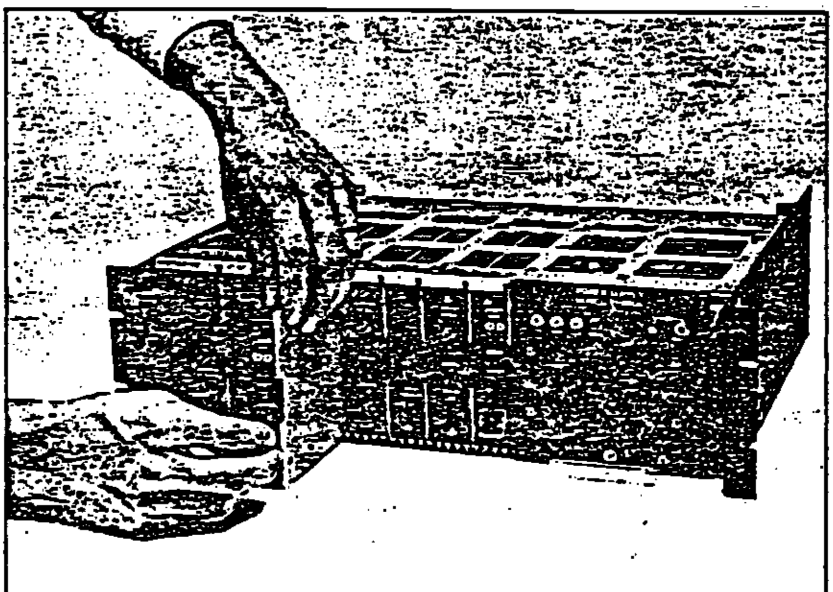
†Formerly designated types T-491 to T-499
††Formerly designated types T-411 to T-419
**Delete "T" prefix
***For color-coded fibers, add suffix "C" after Fiber Type Number

EXAMPLE: T-2502-07-1208 is a filled, sheathed seven fiber cable using graded index fiber with an outer jacket diameter of 0.5 mm exhibiting 4.0dB/km maximum attenuation at 0.85μm, and maximum −3 dB intermodal dispersion of 0.5 ns/km at 0.9 μm. (fiber type, fiber outer jacket diameter, attenuation, and dispersion are taken from Graded Index Optical Fiber data sheet.)

ELECTRO-OPTICAL PRODUCTS DIVISION ITT
7635 Plantation Rd., Roanoke, VA 24019. Telephone (703)563-0371

Video Laser Transmission System





Linear, High Quality Video Transmission to Ten (10) Kilometers Without Repeaters Using Fiber Optics

Designed to accommodate a wide range of custom system requirements, ITT's Video Laser Transmission System is a single, modularized package that expands to satisfy multiple channel transmission of simplex or duplex signals. The standard 5¼" x 19" equipment shelf has provisions for accepting up to four (4) video channel units and an AC power supply unit. Superior video quality for signal bandwidths to 10 MHz is combined with the ability to transmit over nonrepeated fiber optic links up to ten (10) kilometers.

A low noise, high linearity fiber optic transmission system, the ITT VLT unit employs F.M. modulation to provide a signal-to-noise ratio (weighted) of greater than 60 dB and differential gain of less than 1.5%.

Easy to install and maintain, it is an ideal transmission system for video and other wideband analog signals where the signal quality is critical.

Uniquely suited to new system configurations, the ITT Video Laser Transmission System bypasses the traditional installation problems associated with copper cable systems and is capable of transmission in high noise environments, because it is inherently immune to radio frequency and electromagnetic interference.

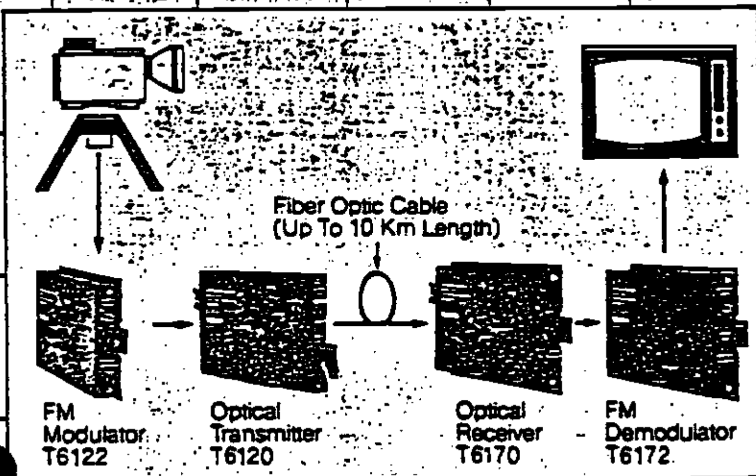
ITT
ELECTRO-OPTICAL PRODUCTS DIVISION

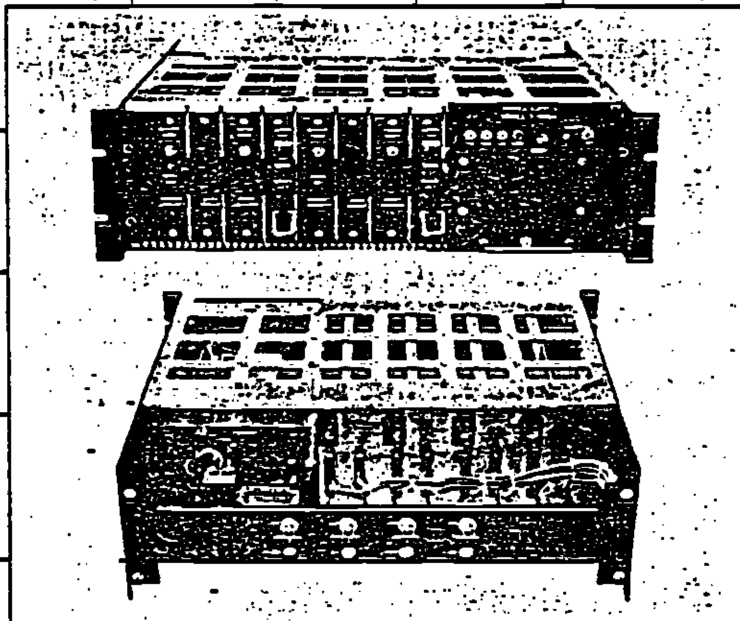
Video Laser Transmission System

The highly flexible packaging configuration will accept other modules in the T6100 Series to accommodate a variety of digital or analog signals.

Features

- 10 kilometer nonrepeatered links
- Low noise/high linearity
- Modular construction
- RS 250C compatible
- NTSC compatible





VIDEO LINK SPECIFICATIONS T6120/6170/6122/6172

Electrical

Electrical Interface	RS-170
Input Impedance	75 Ω, 1 vpp
Output Impedance	75 Ω, 1 vpp
Frequency Response (±1.5 dB)	to 10 MHz
Line Tilt	<1%
Weighted Signal-to-Random Noise	>60 dB
Differential Gain	<1.5%
Differential Phase	<1.3°
Power Requirements	117 Vac ±10%

Optical

Optical Wavelength	0.84 μm nominal
Transmitter Output Power	>0 dBm (1 mW)
Receiver Sensitivity	<−46 dBm (25 nW)
Receiver Dynamic Range	>20 dB
Optical Fiber	50 μm core, graded index
Fiber Bandwidth (minimum)	80 MHz

Mechanical

Video Modulator, T6122	1.24" x 4.75" x 8.56"
Wideband Transmitter, T6120	0.87" x 4.75" x 8.56"
Wideband Receiver, T6170	0.87" x 4.75" x 8.56"
Video Demodulator, T6172	1.24" x 4.75" x 8.56"
Power Supply—117 Vac, T6904	5.56" x 5.22" x 10.75"
Video Chassis, T6902	19.00" x 5.25" x 15.75"
Electrical Connection	BNC Connector
Optical Connection	Cannon FOT Connector

For Additional Information Write or Call:

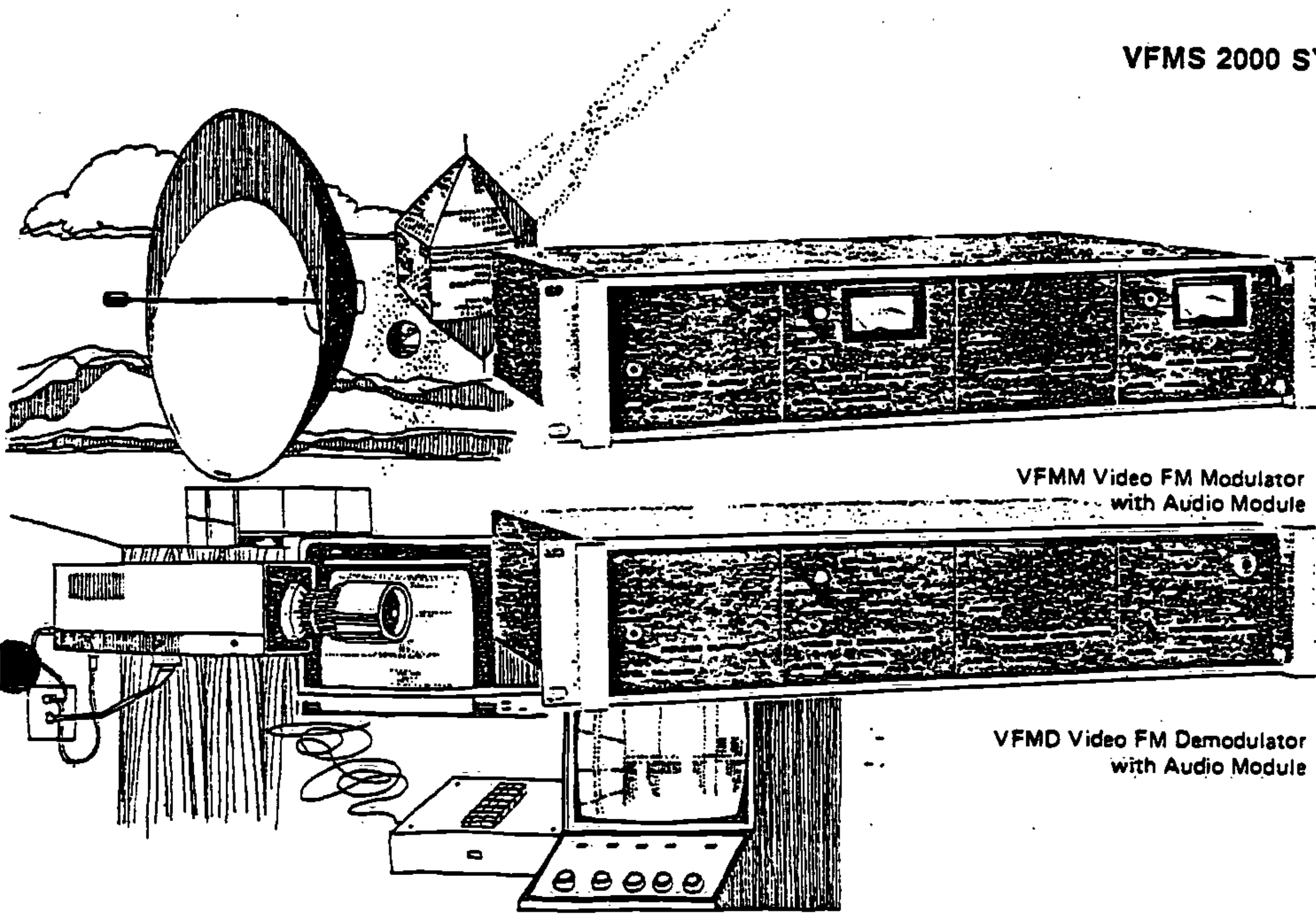
Marketing Department
ITT
Electro-Optical Products Division
7635 Plantation Road
P.O. Box 7065
Roanoke, Virginia 24019
Telephone (703) 563-0371
Telex 829458

Represented By:

ITT
ELECTRO-OPTICAL PRODUCTS DIVISION
7635 Plantation Rd., Roanoke, Va. 24019. Telephone (703) 563-037

CATEL

VFMS 2000 SYSTEM



Video/FM Coaxial Cable Transmission System

FEATURES:

Greater than 60 dB Signal to Noise
Improved Impulse Noise Immunity
Longer Transmission Runs with Less Distortion
No Gain and Tilt Compensation Required
Low Maintenance, Solid State Design
Minimum Cross-Modulation Effect
High Level Signals
Improved Group Delay Performance
Ideal for PCM Multiplex
Lower Cost than Comparable AM Systems
Minimum Effect from Intruded Signals—FM Capture Effect

DESCRIPTION

The Catel VFMS Video FM Transmission System consists of a VFMM-2000 Video FM Modulator and a VFMD-2000 FM Video Demodulator. Frequency range is available from 19 to 293 MHz with standard bandwidth of 14 MHz. (Special bandwidths optional)

Due to the noise immunity advantages inherent in FM, the system is capable of long distance transmission of high speed data, television pictures and facsimile with minimum distortion.

Unique Advantages of FM/Video Transmission...

Special features of Frequency Modulation make it ideally suited for wideband cable transmission applications.

First, the high signal to noise and impulse noise immunity characteristics of FM provide improved performance in three areas: longer runs with minimum distortion, multiple regeneration in cascaded systems with fewer amplifiers and improved overall transmission of high speed data, television pictures and facsimile.

Secondly, the straight-forward, design of the FM system lowers purchase price, maintenance costs, and reduces the number of additional active elements in the system.

"Off-Air" Video

Figure A

"Off-Air" Video

Figure B

Figure A shows AM video display from input through 8 amplifier cascade. Figure B shows improved characteristics of FM transmission within the same parameters.

Versatile, Modular Design Concept.

The chart shows various combinations of Catel video and audio bandwidth modules which make up specific frequency- and application-tailored systems. Full pricing available on request.

		MODULATOR		
VFMS-2000 DATA	MODULES	Video 19-33 MHz	Video 34-293 MHz	Video/Audio 19-33 MHz
Cabinet with tamper-guard panel	CA2100	XXX	XXX	XXX
Power Supply	PS2500	XXX	XXX	XXX
Video Modulator	VFMM2000	XXX	XXX	XXX
Video Demodulator	VFMD2000			
Down Converter	TC2500D	XXX		XXX
Band Pass Filter	BPF2100			
Audio Modulator	FMX2100[2]			XXX
Audio Demodulator	FMRX2200[2]			
Panel Spacer	CS2000	XXX	XXX[4]	

[1] Two way audio/visual Teleconferencing modem—at a much lower terminal price than conventional AM System.
[2] Standard Catel Audio Modulator/Demodulator.
[3] Requires two cabinets
[4] Requires two spacers.
[5] -

SPECIFICATIONS

VFMS-2000 Video FM System

Frequency Range	19 MHz to 293 MHz — System (Specify)
Input Base Bandwidth Options	10 Hz to 500 kHz Min. 10 Hz to 5 MHz Max.
Channel Bandwidth	14 MHz
Channel Guard Band	1.5 MHz at maximum bandwidth
Base Bandwidth Response	±0.5 dB 30 Hz to 4.2 MHz
Phase Delay	±50 nsec 30 Hz to 4.2 MHz
Differential Gain	0.5 dB
Differential Phase	±1°, 3.58 MHz
Signal to Noise Ratio	60 dB Minimum Back to Back (Unweighted) +15 dBm Input
Sync Tilt	2% Max.

VFMM-2000 Video FM Modulator

Input Level	1.0V Peak-Peak Adjustable over 0.75 to 2.0V Range
Input Impedance	75 Ohm Unbalanced 20 dB Return Loss
Output Impedance	75 Ohm Unbalanced 16 dB Return Loss
Output Level	54 dBmV (Levels as High as 72 dBmV Available on Special Order)
Frequency Stability	0.1%
Hum and Noise	70 dB Down at M = 1.5
Input Bandwidth Options	10 Hz to 500 kHz Min. 10 Hz to 5 MHz Max.
Spurious Output	60 dB Minimum Below Peak Carrier Level Outside 14 MHz Bandwidth
Power Requirements	

VFMD-2000/BPF-2100 Video FM Demodulator

Input Level	+10 dBmV Min. to +30 dBmV Max.
Input Impedance	75 Ohm Terminating Unbalanced 16 dB Return Loss
Or	High Impedance Loop Through (Specify)
Output Level	1 V Peak-to-Peak Adjustable
Output Impedance	75 Ohm Terminating 20 dB Return Loss

PS-2500 Power Supply

Power Input	105 to 125 VAC, 60 Hz (230 V., 50 Hz Optional)
Power Output	12.6 VDC at 1.0 Amperes (−15 VDC at .5 Amperes)
Ripple	Less than 1 mV
Regulation	Electronic (I.C.)
Protection	Input—Fused Output—Electronic Short Circuit Protected

OPTIONS: Special Bandwidths
Premium Specifications
DC Coupling for Data Transmission
BNC Connectors

AUDIO MODULES

FMX-2100

Output Control	Continuously Variable
Response	±1 dB of 75 Microsecond Pre-emphasis curve or 50 Hz to 80 kHz (optional)
Modulation	Oven regulated VCO
Modulation Capability	75 kHz deviation
Hum and Noise	60 dB below max. output
Input Level	−10 dBm (pre-amp available)
Input Impedance	5000 Ohms unbalanced or 600 Ohms balanced
Spurious Signals	60 dB below max. output
Frequency Range	14-300 MHz
Output Level	+45 dB MV
Frequency Stability	0.005% (crystal controlled)
Power Requirements	12.6 VDC, 150 mA average; 220 mA max. (Powered by PS2500 Power Supply)

FMRX-2200

Frequency Range	4.0 MHz to 300 MHz (Specify)
Audio Output	2.5 V Peak-to-Peak into 600 Ohms Unbalanced, +10 dB with 600 Ohm (Balanced option)
Spurious Response	−60 dB Minimum
Hum and Noise	−60 dB Minimum
Stability	0.005% (Crystal Controlled)
Image Rejection	80 dB
Sensitivity	3 µV for 30 dB Quieting (1 HF)
Selectivity	Less than 150 kHz at 30 dB down Less than 250 kHz at 50 dB down
Passband	200 kHz (Ceramic Filter)
AM Rejection	50 dB
Harmonic Distortion	Less than 1% (50 Hz to 15 kHz)
Capture Ratio	2.5 dB
Signal plus Noise/Noise	60 dB
Power Requirements	12.6 VDC, 115 mA (Powered by PS2500 Power Supply)

OPTIONS: 600 Ohm Balanced Audio Output

CATEL
DIVISION OF UNITED SCIENTIFIC CORPORATION
1400 D STIERLIN ROAD
P.O. BOX 1389
MOUNTAIN VIEW, CA 94042
415/965-9000 - TWX 910 379-6614

Litho in U.S.A. 7/76

T-3 RATE FIBER OPTIC TRANSMITTER MODEL FT-3201

GENERAL

DCC's T-3 Rate Fiber Optic Transmitter FT-3201 shown in Figure 1, accepts differential ECL inputs. It is capable of operation from DC to 100MB/s. The equipment meets telephone standards for high reliability transmission of telephone, data, or video traffic. The FT-3201 has been designed for use in DCC's FT-3 and FT-3C fiber optic transmission equipment. A block diagram of the transmitter is shown in Figure 2.

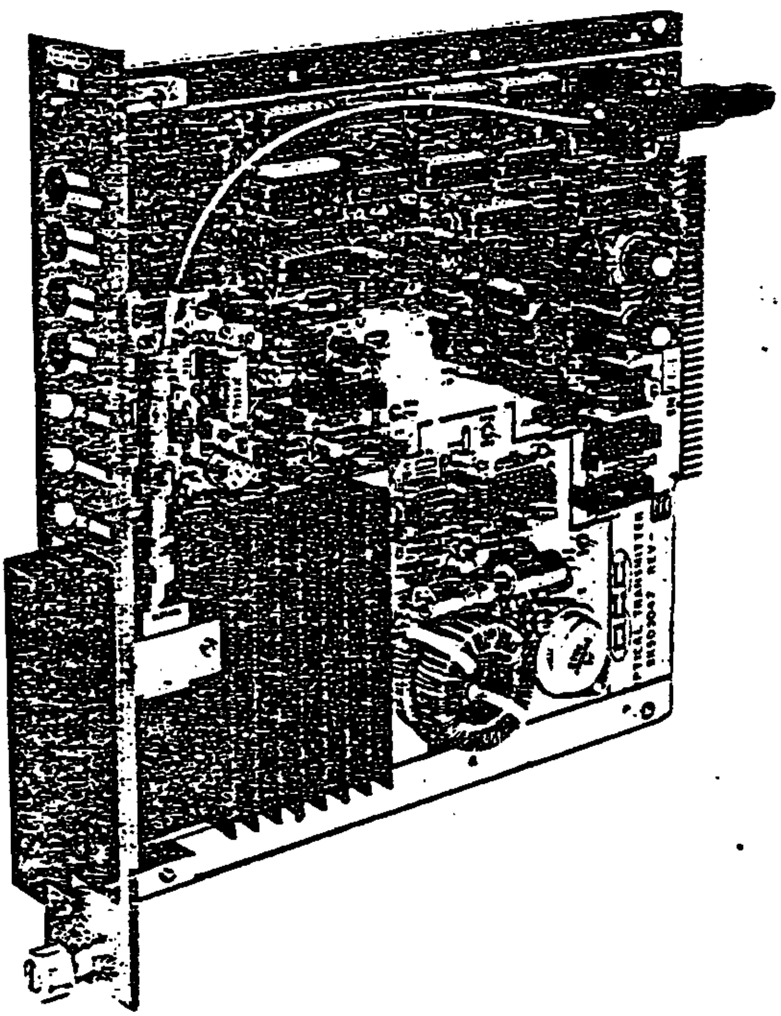


FIGURE 1.T-3 RATE FIBER OPTIC TRANSMITTER, FT-3201

FEATURES

- Injection Laser Diode Source
- DC to 100 MB/s Operation
- 10 Bit Scrambler
- Optional Thermoelectric Cooler
- Major and Minor Alarms
- Optical Feedback – Preventive Maintenance

Excellence in Telecommunications Engineering
Digital Communications Corporation
A M/A-COM COMPANY
11717 Exploration Lane
Germantown, Maryland 20767

SPECIFICATIONS

General	
Transmission Rate	DC to 100MB/s optimized for DS-3 and DS-3C operation
Electrical Signal Interface	NRZ-L ECL-Level, Differential
Optical	
Light source	Injection Laser
Operating Wavelength	820 nm (typical)
Fiber Pigtail	125 μ m dia. 50 μm core NA = 0.21 graded index fiber
Average Optical Power (at bulkhead connector)	OdBm. (typical)
Extinction ratio	>10:1
Electrical Power	
Operating voltage levels	± 8 v dc
Electrical power consumption	10 watts (max)
Mechanical	
Size	8.75"H x 1.375"W x 8.5"D
Mounting	19 inch terminal tray
Temperature	0°C to 50°C
Humidity	0-95% (no condensation)
Laser Temperature With TEC Cooler	30°C (Max)

In accordance with standards established by the Bureau of Radiological Health, DHEW, each of the labels below are attached to transmitter equipment.

****** DANGER ******

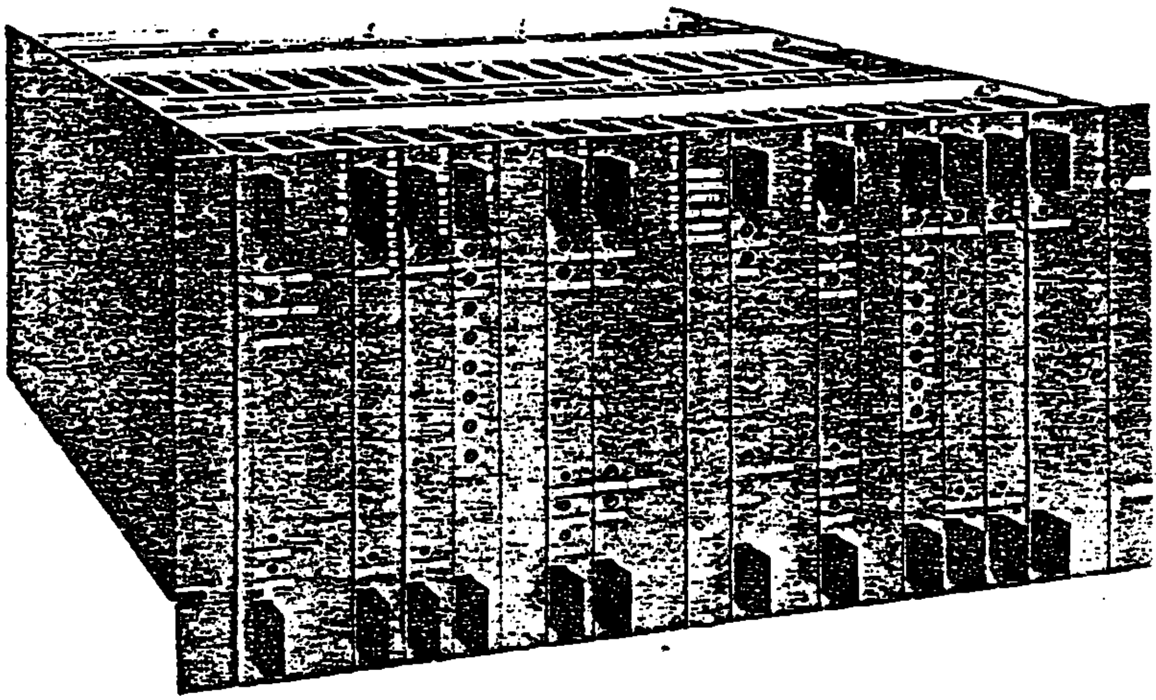
INVISIBLE LASER RADIATION
WHEN OPEN
(CONNECTOR REMOVED)
AVOID DIRECT EXPOSURE
TO BEAM

DIGITAL COMMUNICATIONS CORPORATION

MANUFACTURED ____________

COMPLIES WITH 21CFR 1040.10 & 1040.11

45 Mbps DIGITAL TELEVISION CODEC MODEL 6013



INTRODUCTION

The Model 6013 Digital Television Codec is a low cost, bandwith efficient digital video codec. It provides good quality digital NTSC color video at one-half the bit rate of standard PCM encoded video.

The Model 6013 Digital Television Codec offers TV transmission capability over digital links at the Bell System Standard T-3 rate of 44.736 Mbps. Its primary application is video transmission over fiber optic cable but will operate over other digital links as well.

KEY FEATURES

- **High quality television transmission.**
- **Two-to-one compression of the digital video using Differential PCM (DPCM) techniques.**
- **Interframe coding with adjacent pixel as well as previous line prediction.**
- **Line substitution for lines received in error.**
- **Adaptive quantizer (based on buffer memory fill status).**
- **Program audio (mono or stereo).**
- **Standard T-3 frame compatible (allows use of Standard T-3 rate monitoring equipment on digital link).**
- **Alarm LEDs on front panels.**
- **Front panel test points.**
- **Internal or external 44.736 MHz clock.**

There are two versions (network quality and CATV quality) of the Model 6013 Digital Television Codec. These two differ in their video performance specifications which result from different hardware implementations. The CATV quality version is upgradable to the network quality version by adding the Entropy Encoder Module and Buffer Memory Module to all encoders and by adding that Entropy Decoder Module and the Buffer Memory Module to all decoders. Additional jumper changes are also required. The CATV quality version has been given the designation 6013C and the network version has been given the designation 6013N.

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Digital Communications Corporation
A M/A-COM COMPANY
11717 Exploration Lane
Germantown, Maryland 20767
301/428-5500 TWX 710/828-[illegible]

SPECIFICATIONS

VIDEO INTERFACE **(BNC Coaxial Connectors)**

Signal Type	NTSC (color or monochrome)
Amplitude	1.0 V p-p
Impedance	75 ohms unbalanced
Polarity	Black negative
Bandwidth	0 - 4.2 MHz

AUDIO INTERFACE **(Terminal Block)**

Impedance	600 ohms balanced
Input and Output Level	0 dBm (nominal) (± 6 dB adjustment capability)

TRANSMISSION INTERFACE **(BNC Coaxial Connectors)**

Bit Rate	44.736 Mbps ± 20 ppm (Standard T-3 rate)
Clock	Internal crystal oscillator or external ECL level reference

VIDEO PERFORMANCE

	Model 6013C (CATV Quality)	Model 6103N (Network Quality)
Subjective Equivalent Signal-to-Noise Ratio (Peak signal to RMS weighted)	≥45 dB	≥54dB
Differential Phase	6° max.	4° max.
Differential Gain	12% max.	8% max.

AUDIO PERFORMANCE

Signal-to-Noise (Weighted)	62 dB
Harmonic Distortion (400 Hz)	≤0.5%
Total Distortion	≤0.75%

BER REQUIREMENT	1×10^{-8}
BER THRESHOLD	Good quality operation at 1×10^{-6}

MECHANICAL

Modular Arrangement

- Two sets of encoder modules, or
- Two sets of decoder modules, or
- One set of encoder modules and one set of decoder modules (shown in photo)

Size

Codec Tray	8.75" X 19" X 18"
Power Supply	Varies depending on configuration

ENVIRONMENT

Temperature	10° C to 40° C
Humidity	10% to 90% (noncondensing)
Power	115/230 VAC, 50/60 Hz, 48 VDC option available

OPTIONS

- Extender boards (two types)
- Mounting rack and blower
- Redundant power supplies

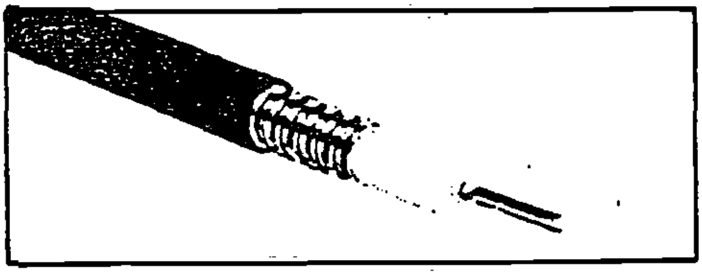
Information is preliminary and subject to change.

Digital Communications Corporation
A M/A-COM COMPANY

1/2″ FOAM-DIELECTRIC HELIAX® CABLE, TYPE LDF4-75

ANDREW

BULLETIN 1259



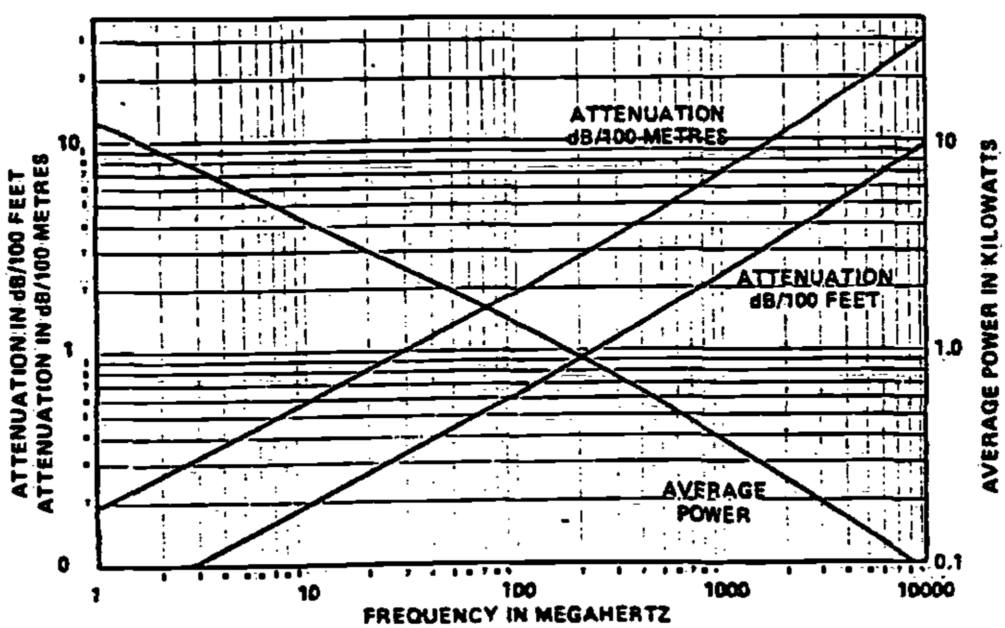
This 75-ohm LDF series foam-dielectric HELIAX coaxial cable provides a combination of strength, flexibility, and efficiency not available in other cables. The proprietary low-loss foam dielectric offers attenuation performance equalling that of air-dielectric cables of similar size. An annularly corrugated outer conductor, in conjunction with the connector "O"-ring seals, provides a longitudinal moisture block. Differential expansion is eliminated by mechanically locking the outer conductor and bonding the inner conductor to the dielectric.

The connectors feature a unique self-flaring design for superior electrical contact, high resistance to connector pull-off and twist-off and easy assembly with ordinary hand tools.

LDF4-75 is available in long continuous lengths for easy installation and maintenance-free service. The rugged black polyethylene jacket makes the cable suitable for direct burial or for installation in corrosive environments. The cable is suitable for installation down to −40°C (−40°F) and for operation up to 80°C (176°F).

CHARACTERISTICS FOR TYPE LDF4-75

Nominal Size	1/2″	Jacket Spark, volts, RMS	8000
Characteristic Impedance, ohms	75	Capacitance, pf/ft (m)	15.4 (50.5)
Inner Conductor	Cooper-Clad Aluminum	Inductance, μ h/ft (m)	0.087 (0.28)
Outer Conductor	Copper	Diameter over Jacket, in. (mm)	0.64 (16)
Maximum Frequency, GHz	10	Minimum Bending Radius, in. (mm)	5 (125)
Velocity, percent	88	Cable Weight, lbs/ft (kg/m)	0.14 (.21)
Peak Power Rating, kW	13	Bending Moment, *ft-lbs* (N · m)	2.8 (3.8)
D.C. Resistance, ohms/1000 ft (1000 m)		Tensile Strength, lbs (kg)	200 (90.7)
Inner	1.22 (4.00)	Flat Plate Crush Strength, lbs/in (kg/mm)	110 (2.0)
Outer	0.60 (1.97)	Number of Bends, Minimum	15
D.C. Breakdown, volts	4000	Typical	50



7/79

Andrew Corporation 10500 W. 153rd St. Orland Park, IL U.S.A. 60462

Andrew Antennas Lochgelly, Fife, Great Britain

Andrew Antenas Limitada Sorocaba, SP, Brazil

Antennes Andrew S.A.R.L. Nogent-le-Rotrou, France

Andrew Antenna Company Ltd.

Andrew Antennas

Antenas Y Peritajes

	Northern Telecom		Sieverts Kabelverk	
	mean	σ	mean	σ
Specified maximum	5.0		5.0	
On drums	2.9	0.5	3.1	0.2
After laying	3.0	0.5	3.3	0.3
Change	0.1	0.3	0.2	0.2

Table 4
Measured attenuation of the fibre lengths converted to 850 nm wavelength

50 % pulse height	Northern Telecom		Sieverts Kabelverk	
	mean	σ	mean	σ
Specified maximum 3 ns/km	1.5		1.5	
On drums	1.3	0.2	1.2	0.7
After laying	1.3	0.3	1.4	0.8
Change	0	0.1	0.2	0.3

Table 5
Measured dispersion of the fibre length at 850 nm wavelength

Cable length	8 km				10 km			
	Loop 1	Loop 2	Loop 3	Mean	Loop 1	Loop 2	Loop 3	Mean
Attenuation, dB	31.7	27.3	27.8	28.9	40.7	38.3	37.2	38.7
Dispersion at 50 %, ns	4.4	4.9	4.9	4.7	5.4	5.4	*)	
Bandwidth, MHz	101	88	86	92	85	85	*)	

*) No comparable measurement results are available

Table 6
Transmission data at 8 and 10 km.
Wavelength 850 nm. NT cable

Cable length	8 km				10 km			
	Loop 1	Loop 2	Loop 3	Mean	Loop 1	Loop 2	Loop 3	Mean
Attenuation, dB	32.5	33.7	31.3	32.5	43.0	42.2	41.1	42.1
Dispersion at 50 %, ns	4.2	6.6	4.6	5.1	5.4	6.4	5.7	5.9
Bandwidth, MHz	78	60	76	71	70	65	68	68

Table 7
Transmission data at 8 and 10 km.
Wavelength 850 nm. SKV cable

DATA SHEET ERICSSON GROUP

References

1. Giertz, H. and Vucins, V.: *34 Mbit/s Optical Fibre Line System, ZAM 34-1.* Ericsson Rev. 57 (1980):3, pp. 104–108.
2. Endersz, G.: *Optical Fibre Cables.* Ericsson Rev. 57 (1980):3, pp. 86–91.
3. Böttcher, U.: *Jointing of Optical Fibre Cables.* Ericsson Rev. 57 (1980):3, pp. 92–96.
4. Endersz, G. and Rodhe, P.: *Transmission Measurements on Optical Fibre Cables.* Ericsson Rev. 57 (1980):3, pp. 97–103.

APPENDIX J

HANDWRITTEN NOTES

TELEPHONE COST ESTIMATES

HANDWRITTEN CALCULATIONS

dBmV

NF Vin 10 w1

CNR = 59 - 8.5 + 10 - 10 log 11 = 50.09

Loss 1/2" 1.32/100 300

5/8" 1.08/100'

3/4" 0.91/100'

7/8" 0.79/100'

1.0" 0.75/100'

54 - 300

Trunk amplifier 1,000 each

54-300 MHz ±.25

Notes on CATV system

Highest frequency in cable typically 401 MHz

Band for TV = 350 MHz bandwidth or

35 channels of TV with 600 lines resolution

Amplifiers have 27 dB gain - operate at +10 dBm input with +37 dBm output

Cable should be selected such that trunk amplifiers can be mounted in cross passage

then 27 dB loss, at 401 MHz at multiple of 600' is ideal

7/8" = .82 dB/C = 3292 feet 27 dB

1/2" = 1.58 dB/C = ~~1588 feet~~ 1708 feet

P = .001 r

~~112~~16

31184

11 amplifiers

DELEUW
CATHER
De Leuw, Cather & Company
Engineers and Planners

SUBJECT ____ JOB NO. ____
Smalley
SHEET NO. ____ OF ____
MADE BY ____ DATE ____ CHECKED BY ____ DATE ____

House made cable 36 fibers

good cable 400 MHz/Km 3.5 dB/km atten.

bud type cable T2500-08-11

cost 6.33 per meter

for rodent shield add $1.00/meter

CATHER

De Leuw, Cather & Company
Consulting Engineers and Planners

SHEET NO. ____ OF ____

MADE BY ____ DATE ____ CHECKED BY ____ DATE ____

Calculate composite #19/22 cable lengths

Circuit to La Brea

$36.16x + 18y = 1500$

$x + y = 42.916$

$-18.16x = -772.488$

$-18.16x = 727.512$

$x = 40.061$ Kft #22 1448.6 Ω

$y = 2.855$ Kft #19 51.4 Ω

Circuit to Studio City 7 coils × 8.5 Ω = 59.5

$36.16x + 18y = 3500$

$x + y = 92.938$

$-18.16x = +1672.884$

$x = 100.812$

92.938
× 36.16
3361
+ 59.5
3420.5 Ω

Circuit to North Yard 18 coils × 8.5 Ω = 157.34

$36.16x + 18y = (3500 - 157.34) = 3342.$

$x + y = 108.951$

$-18.16x = +1961.12$ x+8

$= 1381.54$

-18.16

$x = 76.08$ Kft #22

32.794 Kft #19

Memorandum from
T. L. Green

Resistance of copper at 50°C

1,000'

#18 = 6.51 × 1.096 = 7.135/conductor

#19 = 8.21 × 1.096 = 8.998/conductor

#22 = 16.5 × 1.096 = 18.084/conductor

#19 loop resistance = 18Ω /1000'

#22 loop resistance = 36.2Ω/1000'

14 915

19 + 14 + 1 139087

Memorandum from
R. R. Williams

Tom,

Dan Page quoted the $ expense figure for the underground cable as 3.4%

If there is any need to call him, his number is 213 - 972 - 3402

ALTERNATIVE #1
MAINTENANCE & SPARES.

DeLEUW CATHER

De Leuw, Cather & Company
Engineers and Planners

SUBJECT ______ JOB NO. ______
______ SHEET NO. ______ OF ______
MADE BY ______ DATE ______ CHECKED BY ______ DATE ______

[illegible] 2 — T1 @ 3?? 91200

430 2 wire FXO @ [illegible] 61997

10 [illegible] @ 94.05 941

154,138

[illegible] one DOU/[illegible] Trunk @ 8400 8400

37 FXO 144.18 5335

8 [illegible] 94.05 752

1 data 468 468

6 NITEL 216.38 1298

16253

[illegible] PCM TRUNK CARRIER SYSTEM 96 chan.

6.312 MBS

North Yard T-2 12 port [illegible] 3700

24 T1 91200

~~[illegible]~~

North yard 1900

Phone 13841
468
1411
15720

~~S-521478 Line Connector 150.45~~
~~S-521772 Line Access unit 51.75~~
~~S-521497 Line Power unit 1 port 177.25~~
~~S-521575 Line Terminating kit 115~~
~~S-521494 4 repeater housing 144.51~~

Price out T1 carrier T1 = 2292

S521691	MUX shelf unit	1090.45
S521703	Transmit logic	169.25
S521704	Receive logic	169.25
521705	Switch power unit	176.65
521706	Power Connector	380.75
521707	Mode 3 line interface	89.35
521708	4-wire E&M channel unit	94.05
521713	2-wire E&M channel unit	112.85
521714	2-wire FXO	144.18
521715	2-wire FXS	155.15
521726	2-wire Auto Ringdown	216.38
521767	2.4KB data port	468.00
521698	fuse alarm	21.41

Today wire 1198 3 EACH T1 Board

Each T1 2292

3957

+ INTELE 2116?

Channel unit ... 395

+ cable

Full motion TV = 6.3 mbps TERMINAL = $90,000
interlace TV & Voice

44.7 mbps CODEC Xmit $12K
TV 45-50dB Rec $9K

45 mbps CODEC Interframe coding Xmit $28K
57-60 dB Rec $23K

T-3 optical terminal $8720
T-2 optical terminal 4500
T-2 line repeater 8200

Need quotation (budgetary) for Okonite RTT-MR cable in following quantities

Guage	Pairs	Length	Okonite Product	
#22	300	80,000'	707-15-3300	3609/kft.
#22	200	170,000'	707-15-3200	2398/kft
#22	150	30,000	707-15-3150	1820/kft
#22	75	6,000	707-15-3075	970/kft
#19	200	60,000	707-15-4200	4405/kft
#19	150	9,000	707-15-4150	3412/kft.
#19	75	22,000	707-15-4075	1766/kft

APPENDIX K

COST ESTIMATE SHEETS

DeLEUW CATHER

De Leuw, Cather & Company
Consulting Engineers and Planners

SUBJECT COST ESTIMATE JOB NO. 3469-00

WIRELINE - ALTERNATIVE #1 - PRIMARY CIRCUIT #1 SHEET NO. ____ OF ____

MADE BY ____ DATE ____ CHECKED BY ____ DATE ____

NO	ITEM NO.	DESCRIPTION	NOTES	QUANTITY	UNIT	UNIT PRICE $	AMOU[NT] $
	1	Cable	AWG #22, 300 pair OKONITE 717-15-3300	8.4	Kft	3609	30 31
	2	Cable	AWG #33, 150 pair OKONITE 717-15-3150	8.4	Kft	1820	15 28
	3	Splice Cases	For Armored, buried cable	6	EA	18	10
	4	Splice Sleeves		5400	EA	0.10	54
	5	Protector Blocks	4 X 26	17	EA	167	2 83
			Total Material				49 091
			INSTALLATION COSTS				
	1	Equipment Rental	@ 8 hrs / 1,000' cable	67.2	HRS	27.70	2 352
	2	LABOR	Pull Cable, Electrician 40 HRS/1,000'	320	HRS	27.70	8 864
	3	Splice Cable	Electrician @ 0.033 HRS/Splice	180	HRS	27.70	4 986
	4	Terminate Cables	Electrician @ 0.083 HRS/pair	75	HRS	27.70	2 078
			Total Installation				18 280
			Total Circuit Cost				67 371

DeLEUW CATHER

De Leuw, Cather & Company
Consulting Engineers and Planners

SUBJECT: COST ESTIMATE
WIRELINE – ALTERNATIVE 1 – PRIMARY CIRCUIT #2

JOB NO. 3469-00
SHEET NO. ____ OF ____
MADE BY ____ DATE ____ CHECKED BY ____ DATE ____

NO	ITEM NO.	DESCRIPTION	NOTES	QUANTITY	UNIT	UNIT PRICE $	AMOU $
	1	Cable	AWG#22, 300 pair, OKONITE 717-15-3300	5.124	Kft	3609	18 49
	2	Cable	AWG#22, 200 pair, OKONITE 717-15=3200	4.139	Kft	2398	9 92
	3	Cable	AWG#22, 150 pair, OKONITE 717-15-3150	2.826	Kft	1820	5 14
	4	Cable	AWG#22, 75 pair, OKONITE 717-15-3075	2.826	Kft	970	2 74
	5	Splice Cases	Buried Cable	4	EA	18	7
	6	Splice Sleeves		2800	EA	0.10	28
	7	Terminal Blocks	Bee hive	7	EA	16	13
	8	Protector Blocis	4 X 26	24	EA	167	4 008
			MATERIAL COSTS				41 439
			INSTALLATION COSTS				
	1	Equipment	Rental @ 8 hrs/1,000'	119	HRS	35.00	4 165
	2	Labor	Pull Cable Electrician @ 40 hrs/1,000'	597	Hrs	27.70	16 537
	3	Splice Cable	Electrician @ 0.033 hrs/splice	93	Hrs	27.70	2 576
	4	Terminate Cables	Electrician @ 0.083 hrs/pair	95.5	Hrs	27.70	2 645
			Total Installation				25 923
			TOTAL COST CIRCUIT #2				67 362

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De Leuw, Cather & Company
Consulting Engineers and Planners

SUBJECT: COST ESTIMATE JOB NO. 3469-00

WIRELINE - ALTERNATIVE #1 - PRIMARY CIRCUIT #3 SHEET NO. ____ OF ____

MADE BY ____ DATE ____ CHECKED BY ____ DATE ____

NO	ITEM NO.	DESCRIPTION	NOTES	QUANTITY	UNIT	UNIT PRICE $	AMOU[illegible] $
	1	Cable	AWG#22, 300 pair OKONITE 717-15-3300	26.232	Kft	3609	94 67
	2	Cable	AWG#22, 200 pair OKONITE 717-15-3200	2.826	Kft	2398	6 77
	3	Cable	AWG#22, 150 pair OKONITE 717-15-3150	2.826	Kft	1820	5 14
	4	Cable	AWG#22, 75 Pair OKONITE 717-15-3075	5.0	Kft	970	4 85
	5	Cable	AWG#19, 75 pair OKONITE 717-15-4075	6.0	Kft	1766	10 59
	6	Splice Cases	Buried Cable	15	EA	18	27
	7	Splice sleeves		9000	EA	0.10	90
	8	Loading Coils	88mh, 300 stack	4	EA	832	3 23
	9	Loading Coils	88mh, 200 stack	1	EA	585	58
	10	Loading Coils	88mh, 75 stack	1	EA	215	21
	11	Terminal Blocks	Bee Hive	10	EA	16	16
	12	Protector Blocis	4 X 26	22	EA	167	3 674
			Material Costs				134 164
			INSTALLATION COSTS				
	1	Equipment	Rental @ 8 hrs/1,000'	255	HRS	35.00	8 925
	2	Labor	Pull Cable Electrician @ 40 hrs/1,000'	1276	HRS	27.70	35 345
	3	Splice Cable	Electrician @ 0.033 hrs/splice	300	HRS	27.70	8 310
	4	Terminate Cable	Electrician @ 0.083 hrs/pair	174	HRS	27.70	4 820
	5	Mount Coil Stacks	@ 4 hours per location.	24	HRS	27.70	665
			Total INstallation				58 065
			Total Circuit Costs				191 987

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SUBJECT COST ESTIMATE JOB NO. 3469=-00
WIRELINE - ALTERNATIVE #1 - PRIMARY CIRCUIT # 4 SHEET NO. ____ OF ____
MADE BY ____ DATE ____ CHECKED BY ____ DATE ____

NO	ITEM NO.	DESCRIPTION	NOTES	QUANTITY	UNIT	UNIT PRICE $	AMOU $
	1	Cable	AWG#22, 300 pair OKONITE 717-15-3300	55.218	Kft	3609	199 282
	2	Cable	AWG#22, 200 pair OKONITE 717-15-3200	5.452	Kft	2398	13 07
	3	Cable	AWG#22, 75 pair OKONITE 717-15-3075	32.169	Kft	970	31 20
	4	Splice Cases	Buried Cable	61	EA	18	1 09
	5	Splice sleeves		35350	EA	0.10	3 53
	6	Loading Coils	88mh, 300 stack	9	EA	832	7 48
	7	Loading Coils	88mh, 200 stack	2	EA	580	1 16
	8	Loading Coils	88mh, 75 stack	5	EA	215	1 075
	9	Long Line Adaptor	Loop Extender	300	EA	167	50 100
	10	Amplifiers	Voice Frequency	300	EA	116	34 800
	11	Equipment Racks	7 feet tall, 19 inch panel	4	EA	200	800
	12	Card Shelves	10 card, 19"	60	EA	64	3 840
	13	Power Supply	48 volts	1	EA	560	560
	14	Fuse Panels		13	EA	68	884
	15	Fuses		300	EA	0.35	10
	16	Terminal Blocks	Bee Hive	9	EA	16	14
	17	Protector Blocks	4 X 26	24	Ea	167	4 00
			MATERIAL TOTAL				322 51

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SUBJECT: COST ESTIMATE
WIRELINE - ALTERNATIVE #1 - PRIMARY CIRCUIT #4

JOB NO. 3469-00
SHEET NO. ____ OF ____
MADE BY ____ DATE ____ CHECKED BY ____ DATE ____

NO	ITEM NO.	DESCRIPTION	NOTES	QUANTITY	UNIT	UNIT PRICE $	AMOU $
			INSTALLATION COSTS				
	1	Equipment	Rental at 8 hrs/1,000'	743	Hrs	35.00	26 005
	2	Labor	Pull Cable Electrician @ 40 hrs/1,000'	3714	Hrs	27.70	102 876
	3	Splice Cable	Electrician @ 0.033/splice	1178	HRS	27.70	32 631
	4	Terminate Cable	Electrician @ 0.083 hrs/pair	146	HRS	27.70	4 044
	5	Mount Load Coils	4 hrs per location	64	HRS	27.70	1 773
	6	Mount Racks	2 HRS/rack	8	Hrs	27.70	222
	7	Install Shelves	1 Hr/shelf	60	HRS	27.70	1 662
	8	Install Cards	Wire backplane @ 1 hr/card	600	HRS	27.70	16 620
	9	Power Supply	Install and wire to racks	24 HRS	HRS	27.70	665
	10	Fuse Panels	Mount in racks and wire, 1/2 hr each fuse	150	HRS	27.70	4 155
			TOTAL INSTALLATION				190 665
			TOTAL CIRCUIT #4				513 182

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SUBJECT COST ESTIMATE JOB NO. 3469-00

WIRELINE - ALTERNATIVE # 1 - PRIMARY CIRCUIT #5 SHEET NO. ____ OF ____

MADE BY ____ DATE ____ CHECKED BY ____ DATE ____

NO	ITEM NO.	DESCRIPTION	NOTES	QUANTITY	UNIT	UNIT PRICE $	AMOU $
	1	Cable	AWG#22, 200 pair, OKONITE 717-15-3200	76.080	Kft	2398	182 440
	2	Cable	AWG#19, 200 pair, OKONITE 717-15-4200	28.504	Kft	4405	136 962
	3	Cable	AWG#19, 150 pair, OKONITE 717-15-4150	4.467	Kft	3412	15 241
	4	Splice Cases	Buried Cable	34	EA	18	612
	5	Splice Sleeves		13500	EA	0.10	1 350
	6	Loading Coils	88mh, 200 stack	18	EA	580	10 440
	7	Long Line Adaptor	loop extender	200	EA	167	33 400
	8	Amplifier	Voice Frequency	200	EA	116	23 200
	9	Equipment Racks	7 feet high, 19 inch panel	3	EA	200	600
	10	Card Shelves	10-card, 19 inch panel	45	EA	64	2 880
	11	Fuse Panels		8	EA	68	544
	12	Fuses		200	EA	0.35	70
	13	Power Supply		1	EA	560	560
	14	Terminal Blocks	Bee Hive	2	EA	16	32
	15	Protector Blocks	4 X 26	14	EA	167	2 338
			TOTAL MATERIAL				407 789

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SUBJECT COST ESTIMATE
WIRELINE - ALTERNATIVE #1 - PRIMARY CIRCUIT #5

JOB NO. 3469-00
SHEET NO. ____ OF ____

MADE BY ____ DATE ____ CHECKED BY ____ DATE ____

NO	ITEM NO.	DESCRIPTION	NOTES	QUANTITY	UNIT	UNIT PRICE $	AMOU[NT] $
			INSTALLATION COSTS				
	1	Equipment	Rental @ 8 hrs/1,000'	147	HRS	35.00	5,14
	2	Labor	Pull CAble, Electrician @ 40 hrs/1,000'	5563	HRS	27.70	154,09
	3	Splice Cable	Electrician @ 0.033 hrs/splics	450	HRS	27.70	12,46
	4	Terminate Cable	Electrician @ 0.083 hrs/pair	562	HRS	27.70	15,56
	5	Mount Load Coils	@ 4 hrs per location	72	HRS	27.70	1,99
	6	Mount Racks	2 hrs/rack	6	HRS	27.70	16
	7	Install shelves	1 hrs/shelf	45	HRS	27.70	1,24
	8	Install CArds	Wire backplane @ 1 hr/card	400	HRS	27.70	11,08
	9	Power Supply	Install and wire to racks	24	HRS	27.70	66
	10	Fuse Panels	Mount in racks and wire 1/2 hour/fuse	100	HRS	27.70	2,77
			TOTAL INSTALLATION				205,19
			TOTAL CIRCUIT #5				612,98

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SUBJECT: COST ESTIMATE — JOB NO. 3469-00

VIDEO CIRCUIT #1 - ALTERNATIVES 1 & 2 — SHEET NO. ____ OF ____

MADE BY ____ DATE ____ CHECKED BY ____ DATE ____

NO	ITEM NO.	DESCRIPTION	NOTES	QUANTITY	UNIT	UNIT PRICE $	AMOU $
	1	MODULATORS	FM, SINGLE CHANNEL, NTSC	22	EA	2780	61 160
	2	DEMODULATORS	FM SINCLE CHANNEL , NTSC	22	EA	2966	65 252
	3	TRUNK AMPLIFIERS	54-400 Mhz	18	EA	1050	18 900
	4	EQUALIZERS		18	EA	240	4 320
	5	CABLE	COAXIAL 1/2", 75 ohm	22,321	FT	2.02	45 088
	6	CABLE CONNECTORS	CATV TO FIT TRUNK AMPLIFIERS	38	EA	11.00	418
	7	SPLITTER	4-WAY Combiner	3	EA	750	2 250
	8	SPLITTER	4-WAY SEPARATOR	3	EA	750	2 250
	9	SPLITTER	5-WAY Combiner	2	EA	900	1 800
	10	SPLITTER	5-WAY SEPARATOR	2	EA	900	1 800
	11	RACKS	7 feet tall, 19 inch panels	10	EA	200	2 000
	12	POWER SUPPLY, DC	TRUNK AMPLIFIERS	1	395		395
	13	DIRECTIONAL COUPLERS		5	EA	85	425
			MATERIAL COSTS				204 438

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Consulting Engineers and Planners

SUBJECT COST ESTIMATE JOB NO. 3469-00

VIDEO CIRCUIT #1 - ALTERNATIVES 1 & 2 SHEET NO. ____ OF ____

MADE BY ____ DATE ____ CHECKED BY ____ DATE ____

NO	ITEM NO.	DESCRIPTION	NOTES	QUANTITY	UNIT	UNIT PRICE $	AMOU $
	1	Install Racks	2 hrs per rack	20	HRS	27.70	554
	2	Modulators/demodulators	Install and Wire. 1 Hr/each	44	HRS	27.70	1 219
	3	Trunk Amplifiers	Install @ 2 hrs each	36	HRS	27.70	997
	4	Equalizers	Install @ 1 hr each	18	HRS	27.70	499
	5	Ancillary Equipment	Install & Test @ 40 hrs/site	240	HRS	27.70	6 648
	6	Cable	Pull In Cable Electrician @ 40 hrs/1,000'	893	HRS	27.70	24 736
	7	Cable	Attach connectors @ 1 hr each	38	HRS	27.70	1 053
	8	Cable.	Equipment rental @ 8 hrs/1,000'	179	HRS	35.00	6 265
			INSTALLATION COSTS				41 971

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SUBJECT: COST ESTIMATE
VIDEO CIRCUIT #2 - ALTERNATIVES 1 & 2

JOB NO. 3469-00

SHEET NO. ______ OF ______

MADE BY ______ DATE ______ CHECKED BY ______ DATE ______

NO	ITEM NO.	DESCRIPTION	NOTES	QUANTITY	UNIT	UNIT PRICE $	AMOU[NT] $
	1	MODULATORS	FM, SINGLE CHANNEL, NTSC	25	EA	2780	69 50
	2	DEMODULATORS	FM, SINGLE CHANNEL, NTSC	25	EA	2699	74 15
	3	TRUNK AMPLIFIERS	54-400 MHZ	38	EA	1050	39 90
	4	EQUALIZERS		38	EA	240	9 12
	5	CABLE	Coaxial Cable, 1/2", 75 ohm	54818	FT	2.02	110,73
	6	CABLE CONNECTORS	CATV TO ATTACH TO TRUNK AMPLIFIERS	78	EA	11.00	85
	7	SPLITTER	4-WAY, COMBINER	5	EA	750	3 75
	8	SPLITTER	4-WAY, SEPARATOR	5	EA	750	3 75
	9	SPLITTER	5-WAY, COMBINER	1	EA	900	90
	10	SPLITTER	5-WAY, ~~COMBINER~~ separator	1	EA	900	90
	11	RACKS	7 FEET TALL, 19 INCH PANELS	12	EA	200	2 40
	12	POWER SUPPLY		1	EA	395	39
	13	DIRECTIONAL COUPLERS		6	EA	85	51
			MATERIAL COSTS				316 86

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Consulting Engineers and Planners

SUBJECT COST ESTIMATE
VIDEO CIRCUIT #2 - ALTERNATIVES 1 & 2

JOB NO. 3469-00
SHEET NO. ____ OF ____

MADE BY ____ DATE ____ CHECKED BY ____ DATE ____

NO	ITEM NO.	DESCRIPTION	NOTES	QUANTITY	UNIT	UNIT PRICE $	AMO[illegible] $
	1	MODULATOR/DEMODULATOR	Install & wire, @ 1 hr/unit	50	HRS	27.70	1 38[illegible]
	2	RACKS	Install @ 2 HRS EACH	24	HRS	27.70	66[illegible]
	3	TRUNK AMPLIFIERS	INSTALL @ 2 HRS EACH	76	HRS	27.70	2 10[illegible]
	4	EQUALIZERS	INSTALL @ 1 HR EA	38	hrs	27.70	1 05[illegible]
	5	ANCILLARY EQUIPMENT	INSTALL & TEST @ 40 HRS/SITE	280	HRS	27.70	7 75[illegible]
	6	CABLE	INSTALL CONNECTORS @ 1 HR EACH	78	HRS	27.70	2 16[illegible]
	7	CABLE	PULL IN - ELECTRICIAN @ 40 HRS/1,000'	2193	HRS	27.70	60 74[illegible]
	8	CABLE	EQUIPMENT RENTAL @ 8 HRS/1,000'	439	HRS	35.00	15 30[illegible]
			INSTALLATION COSTS				91 2[illegible]
			TOTAL CIRCUIT COSTS				408 1[illegible]

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SUBJECT COST ESTIMATE JOB NO. 3469-00

VIDEO CIRCUIT #3 - ALTERNATIVES 1 & 2 SHEET NO. ____ OF ____

MADE BY ____ DATE ____ CHECKED BY ____ DATE ____

NO	ITEM NO.	DESCRIPTION	NOTES	QUANTITY	UNIT	UNIT PRICE $	AMO[UNT] $
	1	MODULATORS	FM, SINGLE CHANNEL, NTSC	12	EA	2780	33 3
	2	DEMODULATORS	FM, SINGLE CHANNEL, NTSC	12	EA	2966	35 5
	3	trunk amplifiers	54-400 MHZ	50	EA	1050	52 5
	4	EQUALIZERS		50	EA	240	12 0
	5	CABLE	COAXIAL 1/2", 75 ohm	104384	FT	2.02	210 8
	6	CABLE CONNECTORS	CATV TO FIT TRUNK AMPLIFIERS	102	EA	11.00	1 1
	7	SPLITTER	4-WAY COMBINER	3	EA	750	2 2
	8	SPLITTER	4-WAY SEPARATOR	3	EA	750	2 2
	9	RACKS	7 FEET TALL 19" PANELS	6	EA	200	1 2
	10	POWER SUPPLY		1	EA	395	3
	11	DIRECTIONAL COUPLERS		3	EA	85	2
			MATERIAL COSTS				350 5

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SUBJECT: COST ESTIMATE
VIDEO CIRCUIT #3 - ALTERNATIVES 1 & 2

JOB NO. 3469-00

SHEET NO. ____ OF ____

MADE BY ____ DATE ____ CHECKED BY ____ DATE ____

NO	ITEM NO.	DESCRIPTION	NOTES	QUANTITY	UNIT	UNIT PRICE $	AM
	1	RACKS	INSTALL AT 2 HRS each	24	HRS	27.70	6
	2	MODULATORS/DEMODULATORS	INSTALL & WIRE @ 1 HR	24	HRS	27.70	6
	3	TRUNK AMPLIFIERS	INSTALL @ 2 HOURS PER AMPLIFIER	100	HRS	27.70	2 7
	4	EQUALIZERS	INSTALL @ 1 HR EA	50	HRS	27.70	1 8
	5	ANCILLARY EQUIPMENT	INSTALL & TEST AT 40 HOURS/	320	HRS	27.70	8 8
	6	CABLE	CONNECTORS INSTALL @ 1 HR EA	102	HRS	27.70	2 8
	7	CABLE	PUL IN @ 40 HOURS ELECTRICIAN/1,000'	4175	HRS	27.70	115 6
	8	CABLE	EQUIPMENT RENTAL @ 8 HOURS/1,000'	835	HRS	27.70	23 1
			TOTAL INSTALLATION COST				156 4
			TOTAL CIRCUIT COST				506 9

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SUBJECT: COST ESTIMATE — JOB NO. 3469-00

VIDEO CIRCUITS - ALTERNATIVES 1 & 2 - REDUNDANT CABLE — SHEET NO. ____ OF ____

MADE BY ____ DATE ____ CHECKED BY ____ DATE ____

NO	ITEM NO.	DESCRIPTION	NOTES	QUANTITY	UNIT	UNIT PRICE $	A
	1	CABLE	1/2 INCH COAXIAL, 75 ohms	181,523	FT	2.02	366
	2	CABLE	CONNECTORS	218	EA	11.00	2
	3	TRUNK AMPLIFIERS	54-400 MHZ	106	EA	1050	111
	4	EQUALIZERS		106	EA	240	25
	5	POWER SUPPLY		3	EA	395	1
	6	COUPLERS	DIRECTIONAL	14	EA	85	1
	7	SWITCH	AUTOMATIC, COAXIAL WITH LOGIC	3	EA	870	2
			MATERIAL COST				510
			INSTALLATION COSTS				
	1	CABLE	EQUIPMENT RENTAL @ 8 HRS/1,000 feet	1452	HRS	35.00	50
	2	CABLE	PULL IN ELECTRICIAN @ 40 HRS/1,000	7261	HRS	27.70	201
	3	CABLE	CONNECTORS @ 1 HR EACH	218	HRS	27.70	6
	4	TRUNK AMPLIFIERS	INSTALL @ 2 HRS EACH	212	HRS	27.70	5
	5	EQUALIZERS	INSTALL @ 1 HR EACH	106	HRS	27.70	2
	6	ANCILLARY EQUIPMENT		72	HRS	27.70	1
	7	COAXIAL SWITCHES	INSTALL & TEST	96	HRS	27.70	2
			INSTALLATION COSTS				271
			TOTAL REDUNDANT CABLE COST				781

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SUBJECT COST ESTIMATE — OUTBOUND COAXIAL CABLE - ALTERNATIVE #2

JOB NO. 3469-00

SHEET NO. ______ OF ______

MADE BY ______ DATE ______ CHECKED BY ______ DATE ______

NO	ITEM NO.	DESCRIPTION	NOTES	QUANTITY	UNIT	UNIT PRICE $	AM
	1	COAXIAL CABLE	COAXIAL, 1/2", 75 OHMS	119,352	FT	2.02	241 09
	2	CABLE CONNECTORS	CATV TO MATE WITH TRUNK AMPLIFIERS	66	EA	11.00	72
	3	AMPLIFIERS, TRUNK	54-400 MHZ	32	EA	1050	33 60
	4	EQUALIZERS		20	EA	240	4 80
	5	DEMODULATORS		17	EA	2966	50 42
	6	DIRECTIONAL COUPLERS		16	EA	85	1 36
	7	RACKS	7 FEET TALL, 19 INCH PANEL	16	EA	200	3 20
			MATERIAL COSTS				304 95
			INSTALLATION				
	1	RACKS	INSTALL AT 2 HRS EA	32	HRS	27.70	886
	2	EQUALIZERS	@ 1 HR EACH	20	HRS	27.70	554
	3	TRUNK AMPLIFIERS	@ 2 HOURS EACH	64	HRS	27.70	1 77
	4	DEMODULATORS	INSTALL AND WIRE @ 1 HR EACH	17	HRS	27.70	47
	5	DIRECTIONAL COUPLERS	@ 1 HR EACH	16	HRS	27.70	44
	6	CABLE	PULL IN ELECTRICIAN @ 40 HRS/1,000'	4774	HRS	27.70	132 24
	7	CABLE	EQUIPMENT RENTAL @ 8 HRS/1,000'	955	HRS	35.00	33 42
	8	CABLE	CONNECTORS @ 1 HR EACH	66	HRS	27.70	1 82
			INSTALLATION COSTS				171 61
			TOTAL COST OUTBOUND CABLE				476 57

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SUBJECT COST ESTIMATE JOB NO. 3469-00

REDUNDANT OUTBOUND COAXIAL CABLE - ALTERNATIVE 2 - VOICE CIRCUITS SHEET NO. ____ OF ____

MADE BY ____ DATE ____ CHECKED BY ____ DATE ____

NO	ITEM NO.	DESCRIPTION	NOTES	QUANTITY	UNIT	UNIT PRICE $	AMOUN $
	1	CABLE	1/2 INCH COAXIAL, 75 OHMS	120,352	FT	2.02	243 111
	2	CABLE	CONNECTORS CATV TYPE TO FIT TRUNK AMPLIFIERS	82	FT	11.00	902
	3	TRUNK AMPLIFIERS	54-400 MHZ	40	EA	1050	42 000
	4	EQUALIZERS		40	EA	240	9 600
	5	DIRECTIONAL COUPLERS		16	EA	85	1 360
			MATERIAL COST REDUNDANT OUT				296 973
			INSTALLATION COSTS				
	1	TRUNK AMPLIFIERS	INSTALL @ 2 HRS EACH	80	HRS	27.70	2 216
	2	DIRECTIONAL COUPLERS	@ 1 HR EACH	16	HRS	27.70	443
	3	CABLE CONNECTORS	@ 1 HR EACH	82	HRS	27.70	2 271
	4	CABLE	PULL IN ELECTRICIAN 40 HRS/1,000"	4818	HRS	27.70	133 459
	5	CABLE	EQUIPMENT RENTAL @ 8 HRS/1,000"	979	HRS	27.70	34 265
			TOTAL INSTALLATION COSTS				172 654
			TOTAL COST REDUNDANT OUTBOUND VOICE				469 627

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Consulting Engineers and Planners

SUBJECT: COST ESTIMATE
INBOUND COAXIAL CABLE - ALTERNATIVE 2 - VOICE CIRCUITS

JOB NO. 3469-00
SHEET NO. ______ OF ______

MADE BY ______ DATE ______ CHECKED BY ______ DATE ______

NO	ITEM NO.	DESCRIPTION	NOTES	QUANTITY	UNIT	UNIT PRICE $	A
	1	CABLE	1/2 INCH COAXIAL, 75 OHMS	120,352	FEET	2.02	243
	2	CABLE	CONNECTORS CATV TO FIT TRUNK AMPLIFIERS	82	FT	11.00	
	3	TRUNK AMPLIFIERS	54-400 MHZ	40	EA	1050	42
	4	EQUALIZERS		40	EA	240	9
	5	MODULATORS	FM, SINGLE CHANNEL, NTSC	16	EA	2780	44
	6	DIRECTIONAL COUPLERS		16	EA	85	1
	7	RACKS	7 FEET, 19 INCH PANEL	16	EA	200	3
			MATERIAL COSTS				344
			INSTALLATION COSTS				
	1	RACKS	@ 2 HRS EACH	32	HRS	27.70	8
	2	CABLE CONNECTORS	@ 1 HRS EACH	82	HRS	27.70	2
	3	TRUNK AMPLIFIERS	@ 2 HRS EACH	80	HRS	27.70	2
	4	MODULATORS	INSTALL & WIRE @ 1 HR	16	HRS	27.70	
	5	DIRECTIONAL AMPLIFIERS	INSTALL @ 1 HR EACH	16	HRS	27.70	
	6	CABLE	PULL IN ELECTRICIAN 40 HRS/1,000'	4818	HRS	27.70	133
	7	CABLE	EQUIPMENT RENTAL @ 8 HRS/1,000'	979	HRS	35.00	34
			INSTALLATION COSTS				173
			TOTAL INBOUND CIRCUIT				518

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SUBJECT COST ESTIMATE JOB NO. 3469-00

REDUNDANT INBOUND COAXIAL CABLE - ALTERNATIVE 2 VOICE CIRCUITS SHEET NO. ____ OF ____

MADE BY ____ DATE ____ CHECKED BY ____ DATE ____

NO	ITEM NO.	DESCRIPTION	NOTES	QUANTITY	UNIT	UNIT PRICE $	A[illegible]
	1	CABLE	1/2 INCH, COAXIAL CABLE, 75 OHMS	119,352	FT	2.02	241
	2	CABLE CONNECTORS	CATV TYPE TO FIT TRUNK AMPLIFIERS	66	EA	11.00	
	3	TRUNK AMPLIFIERS	54-400 MHZ	32	EA	1050	33
	4	EQUALIZERS		20	EA	240	4
	5	DIRECTIONAL COUPLERS		16	EA	85	1
			MATERIAL COSTS				281
			INSTALLATION COSTS				
	1	CABLE CONNECTORS	@ 1 HR EACH	66	HRS	27.70	1
	2	TRUNK AMPLIFIERS	@ 2 HRS EACH	64	HRS	27.70	1
	3	COUPLERS	@ 1 HOURS EACH	16	HRS	27.70	
	4	CABLE	PULL IN ELECTRICIAN @ 40 HRS/1,000"	4774	HRS	27.70	132
	5	CABLE	EQUIPMENT RENTAL @ 8 HRS/1,000"	955	HRS	35.00	33
			INSTALLATION COSTS				169
			TOTAL COST REDUNDANT INBOUND CABLE				451

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SUBJECT COST ESTIMATE JOB NO. 3469-00

COAXIAL CABLE - ALTERNATIVE 2 - CENTRAL CONTROL VOICE SHEET NO. ______ OF ______

MADE BY ______ DATE ______ CHECKED BY ______ DATE ______

NO	ITEM NO.	DESCRIPTION	NOTES	QUANTITY	UNIT	UNIT PRICE $	A
	1	MODULATORS	FM SINGLE CHANNEL	5	EA	2780	13
	2	DEMODULATORS	FM SINGLE CHANNEL	16	EA	2966	47
	3	RACKS	7 FEET, 19 INCH PANELS	5	EA	200	1
			MATERIAL CENTRAL CONTROL				63
			INSTALLATION				
	1	RACKS	@ 2 HRS EACH	10	HRS	27.70	
	2	MODULATORS	INSTALL & WIRE @ 1 HR EACH	5	HRS	27.70	
	3	DEMODULATORS	INSTALL & WIRE @ 1 HR EACH	16	HRS	27.70	
	4	INTERCONNECT	VIDEO MODULATORS TO MULTIPLEXERS	160	HRS	27.70	4
	5	TEST		40	HRS	27.70	1
			[illegible]				[illegible]
			OTAL INSTALLATION COSTS				6
			TOTAL RF EQUIPMENT COSTS				68

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SUBJECT COST ESTIMATE JOB NO. 3469-00

COAXIAL CABLE - ALTERNATIVE 2 VOICE CIRCUITS SHEET NO. ____ OF ____

MADE BY ________ DATE ________ CHECKED BY ________ DATE ________

NO	ITEM NO.	DESCRIPTION	NOTES	QUANTITY	UNIT	UNIT PRICE $	A
			T1 & T2 PCM EQUIPMENT BY LOCATION				
		CENTRAL CONTROL	INCLUDES CHANNEL UNITS				528
		MAIN YARD	INCLUDES CHANNEL UNITS				161
		UNION STATION	INCLUDES CHANNEL UNITS				22
		CIVIC CENTER	INCLUDES CHANNEL UNITS				22
		FIFTH & HILL	INCLUDES CHANNEL UNITS				22
		SEVENTH & FLOWER	INCLUDES CHANNEL UNITS				24
		ALVARADO	INCLUDES CHANNEL UNITS				23
		VERMONT	INCLUDES CHANNEL UNITS				22
		NORMANDIE	INCLUDES CHANNEL UNITS				22
		WESTERN	INCLUDES CHANNEL UNITS				25
		LA BREA	INCLUDES CHANNEL UNITS				23
		FAIRFAX	INCLUDES CHANNEL UNITS				24 2
		BEVERLY	INCLUDES CHANNEL UNITS				23 3
		SANTA MONICA	INCLUDES CHANNEL UNITS				33 1
		STUDIO CITY	INCLUDES CHANNEL UNITS				25 9
		NORTH HOLLYWOOD	INCLUDES CHANNEL UNITS				23 1
		NORTH YARD	INCLUDES CHANNEL UNITS				37 7
			PCM MATERIAL COSTS			1	077 6
		INSTALL & TEST	@ 80 HOURS PER T-1 TERMINAL	11360	HRS	27.70	314 6
			COST FOR PCM VOICE EQUIPMENT			1	392 2

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SUBJECT COST ESTIMATE JOB NO. 3469-00

FIBER OPTICS - ALTERNATIVE 3 - CABLE CIRCUIT 1 SHEET NO. ____ OF ____

MADE BY ____ DATE ____ CHECKED BY ____ DATE ____

NO	ITEM NO.	DESCRIPTION	NOTES	QUANTITY	UNIT	UNIT PRICE $	AMO $
	1	FIBER CABLE	38 FIBERS, RODENT SHIELD	1.5	KM	32480	48 600
	2	FIBER CABLE	32 fibers, rodent shield	1.2	KM	27600	33 120
	3	FIBER CABLE	25 FIBERS, RODENT SHIELD	0.8	KM	21500	17 200
	4	FIBER CABLE	18 FIBERS, RODENT SHIELD	0.8	KM	14490	11 590
	5	FIBER CABLE	12 FIBERS, RODENT SHIELD	2.0	KM	10260	20 520
	6	FIBER CABLE	6 FIBERS, RODENT SHIELD	1.6	km	5890	9 420
			MATERIAL COST				140 045
			INSTALLATION COSTS				
	1	EQUIPMENT	RENTAL @ 919/KM	7.9	KM	919	7 260
	2	LABOR	PULL CABLE @ 3637/KM	7.9	KM	3637	28 732
	3	SPLICES	1,000' REELS	531	EA	10.00	5 310
	4	CABLE BOOTS	EACH SPLICE LOCATION	4	EA	50.00	200
			INSTALLATION COSTS				41 502
			TOTAL CIRCUIT COST				181 547

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SUBJECT: COST ESTIMATE — JOB NO. 3469-00

FIBER OPTICS - ALTERNATIVE 3 - CABLE CIRCUIT 2 — SHEET NO. ____ OF ____

MADE BY ________ DATE ________ CHECKED BY ________ DATE ________

NO	ITEM NO.	DESCRIPTION	NOTES	QUANTITY	UNIT	UNIT PRICE $.	AM
	1	FIBER CABLE	37 FIBER, RODENT SHIELD	8.7	KM	31600	274 9
	2	FIBER CABLE	31 FIBER, RODENT SHIELD	0.8	KM	26800	21 4
	3	FIBER CABLE	25 FIBER, RODENT SHIELD	3.3	km	21500	70 95
	4	FIBER CABLE	19 FIBER, RODENT SHIELD	1.6	KM	15290	24 4
	5	FIBER CABLE	12 FIBER, RODENT SHIELD	2.3	KM	10260	23 6
	6	FIBER CABLE	6 FIBER, RODENT SHIELD	1.6	KM	5890	9 4
	7	LINE REPEATER	T-2 CARRIER	12	EA	8300	99 6
	8	LINE REPEATER	T-3 CARRIER	21	EA	12000	252 0
			MATERIAL COST				776 3
			INSTALLATION COSTS				
	1	EQUIPMENT	RENTAL @ 919/KM	18.3	KM	919	16 8
	2	LABOR	PULL CABLE @ 3637/KM	18.3	KM	3637	66 5
	3	LINE REPEATERS	T-2 CARRIER, INSTALL @ 16 HRS EACH	192	HRS	27.70	5 3
	3	LINE REPEATERS	T-3 CARRIER, INSTALL @ 16 HRS EACH	252	HRS	27.70	6 9
	4	SPLICES	1,000' REELS	1646	EA	10.00	16 4
	5	SPLICE BOOTS	EACH SPLICE LOCATION	60	EA	50.00	3 0
			INSTALLATION COSTS				115 1
			~~TOTAL CIRCUIT COST~~				891 56

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Consulting Engineers and Planners

SUBJECT COST ESTIMATE JOB NO. 3469-00

FIBER OPTICS - ALTERNATIVE 3 - CABLE CIRCUIT 3 SHEET NO. ____ OF ____

MADE BY ____ DATE ____ CHECKED BY ____ DATE ____

NO	ITEM NO.	DESCRIPTION	NOTES	QUANTITY	UNIT	UNIT PRICE $	AM
	1	FIBER CABLE	14 FIBER, RODENT SHIELD	28.1	KM	11640	327 0
	2	FIBER CABLE	8 FIBER, RODENT SHIELD	3.7	KM	7330	21 9
	3	FIBER CABLE	2 FIBER, RODENT SHIELD	1.3	KM	3650	4 7
	4	LINE REPEATER	T-2 CARRIER	6	EA	8300	49 8
	5	LINE REPEATER	T-3 CARRIER	8	EA	1200	96 0
			MATERIAL COST				499 6
			INSTALLATION				
	1	EQUIPMENT	RENTAL @ 919/KM	33.1	KM	919	30 4
	2	LABOR	PULL CABLE @ 3637/KM	33.1	KM	3637	120 3
	3	LINE REPEATERS	T-2 CARRIER, INSTALL @ 16 HRS EA	96	HRS	27.70	2 6
	4	LINE REPEATERS	T-3 CARRIER, INSTALL @ 16 HTS EA	128	HRS	27.70	3 5
	5	SPLICES	1,000' REELS	1395	EA	10.00	13 9
	6	SPLICE BOOTS	EACH SPLICE LOCATION	109	EA	50.00	5 4
			INSTALLATION COSTS				176 4
			TOTAL CIRCUIT COSTS				676 0

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SUBJECT COST ESTIMATE JOB NO. 3469-00

FIBER OPTICS - ALTERNATIVE 3 - CIRCUIT $ SHEET NO. ____ OF ____

MADE BY ____ DATE ____ CHECKED BY ____ DATE ____

NO	ITEM NO.	DESCRIPTION	NOTES	QUANTITY	UNIT	UNIT PRICE $	AM
	1	FIBER CABLE	2 FIBERS, RODENT SHIELD	2.5	KM	3650	9
			MATERIAL COSTS				9
			INSTALLATION COSTS				
	1	EQUIPMENT	RENTAL @ 919/KM	2.5	KM	919	2
	2	LABOR	PULL CABLE @ 3637/KM	2.5	km	3637	9
	3	SPLICES	1,000' REELS	16	EA	10.00	
	4	CABLE BOOTS	EACH SPLICE LOCATION	8	EA	50.00	
			INSTALLATION COSTS				11
			TOTAL CIRCUIT COST				21

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SUBJECT COST ESTIMATE JOB NO. 3469-00

FIBER OPTICS - ALTERNATIVE 3 - CCTV EQUIPMENT SHEET NO. ____ OF ____

MADE BY ____ DATE ____ CHECKED BY ____ DATE ____

NO	ITEM NO.	DESCRIPTION	NOTES	QUANTITY	UNIT	UNIT PRICE $.	AM
	1	T-3 ENCODER (CODEC)	TRANSMIT END (ITT)	59	EA	12,000	708 0
	2	T-3 DECODER (CODEC)	RECEIVE END (ITT)	59	EA	9,000	531 0
	3	MULTIPLEXER	T-3 OPTICAL TERMINAL - TRANSMIT & RECEIVE	118	EA	8,720	1 028 9
			TOTAL MATERIAL				2 267 9
			INSTALLATION				
	1	TRANSMIT ENCODER	INSTALL @ 24 HOURS EACH TERMINAL	1416	HRS	27.70	39 2
	2	RECEIVE DECODER	INSTALL @ 24 HOURS EACH TERMINAL	1416	HRS	27.70	39 2
	3	T-3 MULTIPLEXER	INSTALL @ 16 HOURS EACH TERMINAL	1888	HRS	27.70	52 2
			TOTAL INSTALLATION				130 7
			TOTAL CCTV HARDWARE				2 398 7

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SUBJECT COST ESTIMATE JOB NO. 3469-00

FIBER OPTICS - ALTERNATIVE # - FIBER TERMINAL COSTS SHEET NO. ____ OF ____

MADE BY ____ DATE ____ CHECKED BY ____ DATE ____

NO	ITEM NO.	DESCRIPTION	NOTES	QUANTITY	UNIT	UNIT PRICE $	AM
	1	T-3 OPTICAL TERMINAL	MAIN YARD	1	EA	8720	8
	2	T-2 OPTICAL TERMINALS	CENTRAL CONTROL	14	EA	4500	63
	3	T-3 OPTICAL TERMINALS	CENTRAL CONTROL	2	EA	8720	17
	4	T-2 OPTICAL TERMINALS	PASSENGER STATIONS &	14	EA	4500	63
	5	T-3 OPTICAL TERMINALS	NORTH YARD	1	EA	8720	8 7
			MATERIAL COSTS				160
			INSTALLATION COSTS				
	1	INSTALL T-2 TERMINAL	@ 24 HOURS	672	HRS	27.70	18 6
	2	INSTALL T-3 TERMINAL	@ 16 HOURS	64	HRS	27.70	1 7
			INTALLATION COSTS				20 3
			TOTAL OPTIC HARDWARE				201 2

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SUBJECT COST ESTIMATE JOB NO. 3469-00

FIBER OPTICS - ALTERNATIVE 3 - T-1 CARRIER MULTIPLEXERS SHEET NO. ______ OF ______

MADE BY __________ DATE __________ CHECKED BY __________ DATE __________

NO	ITEM NO.	DESCRIPTION	NOTES	QUANTITY	UNIT	UNIT PRICE $	AMO[UNT] $
			T-1 CARRIER MULTIPLEXERS BY LOCATION				
	1	T1-MULTIPLEXER	CENTRAL CONTROL COMPLETE WITH CHANNEL MODULES	71	LS		399 41
	2	T1-MULTIPLEXER	MAIN YARD COMPLETE WITH CHANNEL MODULES	24	LS		144 13
	3		UNION STATION COMPLETE WITH CHANNEL MODULES	3	LS		14 25
	4		CIVIC CENTER COMPLETE WITH CHANNEL MODULES	3	LS		13 82
	5		FIFTH & HILL COMPLETE WITH CHANNEL MODULES	3	LS		13 82
	6		SEVENTH & FLOWER COMPLETE WITH CHANNEL MODULES	3	LS		15 33
	7		ALVARADO COMPLETE WITH CHANNEL MODULES	3	LS		14 68
	8		VERMONT COMPLETE WITH CHANNEL MODULES	3	LS		13 82
	9		NORMANDIE COMPLETE WITH CHANNEL MODULES	3	LS		13 82
	10		WESTERN COMPLETE WITH CHANNEL MODULES	3	LS		16 85
	11		LA BREA COMPLETE WITH CHANNEL MODULES	3	LS		14 68
	12		FAIRFAX COMPLETE WITH CHANNEL MODULES	3	LS		15 55
	13		BEVERLY COMPLETE WITH CHANNEL MODULES	3	LS		14 68
	14		SANTA MONICA COMPLETE WITH CHANNEL MODULES	3	LS		24 42
	15		STUDIO CITY COMPLETE WITH CHANNEL MODULES	3	LS		17 28
	16		NORTH HOLLYWOOD COMPLETE WITH CHANNEL MODULES	3	LS		14 47
	17		NORTH YARD COMPLETE WITH CHANNEL MODULES	5	LS		29 07
			MATERIAL COST				790 12
			INSTALLATION				
	1	INSTALL T-1 CARRIERS	INSTALL, WIRE & INTERCONNECT @ 80 HRS/T-1 TERMINAL	11360	HRS	27.70	314 67
			TOTAL PCM HARDWARE COST				1,104 79