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Final Draft Report

COMMUNICATIONS ALTERNATIVES ANALYSES

WBS 14CAC

KE Job 81152-403

Prepared for the
Southern California Rapid Transit
District
by
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C.2

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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. (Telephones for emergency calls by patrons are separate.) 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, with separate patron emergency phone instruments, 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.

Table A

COST SUMMARY OF COMMUNICATION ANALYSES*

VEHICLE RADIO SERVICE			
Nonremovable Radio			100,350
Removable 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		
CCTV MONITORS			
Multiple Camera Sequencing		962,907	
Split-Screen Projection			1,503,435
Split-Screen Sequencing	923,218		

*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:

- o The most cost-effective components
- o Differences in performance characteristics and operating experience
- o 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:

- o Vehicle radios
- o Telephone service configuration
- o Closed circuit television monitors
- o Cable transmission system
- o Controlled aperture cameras
- o 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, and F. 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.

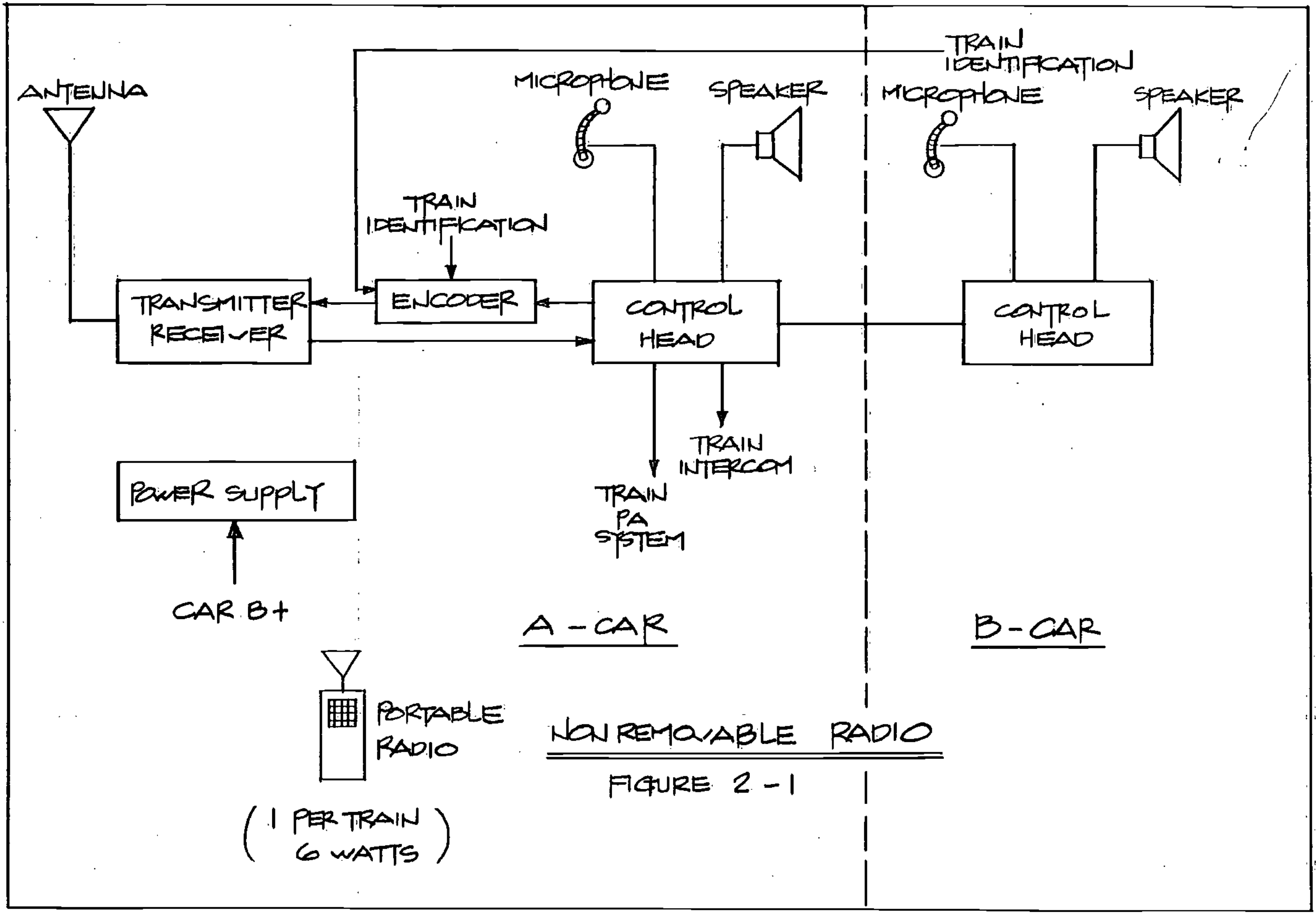
2.2 DESCRIPTION OF ALTERNATIVES

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.

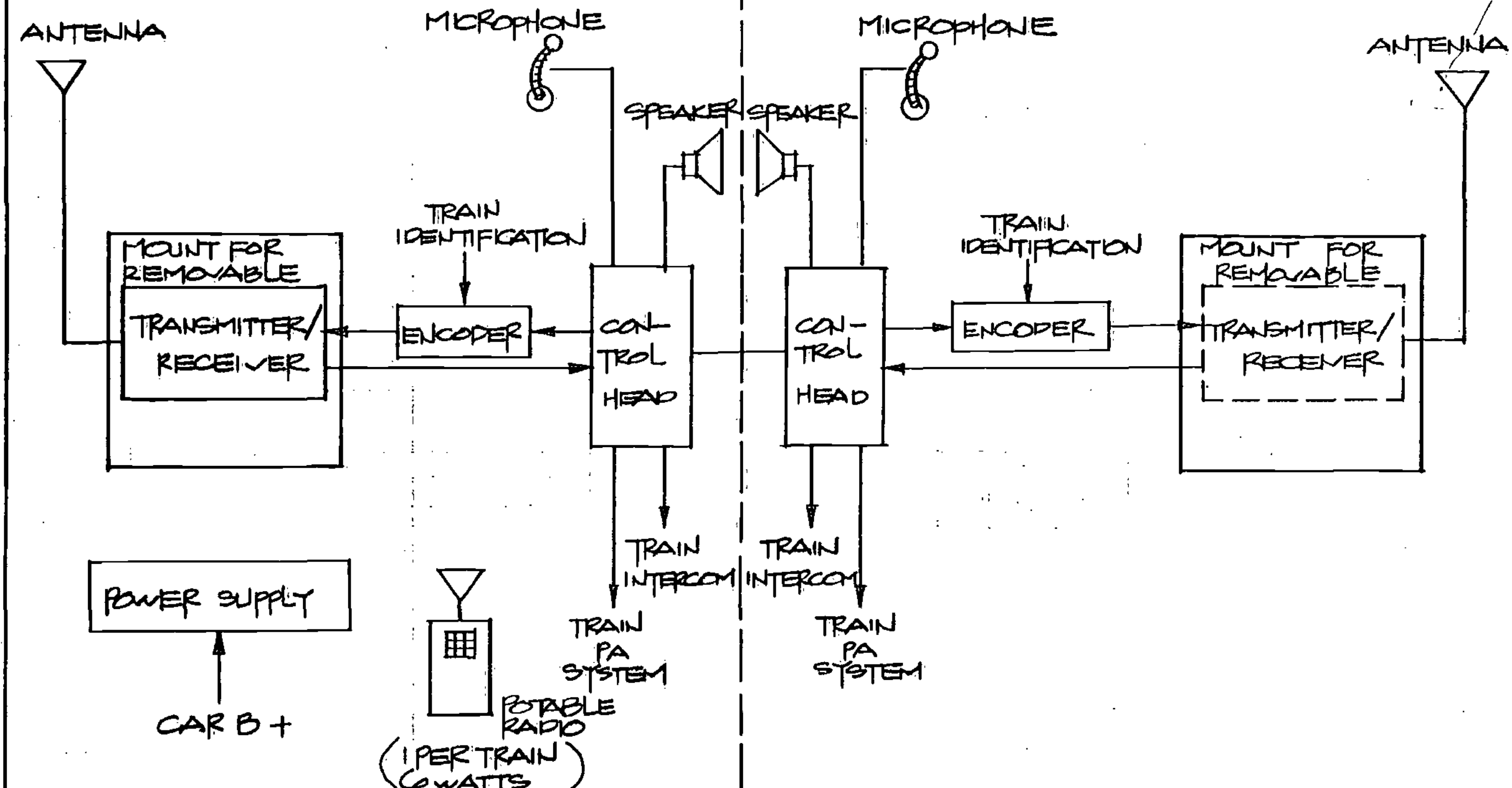
2.2.3 Removable Operable Radio (Alternative 3)

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.

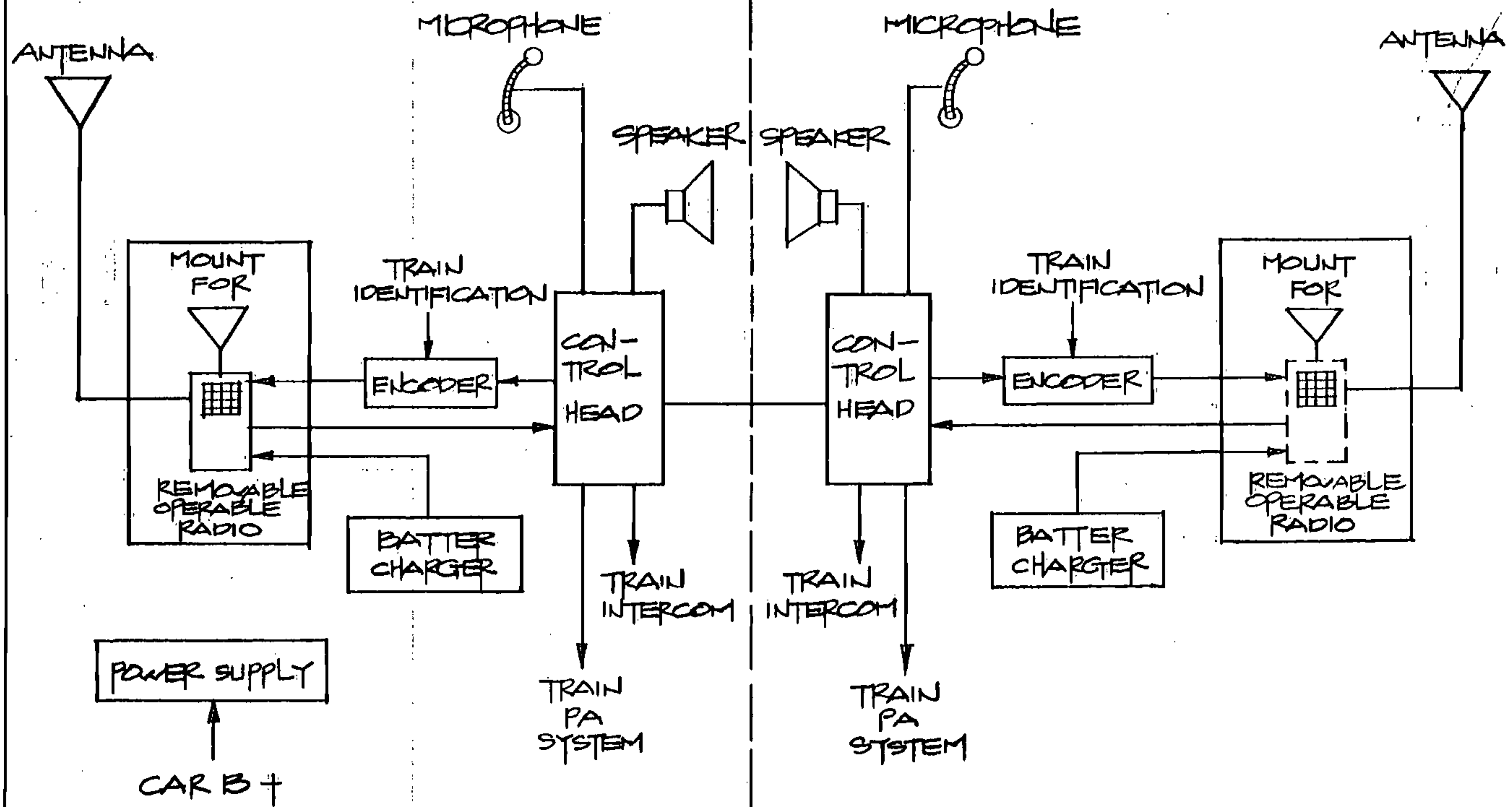


A-CAR

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:

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

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[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:

- o Telephone instruments
- o Cable transmission system (outside cable)
- o 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~~ 5
Yard signals	–	–	–	35	–	–	~~35~~ 10
Signal towers	3	12	3	25	–	12	~~25~~ 10
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	809

*Figures include an allowance for outside trunks of approximately 20% of the number of telephone lines connected except 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.

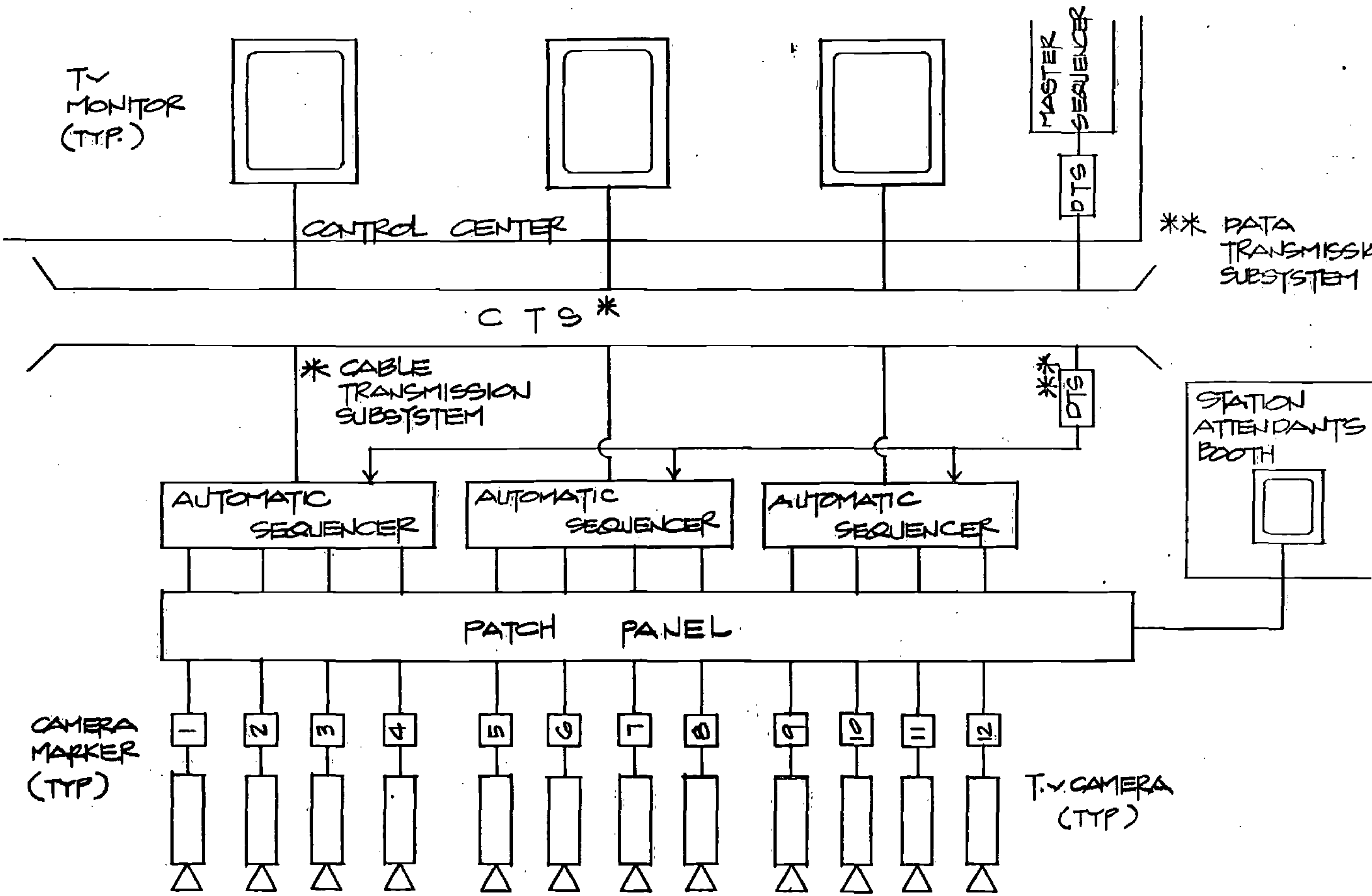

FIGURE 4-1. ALTERNATIVE #1 MULTIPLE CAMERA SEQUENCING

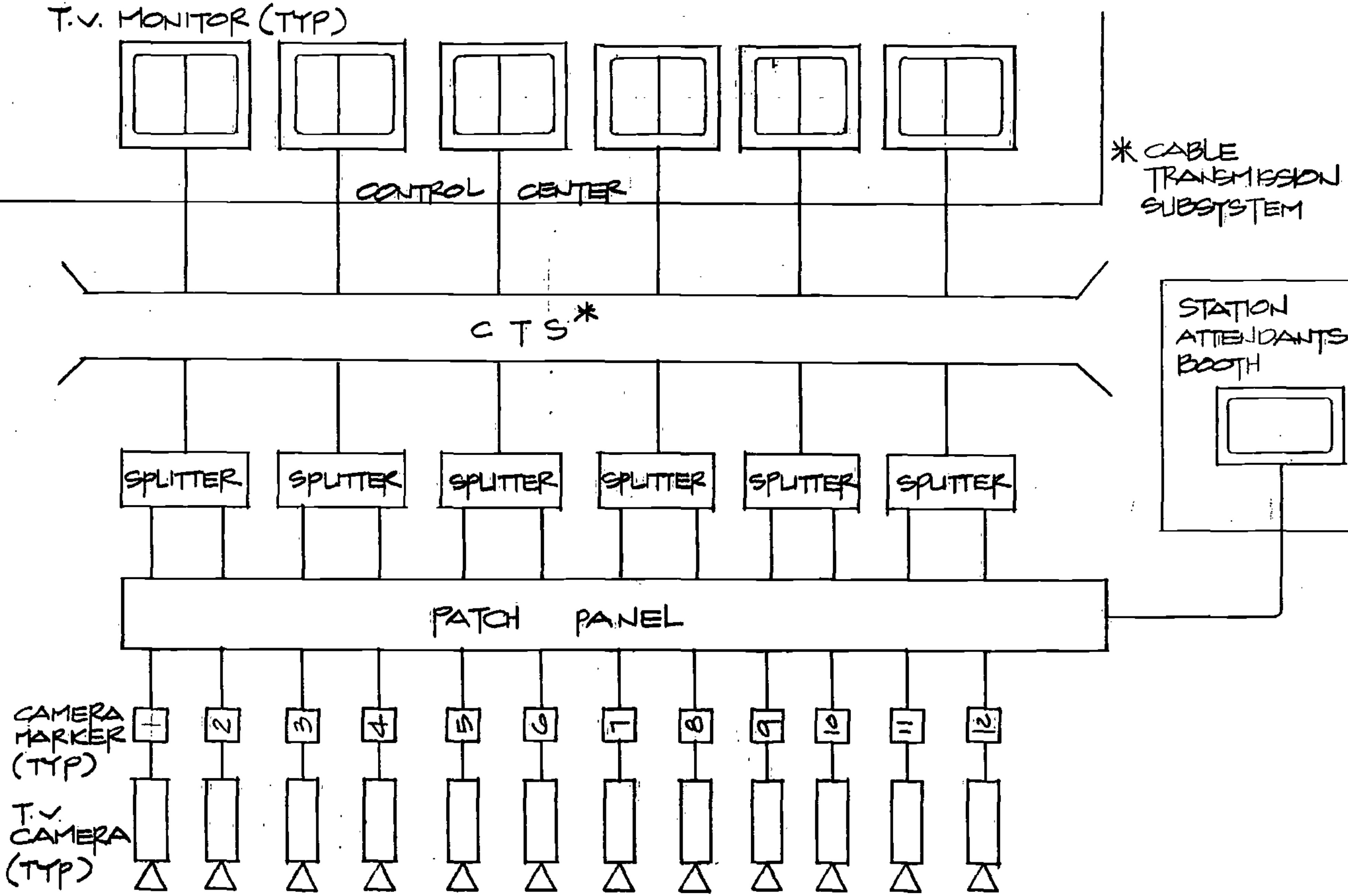

FIGURE 4-2. ALTERNATIVE #2 SPLIT-SCREEN PROJECTION

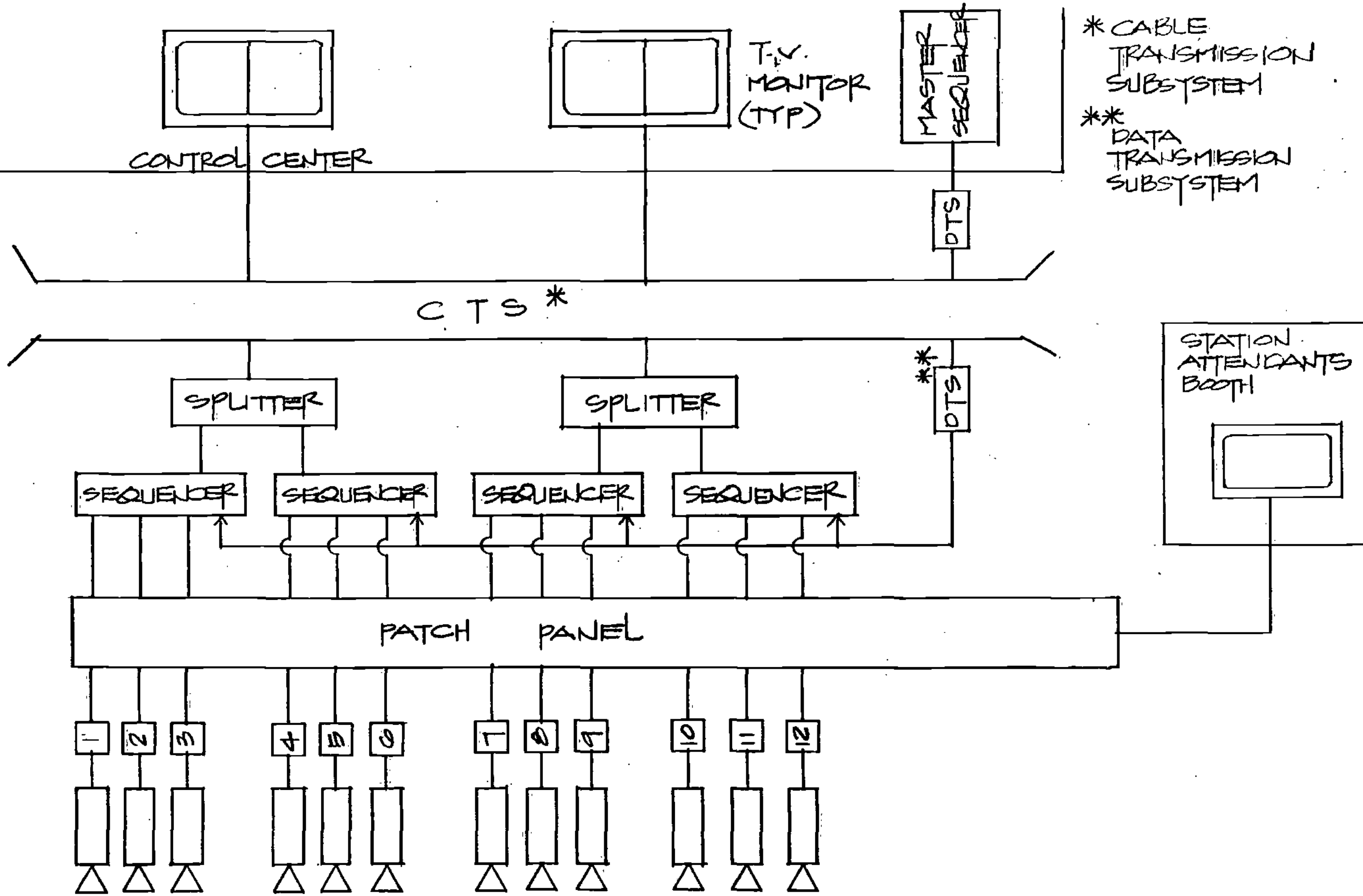

FIGURE 4-3. ALTERNATIVE #3 SPLIT-SCREEN SEQUENCING

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.

* 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 I 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 ANALYSIS

This chapter will follow under separate cover in January 1983.

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

Kaiser Engineers
Tony Kan
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. 8112.403

DESIGNED BY [initials] DATE 5/24/

CHECKED BY DATE

MEETING WITH GENERAL ELECTRIC
— RADIO —

ATTENDEES:

RTD	G.E.	K.E.
MIKE BECHER	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 EXISTING 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 THOSE INFO ARE NOT AVAILABLE FOR THE DESIGNED PRODUCT, HOWEVER, THESE INFO ARE BASED ON EXISTING UNITS INSTALLED; HE INDICATED THAT HE WILL SEND THEM TO RTD.

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

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. 8117

Sheet 3 of 3

DESIGNED BY ______ DATE ______
CHECKED BY ______ DATE ______

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

G. 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

GE REP JIM TWITTY
619-565-8320

KIRK RUMMEL

Telecon with Pete Tereshuk 12/02/82
SAN Diago Trolley 619-239-6054

Ref: Carbourne Communications

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

10 transportation — { 5 operators on train, 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 administration effort would be 1/4 of a person's time at all time ∴ 3 shift × 1/4 = 3/4 of a person's time = 30 hours per week

$\frac{30}{17}$ = 1.8 manhours/radio = say 2 hr/radio

Raymond Kaiser Engineers

JOB NO. ______

VEHICLE RADIO CACULATION
CAPITAL COSTS.

DESIGNED BY C FISHER DATE 1-6-83

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)~~		~~17,964~~
		~~262,484~~

OPTION B 142 CAR ENDS

CAR EQP.	142 × [445 = (350 + 95)] = 63,190 (PER 4-8-82 TELECON)	63,190
XMIT/REC	25 × 2136 (PER 4-8-82 TELECON)	53,400
PORT.	25 × 2595 = 64,875	64,875
BATT CHG.	3 × 360 = 1,080	1,080
		182 545
~~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.)~~		~~13,597~~
		~~214,442~~

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

Raymond Kaiser Engineers

JOB NO.

REPLACEMENT COST OF PORT. RADIOS FOR TRAIN OPERATION

DESIGNED BY C. FISHER DATE 1-6-83

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 Form No. E-6 Rev. 10-71

NOTES RE: TEL. CONV. w/ G. GELLMAN 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 P3AK6AG 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 (corr 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

MAY 16, 1982
10:35 A

TELEPHONE CONVERSATION NOTES:
WITH MR. JOHN T. BOOTH OF
PACIFIC INTERNATIONAL CORPORATION
REPRESENTING: JAVELIN ELECTRONICS AND
PANASONIC CCTV PRODUCTS

DISCUSSED THE SCRTD METRO RAIL PROJECT AND REASON FOR COST 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[illegible] 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/UNIT 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.—

(A) FAILURES: 1/YR: AVE:

1. LENSES — ~~FIRST TO FAIL~~ REPLACEMENT —
   - WIDE ANGLE LENS f 1.8 — 245.00
   - ~~[illegible]~~ MOTORIZED IRIS LENS 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 — JUN 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 RECORDING W/ - 3700—
60 MIN TAPE CASE AND
TIME/DATE GENERATOR
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 files
JUN ADELA

RUPTEL

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.

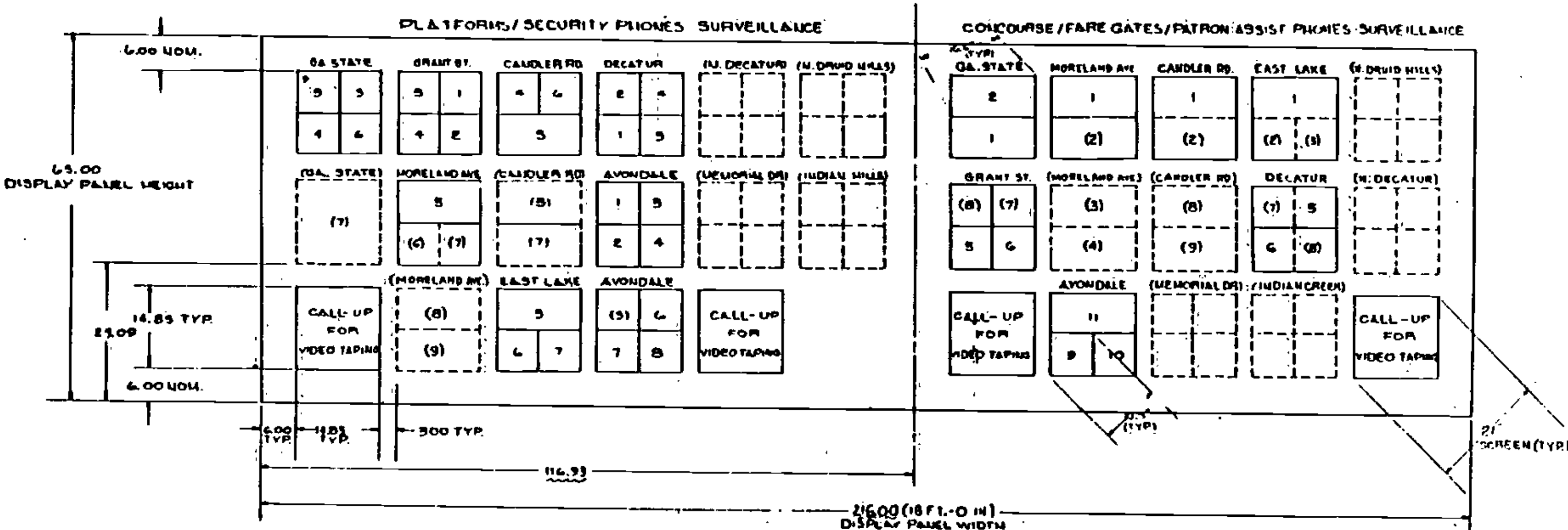
Increasing the sequencing time period would result in a correspondingly longer unobserved period of time, which would permit undesirable activity to ensue.

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



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

REV	DATE	BY	CHK	APP	DESCRIPTION

METROPOLITAN ATLANTA RAPID TRANSIT AUTHORITY

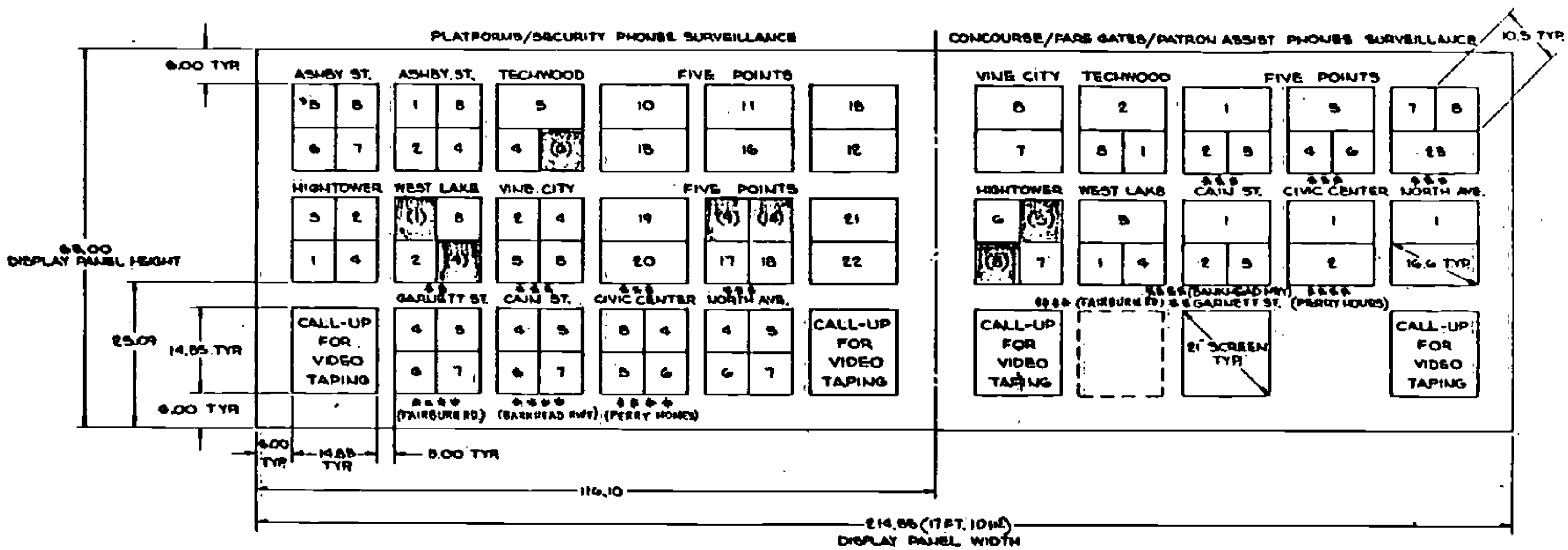
PARSONS BRINCKERHOFF - TUDOR - BECHTEL
GENERAL ENGINEERING CONSULTANTS

MONITOR ARRANGEMENT
AVONDALE ZONE CENTER

SCALE 1/10

CM X110

6-30-76



NOTE: (NAME) OR (NUMBER) DENOTES FUTURE REQUIREMENTS

- $ DENOTE CAMERA I.D.
- $$ INTERIM LOCATION-ULTIMATE LOCATION AT LAKEWOOD
- $$$ INTERIM LOCATION-ULTIMATE LOCATION AT LINDBERGH/PIEDMONT
- $$$$ FUTURE LOCATION

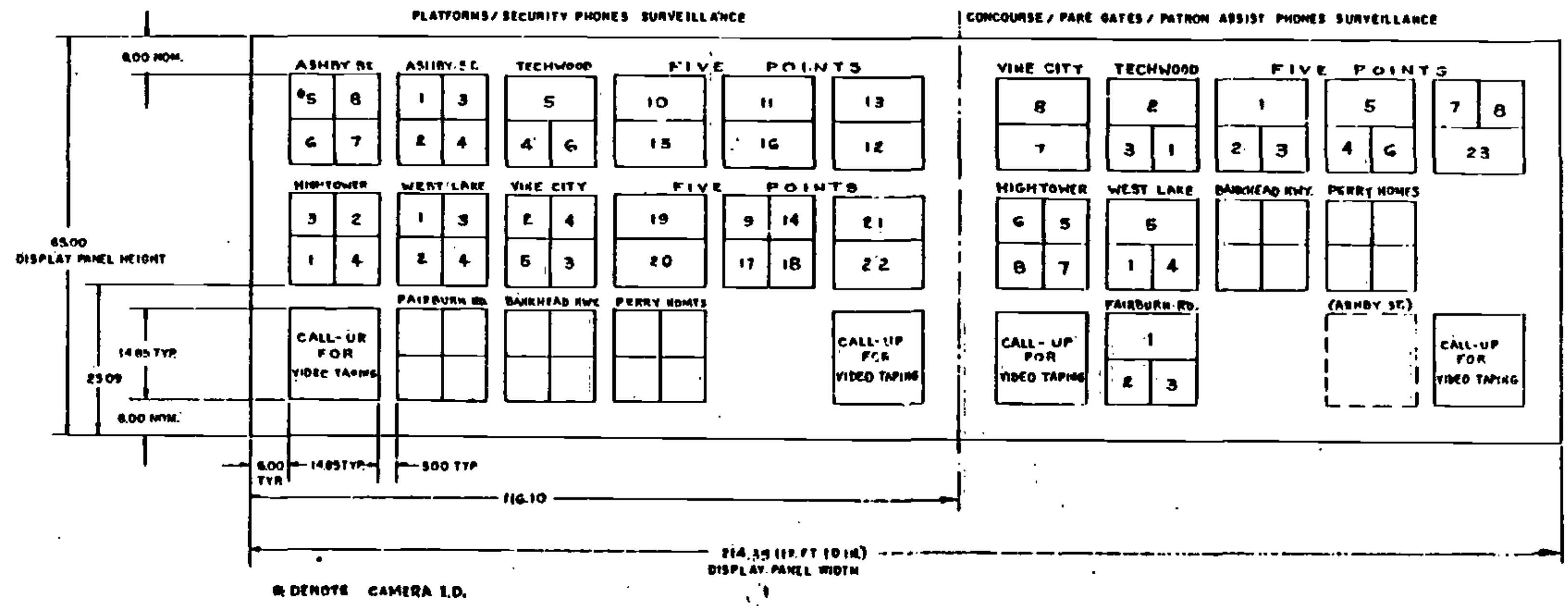
F-20

METROPOLITAN ATLANTA RAPID TRANSIT AUTHORITY

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

1/10

CUX 210



F-21

METROPOLITAN ATLANTA RAPID TRANSIT AUTHORITY

PARSONS BRINCKERHOFF - TUDOR

MONITOR ARRANGEMENT

WESTLAKE ZONE CENTER

(FOUR ZONE - ULTIMATE SYS. CONCEPT)

1/10

MX 220

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

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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 <u>great deal of movement</u>, a 100% likelihood of detecting incidents requires viewing only <u>one monitor</u> display. If it is necessary to watch more than 1 screen with a great deal of movement, then no more than <u>9</u> 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 <u>very little movement</u> is present in the viewed scenes, then <u>16</u> 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 upo[illegible]her knowledge of available options. Those options range from minimal respon[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, identific[illegible]ion and evaluation functions occur almost simultaneously. The operator next ca[illegible]ries out the response, taking responsibility for its completion unless that respon[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
6th 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: Composite List of WBS 14 Alternatives*

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

DISTRIBUTION | A | I

File	
Chief	
Asst. Chief	
CSA	
Oprns.	
Admin.	
Invest.	
Serv. Inspc.	
Support	

RECEIVED
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 AT	P. M. Burgess	DATE	March 22, 1982
		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
Gneral Purpose	1FC - 100 FC SHOULD READ (1 FC - 1000FC) CORRECTION PER TELE CONV W/ JUN A /CML
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
KE - Los Angeles

DATE April 27, 1982

FROM A. P. Adela, Jr.

COPIES TO Ed Freeman, UII

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

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

1 Copy → Dorothy
" → 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

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 camera 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:

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

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

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

1 Copy → Dorothy
→ PMB

KAISER ENGINEERS, INC.
425 SOUTH MAIN STREET
6th FLOOR
LOS ANGELES, CALIFORNIA 90013
TELEPHONE: (213) 972-6033

May 28, 1982

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

MEMO TO: W. J. Rhine

FROM: P. M. Burgess

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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.

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 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.