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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
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16. Abstract

The purpose of this document is to provide guidelines for procedures and practices used in the remote surveillance of transit stations via Closed Circuit Television (CCTV). It is intended that readers will acquire information from this document that will help in planning, designing, installing, operating and evaluating the most appropriate CCTV transit surveillance system for their own purposes.

Chapters are arranged first to identify key concepts in the main areas associated with CCTV transit station security systems, and then to focus individually on those main areas which include equipment, personnel, procedures, evaluation and costs. Those chapters are followed by appendices which include lists of manufacturers of CCTV components, glossaries of terms and abbreviations, and a comprehensive bibliography. The information was obtained from literature surveys, suppliers, visits to existing transit CCTV installations, consultations with subject-matter experts, and the prior experiences of the project staff.

This guidebook attempts to provide enough detail and references about CCTV systems in transit station applications so that readers can be somewhat independent of suppliers for planning and operating their own systems.

17. Key Words
CCTV, Closed Circuit Television, Transit Systems, Guidelines, Human Factors Engineering, AGT Systems

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16. Abstract

The Urban Mass Transportation Administration, in order to examine specific Automated Guideway Transit (AGT) developments and concepts, has undertaken a program of studies and technology investigations called the Automated Guideway Transit Technology (AGTT) program. The objective of one segment of the AGTT program, the Systems Safety and Passenger Security (SS&PS) study, was the development of guidelines for the assurance of actual and perceived passenger safety and security in AGT systems. The SS&PS study has involved seven related but separate tasks. The first three were concerned with the development of guidebooks dealing with passenger security, evacuation and rescue, and passenger safety and convenience services. The fourth task required the development of a passenger value structure model; the fifth involved research on the retention of seated passengers during emergency stops; the sixth involved the conduct of a joint Government and industry workshop to review and revise the three guidebooks; and the seventh task required the development of this guidebook of procedures and practices used in the remote surveillance of transit station via closed circuit television (CCTV).

It is intended that readers will acquire information from this document that will help in planning, designing, installing, operating, and evaluating the most appropriate CCTV transit surveillance system for their own purposes. This report is arranged to first identify key concepts in the main areas associated with CCTV transit station security systems, and then are focused individually on those main areas which include equipment, personnel, procedures, evaluation, and costs. Appendices which include lists of manufacturers of CCTV components, glossaries of terms and abbreviations, and a comprehensive bibliography are included in this report. The information for this study was obtained from literature surveys, suppliers, visits to existing transit CCTV installations, consultations with subject-matter experts, and the prior experience of the project staff.

17. Key Words	18. Distribution Statement
AGT; Automated Guideway Transit; CCTV; Closed Circuit Television; Guidelines; Human Factors Engineering; Passengers; Remote Surveillance; Safety; Security; Surveillance; Transit Stations	Available to the public through the National Technical Information Service, Springfield, Virginia 22161.

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PREFACE

The U.S. Department of Transportation's Urban Mass Transportation Administration (UMTA), in order to examine specific Automated Guideway Transit (AGT) developments and concepts, has undertaken a program of studies and technology investigations called the Automated Guideway Transit Technology (AGTT) program. The objective of one segment of the AGTT program, the Systems Safety and Passenger Security Study (SS&PS), was the development of guidelines for the assurance of actual and perceived passenger safety and security in AGT systems. This work was contracted, through the Transportation Systems Center (TSC), to a team composed of Dunlap and Associates, Inc., the University of Virginia, and the Vought Corporation.

The System Safety and Passenger Security (SS&PS) study has involved seven related but separate tasks. The first three were concerned with the development of guidebooks dealing with: 1) passenger security, 2) evacuation and rescue, and 3) passenger safety and convenience services. A fourth task required the development of a passenger value structure model; a fifth involved research on the retention of seated passengers during emergency stops; a sixth involved the conduct of a joint Government and industry workshop to review and revise the three guidebooks; and the seventh task required the development of this guidebook of procedures and practices used in the remote surveillance of transit stations via CCTV.

The objective of this CCTV Applications Guidebook is to provide AGT system planners, designers and operators with a convenient source of easy to use information on CCTV in transit stations that is relevant to different categories and designs of AGT systems. It includes a review of CCTV concepts, and individual guidance regarding equipment, personnel, procedures, evaluation and costs. It also provides lists of suppliers, glossaries and a bibliography.

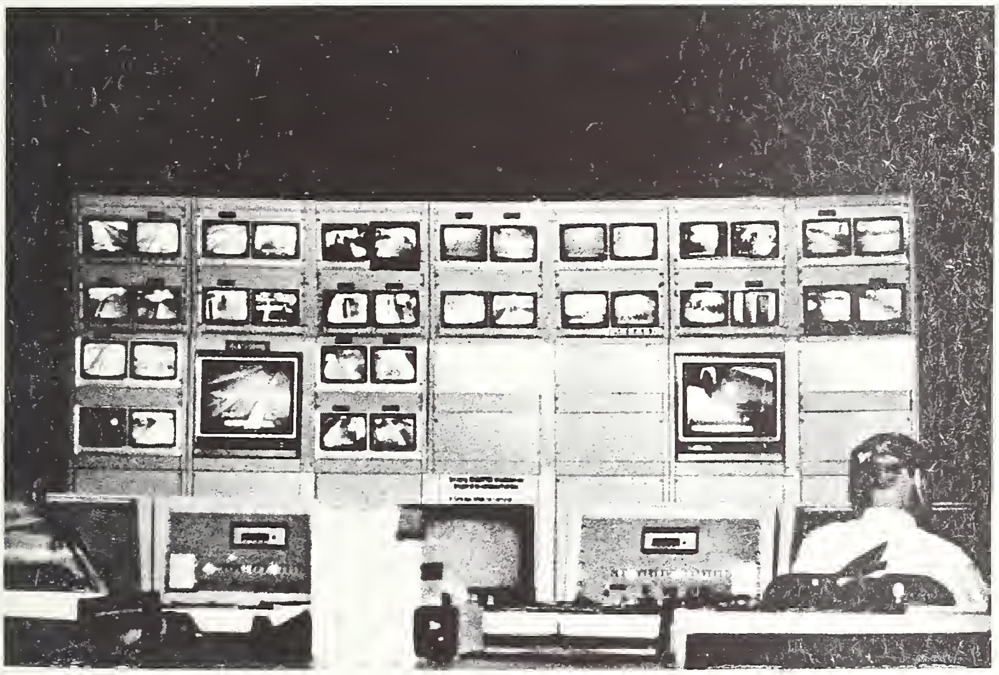
The preparation of this guidebook required assistance from many experts and colleagues whose valued contributions are sincerely appreciated and acknowledged. They include CCTV users, equipment suppliers and technical researchers whose important efforts are noted briefly here.

Among transit CCTV users have been many individuals from the New York City Transit Police (NYCTP), including: James Meehan (Chief), Sanford D. Garelik (former Chief), Sydney C. Cooper, formerly Chief of Inspectional Services, NYPD, (Consultant to the Chief), Captain Nicholas Bole (Commander, District 23), Captain Charles M. Mills (Commander, District 1), Bernard Jacobs (Detective), James McHugh (Detective), Lt. Frank Cerar (District 23), and Lt. Philip Farrel (District 23). These individuals have cooperated on this overall study for the past two years, and have been most generous in sharing their time and expertise on all subjects. Chief Cooper also served as a special consultant to Dunlap and Associates, Inc., for the preparation of this guidebook.

We are also indebted to very helpful and cooperative individuals from other transit systems. They include: Jack McDowell, Manager of Station Operations, BART; Al Brasill, Chief of Transit Police, and John L. Waters, Assistant Chief of Transit Police, MARTA; John J. McBride, Captain of Police, and David L. Andrus, Supervisor of Research and Planning, PATCO; and Joseph Slawsky, Police Commanding Officer, Rober Riker, Supervising Engineer, and Robert Mutschler, Operations Specialist, PATH.

In addition to transit system personnel, we are grateful for information and cooperation received from other CCTV users, including: Michael Hitchuk, Security Manager, and Cheryl Gregory, Assistant Security Manager, A&S Department Store (Paramus, New Jersey); Joseph Valpato and Robert Rackwill, Security Department, Metropolitan Museum of Art (New York City); and Richard T. Beckel, Director of Security, and Louise Hansen, Security Staff, Roosevelt Island Security (New York City). Other subject matter experts who gave freely of their time and knowledge include: Dr. W.P. Colquhoun, Director of the Perceptual and Cognitive Performance Unit, Medical Research Council (Brighton, England); Gerald Rich, Concord Communications (Connecticut); Stanley Rosoff, Security Resources, Inc. (Connecticut); and Yolanda Akerib, General Manager, PSA International (Connecticut). Finally, among the CCTV system specialists, there are the innumerable manufacturers' representatives, applications engineers, and sales managers, who provided many helpful leads, suggestions, documents and technical literature. Though too numerous to mention here, each of them is individually thanked for the valuable help received. We also wish to thank the UMTA and TSC technical personnel for their assistance in the performance and documentation of this work and, in particular, Duncan MacKinnon and Robert Hoyler, Program Manager and Monitor, respectively, for UMTA; and Drs. Donald Sussman and Janis H. Stoklosa, Project Monitors for TSC.

The actual day-to-day technical effort in creating this guidebook could not have been completed effectively without the remarkable diligence and good-humored help provided by the author's colleagues at Dunlap and Associates, Inc. Foremost among them is Dr. Richard D. Pepler, Vice President, whose initial and sustained efforts made this project possible, and whose technical contributions and confident support have affected the entire guidebook. Special thanks go to Joan M. Edwards, Associate, whose hard work and perseverance resulted in the glossaries and list of suppliers appearing in the appendices. Additional special thanks go to Bernice Astheimer, Research Librarian, who took responsibility for the tedious effort of obtaining documents and preparing the comprehensive bibliography found in the appendices. Other valuable help in preparing this manuscript was received from Associate Carol Preusser and many of the firm's Technical Assistants, including: Frances Kowaleski, Karen Kolenda, Janet Vartuli, Susan Redford, Patricia Teitelbaum, and Diane Costello. Although the final responsibility for the accuracy and presentation of the material contained herein remains with the author, the satisfaction and recognition for this accomplishment are gladly shared with all of those mentioned above.



A CCTV Monitoring Center for Transit Operations

(Photo courtesy of Metropolitan Atlanta Rapid Transit Authority)

METRIC CONVERSION FACTORS

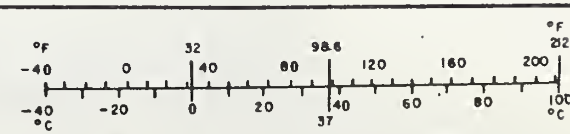
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	6	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in ≡ 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.6	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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EXECUTIVE SUMMARY

Closed circuit television (CCTV) is one of the important technological developments that have been in growing use to help assure the security and safety of transit system passengers. It is employed on numerous transit systems in the United States and abroad, primarily in stations and their collateral locations. Some applications on transit vehicles are also being tried, and it is even possible to place CCTV cameras along guideways, if desired.

CCTV systems are most useful when observation is required and where direct viewing by an individual is undesirable, inconvenient or impossible. They can provide better vantage points for observations, and can augment the visual abilities of the observer in terms of light-level sensitivity, range and spectral responsiveness. In transit station security applications, CCTV provides many more "eyes,' at many more locations, for indefinitely longer periods of time, at relatively lower cost than most security organizations are able to provide by using people only. Observers can be changed easily, and permanent recordings can be made of incidents. CCTV also facilitates the coordination of responses because a situation can be followed readily and visually from a central location where links to other agencies and services are also available. Further, the CCTV system can be enhanced in carrying out its function by integrating it with a two-way audio communications capability with passengers and related services. It can also tie in with automatic sensor alarm networks and with automatic response capabilities, such as remotely controlled gates and locks.

CCTV surveillance systems at transit stations can help in providing increased levels of safety through their usefulness in detecting and coordinating responses to accidents, medical crises, psychiatric emergencies, fire, and physical hazards. They also can be used to enhance transit operations by identifying crowd levels, movements and trends at key locations. They can aid in passenger convenience services by allowing a combined visual and audio query and response with passengers requesting information or having a problem with the station's automatic ingress or egress equipment. Finally, the presence of CCTV systems on transit stations can increase the passengers' perceptions of security and safety, thereby contributing to increased ridership and revenue.

The purpose of this document is to provide guidelines for procedures and practices used in the remote surveillance of transit stations via CCTV. It includes information about equipment, personnel and procedures. Guidelines are sometimes based on scientifically supportable and objective information, and sometimes on the opinions of experienced individuals. The differences in scientific foundations and state-of-the-art account for individual guidelines being more or less quantitative or qualitative, objective or subjective, precise or vague, demonstrated or undemonstrated. In fact, those differences help one to realize that there are important research areas remaining to be addressed in the use of CCTV surveillance generally, and in transit station applications particularly. For instance, there are few research studies but many opinions regarding the personal attributes that should be sought in potential operators, if one wants to optimize performance in tasks or adaptability to shift work.

The guidelines found here should be regarded as generalizations about effective CCTV practices in some typical transit station applications. Illustrations of CCTV systems are provided more for the purposes of clarifying concepts and practices than recommending a specific design that would be "best" in all cases. The scope of this document is quite wide and much information is provided. Yet, this is not a comprehensive course in CCTV technology or human factors engineering. Therefore, numerous references are cited within each chapter so that more details can be obtained on specific topics. This guidebook attempts to provide enough detail and references about CCTV systems in transit station applications so that readers can be somewhat independent of suppliers for planning, design, installing, operating and evaluating the most appropriate CCTV transit station surveillance system for their own purposes. The chapters of this guidebook are arranged so as to first identify key concepts in the main areas associated with CCTV transit station security systems. They then focus individually on those main areas which include equipment, personnel, procedures, evaluation and costs. Those chapter are followed by appendices which include lists of manufacturers of CCTV components, glossaries of terms and abbreviations, and a comprehensive bibliography.

The first group of equipment addressed is that in the monitoring center. The various displays, controls and other associated apparatus are identified and compared in terms of their most important characteristics. The optimum number of operators required to staff the center is discussed, as are their other possible duties and the best shifts and schedules for their job assignments. The physical environment is considered, and the accompanying layouts of equipment and operator workplaces are addressed. The use of an audio subsystem, other communications networks and some special features that can be incorporated into the CCTV security system are also treated here.

The next chapter provides information and guidelines regarding the sensing portion of the CCTV surveillance system, as found typically outside of the monitoring and control center. It addresses the technical features of cameras, their lenses, required lighting, positioning, protection, transmission links and the maintenance of all equipment associated with this part of the system. In transit stations, television cameras are typically positioned to monitor areas around vehicle doors, platforms, stairways, mezzanines, concessions, station entrances and exits, money-handling installations, and other facilities requiring protection (including the television system itself). The transit station is often unusual because of special problems with lighting, vibration, dirt and dust, electrical power, crime and vandalism, communications, and the variety of people found there. The proper selection of natural and artificial lighting conditions is essential in considering camera placement, special features, cost and utilization. Camera placement also must consider the remainder of the environment, including temperature and humidity conditions, weather extremes, and potential vandalism. These factors also influence the medium chosen for transmission of the camera's video signal to the monitoring center. There are radio, wire, and optical links possible for transmitting the video, audio and control signals used in a typical system.

Personnel practices are addressed in the next chapter. Guidelines and comments about personnel selection are directed at helping to identify measurable factors which predispose individuals to good performance on tasks (e.g., monitoring), and identifying methods for selecting such individuals. The degree to which shift work affects performance, though not unique to CCTV monitoring, is addressed as a selectable individual attribute. Some of the other issues covered are the relevance to the selection process of prior experience, age and personality traits. Statements about training address the issues of classroom vs. "on-the-job" training, the use of job-aids, the degree of reality of CCTV monitor training exercises, maintaining levels of proficiency by periodic refresher exercises, and characteristics of the trainer which could enhance learning. With regard to motivation, a wide range of factors are considered. Some of those motivational factors are inherent to the individual's intrinsic personality traits, while others are inherent to the required tasks and the organizational context.

The next chapter provides 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 personnel practices addressed previously. It is considerably more specific, however, about step-by-step procedures employed when detections are made on the monitor displays.

The evaluation of CCTV monitoring systems is the subject of another chapter, addressing a number of different issues which depend on the intended purposes of the system. For example, one set of evaluation measures must assess the ability of the system to correctly detect criminal activity or safety hazards. A second set of measures must assess the adequacy and expediency of response procedures in emergency situations. Another set of measures should be designed to assess the usefulness of the monitoring system as a crime countermeasure, while still another set is used to assess its usefulness as a tool in passenger safety and convenience services. Finally, the cost (in economic and social terms) for achieving specific levels of effectiveness or benefit are sometimes viewed as the ultimate indicator for assessing and comparing systems. These are the familiar cost/benefit or cost/effectiveness ratios. Evaluation must consider the viewpoint of the transit system, the community, and any other group (even the offenders) whose interests are affected.

To aid the reader in calculating some costs associated with a CCTV transit station security system, the last chapter identifies typical categories of costs and provides some representative dollar figures of possible items for which one must pay. 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. It is also noted 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.

Ultimately, each CCTV transit station security organization must develop its own kind of guidebook, to be used for both training purposes and as a manual of standard operating procedures. It is hoped that this document contains many of the ideas and concepts which will make that task easier and more meaningful.

1. INTRODUCTION

1.1 BACKGROUND AND PURPOSE

This guidebook was prepared for the Transportation Systems Center, U.S. Department of Transportation, as one part of a two-year study of transit security and safety, under contract number DOT-TSC-1314. One of the primary objectives under that contract was to develop state-of-the-art information and guidebooks to be used by transit system planners for the purpose of assuring the security and safety of passengers, especially on future "unmanned" automated guideway transit (AGT) systems. Among the important technological developments that have been growing in use for that purpose is closed circuit television (CCTV). CCTV is actively employed on numerous transit systems in the United States and abroad, primarily in stations and their collateral locations. Some applications on transit vehicles are also being tried in a few places. It is even possible to place CCTV cameras along guideways, if desired.

The purpose of this document is to provide guidelines for procedures and practices used in the remote surveillance of transit stations via CCTV. It includes information about equipment, personnel and procedures. The information was obtained from literature surveys, suppliers, visits to existing transit CCTV installations, consultations with subject-matter experts, and the prior experiences of the project staff in the fields of engineering, psychology and human factors.

1.2 HOW TO USE THIS GUIDEBOOK

The chapters of this guidebook are arranged first to identify key concepts in the main areas associated with CCTV transit station security systems. It then focuses individually on those main areas which include equipment, personnel, procedures, evaluation and costs. Those chapters are followed by appendices which include lists of manufacturers of CCTV components, glossaries of terms and abbreviations, and a comprehensive bibliography.

The guidelines found here should be regarded as generalizations about effective CCTV practices in some typical transit station applications. The readers' applications may have their own unique aspects requiring some reasonable variation from the general guidelines. Illustrations of CCTV systems are provided more for the purposes of clarifying concepts and practices than recommending a specific design that would be "best" in all cases. It is intended that readers will acquire information from this document that will help in planning, designing, installing, operating and evaluating the most appropriate CCTV transit station surveillance system for their own purposes.

The scope of this guidebook is quite wide and much information is provided. Yet, this is not a comprehensive course in CCTV technology or human factors engineering. Therefore, numerous references are cited within each chapter so that even more details can be obtained on specific topics. Where references are cited within a chapter, the individual paragraphs conclude with the citation numbers in parentheses, such as (2, 7, 8). Those numbers refer to the numbered reference list at the end of the chapter. Where no references are cited, the information presented represents the project staff's integrated accumulation and interpretation of readings, interviews and personal experience in the applications of CCTV and transit systems. This guidebook attempts to provide enough detail and references about CCTV systems in transit station applications so that readers can be somewhat independent of suppliers for planning and operating their own systems.

Guidelines are sometimes based on scientifically supportable and objective information, and sometimes on the opinions of experienced individuals. The former type of guidelines might refer to measurable equipment characteristics, such as the required light levels for certain camera tubes. The latter type of guidelines might involve less measurable human characteristics, such as the number of video screens that can be monitored effectively by one person. The differences in scientific foundations or state-of-the-art account for individual guidelines being more or less quantitative, qualitative, objective, subjective, precise, vague, demonstrated or undemonstrated. In fact, those differences help one to realize that there are important research areas remaining to be addressed in the use of CCTV surveillance generally, and in transit station applications particularly. For instance, there are few research studies but many opinions regarding the personal attributes that should be sought in potential operators, if one wants to optimize performance in the tasks of routine monitoring and detecting of critical incidents, or if one wants to optimize adaptability to the shifts and routines of a 24-hour-a-day monitoring center.

Ultimately, each CCTV transit station security organization must develop its own kind of guidebook, to be used for both training purposes and as a manual of standard operating procedures. It is hoped that the present document contains many of the ideas and concepts which will make that task easier and more meaningful.

2. CONCEPTS RELATING TO THE USE OF CLOSED CIRCUIT TELEVISION (CCTV)

2.1 GENERAL

This section introduces some of the principal concepts that are addressed in the remainder of this document. It views the CCTV Transit Station Security System as a combination of equipment, people and procedures that have been brought together to fulfill a particular need at a cost which can be measured in dollars and social impact. To one degree or another, each of those system considerations is addressed here. Guidelines are presented which are more or less concrete, depending on the state of knowledge and information currently available. Some references are cited at the end of this chapter for the reader who seeks additional background information.

2.2 ROLES OF CCTV AT TRANSIT STATIONS

2.2.1 The Value of Surveillance Using CCTV

CCTV systems are most useful when observation is required and where direct viewing by an individual is undesirable, inconvenient or impossible. They can provide better vantage points for observation, and can augment the visual abilities of the observer in terms of light-level sensitivity, range and spectral responsiveness. In transit station security applications, CCTV provides many more "eyes," at many more locations, for indefinitely longer periods of time, at relatively lower cost than most security organizations are able to provide by using people only. Observers can be changed easily, and permanent recordings can be made of incidents. CCTV also facilitates the coordination of responses because a situation can be followed readily and visually from a central location where links to other agencies and services are also available. Further, the CCTV system can be enhanced in carrying out its function by integrating it with a two-way audio communications capability with passengers and related services. It can also tie in with automatic sensor alarm networks and with automatic response capabilities, such as remotely controlled gates and locks.

CCTV surveillance systems at transit stations can help in providing increased levels of safety through their usefulness in detecting and coordinating responses to accidents, medical crises, psychiatric emergencies, fires, and physical hazards. They also can be used to enhance transit operations by identifying crowd levels, movements and trends at key locations. They can aid in passenger convenience services by allowing a combined visual and audio query and response with passengers requesting information or having a problem with the station's automatic ingress or egress equipment. Finally, the presence of CCTV systems on transit stations can increase the passengers' perceptions of security and safety, especially when those systems are seen to be in active use with rapid and certain response actions. This positive change in perception, in turn, can result in an increase of ridership and income for transit systems. Among the existing transit systems employing CCTV systems for various purposes are: Airtrans (Dallas/Fort Worth Airport), BART (San Francisco), MARTA (Atlanta), MPRT (Morgantown, West Virginia), NYCTA (New York), PATCO (Philadelphia-Camden), PATH (New York-Jersey City), Sea-Tac (Seattle-Tacoma Airport), SEPTA (Southestern Pennsylvania), and WMATA (Washington, D.C.). (1, 2, 3, 6, 7, 8, 9, 10, 13, 14, 15, 16, 18)

2.2.2 Selection of the CCTV Approach

CCTV systems (with audio capabilities) are considered by many to be essential for unstaffed stations, because they provide both the surveillance and the passenger contact essential for secure, safe and convenient operations, and they do so more or less economically. However, CCTV must be considered as one approach out of several that may be possible to meet particular goals. If a crime countermeasure is sought, possible other alternatives include: an increased number of security personnel, audio surveillance equipment, automatic sensor alarms, still cameras, motion-picture cameras, increased lighting, gates and barriers, one-way mirrors, and police dogs. If a passenger assistance system is sought, possible other alternatives include: wall and pocket maps of the transit system, automatic machines for obtaining route information, passenger assistance telephones, staffed information booths, lost and found centers, multi-lingual information clerks, and change-making machines. If safety is sought, possible other alternatives include: gates and barriers, signs and signals, reduced operating speeds, elimination of physical hazards, emergency exits and exiting devices, public address systems, improved lighting, increased maintenance, safety training and information programs, increased equipment reliability, and direct lines to decentralized medical emergency services. The use of CCTV should be considered in comparison with the alternatives and evaluated accordingly. Some factors which could be seen as disadvantages to the CCTV approach include: the cost (initial investment and operating costs); the maintenance of high technology equipment (may require outside service contracts); space requirements (as for a monitoring center); specialized personnel requirements (operators and technicians); incompatibility of the transit stations with use of CCTV (architectural and installation problems); fatiguing nature of the monitoring task; objections by the public (if seen as an invasion of privacy); or even existing restrictions in contracts with labor organizations (limitations in job descriptions). (6, 15, 16, 17)

Once a decision is made to select CCTV as a desired approach to meeting transit system objectives, the potential user is likely to require a review or education in the technology and application of CCTV systems. That is the purpose of this document. However, a reading of this document cannot qualify one as a competent designer of CCTV systems. Consequently, the first and possibly most important guideline to the reader is: obtain the services of a reliable expert in the field of CCTV surveillance systems. The information gained from this guidebook will help the reader to plan and translate needs into equipment concepts, to communicate about CCTV in meaningful technical language, and to assess the quality of services received from the expert.

2.3 HUMAN-MACHINE SYSTEMS

A human-machine system is an operating combination of one or more persons with one or more equipment components, using given inputs, in a given environment, interacting according to some procedure to bring about a desired outcome. A common human-machine system is the automobile and driver; a less common one is the CCTV surveillance system.

Every human-machine system has at least one purpose. The CCTV system's first purpose may be to enhance transit station security by increasing the surveillance capability of the security force. A second purpose may be to enhance human safety by the same means. Other purposes could involve passenger convenience services, train operations or the training of monitoring center and police personnel.

The components of a human-machine system include the items of physical equipment and the persons who conduct activities with the equipment. Among the important problems in these kinds of systems are allocating functions between people and equipment, developing an arrangement of those system components to facilitate their interaction, and developing procedures to insure optimum overall system performance. Humans are generally better in their abilities to: sense very low levels of stimuli within the range of the senses, detect stimuli against high "noise" backgrounds, recognize patterns of complex stimuli, sense unusual and unexpected events in the environment, remember large amounts of information for a long time, retrieve pertinent information from memory, draw upon varied experience to make decisions, reason inductively or generalize from observations, apply principles to solve problems, and make subjective evaluations. Machines are generally better in their abilities to: sense stimuli outside the range of human senses, apply deductive reasoning, monitor for pre-specified events, store coded information, retrieve coded information, process quantitative information following specified programs, make rapid and consistent responses to input signals, perform repetitive activities reliably, exert considerable force in a highly controlled manner, maintain performance for long periods of time, count or measure physical quantities, and perform several programmed activities simultaneously. (11)

Once functions and tasks are allocated to system components, the interaction between human operators and equipment must be implemented. The interface between operators and equipment are: displays by which the equipment provides information to operators, controls by which operators provide information or instructions to equipment, and communications devices by which equipment and operators transmit information to other equipment or operators. Many of the guidelines in this document are directed at providing a proper match between the various equipments, the environment, operators, passengers, and support organizations. Matching the capabilities for transferring information insures optimum system performance by minimizing distortions in the exchange of signals, maximizing discernibility of important differences in signals, minimizing extraneous signals or "noise," and minimizing human fatigue or strain. Consequently, the guidelines in this document range from the matching of coaxial transmission lines, cameras and video monitors, to the matching of monitor screen size, distance and human visual capabilities.

2.4 SYSTEM PLANNING AND DESIGN

2.4.1 General

The amount of effort expended and detail required in this stage can vary widely from one transit system to another. For ease of discussion, an actual, but simple, planning and design effort is used to illustrate the major concepts below.

2.4.2 Establishing Locations for CCTV Coverage

Once a transit station or group of stations is designated to have purposeful CCTV and supplementary capabilities (e.g., a two-way audio communication network between operators and passengers), site examinations should be conducted. During such examinations, the sites are looked at by security and technical personnel to identify the best locations for such components as cameras, talk-back loudspeakers, audio and video transmission lines, power lines, and a monitoring center. Preliminary drawings can then be prepared to begin identifying what the system will consist of and how it will look. Figure 2-1 is a simplified drawing of an actual one-station CCTV-audio system involving eight cameras, four talk-back loudspeakers and a monitoring center placed at the desk of an adjacent transit police office. Environmental and tamperproof component housings were required on the outdoor platform which has an eight-foot high roof. All other cameras, loudspeakers and cables could be located about 15 feet above the floor for protection from vandalism. For the security of the CCTV-audio components themselves, every camera and loudspeaker is in the view of at least one other camera. In some transit systems, drawings as simple as Figure 2-1 would eventually have to be translated in greater detail onto the actual architectural drawings of the facility.

2.4.3 Establishing System Requirements and Specifications

After the preliminary layout has received general review and acceptance, another examination of the site is required to measure the illumination levels under all expected conditions, so that the need for extra lighting or low-light-level cameras in certain locations can be assessed. Further consideration should also be given to the individual tasks that will be performed by monitor operators and any other persons who are part of the system (e.g., supervisors, maintenance technicians) or who would be responding to incidents (e.g., police, fire, medical services). By this time, potential vendors of the equipment should be identified and contacted for general information about their equipment, capabilities, and services offered. Ultimately a written description of system requirements should be prepared, outlining the quantity of each type of component needed at each location, how those components will be interconnected to form an operating system, how the system will be maintained, who will operate it and how, and what the time schedule is for installation and operation. The system requirements document should reflect the performance needs of the transit system, but

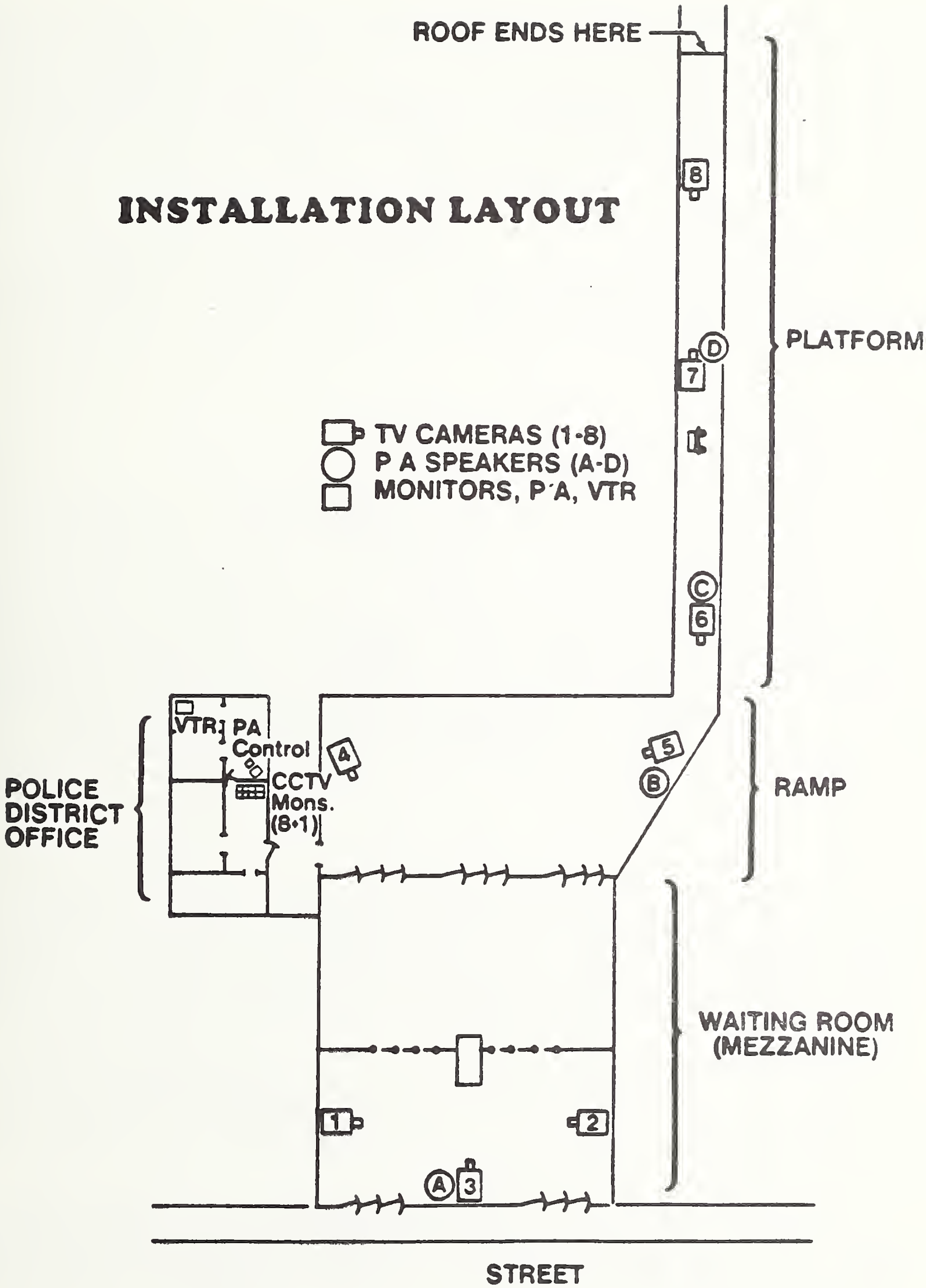

Figure 2-1. Installation Layout

should allow for any vendors to make their own competitive recommendations in meeting those needs with the equipment and technologies available to them. If major construction is required for large installations and monitoring centers, architectural requirements will have to be developed and appropriate firms contacted. Full details of anticipated operating procedures should form the basis for room dimensions, number of operators, component sizes and locations, workplace layouts, console panel configurations and support facilities. In smaller transit installations a simple description of system requirements may suffice as a basis for soliciting vendor bids and entering into early construction. In larger installations, the more general system requirements may have to be further developed into detailed and approved system specifications, a process which could take one or two years, in some cases. Plans for personnel selection and training should also be made at this time.

2.5 EQUIPMENT AND MAINTENANCE

A basic CCTV system includes a camera for converting light from the scenes into an electrical signal, a camera lens for focusing light from the scene onto a light sensor in the camera, a transmission medium (such as coaxial cable) to convey the camera's electrical signal to a video monitor, a video monitor which converts the signal into a visible picture on its screen, power supplies to provide power to all components, and a monitor operator who views the scene. Additional components can be added, depending on the purpose and size of the system. At the camera end, one can incorporate pan, tilt and zoom features, an environmental housing, a synchronization generator, an image splitter, a low-light-level sensor, an image intensifier, a telephoto or wide-angle lens, and an automatic iris. On the transmission link, one can incorporate repeaters, amplifiers, multiplexing, control-signal paths, radio or cable segments, conduits and other security devices. Rights-of-way for transmission cables may have to be obtained. At the monitor end, one can incorporate line equalizers, hum clampers, video presence sensors, remote-control devices, video switchers, automatic sequencers, a synchronization generator, videotape recorders, a multiplicity of individual video monitors, time/date/information character generators, and motion detection devices. In addition, the system can be supplemented by a two-way audio link between the monitoring center and passenger areas, direct-line telephone and radio links to related services, sensor alarm networks and a multiplicity of operators and maintenance technicians with varying assignments. Centralized or decentralized maintenance centers can be established, or equipment servicing can be provided under contract by an outside organization. Descriptions and guidelines for the use of these and other options are found in the remaining chapters of this document.

Once system requirements and equipment needs have been identified, procurement of equipment and construction services can take place. Unless considerable CCTV expertise exists within the transit system, one should make use of a reliable outside expert, deal only with reputable suppliers, and avoid used or modified components. Equipment should be procured with careful consideration for ease of future maintenance and the provision of full documentation (e.g., manuals, schematic diagrams, mechanical layouts, circuit descriptions, installation instructions, parts lists, test and alignment procedures, training requirements, and warranties). The equipment should be tried out beforehand in locations where questionable operating conditions (e.g., inadequate lighting) exists. The supplier can also be requested to provide information for a preventive maintenance program, operator training programs and lists of interchangeable spare parts. (5, 12, 13)

2.6 PERSONNEL AND PROCEDURES

Recognizing the CCTV transit station surveillance installation as a human-machine system requires that specific consideration be given to the roles of personnel, and to personnel screening, selection, training and evaluating in the context of those roles. For example, performance on some tasks (e.g., recognition of crimes in progress, communication with the public) has been found to be correlated with various factors, such as age, prior training and experience, and personality traits. Those findings have implications for personnel selection. Various methods of training personnel are also available, as are different methods for motivating them. All of these issues are addressed in subsequent chapters. Detailed specifications of appropriate operator response sequences to critical incidents should be developed, helpful job aids should be provided, and a record-keeping system must be established. Proper recognition must be made of human abilities to work in shifts, to change shifts, and to adapt to those changes. Some research and practical experiences have helped to establish rules-of-thumb regarding how many video monitors can be effectively observed for given periods of time, by one operator, under various levels of scene activity. These issues also are addressed by the guidelines in later chapters.

2.7 COST

The costs of CCTV surveillance systems depend upon such a large number of factors that it is best to consider some of the typical categories of costs and representative dollar figures within those categories. Although the comments here refer to financial costs, one must also recognize that there can be social or political costs associated with the implementation of these systems.

Among the first set of factors which determine overall cost are items like: the purposes and special requirements of the system, its overall size, unusual construction or property acquisition requirements, schedule of operations and shifts, built-in response capabilities, maintenance policies, buy or lease decisions, collective bargaining agreements, and career levels of personnel. Administrative costs could increase if formal and detailed documentation and lengthy approval procedures must be followed in the planning and design stages. Eventually, the equipment acquisition cost must be calculated, along with labor, outside services and other expenses.

For convenience, the system's life cycle can be used as one set of categories for analyzing and estimating costs. The life cycle of any human-machine system can include many stages: (1) concept formulation and definition; (2) technology development and demonstration; (3) concept selection; (4) system definition and planning; (5) detail design and development; (6) construction, fabrication, assembly, test and checkout; and (7) operation, maintenance, modification and removal. Clearly, advanced technology systems will have a different distribution of costs across the life cycle than would a conventional, "off-the-shelf" system. To estimate costs within each stage, one can use generally accepted accounting concepts. Thus, the costs would be divided into one-time (e.g., purchase) costs, fixed (e.g., rent) costs, variable (e.g., repairs) costs, and general and administrative costs.

Another factor which influences the cost of equipment is the acquisition authority of the purchasing agency, that is, the ability of the agency to solicit competitive bids, to demand "most favored customer" prices, to obtain grants and low interest bonds or loans, and to gain economic advantages in any other way. The availability of capital funds as compared to operating funds is an additional factor to influence the acquisition plan, in that it could make leasing more attractive than buying of equipment.

Although the purchase cost of equipment can range from about $1,500 to $20,000 per camera/monitor installed, the operating costs of the system can rapidly exceed those purchases. Labor costs and maintenance of equipment are two of the major continuing expenses of operation. The guidelines in this document offer various alternatives that could help minimize all those costs in any given system.

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3. MONITORING CENTER EQUIPMENT AND STAFFING

3.1 GENERAL

The information and guidelines provided in this chapter are concerned with that portion of the transit station CCTV surveillance system that is often referred to as the control center, central control, monitoring center or some other similar term. It is distinguished from the remaining components of the CCTV system, like cameras, loudspeakers, station microphones, lighting, and transmission links, by being physically separate and usually centralized, with one or more operators who perform routine monitoring and respond to incidents as they arise. For purposes of this document, the system's maintenance operation is also treated in the present chapter, with some specific supplementary treatment in other chapters.

The monitoring center is addressed here in terms of equipment, staffing and scheduling. The various displays, controls and other associated apparatus are identified and compared across their most important characteristics. The optimum number of operators required to staff the center is discussed, as are their other possible duties and the best shifts and schedules for their job assignments. The physical environment is considered, and the accompanying layouts of equipment and operator workplaces are addressed. The use of an audio subsystem, other communications networks and some special features that can be incorporated into the CCTV security system are also treated here. In some cases, the information presented is based on the results of carefully designed research studies, while in others it represents current practices and opinions of practitioners in the field. To help the reader identify sources and find more information, references are cited at the end of some paragraphs, and the consolidated list of cited references appears at the end of this chapter. These same references also appear in the more comprehensive bibliography of Appendix C.

3.2 DISPLAYS, CONTROLS AND ASSOCIATED EQUIPMENT

3.2.1 Monitoring Center Equipment

Figure 3-1 is a simplified block diagram indicating a hypothetical array of equipment in a monitoring center. The sources and destinations of the center's inputs and outputs include the CCTV cameras from different station locations, automatic alarm sensors, call-for-aid passenger telephones, direct telephone lines to related services, commercial telephone lines, and various radio links to related services and patrol units. Obviously, monitoring centers can be even simpler or more complex than is illustrated here. It is clear, however, that many channels can connect the center's equipment to the "outside world" and to the monitor operators. The subparagraphs of this section describe numerous devices that can be used in the monitoring center, including: video monitors, video switchers and sequencers, video recorders, time/date and other information-display generators, sync generators, distribution amplifiers, line equalizing amplifiers, clampers, and

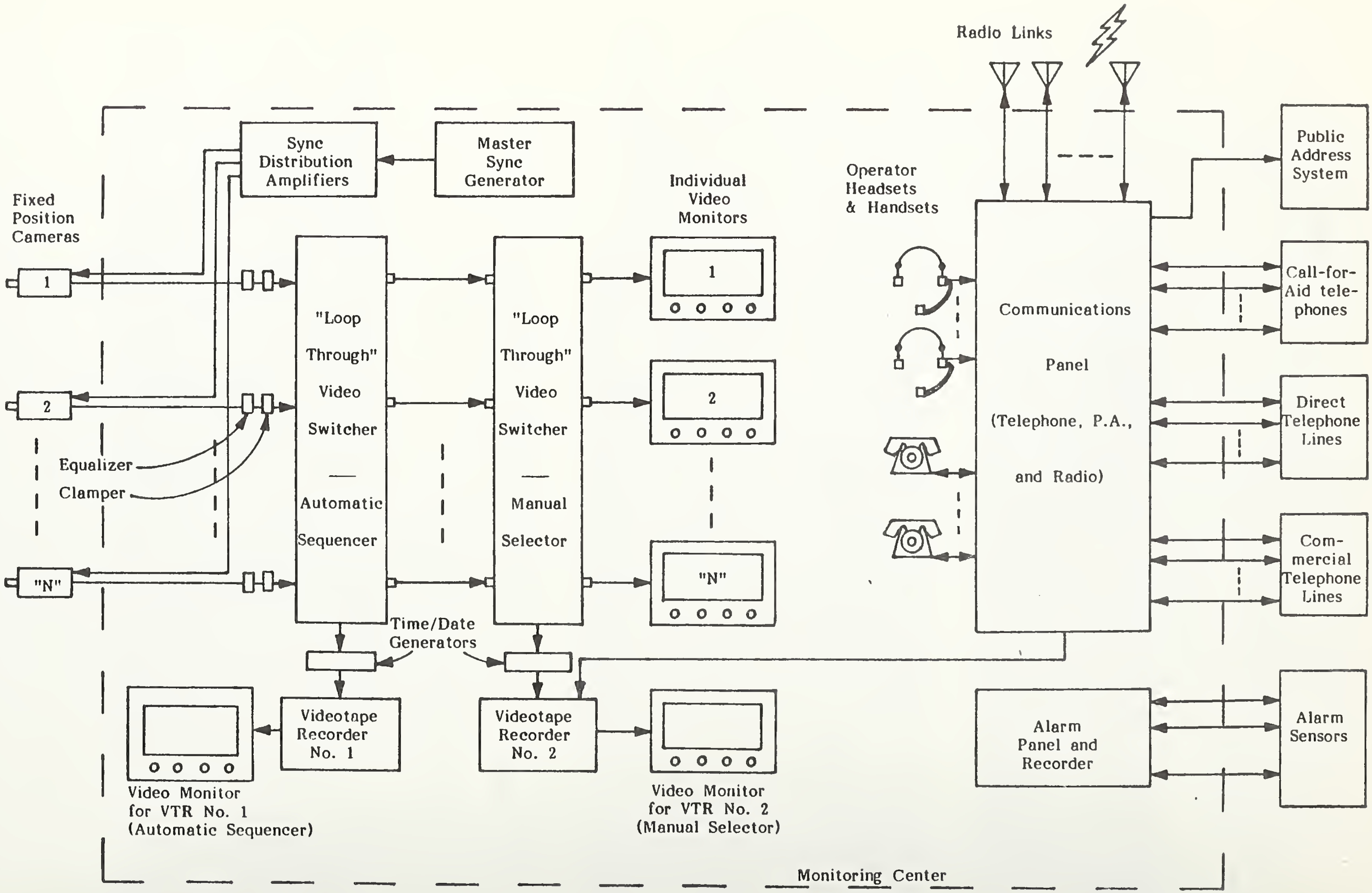


Figure 3-1. Simplified Block Diagram of Equipment in a Monitoring Center (Hypothetical)

other miscellaneous items (cable connectors, power and signal line surge suppressors, power supplies, station and equipment status indicators). Logs and manuals, audio and communications apparatus, special devices and maintenance equipment are described later in this chapter.

3.2.1.1 Video Monitors - The video monitor is the main output display for the CCTV system. Key characteristics of video monitors that determine the quality of the picture viewed are: size, brightness, contrast ratio, gray scale response, resolution, interlacing, distortion, and stability.

a. Monitor size - One supplier's general rule of thumb, based on industry experience, is that viewing distance and diagonal screen size should be in the ratio of between 5:1 and 8:1. That is, observers should be placed back from the monitor screens a distance equal to five to eight times the diagonal size of the screen. Not all industry sources recommend the same relationship, however. Table 3-1 lists the minimum and maximum distance, as adopted from a more liberal industry source, for providing the best detail to the average viewer. The designer is well advised to try various-size monitors to see which is best for his/her system. One way of accomplishing this tryout is by visiting existing systems. During such visits, one can also expect to learn that most CCTV transit security personnel seem to prefer 17" or 19" monitors (at least for the main display) in order to see, in comfort, the desired amount of detail for surveillance operations. This size also permits others nearby to view the same displays without crowding. The actual screen size that is best can vary depending upon the type of scene viewed, the operator, lighting conditions (at the scene and in the monitoring center), the number of video monitors being viewed, and the tasks required of the operator. If reading of signs or documents is important, then the larger screens (or shorter viewing distances) are recommended. For more generalized surveillance applications, screens even smaller (or distances even greater) than those recommended may be satisfactory. In the CCTV security systems examined during the preparation of this document, screen sizes varied from 9 to 19 inches. The small screens tended to be in cramped locations (e.g., pre-existing small offices or booths), while the larger screens were found where rooms were built specifically to accommodate them. (11, 19, 22)

TABLE 3-1. SCREEN SIZES AND VIEWING DISTANCES FOR VIDEO MONITORS

Monitor Screen Size [Diagonal] (inches)	Maximum Viewing Distance (feet and inches)	Minimum Viewing Distance (feet and inches)
9"	7'0"	3'0"
12"	10'0"	3'4"
14"	12'0"	3'7"
17"	14'9"	3'9"
19"	16'11"	4'3"
21"	19'0"	4'6"
23"	20'10"	4'11"

Another advantage to large, more distant screens is that the operator's eyes will avoid fatigue associated with the focusing and eye convergence needed in the near field. The eyes are in a more relaxed state when they are looking at distant ("infinitely far") objects than when looking at closer objects.

b. Brightness, Contrast Ratio, and Gray Scale Response - The ability of a person to perceive an event on a video monitor screen is partly dependent upon the brightness of the image and its range of gradation from full brightness to "black." Generally, the greater the contrast ratio between full brightness and black, the better. However, that gradation should be gradual so as not to obtain an image that contains only the extreme bright and black tones. An ideal monitor would be capable of displaying an infinite number of shades between the extremes. In practice, monitors capable of producing at least 10 discernible shades of gray have been found acceptable. Although one could probably make adequate subjective comparisons of brightness, contrast ratio and gray scale response, it is possible to test these qualities with photometric instruments and the use of test charts. The Electronic Industries Association (Washington, D.C.) makes available a Logarithmic Reflectance Chart, which contains ten levels of brightness from absolute black to white, for this purpose.

c. Resolution - Monitors, like cameras, can be specified in terms of vertical and horizontal resolution to describe their abilities for separately displaying two closely spaced points. The monitor image must be capable of being sharply focused in order to obtain the fullest possible resolution. In the vertical direction, resolution is determined by the number of scan lines. For the systems described here, a minimum of the standard 525 scanning lines per frame (2:1 interlace) should be used for adequate vertical resolution. In the horizontal direction, resolution is generally specified for the center of the screen (where it is usually highest) and for the corners. Horizontal resolution is expressed in terms of lines (or TV lines) and video frequency bandwidth. For indoor images, where shorter distances are viewed, horizontal resolution can be relatively lower, and is recommended to be a minimum of 600 lines in the center and 450 lines in the corners, with a video frequency bandwidth of at least 7.5 MHz. For outdoor use, a minimum of 700 lines in the center and 550 lines in the corners, with a 9 MHz bandwidth, is recommended. It is not unusual to employ 700-800 lines horizontal resolution in 525-line scan rate systems, operating at up to 10 MHz of horizontal system bandwidth. A general rule-of-thumb is that one obtains approximately 80 lines of resolution for each 1 MHz of bandwidth. In any event, the bandwidth or resolution of the monitor should match that of the camera to provide the best detail at the most economic price. Resolution can be measured using the Resolution Chart published by the Electronic Industries Association (Washington, D.C.). (22)

d. Interlacing - To minimize picture flicker and degraded resolution, each full frame of picture video information is made up of two interlaced horizontal fields transmitted sequentially. Each field is generated in 1/60th of a second, so that each full frame is generated in 1/30th of a second. In U.S. broadcast-type systems, the horizontal scan lines (approximately 262) of the second field fall exactly between the horizontal lines (approximately 262) of the first field. This exact scanning line relationship is called 2:1 (two to one) interlacing. A less sophisticated, low-cost system is one in which the two fields of scan lines are not locked together (synchronized) exactly. This free-running or floating system is referred to as random interlacing, and typically produces a picture of completely acceptable quality. However, the reduced stability of the picture can be a problem when included as part of a total system requiring precise synchronization between several cameras or monitors and such other devices as videotape recorders and special effects generators. (11, 16)

e. Distortion (Non-linearity) - Images on a monitor screen can appear out of shape if their component points and lines are not uniformly positioned on the tube face, but rather appear squeezed or stretched in one or more directions. This departure from uniformity or linearity is referred to as non-linearity. Monitors typically have controls to adjust the linearity of the image so that uniformity is achieved. The user should assure that all monitors are adjusted for linearity on installation, checked again after maintenance, and checked also as part of a periodic preventive maintenance program. Linearity Charts are available from the Electronic Industries Association (Washington, D.C.) for this purpose.

f. Stability - Picture roll in the vertical direction, or tearing in the horizontal direction are indications of instabilities in the synchronization between the received video signal and the monitor sweep circuits. Monitors typically have controls to adjust for synchronization. They can also contain an automatic frequency control (AFC) feature in the horizontal oscillator to help overcome inadequacies of sync signals from some videotape recorders that might be used as input sources to the monitor. The user should assure that the monitors remain adjusted for long-term stability.

3.2.1.2 Video Switchers and Sequencers - Video switchers can be described in terms of what is being switched, and how that switching is accomplished. One type of switcher converts two or more video inputs to one output; another type converts one or more video inputs to two or more outputs. Switchers can also be passive or active. A passive switcher is controlled by manually actuating contacts through which the video signal is routed with no additional electronic processing or conditioning. An active switcher may route video signals through relays or semiconductors, and typically includes the use of input and/or output isolation amplifiers, impedance matching circuits, amplitude control, and even automatic circuits to control the relative timing of the switched signals so as to maintain picture stability (important if VTRs are used). Vertical interval switching, for example, is a method of switching video during the vertical interval period of the video waveform. Switchers can further be divided into those which are controlled locally or remotely. Sequencers are typically remote-controlled switchers which automatically scan a number of camera outputs at a selectable rate or image dwell time. For example, 6 cameras may be sequenced at a rate of 1 camera every 3 seconds, completing a full cycle of 6 displays every 18 seconds. Automatic sequencing is not a popular option in CCTV transit station security systems.

Unused input or output terminals on switchers must be terminated in the characteristic line impedance (e.g., using a 75 ohm resistor) in order to maintain the quality of images on the remaining circuits. If a switcher is used to pass the video signals along ("loop through") to subsequent equipment in addition to extracting a selected signal, then it is referred to as a bridging video switcher and does not employ terminating resistors. If no looping through takes place, it is referred to as a terminating video switcher and it provides the proper characteristic terminating impedances to all incoming video lines. (19)

3.2.1.3 Video Recorders - The video recorder provides a medium for preserving camera images for replay at a later time. The recording medium has traditionally been magnetic tape in reel, cartridge or cassette form. In recent years, magnetically coated discs have come onto the market, but their costs are still very high and their storage capacity is still very small compared to the usual needs of a security system. Videotape and video cassette recorders (VTRs and VCRs) can be used for tape recording security incidents, for training purposes, and for system evaluation purposes. The also have the ability to record sound on an audio track alongside the video information. Video tape commonly comes in reel or cassette form and in widths of 1/2 inch, 3/4 inch, or 1 inch. Cassette tapes come in widths of 1/2 inch and 3/4 inch (U-Matic). The 1/2 inch video cassette formats come in two types which are not interchangeable—Beta and VHS. Manufacturers which use Sony's Beta format include: Aiwa, NEC, Pioneer, Sanyo, Sears, Sony, Toshiba and Zenith. Manufacturers which use JVC's VHS format include: Curtis Mathes, General Electric, Hitachi, JVC, Magnavox, Mitsibishi (MGA), Panasonic, Quasar, RCA, Sharp and Sylvania. The major difference between the Beta and VHS formats is in the mechanical nature and interlocks of the video cassette and some of the equipment's playback features. Most current Beta machines will play 90 minutes on standard play (SP) mode and 3 hours on long play (LP) mode. Recently, a 5-hour Beta cassette has become available. VHS equipment has a maximum of 2 hours in SP, 4 hours in LP and 6 hours in extended play (EP) mode. Developments have been announced to produce 8-hour video cassette in the near future. Index numbers (and/or date and time) can be superimposed electronically on the video image by a character generator, or a mechanical counter on the recorder provides the operator with a tape-position index that can then be noted in the recorder log book. Automatic indexing and locating by the machine itself is also available.

Two basic types of recording techniques are in use: quadruplex and helical scan. The quadruplex recorder has been commonly used by TV broadcasters, is of very high quality, and can cost $50,000 or more. Helical scan recorders, costing upwards of $2,000, are usually more appropriate for studio and news-gathering uses, and some editing. The helical scan video cassette is probably the most popular unit employed for transit security. A 3/4-inch tape in a cassette configuration will produce high-quality color or black-and-white reproductions. Some color degradation generally occurs during editing and it should not be used as a master tape for color reproductions. For studio or office black-and-white recordings, the 3/4-inch video cassette recorder appears to be the most convenient and satisfactory configuration. For portable black-and-white work, the 1/2-inch video cassette recorder is generally best. Whichever recorder is obtained, it is advantageous for security work to have "slow motion" and "stop frame" capabilities in the playback mode.

To extend tape storage capacity and to speed up the image review or retrieval process, a "time lapse" (as compared to "real time") recording capability can be used. Real-time recorders store all the fields of video information, while time-lapse recorders store some but not all of the fields. The fewer fields recorded, the greater the time-lapse ratio is, and the less tape is used.

While this feature is often desirable, it is quite possible to completely miss recording an event or to obtain a useless recording if the time-lapse ratio is too high (e.g., 60 to 1). When a time-lapse capability is acquired, it is advantageous to be able to switch between real time and time-lapse from a remote location. In fact, general remote control of the recorder would be advantageous, and has now become an available option by some manufacturers. (19, 22)

3.2.1.4 Time/Date and Other Information-Display Generators - For security and investigation applications, and for possible courtroom evidence purposes, each frame recorded on videotape should have some basic information encoded on it. Typically, this would include the date, time (hour, minute and second), and camera identifier. It is even possible to encode and record environmental conditions, like wind speed and direction, if necessary. The master time source is generally either the 60 Hz AC power-line frequency or an internal crystal-controlled oscillator. Its electronic timing signal is converted by a character-generating device into numerical data which are then superimposed on the video signal. Unless backup battery power is provided for, the timing reference will need to be reset in the event of power failures.

Source identifiers are used to supply an alphanumeric designation of individual cameras or locations. The designations are generally programmed by the operator and stored digitally for future selection and use with each incoming video signal. Environmental data generators operate similarly, except that their inputs come from weather sensors. In these types of units also, backup battery power can be provided to protect the memory in the event of power failure.

Information display generators usually come with position and intensity controls, so that data can be placed in non-essential areas of the scene and in proper contrast with the background. Because the video signal loops through these information-display generators, it is important to choose equipment which will not degrade the video signal or cause its loss if the display-generator fails.

3.2.1.5 Sync Generators - When switching between cameras, as for VTR input purposes, the problem of image synchronization becomes very important to avoid instabilities in the final recorded or viewed picture. In general, a common source of horizontal and vertical drive signals should be used for all cameras.

There are three types of synchronization signals used in video cameras: random, locked interlace and external drive. Cameras utilizing random synchronization generate their horizontal and vertical sweeps independently of one another, with the vertical sweep being derived from the power line. If several cameras are connected to the same power line and in the same phase, the vertical sweeps will be in the same time relationship. The video from these cameras may be switched into a monitor or VTR with minimum instability. Horizontal timing is generally not critical in applications where random synchronization is used. If two or more cameras are connected to different, or out-of-phase, power lines, vertical interference may be seen on the monitor when switching to a monitor or VTR. Cameras utilizing a locked interlace synchronization have the horizontal and vertical sweep rates fixed in a definite relationship to one another. Both sweep signals are derived from a common crystal-controlled oscillator. This fixed relationship between the horizontal and vertical sweep is helpful in resolving fine detail in a picture because of the increased vertical resolution.

If multiple locked synchronization cameras are used in a switching system, vertical picture instability may be present as the video is sequenced. Though each camera provides a locked relationship between its own horizontal and vertical sweep rates, it is entirely independent of other locked synchronization cameras in the system. Another form of locked interlace is provided by the external drive system. Drive signals for horizontal and vertical sweep are supplied to each camera from an external system master drive generator. Since all the cameras in the system are driven from the same source, this form of drive has the advantage of each camera's sweep being precisely in the same time relationship.

When it is necessary to sequence or switch cameras into a VTR or monitor, the system should be designed so that at least the vertical synchronization signals of all cameras to be switched are locked together by use of an external drive system or by the use of random interlace cameras connected to a common 60 Hz power line. In addition, a vertical interval switcher should be used so that the last camera's picture is completely generated before the next camera's picture begins. (19)

3.2.1.6 Distribution, Line Equalizing and Hum Clamping Amplifiers - The distribution amplifier is used to send a single video or synchronization signal in several directions simultaneously. One of its most important functions is to provide isolation from input to output and between outputs, thereby minimizing the transmission of disturbances (e.g., short circuits, crosstalk, etc.) from one line to the others. Separate gain controls should usually be provided for each output to compensate for differences in signal levels that develop from varying cable lengths and circuit characteristics.

The line-equalizing amplifier is used to compensate for frequency-related alterations in phase and amplitude that occur when video signals are sent over long cable runs. Most amplifiers are adjustable to compensate for different types and lengths of cable. If a video monitor input is connected to cable runs of more than about 2,500 feet, a line-equalizing amplifier may be necessary. Various video monitors have a built-in line compensating network that can accommodate as much as 8,500 feet of certain cable types, eliminating the need for separate line equalizers in those applications. Video monitor specifications should be consulted to determine the need for a line-equalizing amplifier. (19)

The hum clamping amplifier is designed to remove undesired power line hum from video signals that have traveled over long lengths of transmission cable. The problem can show up as "hum bars" on the video monitor screen, in which case clampers are appropriate for use. The clamper operates on the principle of sampling the hum signal, inverting it, and using that phase-inverted signal to cancel out the original hum signal. Clampers should be compared and evaluated in terms of their frequency response, maximum hum and signal input levels, hum reduction capability and signal-to-noise ratio.

3.2.1.7 Miscellaneous Monitoring Center Devices - Although this chapter cannot provide details of every possible device that could be used in the monitoring center, a few more of interest that have not yet been described include cable connectors, power and signal line surge suppressors, power supplies and status indicators.

There are several types of cable connectors used for coupling video equipment, the primary ones being referred to as BNC, UHF, Type F and Twinaxial connectors. All have coaxial configurations with a means for mechanically securing the mating parts. The selection of connector types is dictated by the cable in use and the connectors supplied on the other equipment. Crimp and solder types of connectors are available, and both can provide adequate terminations.

The need for surge suppressors is determined by existing or anticipated conditions in the environment, such as induced electromagnetic interference (as from a nearby radar), power line surges, and lightning. These transient effects can damage the input circuitry of certain video equipment and power supplies. When found to be necessary, the protective devices need careful selection to avoid degrading the video and synchronization signals through parasitic capacitance.

In critical CCTV operations, the planners may determine that uninterrupted power is necessary. In such a case, the design should provide for redundant power supplies and automatic switchover should a primary supply fail. Emergency backup to commercial line power may also be found necessary, and can be implemented with automatically started generators.

In addition to the video monitor screens, the operator's workplace will also have various status displays to indicate equipment operating conditions (e.g., off, standby, operate, malfunction, alarm). Often these are in the form of illuminated pushbutton switches, rotating selector switches or colored indicator lights. In more comprehensive and sophisticated systems, status displays are provided on computer-generated video display terminals, and often allow for operator input to the computer through a keyboard. The general guideline is that increasing the amount of equipment and the system complexity tend to reduce system reliability. More items can fail, so more attention is needed to insure continuing operation and confidence on the part of operators, passengers, and others associated with the system.

3.2.2 Documents and Supplies

Not all the devices found in the Monitoring Center are electronic equipment. There are also various documents that are essential to the effective operations in the center, including log books, directories, regulations and procedures, manuals, and job aids. These items are described more completely in

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

3.3 PERSONNEL AND WORK SCHEDULES

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

3.3.1 Number of Monitors Viewed per Operator

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

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

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

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

3.3.2 Viewing Time and Shifts

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

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

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

When operators work in shifts, usually of eight hours each, the issue of changing or rotating shifts must be considered. Typical shifts run from 8 AM - 4 PM, 4 PM - 12 M, and 12 M - 8 AM, give or take an hour and some overlap. While most police and transit departments have experience with shift changing, it may be helpful to consider some of the research findings on this subject. Biological rhythms and personality attributes have been found to be associated with the ability to adjust successfully to shift changes. Certain types of people adjust more easily than others to shift changes and night work. Since those adjustments can take up to two or three weeks for some people, frequent (e.g., weekly, biweekly) reassignment of an individual's work shift is not appropriate under ordinary circumstances. Several studies of individual circadian rhythms have shown that evening-type people adjust better than morning types to night work. Studies of personality have shown that extroverts adjust better than introverts, especially if those extroverts have certain neurotic tendencies. The ability to sleep at unusual times of day, and to overcome drowsiness, is likewise characteristic of those who adapt better among the general population. Interestingly, the indications are that most people, if given the opportunity, will tend to choose the shifts that best fit their combined biological, psychological and social situation. "Permanent" or long-term shift assignments have met with great success in such cases. Finally, there is some early research underway which is investigating the use of drugs to alter biological cycles and possibly aid adaptation to shift changes. Although they have not yet been studied sufficiently, it appears that lithium carbonate and alcohol may slow biological clocks, while imipramine, caffeine and other stimulants may speed them up. Experiments with rats have shown that imipramine speeds adjustment to a sudden reversal of the day-night cycle. One of the motivating forces behind this line of research is the jet-lag problem experienced by long-distance travelers. (1, 2, 7, 9, 12, 13, 14, 15, 21, 23)

3.4 PHYSICAL ENVIRONMENT AND LAYOUT

The factors which create the physical setting for operators include the ambient environment (e.g., lighting, temperature, humidity, noise) and the equipment layout (e.g., room dimensions, display panels, consoles, visual reach dimensions). Some of the principles and practices related to these factors are summarized in this section.

3.4.1 Ambient Environment

The primary ambient conditions affecting human performance in a CCTV transit security monitoring center are temperature, humidity, air movement, noise and lighting.

3.4.1.1 Temperature, Humidity and Air Movement - These factors are considered jointly here because the effective temperature experienced by operators is determined by the combination of those factors. As defined by the Guide and Data Book of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), effective temperature is an empirical sensory index combining into a single value the effects of temperature, humidity, and movement of air on the sensation of warmth or cold felt by the human body. A complex ASHRAE Comfort Chart indicates the likelihood of feeling comfortable under various combinations of conditions. The comfort chart indicates optimum effective temperatures for winter and summer of 68° and 71° F, respectively. That is, virtually all individuals would be comfortable under those conditions. As a point of reference for the reader, an effective temperature of 70° F would occur at a dry bulb temperature of about 76° F and 40% relative humidity (or 75° F and 50% relative humidity), with air movement or turbulence of 15 to 25 feet per minute. The interested reader is referred to the ASHRAE Guide and Data Book for a more detailed explanation of this environmental measure, its relation to other measures, and its utilization. (4)

3.4.1.2 Noise - The characteristics of noise that seem to be most annoying and stressful are high intensities, high frequencies, intermittency, and reverberation effects. There are some indications that noise degrades work performance, though people have considerable (but not complete) capacity to adapt to the annoying characteristics of noise. The subjective perception of sound depends upon its frequency, as measured in Hertz (Hz). Normal human hearing takes place in the range from about 20 to 20,000 Hz, with the greatest sensitivity in the region of 2,000 Hz. The most convenient and common measure of sound intensity is the decibel (db). A reference level of 0 db is arbitrarily fixed to be roughly comparable to the minimum sound at a pitch of 1,000 Hz that can just barely be heard by the average person. Adding 10 db to the sound level is equivalent to multiplying that level by 10. For example, a quiet broadcasting studio would measure about 20 db, which is 100 times the reference level. A quiet office is about 40 db, or 10,000 times the reference level. A large department store would measure about 60 db, while a stenographic room or noisy restaurant would measure about 70 db. A level of 80 db might be measured near a pneumatic drill, a level of 100 db in a boiler shop, and a level of 115 db might be measured about 35 ft. from a riveter. Continuous and extensive exposure to noise levels above 80 or 90 db is generally considered to bring about hearing loss. The pain threshold of sound is approximately 130 db or about 10 trillion times the reference level. (17, 18)

One could probably expect a CCTV monitoring center to be fairly quiet (about 50 db). However, the background noise level must be considered if audible signals or audio communications are used. Noise in a monitoring center is likely to come from equipment (e.g., cooling fans) or talking. For listening in noise, a convenient rule of thumb for specifying the optimum signal level is to select one midway between the masked threshold and 110 db. The signal must exceed its masked threshold by at least 15 db for good discrimination.

3.4.1.3 Lighting - Lighting is perhaps the most troublesome ambient condition to be managed in a CCTV monitoring center because it can so readily interfere with the operator's primary task of viewing the video images. The recommended illumination levels for various situations and tasks are published by the Illuminating Engineering Society located in New York, and their figures are frequently reported in other guidebooks or manuals. Some typical illumination levels recommended are: 5 footcandles (fc) for the storage area of a parking garage or an inactive warehouse, 20 fc for office corridors or stairways, 30 fc for the non-merchandise areas of stores, 50 fc for a kitchen range and work surface or the entrance to a parking garage, 70 fc for a kitchen sink area, 100 fc for regular office work, 150 fc for accounting and bookkeeping work, 200 fc for detailed drafting tasks, 500 fc for fine assembly or machine work, and 1,000 fc for extra-fine assembly or machine work. In the monitoring center one may wish to have 100 fc on the writing surfaces, 50 fc in adjacent non-work areas, and somewhere between 2 and 20 fc around the monitor screens, depending on personal preferences. (18, 20)

Varying and conflicting requirements for illumination are not the only problems in optimizing the lighting design of the monitoring center. The next set of problems comes from glare and reflections. Light falling on a matte surface video monitor screen produces a veiling glare which reduces contrast. Light falling on a non-matte screen produces reflected (or specular) glare. If there is too much contrast between the viewed area and its surrounding area, the brightness of the viewed area can be affected in a manner similar to that caused by direct glare coming from bright lights situated in the line of vision. Regardless of how it is produced, glare can cause discomfort and degradation of visual performance. To reduce direct glare, one can reduce the brightness of light sources (e.g., lower the intensity or use diffusers), place the sources out of the direct line of vision (at least 60° from the line of vision), increase the brightness of the surrounding area so as to lessen the brightness ratio, or use light shields and hoods if no other method is possible. To reduce reflected glare, one can use a larger number of lower brightness individual light sources, avoid excessive brightness ratios between the work area and its surrounding area, use diffuse light (e.g., indirect light, baffles, or window shades), position light sources so as not to reflect into the operator's eyes, and use surfaces that diffuse rather than concentrate reflected light. In particular, lighting should be arranged (e.g., as with diffusers) so that there is no glare affecting the viewing of the video monitor screens or any other display and control panels. (18)

For reasonably optimum operator performance, a video monitor should be viewed under generally dim illumination conditions, in order to preserve the contrast of the displayed scene. On the other hand, operators could have other visual tasks requiring higher levels of illumination. In attempting to satisfy both of these requirements, there is a risk of forcing operators to frequently change their visual adaptation (dark adaptation and light adaptation). This difficult situation can probably best be addressed by the use of a locally controlled lighting system which supplies each area with the proper lighting for the job to be performed in that location. General illumination would then be of secondary, though real, importance. For work surfaces, one may consider the use of ceiling-mounted spotlights or well placed desk lamps. Dimmer controls for individual workplaces, and for the room generally, would allow operators to vary the light levels to suit their own individual preferences. One can also consider methods for providing light around the video monitors without having the light reach the screens themselves. The methods for doing that include carefully focussing the light so that very little reaches the screens, minimizing the number of uncontrolled light sources (e.g., windows) in the monitoring center, using colored light for illumination with a filter over each screen which rejects that color, and using polarized light with a second polarizer over each screen. The risk in using the two latter methods is that perceived picture quality may be degraded. (11, 20)

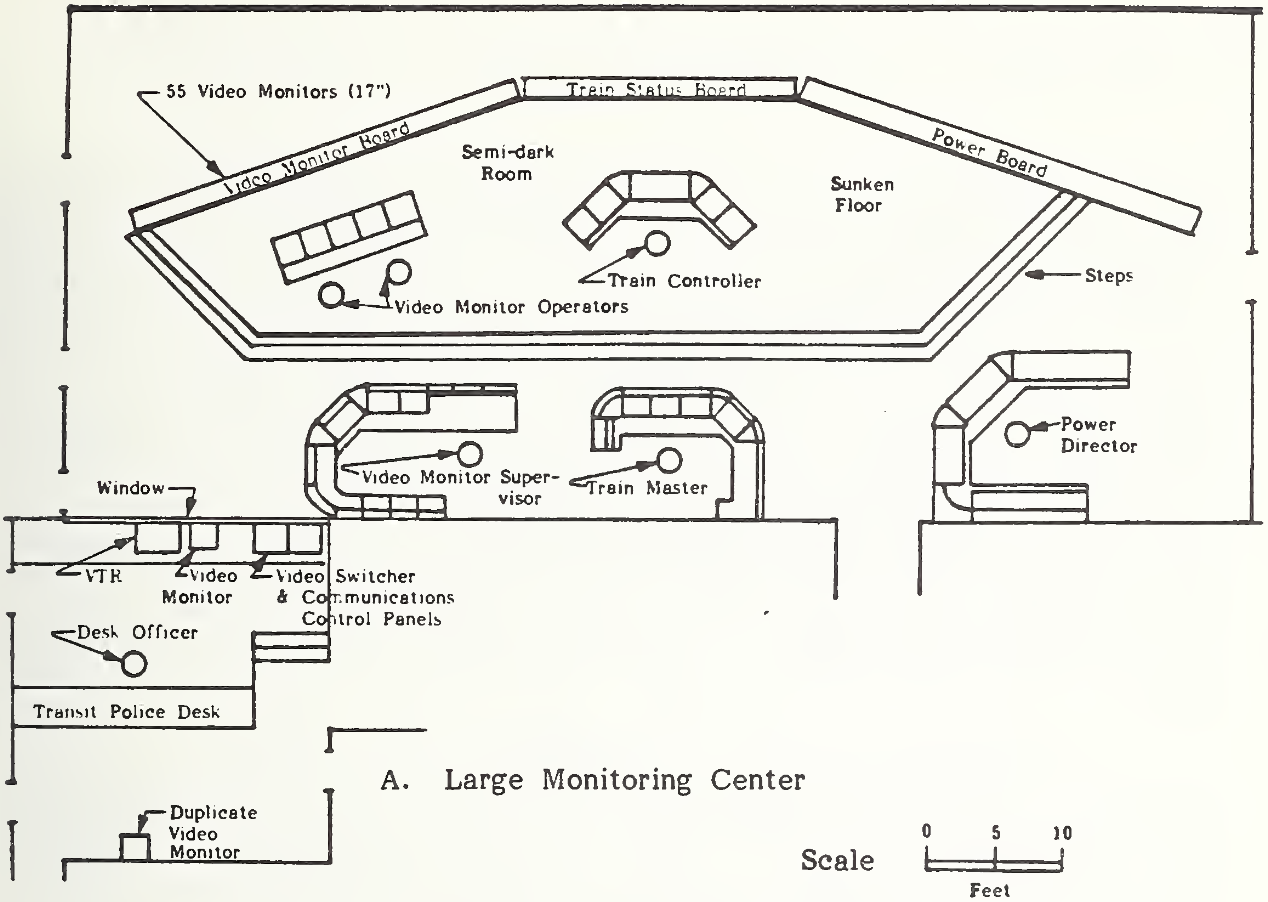
3.4.2 Equipment Layout

The principles of proper physical layout for a monitoring center are concerned with the relative dimensions and placement of apparatus and operators, so that individual comfort and system performance are optimized. In this section, several guiding principles from the field of human factors engineering are provided, and relevant practices of existing monitoring centers are noted.

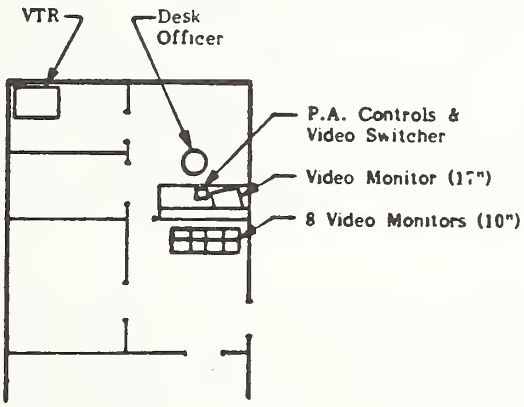
3.4.2.1 Layout Constraints - The major determinants of equipment layout include: (1) available space; (2) number of video monitors required; (3) size(s) of the video monitors; (4) number of operators to be present simultaneously and their roles; and (5) equipment and functions to be provided for, other than video monitors. Available space is determined by the size of existing or new quarters designated for the monitoring center. When these dimensions are not prescribed, then the desired equipment layout and growth plans can be used to generate minimum acceptable space parameters. The number of video monitors required is determined by the number of cameras to be monitored, the number of videotape recorders to be monitored, the number of summary or duplicate supervisor's displays to be used, and the philosophy adopted regarding the use of sequential switching of several cameras onto single video monitors. The size(s) of the video monitors is (are) determined by a trade-off between the optimum screen size (generally 17"-19", diagonal) and the available space (see Section 3.2.1). The number of operators to be present in the monitoring center at the same time is determined by how many screens must be monitored, which monitor-related functions (e.g., pan, tilt, zoom, sequence, select, record) must be performed, and which additional functions (e.g., communicate with other official services or passengers, make public announcements, respond to automatic sensor alarms, answer telephones, write reports) must be performed. The equipment for those additional functions is determined by the overall mission defined for the monitoring center, and will have been designated earlier in the systems analysis phase of development.

3.4.2.2 Large and Small Layouts - Figure 3-2 shows simplified actual layouts of a large custom-built monitoring center and a small, spatially constrained center. In each case, the number and size of the monitor screens are clearly related to the overall room dimensions. The large control center is seen to be co-located with personnel and equipment concerned with train operations, facilitating coordination in case of certain emergencies requiring such action as power shutdown or knowledge of train status. A platform provides an elevated view for the supervisor, who can thus look over the operators' heads at the floor-to-ceiling array of monitors. A wall and large picture window separate the transit personnel from police in an elevated transit police headquarters overlooking the supervisor and the remaining surveillance and operations room. Remote video monitors, a videotape recorder, selection and time/date generator equipment, and communications panels are all available to the desk officer to facilitate police action, if required. The surveillance room is kept in semi-darkness to aid in viewing the displays which are grouped by station. Each of the 13 station groups has illuminated designations and status indicators to provide added information to operators.

The small monitoring center in Figure 3-2 illustrates a representative minimal installation. The layout described here has been adapted from an actual 8-camera transit station center. The video apparatus was installed in the existing transit police district office at a terminal station, and the desk officer was given the additional task of monitoring the video and audio activity in the station. The eight monitors are in front of and about 30° up from the officer, at an average distance of 6 or 7 feet. Because the activity level at the station is relatively low and other tasks need to be performed, the desk officer can use the audio monitor as an alerting device. When a disturbance occurs anywhere in the station, the desk officer ordinarily hears it on the audio monitor and then looks at the video screens to see what is taking place. Although it is possible to miss a critical event with such an arrangement, the police administration decided that the relatively safe nature of this station permitted such a compromise. Many of the incidents can be handled over the 2-way audio link to several station areas, and patrol officers can be summoned for more serious incidents. An automatic sequential switcher with manual override allows the officer



A. Large Monitoring Center



B. Small Monitoring Center

Figure 3-2. Simplified Layouts of Large and Small Monitoring Centers to choose any one of the sequenced camera images to be recorded on the VTR and to be observed on the 17" monitor screen.

3.4.2.3 Layout Principles - Given the constraints of system size and available room, one can prepare a complete list of equipment and people to be accommodated in the monitoring center. The next step is to divide the list into functional groupings (e.g., video monitoring, communication with passengers, communication with other services) that will allow for the clustering of equipment and operators that will work together and indications of their relative importance in center operations. To aid in this process, descriptions of all operator tasks and sequences can be prepared, using techniques from the field of human factors engineering. One product of that analysis is a list of equipment and operators that work together in completing each necessary task. Another product is the criticality of each element in the task sequence, and an indication of the center's most important and/or frequently used displays, controls or communications equipment. In general, devices that are frequently controlled or handled by operators must be within arm's reach. Less frequently handled devices can be further removed. Even though they are of prime importance, the array of video screens (if large enough) can be 6 to 12 ft. away since visual reach exceeds arm reach.

The television industry has found that, for relative freedom from distortion, the maximum viewing angles of video monitor screens should be no more than 30° above or below the centerline axis perpendicular to the tube face, and 30° (at worst 45°) to the left or right of that same perpendicular. In combination with the optimum size and distance guidelines (see Section 3.2.1.1.a), these parameters define a geometric area for the operator-video display interface. For optional viewing, the operator's line of sight should coincide with the centerline axis of the picture tube. To accommodate the required width of an array of monitors without tube face distortion, one can mount the video monitors on a curved surface so that every monitor tube faces the operator. (11, 19, 22)

Operators should not be required to stretch in order to look over objects before them in order to view the lowest monitor screens. On the other hand, the displays should not be so high as to require operators to raise their necks and gaze; ideal display screens allow the operators to look slightly downward from the horizontal.

For desk-type control consoles, the available panel space should be divided into primary (central) and secondary (peripheral) areas. Primary controls should be in the low central area within easy reach of the operator's hands. Primary visual displays should be just above (and sometimes in the same area as) the primary controls. All of those components should be within 10 or 15 inches to the right and left of the operator's centerline, and visually oriented along the operator's slightly downward line of sight. Secondary (less used, less critical) controls and displays can be outside these primary areas. For consoles situated in large monitor centers, the vertical height must not obstruct the operator's view of distant displays. Some guidelines are shown in Figure 3-3. (17, 18)

Communications equipment comprise probably the most abundant group of devices other than the video equipment. These would include: public address

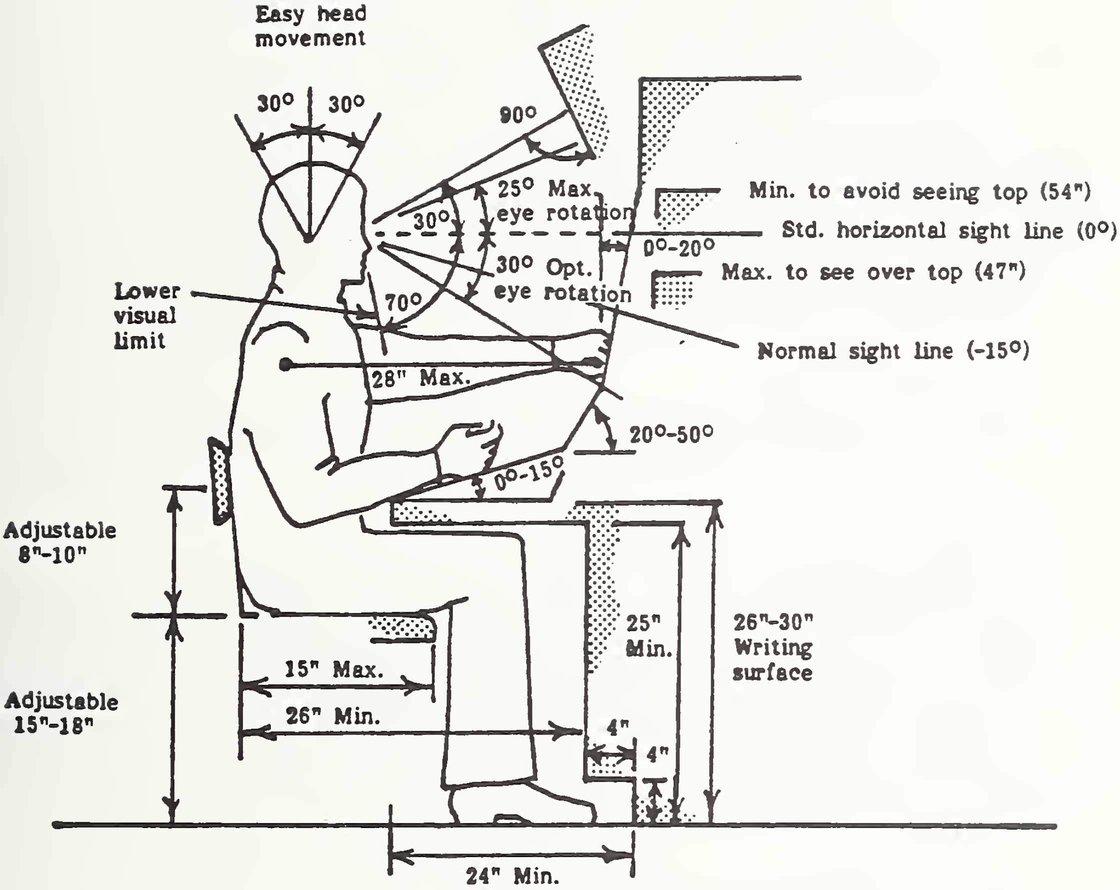


Figure 3-3. Some Human Factors Guidelines for Control Consoles (17)

switches, microphone and speaker(s); conventional dial telephones, radio equipment, and direct telephone lines to related services. Most or all of these devices can be integrated into a control console, along with some video equipment like the VTR and its monitor, selector switch for controlling the VTR input, date/time generator, and perhaps a clock to keep track of time of day. All the controls must be easily reachable and operable with one hand, all displays easily visible, and all auditory communications easily heard. If a telephone handset is used, it should have a long enough wire to allow mobility without getting in the way. The mid-center portion of the console could contain the VTR monitor screen, below which could be the display selector switch. If more than one operator is required in the monitoring center, it may be desirable for each to have some of the same display and communications capability. Storage areas can be built into the lower sections of the console, or in side tables and cabinets. Book shelves are required for manuals, maintenance records and log books. Finally, the hypothetical monitoring center would not be complete without operators' chairs and a console writing shelf or other flat working surface for holding pads and books.

3.5 AUDIO AND OTHER COMMUNICATION SUBSYSTEMS

3.5.1 General

To support the operation of a video surveillance system, and to conduct an effective follow-up action capability, an audio communications network is necessary between operators and passengers, and also between operators and the cooperating police, fire, medical, transit and maintenance services. Regardless of how these audio communications are transmitted (e.g., direct, wire, radio, telephone), the monitor operator must have the input-output and selection devices within easy reach. Typically these controls, displays and communications devices are among the primary items before the operator at a console or desk.

3.5.2 Varieties of Systems and Problems

Audio communication devices are ordinarily arranged according to function. That is, one can usually identify a separate public address (or paging) system, a police radio system, a direct-line administrative or emergency telephone, a commercial dial telephone, a passenger assistance telephone, and a transit operations radio system. Each of those networks should be designed to handle existing and anticipated communications traffic with adequate loudness and a minimum of distortion and interference from other electronic networks or from acoustic background noise. If the system has insufficient capacity for the traffic required, then system reaction time will be lengthened by having to wait for free channels. If volume is too low or distortion and noise are excessive, then the possibility of errors and missed information is increased by poor or absent intelligibility. When intelligibility becomes poor, speakers turn to such tactics as speaking louder and slower, or using military-style phonetic alphabets.

A simple version of any audio communication network that might be used in a monitoring center must include a voice input device or microphone, a voice output device or speaker (room or earphone type), and any necessary channel selection device (pushbuttons, dial, rotary switch, automatic scanner). In a highly integrated system, the operator may wear a single lightweight headset which can be switched into any of the communication networks. In a less integrated system, the several separate input-output units may be retained and used with their appropriate systems. One large center also employs a foot-pedal switch to insure against walking away and leaving a microphone activated. (6)

The determination of channel capacity in each functional network must be based on an analysis of anticipated operations, and what each operator must do to carry out any expected task, especially in an emergency. Designs should be based on worst-case conditions, when delays or errors can be very costly in terms of injury, lives, time or dollars. A typical small monitoring center might have one public address system with a capability of selecting one or all of several station zones for listening or speaking. One zone, for example, could be a waiting room which may also be covered by two or more video cameras. The same small center might have two commercial telephone lines (separate telephone numbers) and at least two handsets with dialing capabilities and pushbutton line (and "Hold") selection. It may have a separate direct-line telephone with pushbutton selection of four or five offices, such as police, fire, train operations or security supervisor. It may also have a direct-line passenger assistance telephone connecting to the network of station telephones (each in view of a surveillance camera) for use by passengers-in-need. Finally, the small center may have a 3- or 4-channel radio capability, with preset selectable connections to monitor police or transit emergency broadcasts, the train radio, or to serve as backup link with the police office in case the wire lines fail. In some centers, operators are provided with a base station for communicating directly with police patrols (mobile or walkie-talkie).

In larger systems, the operator may monitor a "party line" or common intercom that connects all cooperating services and offices together (e.g., the monitor operator, transit police, communications agent, trainmaster, track power director and supervisors). One of the problems in large systems is the increased possibility of noise and interference. For example, a small system may allow for monitoring all station microphones at once for disturbances that would alert the operator to look carefully at the screens, whereas a large system is usually too noisy for that and operators would typically turn the volume down rather than hear the constant noise. In addition, the mere existence of many more electrical circuits increases the possibility of electromagnetic interference or cross-talk on the lines. The placement of microphones is a contributing factor to the noise level, also. If microphones are placed in locations where vehicle activity is high or motors are kept running, the noise could become objectionable. If station repairs are taking place near microphones, excessive noise may be picked up. For cases like this, it may be important to be able to relocate or redirect microphones, or to have individual volume controls for each (which then would require frequent checking to be sure that the operator is able to hear from locations he wants to hear from). Single-purpose station microphones are usually not necessary, since most paging loudspeakers can be used as talk-back microphones.

In fact, many of those loudspeakers are designed for two-way use and can be activated by threshold-sensitive control circuits.

3.5.3 Signalling

Because of the large number of possible audio and other communications links, and the variety of channels available for incoming calls, an audible and visual signalling system may be necessary. If only one such signalling system is possible, it should be a coded audible one that provides the operator with a unique sound (e.g., bell, chime, tone sequence) for each communication network. Where any one of those networks has more than one channel, a flashing indicator light is an appropriate supplementary identifying signal to direct the operator to a waiting caller.

3.5.4 Operator Overload

If the communications become so numerous as to remove too much of the operator's attention from the video monitor surveillance task, then it is time to consider dividing the surveillance and communications tasks by using additional personnel or re-allocating responsibilities. As one would expect, and as research has shown, detection capabilities degrade when one is required to conduct monitoring of multiple auditory signals. (6, 8)

In one system where operators perform a large number of communications tasks including public announcements, an automatic announcing device is used. Routine or specially prepared other messages are recorded on magnetic tape and then selected by the operator to be played automatically over the public address system. This approach helps reduce the overload, fatigue and boredom that comes with repeating these routine messages (e.g., "no smoking" reminders) several times a day.

3.6 SPECIAL FEATURES AND DEVICES

3.6.1 Extended Capabilities of Conventional Equipment

The operational effectiveness of the monitoring center can be enhanced in particular circumstances by the use of special features or devices that provide capabilities beyond those of conventional CCTV monitoring systems. Some extended capabilities are generally available in the conventional systems, and are described elsewhere in this document. They include: the color television image for additional identification capability; the pan, tilt and zoom features which extend camera coverage and allow for tracking targets of interest; and the character (e.g., date/time) generator which permits the annotation of videotaped images with identifying information to fulfill later investigatory or evidentiary purposes. Some conventional equipments described elsewhere also have even more sophisticated features. One device, the automatic sequential switcher which usually dwells on each image for several seconds, can be designed to sequence after every individual frame. For example, if five cameras are being sequenced into a videotape recorder, the sequencer can select every fifth frame from each camera successively. This would provide a recording of six frames per second from each camera, since the conventional frame rate is 30 per second. By playing the videotape into a sophisticated sequencer processor, the frames from any one of the cameras can be retrieved and displayed on a monitor screen. In this way, the desired sense of motion is somewhat preserved, and the likelihood of missing a brief event during the "camera off" time is virtually eliminated.

3.6.2 Special Equipment

Some devices have been designed for special security purposes, including use by the military in war or policing actions. Others have been the result of rapid advances in the field of solid state electronics, computers and digital control techniques. Others may be simply adaptations of old but good ideas from other applications. Some of the resulting features and devices are reviewed here for possible use in CCTV transit security systems. The placement of these devices may extend outside the monitoring center.

3.6.2.1 Motion Detectors - In some surveillance situations where constant video screen observation is not possible or is too tedious due to an absence of activity, the observer can be aided by one of the most advanced surveillance devices—the video motion detector. Changes in a video scene are detected by sophisticated circuits that measure and compare the characteristics of the present scene with those of the same scene stored during a non-intrusion period. Significant changes in light level (e.g., over 5%) causes an audible and visible alarm to be generated. The stored reference scene is updated periodically so that slow changes in light level do not cause alarms. Some motion detection systems are incorporated into the video monitor, while others come as separate units that portray the alarmed area on a remote monitor. (3, 22)

Motion detection devices vary, depending on the method used to sense, process and compare the present and stored reference video signals. Some allow the user to map or "sketch" out areas on the monitor image that are to be analyzed for motion. Any movement that causes a light change greater than the allowed amount in the sensitized areas will generate an alarm. Another type of detection system makes use of several hundred light-sensitive spots located throughout the camera's field of view to detect any changes in the light level. Any of those spots can be desensitized to allow for movement in desired areas or for natural (e.g., vegetation) movement that may occur. A third type of detection system senses light changes under light-sensitive diodes previously attached to the tube face by suction cups. Unfortunately, the area of sensitivity is relatively small, and a separate monitor screen is needed to avoid the scene being blocked by suction cups.

The two primary methods for comparing light levels are integrated comparison (which matches the average light levels of the present and previously stored scene) and fine grain comparison (which compares the two scenes essentially element by element). In addition, some systems provide for the conversion of detected light levels to digital information, thus paving the way for sophisticated computer processing of the video scene.

Probably the biggest problem with motion detection equipment is that of false alarms. These devices are very sensitive to even very slight movements, small changes in illumination, electromagnetic interference picked up on the transmission cables, variations in the power supplies and camera vibration, to say nothing of outdoor conditions like cloud motion and wind-blown objects. For these reasons, the use of motion detection equipment should be limited to indoor areas where little or no movement is expected and where light levels remain constant. Regulated power supplies should also be used.

False alarm rates in these devices also depend on the type of signal processing and comparison employed. For example, fine grain comparison is more sensitive but also leads to more false alarms than integrated comparison designs. Digital systems, with computer processing, tend to have increased sensitivity while holding false alarms to a minimum. Finally, it is possible to use the motion detection alarm to trigger a videotape recorder switchover from time lapse mode to real-time mode, and then back again when the motion stops.

3.6.2.2 Sensor Alarms - For reasons similar to those justifying the use of video motion detection devices, one may also want to employ other automatic sensing devices and alarms. These would include tamper switches and intrusion sensors for critical areas, tamper sensors for camera housings, video presence detectors to indicate the loss of a video signal at the end of a transmission line, and any other sensor deemed necessary to alert the operator to a possible problem.

Tamper switches are useful in protecting video components in exposed locations. These switches can be installed on camera housings, junction boxes and equipment room doors. The device can be as simple as a switch that trips if the equipment is jostled in an abnormal manner, or if access doors are opened. A switch of this type also can be used to generate an alarm if a turnstile is cocked in the reverse direction by a fare evader.

Intrusion sensors are used to detect the presence of moving objects in a guarded area. This is most often accomplished with ultrasonic waves that are altered in frequency if a moving object is present, thereby causing an alarm to be triggered by the detection circuit. Other techniques for detecting intruders include the detection of broken light beams by photocells, the detection of body heat by infra-red sensors, and the detection of audible sounds by microphones. These types of units are useful for closed areas in which no one should be present. However, the main problem is also one of trading off sensitivity for false alarms. The more sensitivity is increased, the more likely false alarms will occur. One way of reducing the false alarm problem is to use two different kinds of systems (e.g., ultrasonic and infra-red), and trigger an alarm only if both systems are actuated.

An interesting application of the light beam-photocell (or electric eye) system is that of detecting fare evaders at turnstiles. In this application, two light beams are used--one above and one under the turnstile bar. A normal fare-paying passenger would break both light beams, whereas a fare evader would probably break only one, causing an alarm to be generated.

The video presence detector is useful where scenes are not always being displayed in the monitoring center. The presence detector itself should be a separate unit so that, should it fail, the video signal can still be monitored or recorded in the conventional manner.

Finally, where many sensors are used in a system, it is current practice to use a computer-driven video display terminal to provide updated alarm summary information, in an alphanumeric list, to operators. To this sensor-alarm display can also be added fire alarms, smoke detector alarms, "panic-button" alarms, and virtually any other "on-off" type alarm signal in use.

3.6.2.3 Remote Control of Equipment - Another adjunct to the monitor operators' capabilities is that of remotely controlling video or other equipment in the system. For example, one can design a system in which the pan, tilt and zoom camera functions are controlled in this way, or in which exit gates can be locked upon receiving certain types of alarms. As in video transmission systems, various alternatives are possible for implementing remote-control functions. The <u>multi-wire method</u> uses individual wires (or pairs of wires) to transmit each unique control signal (e.g., pan camera #1 to the right) from the operator's position to the device being controlled. This system is useful when the distance involved is short and no restrictions are placed on the installation of thick cables. When local electrical codes limit the maximum voltage and current that may be applied to the cables, or require that such "high" voltage cables be installed in a costly conduit network, a <u>relay control system</u> can be used. By installing relays at the remote end, low voltage can be transmitted over the cables, thereby eliminating the need for a costly installation while still adhering to the electrical code. Any needed operating voltages are obtained by site-located power supplies and applied through the relay contacts to the equipment. To eliminate the need for many wires in a cable, a <u>two-wire control system</u> can be employed. The control information is uniquely encoded at the operator's end (e.g., into electrical pulses or audio tones), transmitted to all the remote-control locations, and decoded at the receiving end where it is recognized and actuates the one corresponding unique relay or solid-state switch to accomplish the desired function. That relay or switch passes the necessary operating voltage to the equipment. Some coded, two-wire systems allow only one function operation at a time, while others permit several simultaneously. Finally, there is a <u>wireless control system</u> which employs a radio signal or even a light beam to transmit the required control signals. This system is most useful when operating in railroad yards or any other location where right-of-way is a problem.

3.6.2.4 Keyboard Equipment Selection and Control - Somewhat related to remote control of equipment just described is the technique of using keyboards to enter control commands for activating certain equipment functions and generating information. The keyboard may have numeric, alphabetic, and special-purpose (dedicated) keys. This method is a digital technique for performing such functions as selection of a video signal for display on a certain monitor, entering an identification code on a videotape recording, starting up or shutting down certain portions of the system, changing the switching rate of an automatic sequencer, and changing the cameras being switched by a sequencer. This digital keyboard method of connecting or disconnecting equipment, establishing a desired sequence of particular operations, and entering or accessing information about the system requires a small computer, and a code for instructing that computer to perform the desired operations. It is a relatively sophisticated existing technology but, once it has been made to work properly, it should be quite reliable.

3.6.2.5 Hidden and Mobile Cameras or Observers - Although not very common in CCTV transit security systems, the use of hidden surveillance is a technique for which apparatus is commercially available. Typically this technique makes use of one-way mirrors which allow cameras or observers to see out, but no one can see in. One manufacturer provides a camera assembly enclosed in a completely mirrored spherical or cylindrical glass capsule. While appearing decorative, the capsule in fact prevents a potential perpetrator from discerning in which direction the camera is oriented at the moment. Also available are long cylindrical enclosures which house a rail of virtually any length on which a remotely controlled camera quietly glides. It may be especially suited to single-camera monitoring from a long aisle off which there are numerous other perpendicular aisles.

Perhaps a little more useful in transit station applications is the use of a one-way mirrored window. These windows can be located in security rooms at each station, or even on a roving or parked transit vehicle. The potential perpetrator does not know for sure if an observer is stationed behind the window. An unmanned security room should be protected with intrusion sensors. It can also contain a camera, a video monitor, a videotape recorder, communications equipment, or any other apparatus deemed necessary for the application.

3.7 MAINTENANCE

Maintenance can be provided by an in-house facility or by establishing maintenance contracts with local organizations or manufacturers. An internal maintenance facility entails a substantial investment in test equipment, parts inventory and personnel, but could assure a minimum of equipment downtime. A maintenance contract may involve less of an investment, but downtime may be increased unless greater use is made of replacement units (which could be a costly investment). Whether a system planner decides to form an in-house equipment maintenance group or enter into a service contract with video equipment specialists, it is helpful to be familiar with some of the more frequent maintenance problems associated with the monitoring center. Most of the problems encountered with video equipment will first be made evident by a degraded image on some video monitor screen. These problems may appear suddenly as a result of a "catastrophic" event (e.g., break in a cable), or gradually as a result of time-related degradation (e.g., aging of the picture tube).

Possibly the most likely major piece of equipment to malfunction in the monitoring center is the videotape recorder. This is an intricate device with many moving mechanical parts. Most recorder problems are caused by dirty video heads or the use of improper tape. If the recorder is not kept clean, videotape life and picture quality can be substantially reduced. According to one equipment manufacturer, video heads should last at least 1,500 hours before re-equalization is needed if the proper tape has been used. Heads cannot be replaced in the field, so it is essential to give them proper care. Suppliers recommend that all heads be cleaned at least once a week, and more often if they are subject to heavy use. It is also necessary to replace belts, idlers, pressure rollers and brake pads periodically, according to the equipment instructions. Each manufacturer specifies the proper cleaning agents (e.g., Naphtha, isopropyl alcohol, ethyl alcohol) and procedures for the recorder's different component parts (i.e., heads, guides, head drum, pinch rollers, etc.). Video heads should not be cleaned while they are rotating, because fracture can result. Typical recorders are best operated in a clean environment at a nominal temperature of 20° C (68° F) and 50% relative humidity. Refer to the recorder manufacturer's maintenance manual for detailed precautions and instructions about cleaning, lubricating, adjusting and replacing equipment parts. (19, 22)

Another important maintenance concern is the improper connection or termination of coaxial cables, which results in poor or absent displays on monitor screens. When new connections are made or equipment is replaced, it is necessary to be sure that connectors are firmly attached and that terminating resistors are in place where required for impedance matching purposes.

Switching devices should be checked out periodically to insure that they do indeed perform the functions they are intended to perform, and that signals actually appear where they are supposed to appear.

Video monitors should be checked and adjusted periodically for brightness, contrast, focus, linearity, image size, and resolution. Some of those characteristics and others can be tested with the aid of the Electronic Industries Association (Washington, D.C.) Resolution and Linearity Charts. Recording the results of these periodic tests can help the user determine at a later date if any degradation has taken place.

Finally, complete maintenance records should be kept for each major item of equipment, so that trends or patterns of failure can be discerned, and clues to repetitive failures can be sought. A full set of up-to-date system drawing and equipment schematic diagrams are essential for efficient fault locating or system modification. These records should be kept in a centralized location and reviewed periodically in order to obtain a full understanding of the system's reliability and to help improve it.

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4. CAMERAS, LIGHTING AND TRANSMISSION LINKS

4.1 GENERAL

This chapter provides information and guidelines regarding the sensing portion of the CCTV surveillance system, as found typically outside of the monitoring and control center. It addresses the technical features of cameras, their lenses, required lighting, positioning, protection, transmission links and the maintenance of all equipment associated with this part of the system.

The television camera converts light from the scene coming through lens into a point-by-point electrical (video) signal. That signal can be transmitted by various methods to a remote location where the series of points is reconstructed into an image on the screen of the television monitor. Television cameras are generally classified according to the light sensitivity of their sensing faceplates (or targets) on which the image from the lens is focused. They may be monochrome (black and white) or color cameras, normal or low light-level cameras, and may have their greatest sensitivity in specific regions of the color spectrum. At present, black and white systems are generally used for surveillance and security applications, though more costly color CCTV may have over-riding advantages in certain situations.

A variety of special features, which can be controlled remotely, are available to increase the usefulness and economy of some installations. These features include camera panning to rotate the camera from side to side, camera tilting to rotate the camera up and down, and the use of a zoom lens to provide magnification of the object in view. There are also automatic lens aperture controls to accommodate varying amounts of light falling on the camera's photosensitive faceplate. Remote focusing is still another possibility.

Clearly, the proper selection of natural and artificial lighting conditions is essential in considering camera placement, special features, cost, and utilization. Camera placement also must consider the remainder of the environment, including temperature and humidity conditions, weather extremes, and potential vandalism. These factors also influence the medium chosen for transmission of the camera's video signal to the monitoring center. There are radio, wire, and optical links possible for this purpose.

In transit stations, television cameras are typically positioned to monitor areas around vehicle doors, platforms, stairways, mezzanines, concessions, station entrances and exits, money-handling installations, and other facilities requiring protection (including the television system itself). The transit station is often unusual because of special problems with lighting, vibration, dirt and dust, electrical power, crime and vandalism, communications, and the variety of people found there. Even an experienced system designer can have difficulty balancing all factors so as to properly determine which combination of cameras, lenses, lighting, transmission links, and protective devices may be best suited to a particular application. Since a surveillance camera, for example, can range in price from about $150 to $10,000 depending upon the technical features it contains, the best way to determine the most cost-effective combination of characteristics can often be to take the equipment to the site and test it under actual conditions.

The equipment choice may also be influenced by the maintenance practices anticipated. For example, maintenance may be done by personnel of the transit system, it may be contracted out to a service organization, or some other arrangement may be employed. It is important to keep in mind the capabilities and reliability of the maintenance group and the availability of spare parts and special test equipment when selecting the component parts of a system that is to work effectively for a long period of time. (2,5,8,9)

In the following paragraphs, specific attention is called to selected key facts and concepts that should be remembered when considering that portion of the transit station CCTV system involving the video cameras, scene lighting, and signal transmission. More details related to any particular item can be found in the references noted.

4.2 TECHNICAL FEATURES OF CAMERAS

4.2.1 Light Sensing Elements

Cameras are classified according to the type of light sensing element, or vidicon, they use. As sensitivity increases, so does cost. Most daylight cameras use an antimony trisulfide vidicon tube, and can operate from bright sunlight down to twilight conditions of about 1 footcandle. The advantages of this standard vidicon include good image resolution, ability to be controlled over wide variations in lighting levels, low cost, and availability. Its disadvantages include the susceptibility to burning-in of a fixed scene, and susceptibility to damage and burn spots (white spot on the monitor) from excessively bright, direct light. Picture quality becomes degraded at the lower levels. If lighting conditions are less than 1 footcandle, then more expensive low-light-level cameras should be used (after first considering less expensive, supplementary illumination of the area under surveillance). The most sensitive of the low-light-level TV cameras can operate with nothing but starlight.

One low-light level device, the silicon diode vidicon, is about 10 times more sensitive than a conventional antimony trisulfide vidicon. A second one, the intensified vidicon, uses a built-in light amplifier in conjunction with an antimony trisulfide vidicon to provide as much as 20,000 times the sensitivity of a conventional vidicon. However, its increased sensitivity is accompanied by decreased resolution and consequent image sharpness. Its yellow/blue color sensitivity makes it very effective with sodium vapor lamps. Not quite as sensitive as the intensifield vidicon is the silicon intensified target tube (about 500 times more sensitive than the daylight vidicon). There is also an intensified silicon intensified target camera which is about 15,000 times more sensitive than the daylight version. Finally, one of the newest light sensing elements is the solid state unit, which presently has poorer resolution but is about as sensitive as the silicon diode unit, while at the same time is smaller, more rugged, and more sensitive at the near infrared end of the spectrum (present in incandescant or sodium vapor lighting).

The various light sensors exhibit different susceptibilities to target burn (from high intensity light), target burn-in (from dwelling on a high contrast scene for a long time), picture lag or smearing on moving scenes, blooming (spreading effect of bright spots), and blemishes (dead spots on the screen). The silicon target is less susceptible than the standard vidicon to damage from bright direct light, but its smaller dynamic range may necessitate the use of an automatic optical attenuator (automatic iris) for proper operation. (5,9)

4.2.2 Vidicon Diameter

Standard CCTV cameras use either a 2/3 inch or 1 inch diameter vidicon image tube. If low cost is a primary criterion, the 2/3 inch system should be chosen. If image quality and reliability are the primary requirements, the 1 inch system is preferred. Because of lower cost, the 2/3 inch vidicon is frequently used in security systems. However, the 1 inch format may allow for a greater variety of available lenses, and provides greater resolution (or image detail) due to the effective reduction in lens edge aberrations in actual applications. The image tube diameter, in combination with the focal length of the lens and distance from the surveillance scene, determines the field of view. (5)

4.2.3 Interlacing

To minimize picture flicker and other degrading effects, each full frame of picture video information is made up of two interlaced horizontal fields transmitted sequentially. Each field is generated in 1/60th of a second, so that each full frame is generated in 1/30th of a second. In U.S. broadcast-type systems, the horizontal scan lines (approximately 262) of the second field fall exactly between the horizontal lines (approximately 262) of the first field. This exact scanning line relationship is called 2:1 (two to one) interlacing. A less sophisticated, low-cost system is one in which the two fields of scan lines are not locked together (synchronized) exactly. This free-running or floating system is referred to as random interlacing, and typically produces a picture of completely acceptable quality. However, the reduced stability of the picture can be a problem when included as part of a total system requiring precise synchronization between several cameras and such devices as videotape recorders and special effects generators. (2,8)

4.2.4 Resolution

For adequate resolution, cameras (like monitors) should have the standard 525 scanning lines per frame (2:1 interlace) with a minimum frequency bandwidth of about 7.5 to 9 Mhz. A CCTV system used for personnel identification may require 700 to 800 scanning lines per frame and a correspondingly higher bandwith in order to obtain facial detail. See paragraph 3.2.1.1 c, on monitor resolution, for more details. (9)

4.2.5 Compatibility with Conventional Broadcast Equipment

The user may wish to verify that the camera selected for the CCTV system complies with certain broadcasting standards so that standard monitors or other devices can be used with it if desired. The characteristics to be compatible should include number of scanning lines per frame (e.g., 525 lines per second), bandwidth (e.g., 8.5MHz), frame frequency (e.g., 30 frames per second), and the use of 2:1 interlace scanning (2 interlaced vertical image fields per frame). (9)

4.2.6 Dynamic Range

The dynamic range of a camera refers to the total range of light levels under which the camera yields an acceptable image. Full sunlight, of about 10,000 footcandles, typically defines one end of that range, while the minimum required scene illumination defines the other end. The amount of light reaching the vidicon is typically controlled by an automatic iris control or a neutral density filter (or both). (9)

4.2.7 Night Viewing Attachments

General purpose night viewing devices, or light amplifying telescopes, are available which can be connected to most common cameras using inexpensive adaptors. These devices, which may be battery operated and have interchangeable telephoto lenses, can provide good quality images with only starlight illumination (approaching as low as 0.00001 footcandle).

4.2.8 Color

Opinions of transit security personnel are divided with regard to the use of color rather than black and white CCTV. Some individuals believe that color would aid in the identification and apprehension of persons viewed by the cameras. Others believe that this is not very important, in view of the additional cost of color equipment and, perhaps, the possible slight reduction in picture sharpness when using color.

4.2.9 Pan, Tilt and Zoom

These features are generally not recommended for transit station surveillance applications. Automatic continuous scanning by the camera may reduce an observer's detection capability (which can be very effective when looking for movements against an unchanging background). These features should be employed only if there is an anticipated need to position and focus in on a suspicious activity, and they should be under manual rather than continuous automatic control. These installations can also be hidden in various ways so that persons in the surveillance area do not know where the camera is pointing at any particular instant. (5,9)

4.2.10 Remote Control of Camera Functions

In certain cases where increased complexity can be tolerated, certain camera functions can be controlled or overridden from a remote location. These functions include: pan, tilt, lens focus, lens zoom, and camera electronics (beam current, beam focus, video gain, blanking level, sensitivity, etc.).

4.2.11 Camera Power

Most surveillance cameras operate with conventional, available electrical power of 24, 117 or 220 volts AC, at 50 or 60 Hz, and often consume less than 25 watts of power. Some cameras use only the coaxial cable as a means for transmitting the camera power as well as the video signal. (5)

4.2.12 External Synchronization

When more than one camera feeds into common equipment (such as a videotape recorder, video switcher, or special effects generator), an externally derived, common synchronization signal is preferred. This allows the horizontal and vertical circuits of the cameras to be timed and driven at identical rates, and thereby eliminates the flipping or tearing of pictures when switching from one camera's image to another. Implementation of this feature requires an external synchronization connector on each of the cameras, a cable to distribute the synchronization signal, and possible delay-compensation if the cable runs to the various cameras are substantially different in length.

4.3 LENSES AND LIGHTING

4.3.1 Lens Requirements

The lens selected for a particular camera and surveillance scene should first provide a picture which just covers the monitored area. A compromise will usually be required to conform with the 3 to 4 (height to width) ratio presented at the monitor. To increase scene area use a shorter focal length lens. Second, the lens should provide sufficient depth of field for the scene. To increase depth of field, use a shorter focal length and/or a higher f-number. Finally, the lens should admit sufficient light for normal viewing and adequate picture contrast. To admit more light, lower the f-number. If filters or complex coated lenses are used, the light lost in passing through those elements may be significant enough to be considered in the overall design (e.g., the aperture may have to be enlarged by half an f-stop). A 2/3 inch lens should not be used on a 1 inch camera, although a 1 inch lens can be used on a 2/3 inch camera without image degradation. (1,8)

4.3.2 Lens Speed (f-Number)

This characteristic of the lens is a number (such as 1.4, 2.8, 5.6, 11, 16, 22) which is the ratio of its focal length to the effective diameter of the lens opening. Within limits, the f-number can be adjusted to provide the required sharp focus and depth of field at a particular distance under given lighting conditions. As the lens opening or aperture is decreased (larger f-number), focus gets sharper and depth of field increases but more light is required to provide the same illumination level on the camera faceplate. Reducing the aperture size by one stop (i.e., increasing the f-number by one stop) on a lens assembly reduces the light passing through the lens by one-half. If light levels are relatively low, the lens opening can be kept large (low f-number), and sharp pictures will still be obtained at longer distances (because depth of field increases with focussing distance). (8,9)

4.3.3 Field of View

The size of the scene to be seen by the camera is determined by the image tube size (2/3 inch or 1 inch), the lens focal length, and the distance between the scene and lens. The scene size for a 2/3 inch vidicon is approximately two-thirds that of the 1 inch vidicon. That is, to get the scene size for a 2/3 inch vidicon, multiply scene width and height for the 1 inch tube each by 0.67. For example, a 1 inch vidicon with a lens of focal length 25 mm at a distance of 30 feet will cover a scene approximately 15 feet wide by 11-1/4 feet high. The 2/3 inch vidicon, with all else remaining the same, will cover a scene approximately 10-1/2 feet wide by 7-1/2 feet high.

Similarly, if the distance is multiplied (or divided) by some number, so are the scene dimensions. Longer focal length (e.g., telephoto) lenses reduce the width and height to produce magnified views of a portion of the scene. Multiplying (or dividing) the focal length by some number reduces (or increases) the dimensions of the observable scene by the same number. For the 1 inch vidicon example used above, if the distance to the scene is doubled to 60 feet, then the visible scene dimensions would also double to approximately 30 feet wide by 22-1/2 feet high. Or, if the focal length of the lens were doubled to 50 mm, the scene dimensions would be halved to about 7-1/2 feet wide by 5-1/2 feet high. (5)

4.3.4 Zoom Lens

A zoom lens can be used to enlarge a portion of a suspected target area. A 5:1 zoom lens typically allows changes in focal length from 20 mm to 100 mm, thereby magnifying 5 times. A 10:1 zoom lens typically allows changes in focal length from 15 mm to 150 mm, thereby magnifying 10 times. Range extenders can multiply the focal length, and retro zooms can decrease it. The focal length (or magnification) of zoom lenses can be controlled remotely. Controlled scan capabilities may be necessary with zoom lenses. (9)

4.3.5 Image Splitting

Optical splitters can be used in a lens system to view more than one scene through a single camera. This effect can also be accomplished at the monitoring center in more expensive ways using conventional electronic or sophisticated digital core storage techniques with inputs from multiple cameras viewing one scene each. The optical splitter mounts in the lens position, with separate lenses (generally, two) for the separate scenes to be viewed. The main lens remains in line with the camera axis, while the auxiliary lens off to the side views the other desired scene by pointing a movable mirror in the required direction. (8)

4.3.6 Adequacy of Lighting Level

In the opinion of many security experts, a high illumination level ranks second to large numbers of people as the greatest security device generally available. Illumination should be of sufficient intensity to allow reliable CCTV detection of human movement in the surveillance area, even under the most adverse of expected environmental conditions. Technically, the lighting conditions should be guided by the sensitivity of the light-sensing elements of the camera used (see paragraph 4.2.1). Safety margins should be included to allow for aging and degradation of both the lighting and cameras. A reasonable rule-of-thumb is to specify ambient lighting to be no less than 10 times the lowest light level specified for the light-sensing element. For example, a standard vidicon, sensitive down to 1 foot-candle, should be operated in an environment with no less than 10 foot-candles in the darkest location to be observed. A minimum of 50 foot-candles is recommended in sensitive areas. Table 4-1 lists approximate illumination levels for various conditions.

TABLE 4-1. TYPICAL ILLUMINATION LEVELS UNDER VARIOUS OUTDOOR CONDITIONS

LIGHTING CONDITIONS	APPROXIMATE ILLUMINATION LEVELS (FOOT-CANDLES)
Direct Sunlight	10,000
Full Daylight*	1,000
Overcast Day	100
Very Dark Day	10
Twilight	1
Deep Twilight	.1
Full Moon	.01
Quarter Moon	.001
Starlight	.0001
Overcast Night	.00001

*Not direct sunlight

A photographic light meter of the incident type (measuring light falling on the subject) can be used to estimate scene illumination. For incident light meters set at ASA 810 and 1/30 second, use Table 4-2 to convert from the f-number to foot-candles of incident illumination.

TABLE 4-2. ESTIMATING THE ILLUMINATION LEVEL USING A PHOTOGRAPHIC EXPOSURE METER (SEE TEXT FOR CONDITIONS REQUIRED)

f-number	2.0	2.8	4.0	5.6	8	11	16	11	32	45
Foot-candles	2	4	8	16	32	64	128	256	512	1024

If lower ASA settings are used, a proportionally slower speed setting is also required to make use of Table 4-2 (e.g, ASA 81 and 1/3 second). For taking reflected light readings with a reflected light meter, Table 4-2 applies only if one assumes a scene reflectance factor of about 18 percent. (8,9)

4.3.7 Avoidance of Excessive Light

Cameras should not be aimed in the direction of bright sunlight. Likewise, floodlamps should not be pointed directly into the camera's lens. (9)

4.3.8 Glare

Lighting glare in the camera's field of view can prevent detection of a significant object near or behind the glare source. Even when an automatic light-level feature is used, objects that are not as bright will be more difficult to see. Special equipment is available to automatically black out high intensity light sources. (9)

4.3.9 Reflectance

Camera sensitivity requirements depend upon the amount of light reflected toward the lens from the darkest areas of the scene. Reflecting characteristics, in turn, depend upon the surface texture, surface color, and the location of the light source (distance and direction). Typical approximate reflectances (percent of incident light reflected from the scene) for different scenes are seen in Table 4-3.

TABLE 4-3. APPROXIMATE REFLECTANCE VALUES OF TYPICAL SCENES

SCENE BEING TELEVISED	PERCENT REFLECTANCE
Empty asphalt parking lot	5-7
Parkland area, trees, and grass	20
Red brick building	30-35
Unpainted concrete building	40
Parking lot with automobiles	40
Smooth surface aluminum building	65
Glass windows and walls	70
Snowy field with chain link fence	75-85

Light measurements, if made by the user, should be made of the darkest areas of the surveillance scene. The ability to detect movement can be increased by the use of smooth, light-colored backgrounds. However, excessively bright backgrounds can reduce camera sensitivity and produce various forms of image degradation. (9)

4.3.10 Supplementary Lighting

If it is determined that increased lighting is necessary, the user should keep in mind that the supplementary lighting can be selected so as to optimize its color spectrum with the color sensitivity of the vidicon. Most cameras are more sensitive at the red end of the spectrum, and sodium vapor lamps are high in energy in that same area. However, that pure yellow color may be acceptable in only limited areas (like parking lots). Compromises may be necessary. The user should also remember that fog can cause blinding reflections back into the camera, just as one finds when driving through fog with automobile high beams switched on. It may be helpful to turn off the lights near the camera when fog is present. Equations to determine the number of floodlights to achieve desired levels of illumination can be found in the IES Lighting Handbook. (1,4,8,9)

4.3.11 Lamp Types

The main types of lamps available for CCTV scene illumination include the following.

4.3.11.1 Incandescent - Light is emitted from a heated filament inside an evacuated globe.

4.3.11.2 Quartz Iodine - Light is generated as in an incandescent lamp but the globe is filled with a halogen gas which allows higher intensity.

4.3.11.2 Fluourescent Lamp - Light is generated by an electric current passing through a tube filled with mercury vapor. The low pressure vapor emits ultraviolet radiation which is converted to visible light by fluorescent powders on the inner surface of the tube.

4.3.11.4 High Intensity Discharge Lamp - The light is generated by direct interaction of an arc with the gas to produce visible light. High intensity lamps include mercury vapor lamps, metal halide lamps, and high and low pressure sodium lamps. Argon is normally added to aid starting, and various powders or vapors may be added to modify the color emitted.

Each of these lamps has a different combination of such critical characteristics as intensity, efficiency, spectral distribution, restrike time (startup delays), time to full output, lamp life, operating voltage, and power. Incandescent lamps typically are the least efficient and have the shortest operating lives. Mercury vapor and sodium lamps typically have the highest efficiencies and longest operating lives.

4.4 EQUIPMENT PLACEMENT

4.4.1 Coverage

Critical transit station scenes viewed by cameras typically include areas around vehicle doors, platforms, passenger waiting or seating areas, stairways, escalators, elevators, turnstiles, corridors, over/underpasses, toilet entrances, mezzanines, concessions, station entrances and exits, handicapped access sites, concourses, money counting and handling installations, passenger safety zones, passenger assistance telephones, prisoner detention cells, parking lots, and other areas as required (including the CCTV cameras themselves). Microphones and speakers for the audio subystem, if used, can be located near the cameras. The distance between cameras at transit stations depends very much on the size of the area under surveillance, its criticality, and architectural features. In various representative stations, some cameras are from 50 to 100 feet apart, while others are back to back in one location.

Fixed camera positions should be used to provide continuous coverage of the total surveillance area. Automatic scanning (tilt and pan), and sequencing between surveillance cameras should be used only when carefully justified, since these techniques can result in missing a critical, short duration event. However, camera mounts that permit some infrequent re-orientation can be used in the event that the fixed coverage pattern needs to be altered on the basis of operational experience or if long-term station conditions change. (3,7,9)

4.4.2 Camera Location

Cameras should be located in an area and in a manner which provides protection from weather, tampering and vandalism, and extremes in lighting conditions. (9)

4.4.3 Camera Orientation

The camera lens should not be pointed toward direct sunlight or toward an outside door, because the resulting large variation in light level can result in degraded picture quality. A relatively constant or unchanging level of illumination is preferable. Also to be avoided is pointing the lens directly at intense artificial light which can burn a spot on the vidicon image sensor. (5)

4.4.4 Blind Zone

Elevated and downward tilted cameras have a blind zone between the base of the camera mounting surface and the nearest visible point in the televised scene. An incident occurring in a camera's blind zone would be undetected by that camera. Consequently, at least one camera in another location may be oriented to cover that blind zone and to provide surveillance of the first camera. (3)

4.4.5 Reduction of Illumination Vulnerability

Cameras should be oriented to minimize the possibility of being blinded by someone intentionally shining a bright light into the lens. For example, the camera should be pointed parallel to the perimeter of a commuter parking lot, or downward onto the lot. (9)

4.4.6 Detection Improvement

The probability of detection using the CCTV system can be increased by providing a high contrast background in the area under surveillance. (9)

4.4.7 Mutual Protection of Cameras

Where possible, each camera (and other CCTV system components) should be in the field of view of at least one other camera to reduce the chances of vandalism to those devices. For example, in a two camera platform system, the two cameras can be located at opposite ends of the platform where they can be used to observe each other as well as the necessary passenger areas. (3)

4.4.8 Camera Installation

Among the various ways to install CCTV cameras, three general methods are: (1) using a simple camera bracket; (2) recessing in architectural structures like ceilings or walls; and (3) within mounted housings. Since protection from vandalism and the environment are usually uppermost in transit applications, the protective housing is frequently appropriate. Stainless steel, locked housings with durable plastic windows can weigh less than five pounds. In some well-protected areas, the inexpensive and expendient bracket of steel or aluminum can be used. More complex brackets are used for heavy duty or scanning applications. The least frequently used approach in transit systems is probably the recessed or hidden camera.

4.4.9 Limit Switches

Remotely controlled camera positioning of focusing devices can be electrically or mechanically limited in their range of operation by the use cf position sensing switches. This may be important to protect the equipment from damage or to avoid scanning in areas of no interest.

4.5 ENVIRONMENTAL FACTORS

4.5.1 Environmental Compatibility

Cameras can be equipped with an environmental housing containing a heater, cooling fan, windshield washer/wiper, defrosters or some combination of these. The housing and its mounting may also be tamper-proof, dust-proof, vibration-proof, explosion-proof or water-proof, as needed for the particular application. In addition, alarms are available to detect tampering such as breaking the glass, forcing the housing door or jostling the housing. The combination of features selected should be based on the specific application. Different cameras in a single system can require protection by different combinations of features. (9)

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)

4.6.3 Bandwidth

The transmission system must match the cameras' bandwidth and signal-to-noise ratios if the quality of pictures is to be maintained. (9)

4.6.4 Optical Links

Lenses or mirrors used on optical transmission links may need to be equipped with heaters to prevent fogging. This option is available from most suppliers. (9)

4.6.5 Video Cables

Most CCTV transmission is accomplished over balanced 124-ohm or unbalanced 75-ohm cable links. Coaxial, twinaxial and triaxial core configurations are used, as determined by different technical requirements such as protection from interference, avoidance of excessive power losses. Video cable must be treated with care, because it is very sensitive to damage from heat, abrasion, dents, kinks or abrupt bends. To compensate for specific technical problems in video cables, devices are available such as video equalizers (to deal with differential attenuation at different frequencies), hum clampers (to remove hum from the video signal), video transformers (to provide circuit isolation and impedance matching) and video distribution amplifiers (to provide multiple branching of one video signal). The narrower the required bandwith, the greater the distance the video signal can be transmitted with good quality. Transmission distance is reduced if smaller gauge wire is used, or if stranded wire is used in place of solid wire. Likewise, transmission distance is reduced with each added cable splice, tap, switch or coupling component. (9)

4.6.6 Protection from Electromagnetic Interference (EMI)

Transmission cables passing through areas of high electromagnetic interference should be placed in dedicated, well-grounded metal conduits. In general, lines should be shielded against electromagnetic radiation, including intentional jamming. (9)

4.6.7 Physical Security

All transmission cables should be physically protected or located in protected areas to help insure the physical security and integrity of the CCTV system. (9)

4.6.8 Line Equalization Amplifiers

Most CCTV monitoring equipment has internal cable equalization capability and can, therefore, accommodate cable lengths around 8-9000 feet. Without such internal equalization and with cable runs of over 2500 feet, a line equalizing video amplifier may be required to compensate for the non-linear frequency response of the line and its consequent signal degradation. (8, 10)

4.6.9 Control Signal Transmission

In addition to the video signals and electrical power, more complex CCTV systems may require the transmission of signals to control such devices as pan/tilt units, lens focusing mechanisms, zoom lenses, heaters, blowers, windshield washer/wipers, switches, lights, filters and other components. Synchronization signals may also have to be transmitted to multiple cameras for systems using videotape recorders or other common devices. Although a master synchronizing generator can be located at the surveillance site for several cameras, some control signals will be transmitted from the central control station. Those signals can be transmitted over individual wires, or they can be multiplexed by digital or other techniques so that all signals can be sent over a single pair of wires. For very distant locations, radio links can be used to transmit control signals. (9)

4.7 MAINTENANCE

4.7.1 Preventive Maintenance Procedures

Depending upon the qualifications of the local maintenance personnel, or contracted service personnel, typical preventive maintenance procedures to be carried out include: (1) cleaning of all optical surfaces of the housing, lens and vidicon faceplate; (2) checking optical focus and iris setting; (3) checking controls for beam and focus control; (4) optimizing other internal adjustable controls; (5) inspecting all cables for deterioration or damage; (6) cleaning the camera with the low pressure compressed air and a soft brush; and (7) checking the environmental housing to assure proper operation of all special features (filters, thermostats, windshield wiper/washer, pressurization, etc.). Lighting systems should be checked for inoperative or poorly operating lamps. Corrective actions should be taken as required.

4.7.2 Daily Preventive Maintenance

At the start of each shift or each day, all of the mechanical functions (e.g., tilt, pan, zoom, focus, etc.) for each camera should be tested by operating each to its limits. Environmental housings should be checked for proper operation and the viewing glass should be cleaned as needed. (9)

4.7.3 Longer Term Preventive Maintenance

About every six months, cameras should be checked for centering, corner resolution, linearity, streaking, synchronization, other adjustable features, vidicon burn-in and burned spots. More frequent (e.g., monthly) checks should be made of illumination levels in critical areas to determine if any degradation has taken place. (9)

4.7.4 Maintenance Logs

Log sheets or books for each item of equipment should be kept and entries should be made for all actions related to preventive maintenance, malfunctions, corrective maintenance or modifications. These records should be reviewed periodically to identify fault trends, to indicate poor reliability or to suggest corrective actions that would improve system effectiveness. (9)

4.7.5 EIA Resolution Chart

A standard chart has been developed for use throughout the CCTV industry for measuring or testing camera resolution, streaking, ringing, interlace, shading, scanning linearity, aspect ratio, gray scale reproduction and overall degradation of the system. Copies of the chart can be purchased from the Electronic Industries Association, 2001 Eye Street, N.W., Washington, D.C. 20006 (telephone: area code 202 457-4966). (9)

4.7.6 Reliability of Pan/Tilt Units

Maintenance costs and down time can be significant with pan/tilt units because of the limited life of the moving parts (i.e., motors, gears, limit switches, etc.). These features also typically require added wires or cable runs to operate, although units are available which transmit coded signals on the existing wires for pan, tilt and also zoom functions. The additional bending and flexing of the coaxial cable may also reduce its life and result in more frequent need for replacement. (5,9)

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5. PERSONNEL PRACTICES

5.1 GENERAL

In this chapter, the focus turns more directly to the people who are involved in day-to-day operation of the transit station CCTV system. Specifically, this chapter provides guidelines and background information to help system designers and operators in the processes of personnel selection, training and motivation. It also addresses various kinds of issues to be dealt with at the organizational level.

The guidelines and comments about personnel selection are directed at helping to identify measurable factors which predispose individuals to good performance on tasks (e.g., monitoring) associated with transit station CCTV systems, and identifying methods for selecting such individuals. The degree to which shift work affects performance, though not unique to CCTV monitoring, is addressed as a selectable individual attribute. Some of the other issues covered are the relevance to the selection process of prior experience, age and personality traits.

The statements made about training address the issues of classroom vs. "on-the-job" training, the use of job-aids, the degree of reality of CCTV monitor training exercises, maintaining levels of proficiency by periodic refresher exercises, and characteristics of the trainer which could enhance learning.

With regard to motivation, a wide range of factors are considered. Some of those motivational factors are inherent to the individual's intrinsic personality traits, while others are inherent to the required tasks and the organizational context.

Most of the information presented here was developed from a search of the available literature. Additional information is the result of interviews with transit security personnel at all levels and with various size CCTV installations in their organizations. Although comments about certain issues (e.g., vigilance) are developed from a considerable body of basic and applied research data, comments about other issues (e.g., dealing with labor unions) are developed from the accumulated personal experiences of people in the transit security field.

In trying to develop the best personnel practices for a given transit CCTV system, it is clear that practical considerations will preclude the full application of all the concepts outlined here. Developing a best set of practices will come largely from an intuitive and skillful application of these concepts, often in the context of an already existing set of staffing and operating practices. Where more information is available in the published literature, some references are cited.

5.2 SELECTION

5.2.1 Physical, Emotional and Learned Attributes

There are many personal attributes that have been linked to the various aspects of the transit CCTV operator's job. For purposes of these guidelines, those attributes can be classified into three general categories: physical, mental/ emotional, and knowledge/skills/experience. Because operators in different systems could have widely differing duties, within different kinds of organizational structures and work shifts, it is important to prepare a good job description before deciding which attributes should be sought in the operator selection process. Although various "paper-and-pencil" tests are available for many of the individual attributes, ultimately the best way to select operators is to test them in the actual working situation. Formal tests should be administered by someone trained in testing and test interpretation.

5.2.2 Job Description

The job description should provide enough detail of the operator's duties to determine which physical, emotional and experience attributes are relevant to the selection process. The personnel may have such job titles as: Chief of Security and Safety, Supervisor or Chief of Operations, Tour Commander (Lt.), Desk Officer, Platoon or Shift Sergeant, Patrolman, CCTV Monitor Operator, Console Operator, Security Specialist, Central Control Dispatcher, Passenger Service Specialist, Station Agent, or Equipment Maintenance Specialist. Typical duties for these personnel may include: (1) monitors CCTV screens displaying scenes from cameras located throughout all stations; (2) controls the operation of CCTV and audio equipment located at the stations and in the monitoring center; (3) communicates with the public to provide assistance or convey instructions; (4) communicates with transit authority personnel when required to provide or receive assistance; (5) communicates with local police or fire departments when required to provide assistance; and (6) utilizes Standard Operating Procedures as a guide in carrying out all duties. A typical job or position description can include:

5.2.2.1 Job Title - Security Director, Monitor Operator, etc.

5.2.2.2 Summary of Duties and Tasks - Monitors ... ; controls ... ; communicates ... ; utilizes ... ; develops ... ; recommends ... ; disseminates ... ; initiates ... ; plans ... ; establishes ... ; organizes ... ; coordinates ... ; implements ... ; supplies ... ; designs ... ; tests ... ; evaluates ... ; investigates ... ; determines ... ; prepares ... .

5.2.2.3 Educational Requirements - High school diploma, associate degree, baccalaureate degree in ... , graduate studies in ... , etc.

5.2.2.4 Skill and Knowledge Requirements - Familiarity with all stations on this transit system, ability to use typewriter, etc.

5.2.2.5 Special Physical or Mental Requirements - Clear speaking voice for making public announcements; normal vision, corrective lenses acceptable, color blindness unacceptable; etc.

5.2.2.6 Career Ladder Relationships - Previous (lower) positions, subsequent (higher) positions.

5.2.3 Physical Attributes

These characteristics can include such items as: age, body dimensions, sex, strength, reaction time, dexterity, coordination, sensory-perceptual abilities and disabilities or handicaps. Age has been found to be associated with event detection ability on CCTV monitors. In general, the findings show the best performance to be among relatively young (mid-twenties) monitor operators rather than very young or older monitors. Many researchers claim that individuals above 45 years of age are particularly likely to miss more incidents or make more false detections. Clearly, however, this is a statistical average. Each individual will vary from the average and must be considered on his/her own abilities. The reasons given for degraded performance in older people are associated with a tendency toward age-related degradation in sensory, perceptual and memory abilities. With regard to sex, some researchers report that women tend to make better monitors than men. However, the findings for this tendency seem somewhat controversial and more research may be necessary to clarify the relationship between gender and performance. One of the more promising concepts currently being applied in various transit CCTV security systems is the selection of handicapped or disabled (but otherwise qualified) individuals to work as monitor operators. Many of these individuals have a unique combination of intelligence and motivation that make them particularly suited to this kind of work. Special facilities, such as ramps, elevators, lighting, remote controls and modified consoles may be necessary for particular kinds of disabilities that may be encountered in these workers. In certain job categories, modest limitations on intellectual attributes may be acceptable, so that minimally brain-damaged or mildly retarded individuals can be employed. (1, 5, 9, 15, 21, 32)

5.2.4 Mental/Emotional Attributes

These characteristics can include such items as: reasoning ability, intelligence, foresight, judgment, spatial abilities, memory, concentration, interactions with others, flexibility of thinking, objectivity, sensitivity, attentiveness, dependability, tactfulness, maturity, cooperativeness, persuasiveness, stability, and biological (circadian) rhythms. Many of these attributes, of course, affect more individuals than just the CCTV monitor operator. For example, most security departments operate with different shifts, so the effect on job performance of circadian rhythms is important to all of those people. A considerable amount of research has been conducted on the effects of circadian rhythms, and it has been found that certain types of people adjust more easily to shift changes and night work. Such adjustments can require up to two or three weeks. A number of studies have shown that evening (as opposed to morning) type individuals show a better adjustment to night work. Similarly, extroverts (as opposed to introverts) show better adjustment tendencies, especially if they score above average on certain neuroticism measures. Ability to sleep at unusual times of the day and to overcome drowsiness are often associated with more adaptable individuals. Circadian rhythms are usually determined by measuring body temperature. Some progress has been made towards being able to predict those whose circadian rhythms are more adaptable, by means of questionnaires. One general principle regarding the identification of people who adjust well to shift changes and night work is to accept, as much as possible, those who select themselves (volunteer) for such assignments. Questionnaires are available to measure many other mental and emotional attributes, and those can be identified by a psychological testing consultant or in various available survey documents.

Some other mental attributes which are sought by various transit system and security specialists interviewed during the preparation of this Guidebook are:

a. Ability to concentrate

b. Attention to detail

c. Observant

d. Liking to work with equipment

e. Patience

f. Liking to serve people

g. Perceptive, using CCTV monitors

h. Working well with people

i. Common sense

j. Subdued

k. Low need for stimulation or excitement

l. Low need for social activity

m. Average intelligence (not too low or too high)

n. Logical

o. Ability to interpret events

p. Ability to recognize a problem

q. Ability to anticipate a problem

It must be emphasized that the items in this list of other attributes sought by transit system operators have not necessarily been shown by researchers to have significant associations with high performance. They appear to be appropriate, but for the most part, are intuitively determined. They may some day be assessed as significant, or not, in predicting performance in specific kinds of jobs. (9, 12, 13, 14, 15, 16, 17, 22)

5.2.5 Administration of Psychological Tests and Questionnaires

The reader is cautioned that many psychological questionnaires can be misused and misinterpreted, sometimes with harmful effects to the careers and emotional well-being of those involved. For that reason, many tests are controlled in distribution and often are supplied only to those who demonstrate the qualifications to use them appropriately. If testing of any sort is to be undertaken, the reader is urged to use the services of a psychological or personnel testing consultant, at least to supervise the procedures, if not to do the actual testing.

5.2.6 Knowledge/Skills/Experience Attributes

These characteristics can include such items as: verbal knowledge, arithmetic skills, police experience, transit system knowledge, leadership skills, communication skills, multi-lingual abilities, legibility of handwriting, typewriting skills and knowledge of standard operating procedures.

Both research evidence and interviews with transit security personnel identify experience with police work and with the specific transit system as being associated with better performance. Individuals with police training and experience have been shown to detect suspicious incidents on the CCTV monitor more reliably than those without such backgrounds.

Knowing what to watch for on the CCTV screen is an essential aspect of monitoring and should be emphasized in the training of monitor operators. This becomes increasingly important as the number of monitored CCTV screens increases and the suspicious incidents become briefer, further away, and less distinct. The implications of police experience benefits to the personnel selection process are: (a) to consider using police officers, cadets, or candidates to the police academy as potentially good CCTV monitor candidates; and (2) to consider using civilians for the monitor operator position, provided that their training includes a group of lessons modeled after appropriate police training programs, and perhaps given by police instructors at the police academy. It is also possible to utilize limited duty police officers in these operator positions. However, this is sometimes more a way of keeping those individuals productively employed than it is a way of optimizing fulfillment of the operator role. When practical considerations require the use of limited duty police officers, it is preferable if those selected can serve for long enough periods of time that they can be adequately trained and can develop their own effective monitoring skills to the benefit of the system.

As for having experience with the specific transit system, personal familiarity with the stations and surrounding areas is often sought in CCTV monitor operators. Some transit security officials even prefer that their operators be regular users of the system, so as to remain constantly aware, up to date and realistic in their internalized image of the system. It is believed that personal familiarity with the system improves the operator's ability to recognize, interpret and act in response to observed events. Unfortunately, there may be a potential negative aspect to the quest for operators with familiarity on the system. That problem has to do with labor-management constraints, and the interdepartmental transfer of transit system employees with much seniority but little motivation or ability to be good CCTV monitor operators.

In systems where the duties of the CCTV monitor operator also include a significant amount of verbal communication with the public (such as when a 2-way audio capability is part of the system), selection criteria should include oral communication skill. For this attribute, it is helpful to tape-record the applicant's voice as he or she reads typical announcements or engages in a spontaneous dialogue with someone. In fact, this approach is now being used in a role-playing situation to assess the applicant's ability for being polite, understanding, resistant to provocation, and generally patient and helpful. In ethnic areas, where large numbers of people speak a language other than English, multi-lingual skills are appropriate for operators who must talk with the public.

Other skills, knowledge or experience can be determined by analyzing the operator's job and job description. If written reports are an essential aspect of the work, then relevant writing skill, legibility or typewriting ability should be sought. If numerical and statistical record-keeping are part of the job, then appropriate arithmetic skills should be sought. If the individual is to supervise others, leadership becomes an important trait and should be assessed in applicants. Of course, it is always helpful if the applicant is knowledgeable about standard operating procedures. In systems where the operator could be called to aid a person in distress, emergency medical skills, fire-fighting skills, or other abilities are desirable. Clearly, much knowledge and many of the desired skills can be taught to operators during their initial training program, or later by conducting in-service training programs. (9, 15, 29, 31, 32, 33)

5.3 TRAINING

5.3.1 Current Practice in Transit CCTV System Training

On the basis of a limited but fairly representative sampling of transit systems with CCTV surveillance equipment and personnel, it appears that very little currently exists in the way of specific formal training programs for CCTV monitor operators. At most, the CCTV training is a relatively small part of a much broader training effort. Often, operators are drawn from other departments of the transit system, and receive introductory and on-the-job training by consultants, equipment suppliers or supervisors. In one East coast system, these transferred employees (who have job priority because of their status in the unionized system) are given about 6 months to qualify in the new position or they return to their former position. If new, inexperienced persons were hired, most of the training required by them would not involve the new equipment, but rather would consist of familiarization with the transit system itself, with the layouts of stations, with routine administrative procedures, with the personnel and organization of other departments and with sources of information in the system. This is why some administrators prefer to select current transit system employees, especially if they have experience dealing face to face with the passengers. Selecting such individuals can reduce the scope and duration of any kind of training program.

5.3.2 Specific CCTV Monitoring Operator Skills

The new skills required for an individual who works as a CCTV monitor operator include: the technical abilities to use and maintain the equipment; the mental abilities associated with detecting, recognizing and responding to significant events displayed on the system equipment; and the administrative abilities related to maintaining records unique to the CCTV system (e.g., videotape files. equipment maintenance logs, etc.). The technical abilities for using and maintaining equipment can be obtained at the conceptual level from a guidebook such as this one or others, at the deeper level from the system designer or equipment supplier, and at the deepest level by hiring a consultant or staff technician or by taking a very comprehensive training course. It is not likely that the CCTV monitor operator would require more than the first two levels of training; however, the system administrator should become familiar with resource persons in the region who can provide support at the deepest technical level when necessary. The mental abilities for detecting, recognizing and responding to displayed events constitute what can be considered the critical skills for operators If serious incidents are not to be missed, operators must be trained specifically to recognize potential incidents and those in progress. Some incidents develop over extended time periods (e.g., suicide attempts, stealing from a passenger sleeping in the waiting area), while other incidents occur very quickly (e.g., accidental fall from a station platform, purse-snatching). Police-type training is typically preferred for operators in order to familiarize them with the variety of possible crime- and safety-related incidents. They must learn what they can expect to see in life and on the CCTV screen before, during and after these events. In fact, police instructors may be used for this aspect of the training. Furthermore, excellent use can be made of videotape recordings of representative incidents, both real and staged. At least two transit systems are developing their own libraries of videotapes for general training purposes. The videotape recordings cover incidents which the CCTV operator could encounter, and others (such as investigation of a passenger fatality) which are useful for personnel having little to do with the CCTV system. The real incidents are those for which an alert operator started the videotape recorder in the early stages of a developing situation. Staged incidents can use the existing equipment or a separate (even portable) videotape system.

It is also important for operators to learn the difference between a significant security or safety incident and other activities people may engage in when they believe they are alone. In addition, operators should be trained to pay attention to particular details of people, groups and objects so as to provide identification information that can be useful in apprehensions of suspects, or in directing assistance to the proper location. Sometimes operator responses involve public address announcements or conversations over passenger telephones, in which case a part of the training program should focus on communicating with the public. Both the preparation of verbal messages and development of the speaking voice and style are appropriate topics for such training. The administrative abilities related to record-keeping by the operator should be developed by training in the use and disposition of logs, equipment records, videotapes, and all other new information handling and storage required because of the introduction of the CCTV system. Logs and records, though specific to the CCTV system, would probably resemble other similar documents used elsewhere in the transit system. Videotapes should be indexed and kept for a reasonable period of time (e.g., 30 days) before re-use, in case they become needed for investigative or evidentiary purposes. If videotapes are to be used as evidence, they must be safeguarded in the standard manner for such items to insure their admissibility in a court.

5.3.3 Course Outline

In the absence of the availability of formal operator training programs, the core training outline of Table 5-1 is recommended as a guide to system planners. It is based on personnel requirements that became apparent during the preparation of this document, and identifies major curriculum elements, estimated training durations, and some comments to guide the selection of the teaching staff. This training program can last from about one week to about one month, depending upon the size of the transit system, the amount of equipment involved, and the range of duties assigned to operators. Refresher training on a periodic basis is also recommended to maintain rarely used skills and knowledge and to acquire new ones as changes take place. Training time could possibly be halved if monitor operators are recruited from police and other transit system personnel, since those individuals may already possess much of the information and skills relating to the transit system, security and safety concepts, surveillance, and some of the response and communication procedures.

TABLE 5-1. TRAINING OF CCTV MONITOR OPERATORS—
A CORE OUTLINE

Curriculum Element	Duration	Comments
1. The Transit System—familiarization with all stations, vehicles, surrounding areas, operating procedures, key personnel and responsibilities, regulations, security and safety problems at each location, population profiles at each location, services available for passengers, documentation requirements	1-10 days, depending on system size	Best taught by transit system personnel; provides mental image and knowledge of the locations which will be viewed on video screens; operators should also ride the system often to maintain familiarization
2. Security and Safety Concepts—standard practices of police, fire and emergency medical	1-3 days, depending on degrees of pro-	Best taught by police and personnel from other services;

TABLE 5-1 (Continued)

Curriculum Element	Duration	Comments
services in transit systems; types of crimes and emergencies; emergency plans for specific crises; evacuation operations; rescue operations; apprehension procedures; evidence and courtroom practices; documentation requirements	cedure standardization and formal planning in system	provides understanding and appreciation of the police functions, and those of other services; allows for operators to cooperate rather than conflict with those functions
3. The CCTV System—basic operating principles, components, equipment adjustment and maintenance, recordkeeping	1/2-2 days, depending upon the amount of equipment involved	Best taught by technical personnel, CCTV consultant or supplier personnel; provides "hands on" experience so that operators can feel comfortable in using and adjusting the equipment to suit their needs
4. Ancillary Systems—audio and sensor alarm systems, public address, telephones, direct lines, radio links, emergency communications, transmission links and relays, passenger convenience devices, information sources	1/2-2 days, depending upon the amount of equipment involved	Best taught by technical personnel, engineering consultants or supplier personnel; provides "hands on" experience so that operators can feel comfortable in using and adjusting the equipment to suit their needs
5. Surveillance Operations—concepts of routine monitoring, vigilance and avoiding boredom; detection and recognition of potential incidents and those in progress; measures taken by perpetrators to avoid detection; alarms and audio surveillance as a supplement to CCTV	1-2 days	Best taught by police personnel with experience using CCTV and other types of surveillance, and familiar with overcoming the problems of remaining alert in routine surveillance situations

TABLE 5-1 (Continued)

Curriculum Element	Duration	Comments
6. Response Procedures—sequences of actions to be taken in the event of specific incidents; use of all resources and related services as needed; communication with passengers or others; prepared messages for specific types of incidents; handover or takeover of responsibility for incident management; reporting and documentation requirements	2-5 days, depending on the duties required of operators	Best taught by senior monitoring center personnel or supervisors; can be aided by videotaped or actual simulated incidents in which the operator trainee proceeds through the entire response sequence
7. Communications Techniques--techniques of communicating with the public; the speaking voice and manner; composing messages to convey meaning and reassurance; maintaining verbal contact with passengers in times of crisis; use of prepared messages and prerecorded messages	1-3 days, depending on the kinds of communications required of operators	Best taught by transit personnel well trained in communicating effectively with the public; can be aided by communications consultants
Total:	7-27 days	

5.3.4 Training Manuals

A useful device for standardizing and expediting the training of new operators in the training manual. Properly designed, it can also serve as a reference document (Standard Operating Procedures) for operators on the job. A training manual for CCTV monitor operators might typically contain the following sections and topics of importance.

5.3.4.1 Introduction - Description of the transit system; system personnel and organization; system philosophy relating to serving the public; description of the CCTV installation.

5.3.4.2 How to Perform Routine Duties - Setting up the system; system checkout; routine procedures at each change of shift; routine CCTV monitoring procedures; routine incident procedures; routine announcements to passengers; contact with the media; revenue train procedures; preventive maintenance; closing down the CCTV system (planned).

5.3.4.3 How to Deal with Emergencies - Typical kinds of emergencies; typical response patterns; emergency services available; notification of proper authorities; alerts; emergency announcements; contact with the media.

5.3.4.4 How to Use CCTV and Associated Monitoring Equipment - Cameras and lenses; establishing video and audio coverage; control of equipment; calibration and maintenance; use of the videotape recorder; use of the time and date generator; switchers, sync generators and other equipment; transmission lines; the monitoring center.

5.3.4.5 How to Communicate with the Public - The need to provide and obtain information properly; preparing routine announcements; preparing emergency announcements; priorities for communications; writing announcements; reading and diction.

5.3.4.6 How to Communicate within the System - Written reports; periodic reporting requirements; use of telephones; use of radio communications; use of meetings; use of mail.

5.3.4.7 Appendices - Sample forms used in the system; technical data on equipment used; glossary of terms; bibliography.

5.3.5 Use of CCTV in Training

Besides using videotape recordings of significant security and safety incidents as training materials, the CCTV equipment can be used to record and analyze trainee performance. For example, a training exercise can be set up, played out by the participants, and operator actions and reactions can be recorded on videotape. Those actions can later be critically analyzed as required for training or other (e.g., evaluation) purposes.

5.3.6 Job Aids

In addition to the training manual or standard operating procedures, other devices can be useful aids to the performance of daily routines. These can vary from mechanical devices to diagrams to memory schemes, in order to control apparatus, raise efficiency or reduce interference. One popular and simple job aid is the small checklist, which people can mount in a convenient location to remind them of frequent routine procedures they must follow, or numbers they must remember. The job aid also tends to reduce complex procedures to their essential functions and features, thereby helping to reduce training time.

5.3.7 Motivation of Trainees

There are specific trainer behaviors that support adult learning principles and help accomplish training objectives while building the trainee's self-esteem. While not limited only to training of CCTV transit security operators, they are included here for their general value. First, the trainer and the training situation should maintain and enhance the self-esteem of the trainee. This could mean creating a classroom environment that boosts trainee confidence in his/her ability to perform. Trainers can create this environment by listening, praising, acknowledging, eliciting group participation, using people's names, reinforcing positive behaviors or comments, sharing experiences, avoiding judgments, spending time, giving reasons, and acting in other positive and respectful ways. Second, the focus should be kept on trainee's specific performance and not on personality or attitude. Avoid generalities and urge specificity by requesting examples, demonstrations or alternatives. Third, the trainer should employ active listening techniques, by accepting what is being said without making value judgments, providing clarification and reflecting this back to the individual trainee. This is especially important when emotional issues (e.g., feeling pressed for time, feeling confused, feeling angry) are being raised. Fourth, reinforcement should be used to shape learning. This is based on the principle that rewarded behavior (or performance) tends to be repeated and strengthened. A simple "thank you" or nod of the head, or praise of a particularly cogent remark, all can provide that kind of reinforcement. Overt or covert forms of punishment to induce learning can sometimes generate a defensive reaction that interferes with transference of the training from the classroom to the job. Fifth, achievable goals and follow-up dates should be set, and periodic reporting of progress should be carried out. Moderately difficult and specific goals lead to higher levels of performance than do no goals at all or "do your best" goals. Trainees also can acquire new patterns of behavior by modeling themselves after the trainer. Videotape or films of correct performance are also helpful in this regard. (28)

5.3.8 Training the Trainers

The success of training new operators depends to a large extent on the skills and competencies of the trainer. The system administrator should allocate sufficient time and resources to the training of those who will be training new operators. Trainers must not only know everything that operators are supposed to know, but they must also be teachers, motivators and evaluators. Lesson plans need to be developed, which identify behavioral objectives (what is to be done, under what conditions and to what standards), teaching methods (e.g., lecture, demonstration, role playing, case study, participatory experience, etc.), teaching aids (audiovisual devices, videotape, charts, etc.), trainee's expected involvement (e.g., role play, answer questions etc.), and evaluation methods and criteria (derived from the behavioral objectives). Training consultants should be employed, if required, for training of the trainers.

5.4 MOTIVATION

5.4.1 Intrinsic and Extrinsic Motivation

In general, motivation refers to a state of goal-directed behavior induced by certain internal and external influences. Intrinsic motivation refers to characteristics that a person brings to the situation (e.g., curiosity, drive to succeed, insecurity, fear of rejection, etc.) which cause him/her to try to do well on the task. These individuals are often found to be achievement-oriented and conscientious in other situations. This kind of motivation may be induced by some inherent property of the task to which the individual responds. Extrinsic motivation is derived from influences external to the task at hand, such as rewards, punishments and coercions. Individuals who are intrinsically motivated typically require fewer external influences to perform well. (10, 24, 30)

5.4.2 Monotony and Boredom

A monitoring task is particularly subject to wearisome uniformity and lack of variety, making that task monotonous. Monotony produces boredom and causes a reduction in operator vigilance. In order to avoid the failure of an operator to detect a critical incident, the transit CCTV system supervisor can design procedures which introduce an appropriate variety of activities, some of which are described in this section. However, increasing the amount and variety of tasks can reduce monotony but, in excess, can also result in degraded performance. Shifts of brief or irregular length may sometimes be preferable to shifts of regular length. Paired operators usually perform better than those working alone, particularly if they are extroverts. The monitoring of an audio or alarm annunciator subsystem can sometimes be used to alert the operator to abnormal occurrences in the transit system. However, this works best on small, generally quiet systems. Continuous use of a videotape recorder can preserve the record of events that are missed by an operator. (5, 7, 23, 25, 30)

5.4.3 Rewards and Punishments

The psychological literature and common experience indicate that, within bounds, human performance increases with increasing rewards and/or punishments. The rewarded performance tends to occur more frequently, while the punished performance tends to occur less frequently. The use of rewards and punishments can produce undesired complications, however. For example, false alarms may increase if monitor operators are rewarded for the detection of real incidents but not punished for false alarms. In some systems, this may be an acceptable trade-off. Another complication of using rewards and punishments can occur when rewards are removed. That removal of rewards can be experienced as punishing, and may result in short-term reduction of the desired operator behaviors (partly out of anger). Rewards can be in the form of recognition and praise, job-related incentives like bonus money or time off, or tangible items like job aids, plaques and gift merchandise. They can be used effectively in training as well as operating contexts. (18, 30)

5.4.4 Coercion

Coercion is a general threat of punishment for "not trying hard," and it tends to yield overall performance increases. A simple form of coercion is to tell operators that they are being watched (implying critical scrutiny and possible punishment). Random, brief supervisory observation often can sustain high-level performance. (5, 18, 30)

5.4.5 Artificial Incidents

Some transit security organizations inform their monitor operators that artificial incidents will be "staged" before the cameras at relatively frequent, but unannounced, times. This technique serves as a constant factor in maintaining vigilance, and can be even more coercive if the operator knows that scoring or debriefing will follow the staged incident. This procedure also serves as a training technique to maintain operator proficiency in systems where few such real incidents ordinarily occur. As long as these artificial incidents are considered as important as real ones, they will tend to produce very similar or identical operator behaviors. (2, 19, 27, 30, 34)

5.4.6 Knowledge of Results (Feedback)

Operators can be motivated by making performance levels known on an individual basis, or even to the group as a whole. The knowledge can be informational only (as when tallied by a computer) or can be evaluative as well (as when presented by a supervisor). The use of this method can decrease task monotony by providing variety or demanding use of higher mental processes. It can also be viewed as providing an element of coercion (as when performance ratings are posted on the bulletin board). (3, 5, 11, 20, 25, 30)

5.4.7 Monetary and Other Incentives

Financial rewards, like high salaries or an extra hour's pay, can be established for operators who exceed specified levels of performance (such as in detecting "staged" or artificial incidents). In place of money, operators can also be offered extra time off, extra vacations or even time off to attend interesting training activities. Transit police departments that use cadets or aspiring officers as monitor operators give bonus points toward the police officer qualifying exam as a reward for good performance. Various incentives to provide the operator with added job status are also feasible. One problem with this approach is that of the value placed on each factor by the operator who may feel, for example, that the payoff is not worth the extra effort. (8, 30)

5.4.8 Identification with or Admiration of Supervisor

Some individuals who identify with, or have a high admiration for, the supervisor will perform significantly better than others without such feelings. The attitude of operators can depend on the supervisor's style of managing. Some research has indicated that individuals treated "democratically" will perform better than those treated "autocratically." (6, 18, 30)

5.4.9 Drugs

Though not generally recommended as a regular method, drugs, such as those typically referred to as stimulants, have been shown to help maintain high levels of performance. Clearly, there are dangers associated with the use of drugs, and they should only be employed under strict medical supervision. (5, 25)

5.4.10 Temperature-Humidity Effects

A high atmospheric temperature or a combination of high temperature and high humidity reduces the level of performance. (5, 25)

5.4.11 Rest Periods

Brief rest periods (e.g., 2 to 10 minutes) every half hour can reduce boredom and fatigue, and help to maintain a high level of performance. Some researchers and transit security personnel take the view that monitoring shifts should be as short as half an hour (e.g., 1/2 hour on, 1/2 hour off) if a decline in performance is to be avoided. (5, 25)

5.5 ORGANIZATIONAL CONSIDERATIONS

5.5.1 Legal Entities and Functional Structures

The parent structure of a municipal or other governmental agency, such as a Transit Authority, is typically established by an act of that government's legislative body and it is implemented by the associated administrative body. Within that structure, functional groups are established, such as a Transit Police Department, to carry out the detailed agency missions, such as providing security. Sometimes a counterbalancing structure is established for the employees, such as a Union or equivalent organized representative body. This introduces the need for more formalized labor-management relationships which, in turn, can greatly affect the organizational structure, job requirements, working schedules, equipment utilization, costs, and other items which are of concern in these guidelines. In some instances, there will be constraints on the administrator's freedom to adopt particular guidelines, because those guidelines may come into conflict with existing legal agreements or they may require formal negotiations. The reader is advised to ascertain the decision constraints (legal, political, or otherwise) that may exist in his/her own organization before investing large amounts of energy and other resources into the design of a transit station CCTV security system. It would be prudent to establish a cooperative effort, or at least keep the key individuals of the other bodies aware, apprised and, preferably, in support of the ongoing system plans.

5.5.2 Transit Security Organization and CCTV Systems

The monitor operators in transit security systems may be sworn police officers, police auxiliaries, or civilians. The advantages of using sworn police officers in these positions are: (1) they have the authority to initiate police responses directly, and (2) their training and experience have been found to result, on the average, in higher likelihoods of recognizing incidents in progress and potential incidents. Civilians, on the other hand, would have to interact with a sworn police officer in order to initiate a police response action, and would require special training to learn to recognize incidents in progress and potential incidents. However, the greatest advantage of using civilians in the monitor operator position is probably one of economy. The cost to the transit system of a trained police officer is probably much higher than that of a civilian hired specifically for the operator position. Multiplying that cost by the total number of operator positions and shifts could show a substantial economic difference in the two approaches. Somewhere between the two, with advantages and disadvantages depending on the system, would be the approach using auxiliary police. However, this approach is likely to be strongly opposed by police organizations.

As for the structure of the organization, the wide differences in purpose and size between transit systems around the country would require equally differing organizational structures. Properly organized structures would reflect each system's unique combination of mission, environment, size, legal status, economic condition, political context, history, and personnel. In general, the security department's chain of command would usually lead up to a transit system administrator who would also have responsibility for other (non-security) aspects of the transit organization, such as equipment, operations, finance, personnel and planning. Typical transit security departments would include a Chief and/or Captain under whom would be a few Lieutenants, under each of whom would be a few Sergeants, under each of whom would be a platoon of patrolmen. Civilians in the organization might report administratively through a separate, civilian chain of command to the transit system administrator, while receiving operational direction or otherwise coordinating with the police. Whatever the organizational structure is, however, operating authority and responsibility for each individual must be clear at all times. Monitor operators also may establish other working liaisons (either directly or through a police representative) with transit operations personnel and outside support groups like local fire departments, local police departments and local emergency medical services.

5.5.3 Labor Organizations

Besides their efforts to provide security and protection for their worker members, labor organizations become involved in negotiating the terms and conditions of new working groups in existing organizations. Since many of the transit CCTV security systems are additions to existing systems, there may already be a labor organization in place. Systems with such organizations include WMATA, PATH, MARTA, BART, and NYCTA. The labor group can be national in its affiliation (e.g., Teamsters Union) or it can be local (e.g., Brotherhood, Patrolmen's Benevolent Association). Some systems have no such labor organizations (e.g., PATCO). If the operators are civil service employees, then the local traditions of that body can affect the design and operating latitude of the CCTV security group.

The first way in which labor organizations can affect the CCTV security operations is in constraining the operator selection process. If it is determined (e.g., by negotiation) that these new job positions fall within the job definitions of existing employees, then the organizations are likely to argue for their current members to have first choice for those positions, and the hiring of new employees would be limited. Further, labor groups are likely to argue for selection based on years of membership or years on the job (seniority). This could result in an organization which has a different profile of skills and other attributes than the profile originally sought. Training may have to be modified to help compensate for that difference. Consequently, a second way in which labor organizations can affect the CCTV security operation is in its requirements for particular training programs. Finally, various administrative and working relationships, pay scales and specific job functions can be influenced by the organized representatives of the operators. That influence can be helpful or not, depending on whether the labor organization feels cooperative or threatened. Appropriate attorneys and labor relations specialists should be a part of the planning and implementation phases for any new CCTV security system involving labor organizations.

5.5.4 Standardized Regulations and Procedures

Existing transit authority regulations, security department procedures and individual job descriptions should be reviewed, modified and supplemented as necessary when planning for a new transit CCTV security system. This is necessary to insure that required liaison can take place smoothly between monitor operators and other departments. Transit authority regulations can help serve that purpose. Operators must also be well prepared to respond effectively to the numerous types of situations that can arise. Since it is not possible to write a plan of action for every possible emergency situation, it is imperative that responsible individuals and their alternates for specific emergency actions be clearly identified and be armed with well prepared standard operating procedures and guidelines. A standard procedures manual can only be standard to the originating property, but its major areas would probably include: (1) a description of the system, its organization and relationships with other departments; (2) detailed descriptions of specific day-to-day operations; (3) detailed descriptions of emergency procedures and contingency plans; and (4) preparation and utilization of report forms. In particular, the modifications to standard operating procedures would introduce a description of the CCTV surveillance system, how it is used, the responsibilities of each operator, and the effect of the CCTV addition on all previously existing procedures. Special procedures may also need to be developed for such new operator roles as communicating with passengers over an audio link that may accompany the CCTV system.

5.6 REFERENCES

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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 recognize and identify what is actually taking place. Based upon this determination of what is occurring, the operator next evaluates the need for a response based upon his/her knowledge of available options. Those options range from minimal response (e.g., doing nothing, making a brief announcement over the public address system) to complex responses involving coordination with personnel of other departments (e.g., police, fire, train operations, medical, etc.). Often the detection, identification and evaluation functions occur almost simultaneously. The operator next carries out the response, taking responsibility for its completion unless that responsibility is legitimately assumed by another authority. After the crisis period is over, the operator must frequently follow-up the incident with the preparation of a 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.

6.4 COMMUNICATIONS WITH RELATED SERVICES

6.4.1 Potential Networks

Depending on the mission of the CCTV transit station surveillance system, the need to coordinate responses with other official services will vary. Among the services that could be in established networks with the surveillance center are: transit and local police (fixed and mobile units), fire, emergency medical, transit operations, transit maintenance, utilities, municipal administration, civil defense and almost any others made necessary by the system's charter. The possible communication modes employed with these related services are face-to-face, intercom, dial telephones, direct-connect telephones, radio, CCTV, teletype, digital computer, facsimile and memorandum. The number of channels between the surveillance center and the terminals of related services will range from none to many, depending upon the expected flow of communications traffic in each link. That flow, in turn, depends on the amount of information that is to be exchanged in carrying out the full range of surveillance center activities and responses under all anticipated conditions. The network should be designed to support the most reasonable "worst case" situation, with appropriate spare capacity for future expansion.

6.4.2 Communications Protocol

Each system must set-up its own "chain of command" for communications, under which certain types of messages must be directed to specified individuals. For example, a station agent operating a remote CCTV surveillance installation when the central monitoring unit is closed (if ever) may be prohibited from making direct calls to the local police. Instead, he/she may be required to call a supervisor who, in turn, may be required to call a particular headquarters for police response. Likewise, for reacting to a crime in progress, the CCTV monitor operator in some systems may be required to notify a desk officer or central police dispatcher who, in turn, will instruct the operator as to what action should (or should not) be taken until help arrives. Communications protocol should be defined not only for routine messages, but should also be included in any contingency plans developed for handling special emergencies like bomb threats, riots, hostage-taking, or severe acts of nature.

6.4.3 Portable Radios

Each officer patrolling the system should be equipped with a portable, battery-operated, two-way (walkie-talkie) radio, designed to operate on the system's security-reserved channels. Because of the need to re-charge the batteries in those radios and the necessity for spares in case of malfunctions, the number of devices should exceed the number of individuals that could have simultaneous needs for them. The base communications station would be at the operator's console or that of a superior authority, depending upon the system organization. The public address or paging system can be used as a backup or to supplement the two-way portable radio system. Using the public address system, individuals can be directed to telephones if a two-way conversation is required.

6.4.4 Patrol Car Radio

Patrol cars, when used in the CCTV surveillance and response systems, can use radio channels that keep their occupants aware of emergency transit system communciations, so they do not require such messages to be relayed from another central facility (though such messages should be repeated as a matter of routine by the central facility).

6.4.5 Miscellaneous Communications

There are unforeseen, infrequent and unscheduled instances when it may be necessary to communicate with various individuals or organizations not explicitly provided for in the system design. For example, the occasional need for equipment servicing may require contact with the supplier, a spreading fire situation may require contact with people in premises adjacent to the transit system and legal matters may require contact with law authorities. The simplest and most appropriate way to prepare for these miscellaneous communication needs is to provide standard dial telephones into the local telephone network. If desired, sophisticated telephone dialing systems can be obtained, which may include numerous (e.g., 30) pushbuttons that are each pre-set to important telephone numbers. Those telephones can be used for rapid, error free "dialing" by pressing the single button. Other automatic systems use pre-punched individual cards (each containing one telephone number) that can be inserted into the automatic dialing device of the telephone when one wants to place a call.

In addition to the telephone which provides for miscellaneous two-way voice communication, the system designer may find it useful to provide a standard radio broadcast receiver and a television receiver for use in receiving public announcements, "helicopter" reports or civil defense information during widespread emergencies or disasters.

6.5 COMMUNICATIONS WITH THE PUBLIC

6.5.1 General

In some CCTV transit station surveillance systems, one of the most important functions of the monitor operator is to communicate with passengers and other members of the general public. Typically, this takes place over a public address or paging system, a passenger assistance telephone or some other type of telephone link. The amount of communicating with the public depends upon the kinds of functions being served by the monitoring center. At one extreme, it could be a security monitoring center only with frequent communications to police units and with no communications link to the public. At the other extreme, it could be primarily for passenger convenience in which case there would be a predominance of communications with the public regarding travel instructions, schedules, use of equipment and facilities in the station, fares, and miscellaneous personal concerns of the passengers. Most systems will be somewhere between the two extremes, with a moderate amount of communication with the public being required of operators.

6.5.2 Some Specific Overall Guidelines

It is the task of the system and the individual operator to listen to the passenger and then find the best way of presenting information so that person will comprehend it quickly and act on it without making an error that could cause harm. Specifically, the operator's messages should be kept brief, use common and familiar words, have clear meanings, connote authority when necessary, be phrased in positive rather than negative terms, encourage cooperation, be repeated to emphasize important facts, be calm and reassuring and display respect for the passenger with understanding for the passenger's problem. In emergencies, it is essential that the operator does not make announcements that create unnecessary doubt, anxiety or fear in the passengers. For such situations, the operator can be helped by filling out a Fact Sheet which describes the Who, What, Where, When, How and Why of the event. Those facts must then be organized and phrased in a way that is most relevant to the passengers and what is required of them. They do not require all the details of the situation. (1)

6.5.3 Constructing an Emergency Message

Using the overall guidelines noted above, a detailed sequence of statements for an emergency message could be:

1.	Get the passengers' attention	("May I have your attention, please?")
2.	Tell what is happening	("A fire has been reported at the north end of this station")
3.	Convey the presence of an authority and explain why directions are to be followed	("Central Control would like you to leave the platforms for your own safety")
4.	Tell what to do and where to go	("Please leave the platforms now and walk slowly to the main waiting room")
5.	Give more detailed directions, if necessary	("Please use the stairways in the middle of the platform only")
6.	Provide reassurance that the instructions will be heard again	("These instructions will be repeated while you are leaving the platforms")
7.	Insure that instructions are being carried out	("Please leave the platform now")
8.	Encourage group identification and mutual support	("As you leave the platform, please help anyone who needs assistance")
9.	Repeat the message from the beginning	(repeat all statements above)

(1,4)

6.5.4 Communication with the News Media

In emergencies, it is important to provide as much factual information as is required to as many of the affected individuals as possible. It is highly desirable that any contact with the news media be made through a responsible administrative officer. Otherwise, the control center can expect to receive less formal and perhaps distracting, telephone calls from radio and television stations, newspapers and other media organizations. It may be preferable to establish a "direct" phone line to the news rooms of the local media, and agree upon a signal to notify media personnel that an authorized emergency message is to be transmitted shortly. Then a single official report can be given to all media organizations in a rapid and fair manner. The communicator should anticipate which questions may be asked and include the answers in his brief factual report. Automatic devices, if available, can be used to give updated messages to callers. "All clear" messages should be transmitted "live," just as the initial report was.

6.5.5 Security or Passenger Assistance Telephones

Many transit systems provide emergency or other telephones for passengers or system personnel to use in calling a central control facility. Each of these telephones should be within view of a CCTV camera. Whenever a call is received, the operator should locate the monitor screen that shows the caller. The operator should then determine the nature of the call, and if appropriate, request the caller to remain at the telephone. The operator next takes whatever action is indicated to help the caller (e.g., provide information, summon police, fire or medical aid, etc.). After that, the operator can request the caller's name and other pertinent information required for an incident report, if necessary.

6.5.6 Enhancing Awareness of the CCTV Security System

The riding public is influenced by its perception of security as well as by the statistics reflecting actual security. Both perceived and actual security can be reinforced by the system administrators through certain policies and public anouncements, such as: "For your safety, you are being monitored by a closed circuit television system in this station. You are invited to see it in operation by visiting our monitoring center on the mezzanine of the Main Street station at any time." This same message can be given to the passengers by posting attractive signs near station CCTV cameras. Even if no passengers visit the monitoring center, they are reminded that the CCTV surveillance system is actually working and in active use. This awareness can also be reinforced by making periodic statements over the public address system, even if in response to only minor events or circumstances (e.g., "There is no smoking permitted on this platform. Please extinguish your cigarette now and place it in the receptable under the clock. Thank you.").

6.6 AUTOMATIC CAPABILITIES

6.6.1 General

To assist the operator in routine types of monitoring and responding, certain automatically operated devices are available. They range from motion detection alarms to image sequencers to pre-recorded announcement tapes. In general, they are used to avoid boredom and loss of vigilance, to save the operator's time for other unique activities, to do what operators cannot do as well, or to save money.

6.6.2 Video Intrusion (Motion) Detection System

This is one of the most sophisticated automatic devices available. It employs a digital computer to store the characteristics of a scene in which no motion should be occurring. When the scene is intruded upon, the changes in scene characteristics are noted and stored by the computer. A motion detection alarm alerts the operator, and a set of images can be called up on the screen to display the recorded sequence or map of movements previously carried out by the intruder. It is possible to select those portions of the image in which the motion detection capability is desired. This is accomplished with a light pen used by the operator to "draw" the alarm areas on the face of the special monitor screen. The light pen can also be used to draw a safe pathway on the monitor to allow people to walk through without alarming the system. (5,9)

6.6.3 Automatic Sequential Video Switchers

These devices permit up to eight or more camera images to be viewed in sequence or on a single monitor screen. The dwell time on each image can be varied, typically from about 1 to 60 seconds and indicator lights show which camera is connected to the monitor at any instant. A manual override pushbutton switch is generally provided for the operator to stop the switcher and monitor a single camera continuously (the others go unmonitored at that time). Another press of the override button starts the automatic sequencing again. As discussed elsewhere in these guidelines, a disadvantage of sequential switching of numerous cameras onto a single monitor is that it interferes with one way of alerting operators, who ordinarily would be able to recognize movement on an otherwise unchanging picture. It also may cause the operator (or videotape recorder) to miss a critical incident of brief duration (like a purse snatching) since any one camera's image may be in view for only several seconds every minute.

6.6.4 Automatic Panning

These devices permit a single camera to scan automatically from side to side, through angles from close to 0° up to about 360°. They usually come with manual override switches so the operator can stop and position the camera in any direction. Panning speed is typically about 6° per second. As in the automatic sequential switcher, this technique can interfere with an operator being alerted by movement on an otherwise unchanging picture. It may also result in missing an incident of brief duration, especially if a perpetrator can see which way the camera is looking at any movement. There are one-way mirror devices to hide the camera from an observer and thereby diminish the possibility of a perpetrator defeating the system. One possible application for this automatic capability is in the surveillance of very large areas with low levels of activity (e.g., long term parking lots).

6.6.5 Automatic Sequential Audio Switchers (Scanners)

These devices can be used to scan a sequence of radio channels or remote microphones in an automatic fashion. Radio scanners, like those in the police band, are designed to stop automatically when an actual transmission is picked up. Microphone scanners can be designed and built to provide a similar capability, though the automatic stopping feature may take some ingenuity to develop.

6.6.6 Automatic Telephone Answering Devices

Updated emergency information can be provided to callers automatically by using any of the currently available telephone answering machines. These devices can be set to make recorded announcements only, or to record incoming messages as well. A typical machine might have two tape cassettes: one closed loop ("endless") tape for making the announcement and for timing how long the line will remain open to an incoming message; and one tape cassette for recording the incoming messages. Both cassettes come in various lengths or capacities. For example, the closed loop announcement cassette may have a cycle of 30, 45 or 60 seconds in length, disconnecting the caller at the "end" of its loop. It may contain the operator's latest announcement only or it could also contain a signal ("beep") after which the caller is supposed to leave his/her message. The message cassette may be the common tape cassette that can record 15, 30, 60 or 90 minutes worth of messages on one side. Some machines include a switch to allow the recording of "unlimited" length messages rather then cut the caller off when the end of the loop is reached by the announcement tape. These automatic answering machines can also be monitored by the operator who can listen to incoming calls and pick up the telephone to speak directly to the caller when he/she chooses to do so. Some machines keep a count of how many calls were received. Some can be adjusted readily to answer calls after a selected number of rings. Some can be used as a conventional cassette recorder/player when not used for automatic telephone answering.

6.7 RECORD-KEEPING

6.7.1 General

The longer term tasks of monitor operators include the preserving of information for administrative, technical, evaluative and legal purposes. Most often these will be handwritten or typewritten records, but they also may include automatically generated charts, videotapes, audiotapes, facsimile records and photographs. Departmental procedures will dictate many of the record-keeping requirements, and the the unique nature of a transit station CCTV security system will necessitate others. In this section, some of the CCTV related records are described for possible inclusion in the administrator's overall record-keeping system. The logistics associated with record-keeping have implications for maintaining an inventory of fresh supplies, for refilling or changing the storage media when necessary, for keeping the records in a readily accessible, indexed and safe location and for re-using or disposing of selected records when appropriate.

6.7.2 Events Log

This record kept by the CCTV monitor operator is much like the log kept by the police desk officer. It includes a brief notation of each incident taking place during the operator's tour of duty and identifies date, time, place, persons involved, equipment involved, the nature of the event and references to further records if appropriate. It could be used to record such events as security or safety related incidents, shift changes, communications initiated or received, fire alarms and equipment malfunctions.

6.7.3 Identification of Cameras and Other Equipment

To insure accurate references to equipment involved in recorded incidents, and for general record-keeping purposes, each item of equipment should be assigned a simple identification code. This could be a number, a letter, or a combination of those characters. For example, it will be important for evidentiary reasons to know which camera was used to record a crime in-progress. That reference could easily be made if each camera is uniquely identified (e.g., "W4/2" could be a designation for the West 4th Street Station, Camera No. 2). The designation could be located in large letters on the monitoring panel, and could serve as a constant reminder of which station/camera/monitor combination is being viewed at any particular moment.

6.7.4 Keeping of Videotape Recordings

If a videotape is to be used in any criminal, civil or agency adjudication, the original tape must be preserved and a carefully recorded chain of possession and protection must be presented to the tribunal. In addition, the CCTV observer will most probably be called upon to testify that the event recorded on the tape is the event as he observed it on the screen at the time. He will also be called upon to present a "shop record" showing that he was on duty, that the camera and videotape recorder were operative at the time of the event, and to present some brief details of the event as he observed it. The observer is the witness, not the tape recording. In the event that a recording will be required to be produced as evidence to support the observer's testimony, the accepted procedures for preserving evidence must be followed, with care given to documenting the chain of possession.

Videotapes being used as evidence may have to be held for indefinitely long time periods. Other routine, day-to-day recordings that are made should be kept long enough to insure that the scenes they depict are no longer needed. For example, the victim of a robbery, or a person who alleges to have been robbed, may delay reporting it until several hours (or even days) after the "incident." It would be helpful if the recordings made at the time of the alleged incident have not yet been erased or re-used, so that the recorded scenes could be reviewed as part of the resulting investigation. According to some CCTV users, 30 days is not an unreasonable time period for holding videotape recordings before erasing or re-using them. Clearly, a convenient method for identifying those recordings is necessary. The identifying information should indicate the date, time period, and place of the recording. Locating an incident on these recordings can be a very slow process, and precise time designations on the recordings can greatly facilitate the investigator's search time. The need to store recordings implies the consequent need to maintain an adequate supply of tapes so that ongoing recording needs can be met.

6.7.5 Audio Tape Records

Some control centers make an audio tape recording of every communications channel in use at the center (e.g., city police, transit police, railroad operations telephones, intercom, public address, etc.). This requires a multichannel recorder and should include an automatic time log channel so that events can be designated in terms of when they took place. By recording all channels simultaneously and with a time designation, the reconstruction of events is greatly facilitated. The playback device for these recordings should enable the listener to monitor at least three of the channels at the same time.

6.7.6 Incident Reports

A separate Incident Report may often be required by general system regulations. Typically, these reports should include the date, time, operator's name, nature of the incident, station involved, number and location of the viewing camera, description of the suspects and victims, identification of the videotape used (if any) and the videotape counter (or index) number at the start of the incident.

6.7.7 Computer-Generated Reports

Many alarm reporting systems have an automatic log generating capability. If this capability is included in the CCTV security control center, it may be practical to incorporate CCTV events with the alarm events on a consolidated record. There is a great variation in the capabilities of these automatic, computer-based devices and each system must determine for itself whether it makes sense trying to generate consolidated records. The services of a technical consultant may be required for this determination.

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7. EVALUATION

7.1 ESTABLISHING EVALUATION CRITERIA AND MEASURES

7.1.1 Varieties of Evaluation

The full assessment of CCTV monitoring systems should usually address a number of different issues, depending on the intended purposes of the system. For example, one set of measures must assess the ability of the system (equipment, operators and procedures) to correctly detect criminal activity or safety hazards. A second set of measures must assess the adequacy and expediency of response procedures in emergency situations. Another set of measures, somewhat related to the first two, should be designed to assess the usefulness of the monitoring system as a crime countermeasure, while still another set is used to assess its usefulness as a tool in passenger safety and convenience services. Finally, the cost (in economic and social terms) for achieving specific levels of effectiveness or benefit are sometimes viewed as the ultimate indicator for assessing and comparing systems. These are the familiar cost/benefit or cost/effectiveness ratios.

One possible example of a cost/benefit ratio of interest to the transit system administrators might be the annual dollar cost of a new CCTV station surveillance system divided by the increase in the annual number of passengers and/or revenue (due to an increase in perceived security). A cost/benefit ratio from the community's point of view might be the annual cost of the system divided by the decrease in all crimes or in specific types of crimes (e.g., crimes against persons). Evaluation should consider the viewpoint of the transit system, the community, and any other group (even the offenders) whose interests are affected. (4, 5, 6, 8, 9)

7.1.2 Criteria vs. Measures

As these terms are used here, criteria refer to those more general standards of performance for judging or evaluating the system, while their related measures are quite specific. The criteria can directly reflect the specific goals or purposes of the system. For example, if one of the goals of the CCTV transit security system is to reduce actual crimes, then one appropriate criterion for evaluation might be the "level of crime." In order to assess the level of crime, one would select several measures that can be taken, such as: (1) the number of assaults at a particular location in a given period of time; or (2) the number of each type of crime, by station, in a given period of time.

7.1.3 Comparisons of Measures for Evaluation

To assess the effectiveness of the CCTV system, one would compare the measures under CCTV conditions with equivalent measures under conditions of no CCTV. The "no CCTV" conditions could be: (1) the same station(s) before CCTV was installed; or (2) comparatively similar station(s), but without CCTV, measured in the same time period as the CCTV station(s). The first comparison is called a "repeated measures" design, while the second is a design involving separate "control sites" for comparison with the actual (or "experimental") CCTV sites. The "no CCTV" data can be referred to as "baseline" data against which the CCTV data are compared for indications of significant differences. Every effort must be made to insure that the baseline data and CCTV data are collected under identical conditions (except for the presence or absence of the CCTV system). For a given quantity of comparative data, the repeated measures design is a more powerful statistical approach, because variations due to location differences are virtually eliminated. However, carrying out the repeated measures design may require a longer time period because the two sets of comparative measures are gathered sequentially (i.e., before and after installing the CCTV system). Though less powerful in statistical terms, the use of a separate control site permits comparative data to be gathered simultaneously, and therefore requires a shorter duration to carry out. If time permits, a still more powerful evaluation procedure would involve a combination of the two designs—that is, a "repeated measures" design at both the experimental (CCTV) and control (no-CCTV) sites simultaneously. Since one would usually prefer the most powerful statistical assessment to be conducted for a given expenditure of resources, an expert in experimental design and mathematical statistics should be consulted in planning for this activity.

7.1.4 Identification of the Most Relevant Evaluation Measures

Each group affected by transit system security can be expected to differ somewhat in the kinds of benefits they value most, and the kinds of socio-economic costs they are willing (or unwilling) to pay for those benefits. Prior to the collection of evaluation data, one can hypothesize about which are the distinguishable groups for whom different concerns or attitudes may exist. By defining those groups, the collection of data can include an item which identifies the group, and subsequent data analysis can determine if the hypothesized group differences really exist. The differing groups might be distinguishable by sex, age, ethnic background, relationship to the system (e.g., passenger, transit system administrator, system employee, police officer, offender, victim, community leader, community resident, etc.). Some of the measures of concern to each group are found in the remaining paragraphs of this section. Actual concerns of each group should be obtained from members of the group, perhaps by discussions with some of their key representatives. (6, 7)

7.1.5 Validity of Measures

In deciding which measures to use, the administrator should judge how well the measures under consideration actually measure what they purport to measure. Four important kinds of validity can be judged or inferred for any particular measure: predictive, concurrent, content, and construct validities. The first two (predictive and concurrent) are often referred to as criterion-related validities. They should be considered when one wishes to predict an individual's future level of performance from a knowledge of prior testing or performance, or when one wishes to estimate an individual's present standing on the performance criterion. Predictive validity involves a time interval during which people may become further trained, or gain further experience, or are subjected to some particular conditions. Concurrent validity reflects only the individual's status at the time of measurement. The most commonly judged kind of validity for measures of skill or knowledge is content validity, which describes how well the performance or characteristics demonstrated in testing represent the full range of performance or characteristics required in the real performance situation. If the measure merely appears to be relevant, then it is said to have face validity. Finally, construct validity refers to the degree to which an appraisal measures a scientifically determined trait (or construct) related to the job, such as clerical aptitude or sociability. The development of valid measures can become a complex and controversial task and, at such times, should prompt the administrator to call upon the services of a testing and measurement expert, who will often be a research psychologist with experience in demonstrating test validity in accordance with the standards established by the American Psychological Association. (1)

7.1.6 Sources of Evaluation Data

There are several locations where the required evaluation information can be found: within the transit security organization and records, within other departments of the transit system, from local police and other emergency response departments, from the riding passengers, from the local community in general, from key persons in the community, from the offenders and victims of incidents, and sometimes from equipment manufacturers. Just as there are various information sources, there also are various data-gathering techniques. These include reviewing files of recorded data, observations of passengers or operators, use of mail questionnaires, in-person interviews, testing, and analysis of critical incidents utilizing any of those methods to piece together in-depth descriptions of significant occurrences (in the manner of epidemiological studies).

7.2 ASSESSMENT OF SYSTEM DESIGN

7.2.1 Design Evaluation Criteria

Even before very much operational experience is gained with a new CCTV transit security system, it is possible to do some evaluations of the design which can uncover specific problems and indicate potential performance. This section addresses assessment of the system design on the basis of physical attributes, capacities, and calculated parameters of the system. Design assessment can be helpful in the conceptual stages of system development, since it calls attention to the need for translating relatively abstract goals into tangible and measurable attributes of the system. For example, design evaluation criteria could include: (1) the degree of compatibility between the new CCTV system and any existing systems with which it will operate; (2) the adequacy of expected surveillance coverage; (3) the ease of expected operation; (4) the expected response time; (5) the expected security level of the CCTV system itself; (6) the expected maintainability of the system; (7) the expected reliability of the system; (8) the expected size of the system, physically and electrically; and (9) the expected cost of the system. Some possible measures for each of these criteria are described in the following paragraphs.

7.2.2 Compatibility with Existing Systems

CCTV security systems are sometimes designed for use with an already existing and operational transit system. In such cases, it may be a goal to make use of existing support resources, rather than spend the additional money needed to acquire new resources. Consequently, the new system should be assessed in terms of its ability to make use of the existing: (1) electricity supply system (wiring, voltage and power); (2) personnel; (3) personnel selection and training procedures; (4) communications facilities; (5) physical space; (6) lighting; (7) maintenance capabilities; and (8) regulations and procedures. Where it is found that incompatibilities exist, efforts can then be made to improve compatibility or justify the expenditure of resources to accommodate the mismatch.

7.2.3 Adequacy of Expected Surveillance Coverage

The basic requirement of a surveillance system is to monitor a specified physical space within the transit system. Consequently, one basic measure of the CCTV system's ability to meet this requirement is the proportion of the transit system's physical space located within the range of adequate CCTV monitoring. This proportion can be expressed as a percentage of the total required surveillance area that is actually within monitoring range of the equipment. An alternative computation is the percentage of total passengers under surveillance, or the percentage of total time that surveillance is actually in effect.

Another measure of surveillance coverage is the degree to which the critical areas of the stations are in view of the monitoring equipment. This could be most useful in large stations where 100% coverage is not possible or practical. Yet another assessment measure for systems employing less than 100% coverage is the ease of re-configuring the equipment (e.g., re-positioning the cameras, increasing or decreasing the amount of equipment, etc.) to meet changing security requirements. Finally, for systems in which the information requirements can be described in measurable terms (e.g., types, amount, rate of updating), the evaluator can develop additional measures to insure that the required information is being processed and presented satisfactorily.

7.2.4 Ease of Expected Operation

Of great importance in systems involving people, equipment and procedures is the compatibility between those three elements. Such systems should be designed with specific attention to human factors—the relationship between operators and equipment, and particularly their interface consisting of all the controls and displays. Operators use the controls to alter equipment and operations, and they use displays to determine what is taking place. Ease of operation can be assessed by examining the demands placed upon operators in order to interact with the system's controls and displays. For convenience, those demands can be divided into physical, perceptual and cognitive (intellectual) categories.

Physical measures for assessing the ease of operating the system could include such things as:

a. The suitability of the operator's overall environment, including the atmosphere (temperature, humidity, ventilation), illumination (levels, distribution, contrast, glare), noise (intensity, location, interference with speech), and vibration (may be quite relevant in transit systems);

b. The suitability of the operator's immediate workspace, including general dimensions and flexibility of the workplace (to be compatible with the expected range of operator body dimensions and motion);

c. Console (or equivalent) features, including availability of work surfaces, location and grouping of displays and controls, placement of emergency or warning indicators, amounts of strength and dexterity required to operate the panel controls, amount of physical discomfort or fatigue associated with observing the displays, and the convenience of components for sequential interaction; and

d. Special physical skills required of operators to interact with the system.

Perceptual measures for assessing ease of operation could include:

a. Compatibility of displays with human stereotypical behavior, such as the tendency to associate colors with conditions (e.g., red with danger, yellow or orange with caution, and green or white with operational safeness), the tendency to perform sequential operations in a smooth unidirectional flow (such as from left to right or top to bottom), and the tendency to expect increased activation by moving controls clockwise or upward (and the reverse for decreased activation);

b. The use of non-ambiguous indicators, labeling, and controls, which employ well illuminated and legible characters with a minimum of unconventional abbreviations; and

c. The use of visual, auditory or other signals that are sufficiently above the operators' thresholds of perception in terms of intensity, duration, freedom from interference, refresh rate, and update rate so as to insure their detection and recognition under the worst expected conditions.

Cognitive or intellectual measures for assessing ease of operation could include: (1) the amount of specialized knowledge or information required to be a satisfactory operator; (2) the amount of complex reasoning, analytic thinking, and decision-making required to be a satisfactory operator; and (3) the degree to which the interaction between operators and the rest of the system (including equipment) takes place in terms of abstract concepts, symbolism, representational diagrams and other forms of higher order, processed information.

7.2.5 Expected Response Time

It is possible to estimate the expected time to respond for any given emergency condition. This is accomplished by first preparing a step-by-step sequential list of activities and events in the detection-to-response process (e.g., "confirm nature of incident," "start videotape recorder," "provide responding officer with location and description information," etc.). To this list is next added the expected average (or minimum, or maximum) time to carry out the activity (including waiting time). The sum of all those times provides a reasonable value for the expected response time. It is appropriate to calculate not only the expected average response time, but also the expected minimum time if everything is working perfectly and no delays occur. The process of making these estimates can serve to identify stages of operation for which faster procedures are desirable. This could lead to the modification of the system design, or to the use of job aids as a means of improving response times.

7.2.6 Expected Security Level of the CCTV System

The best CCTV surveillance system is worth very little if it is sabotaged by those it is supposed to detect and apprehend. Measures for assessing the expected security level of the CCTV installation and its operating and support systems require examinations to determine if reasonable precautions have been taken, such as: (1) the use of vandal-resistant camera housings and installations; (2) the use of conduits or other means to achieve vandal resistant transmission links; (3) the use of controlled accesses to the control center; (4) the use of controlled accesses to maintenance and spare parts areas; and (5) the positioning of cameras so that all unprotected components of the system are under constant surveillance (e.g., each camera is observed by at least one other camera).

7.2.7 Expected Maintainability

Unless a CCTV surveillance system is kept in satisfactory operating condition through continued maintenance, it will soon lose its value to the transit system and the riding public. Some of the characteristics that can be assessed in order to determine the ease of maintaining the CCTV system include: (1) the ability of the system to remain in virtually normal operation while under repair, such as through the use of replacement units (e.g., cameras, lenses, etc.) or modular parts (e.g., plug-in printed circuit boards); (2) the accessibility of equipment and maintenance panels/doors; (3) the availability of appropriate space and apparatus for conducting maintenance activities; (4) the availability of spare parts; (5) the degree of standardization of spare parts; (6) the levels of skill required for maintaining each type of equipment used; (7) the levels of skill available among those employees expected to provide maintenance;

(8) the availability of backup maintenance support from manufacturers or outside service organizations; and (9) the guarantee/warranty plans acquired along with purchased equipment.

7.2.8 Expected Reliability

Confidence in the CCTV system grows as it is found to remain relatively free of problems and equipment failures. Reliability refers to the system's ability to resist failures, and it is frequently measured in terms of mean-time-between-failures (MTBF) or its inverse, the expected number of failures per unit time (month, year, etc.). Without attempting to provide the reader here with the sometimes complicated probability calculations that go into the science of reliability engineering, a useful guideline is to at least compare the manufacturer's reliability data with those of competitors, or with general figures for the industry (if available). As a general rule, the expected number of failures in a total system over the course of, say, one year is the sum of expected yearly failures of each component part in the system. By inverting that number, the estimated MTBF for the total system can be obtained. For example, if 4 components making up a small system had expected failure rates of 1, 4, 2 and 5 failures per year, respectively, then the expected rate for the total system would be 12 failures per year or about one failure per month. The expected MTBF for that system would be the inverse of one failure per month, that is, one month (per failure).

In addition to considering the failure rate or MTBF as a measure of reliability, one should also consider the severity and duration of expected failures. Poorly designed systems will tend to experience catastrophic ("total") failures, while better designed systems will tend to degrade gracefully by losing their capabilities in a partial or slower fashion. Redundancy of parts and functions contribute to more graceful degradation. Clearly, the severity and duration of failures are also associated with the maintainability features of the CCTV surveillance system, as described previously.

7.2.9 Expected Physical and Electrical Size

Another way of assessing and comparing systems is by the relative economies that result from smaller physical size and lower power requirements. Without reducing the system's operational capability, it is usually preferable to minimize the need for physical and electrical resources. Consequently, some measures that should be considered in assessing this aspect of a CCTV surveillance system are: (1) the area or volume of space required to house the monitoring center; (2) the station space required for each camera or loudspeaker and its housing; (3) the cumulative length of the transmission links and conduits; and (4) the individual and total power requirements of component units, in terms of voltage needed (e.g., 120 VAC, 220 VAC, etc.) and power consumption (e.g., watts, kilowatts). Obviously, if the necessary physical or electrical resources are not presently available, there are implications for either making them available or changing the system accordingly.

7.2.10 Expected Cost

The most frequent notion of system economy is usually expressed in terms of minimum financial costs. Actual or estimated costs can be used to assess and compare systems. Those costs can be computed for various stages of the system's life cycle, making interpretation of the figures more meaningful. One way of dividing up the system costs is in terms of the following stages: designing, purchasing, operating, maintaining, and disassembling (for storage, sale or scrap). Suppliers, consultants and financial experts should contribute to these cost estimations if the figures are to have reasonable validity. Comparisons can be made in various ways (e.g., bringing all estimates back to their dollar values at a single point in time), but at least one way should be in a manner most meaningful to the system administrator charged with making the financial decisions. As an aid in estimating equipment costs, the next chapter provides some more cost-estimating concepts and some representative equipment costs at the time of this writing. (3, 5, 7, 9)

7.3 ASSESSMENT OF THE CORRECT DETECTION OF INCIDENTS

7.3.1 Assessing Detection of Criminal Activity

The correct detection of criminal incidents by the operational system depends upon several factors: (1) that the CCTV cameras are able to observe those incidents accurately; (2) that the equipment can accurately transmit and display all incidents; and (3) that the operator is able to observe criminal activity accurately in the displayed images. Implied in the use of the term "accurately" is the notion that negative and positive false alarms are possible—namely, criminal incidents can be undetected when they are present (negative false alarm), or detected incidents can be identified as criminal when in fact they are not (positive false alarm). Ideally, the measure of correct detection of criminal activity would be the percentage of all transit station crimes actually identified correctly. Unfortunately, this measure cannot be made because it is very difficult to know the exact number and nature of all crimes committed in the stations. Consequently, estimates of that ideal measure must be sought. The more practical measures for this purpose include: (1) the percentage of "staged" or simulated criminal incidents that are detected correctly; (2) the number or percentage of false crime alarms (both negative and positive) produced by the system; and (3) the correctly detected percentage of all transit station crimes known to the police (e.g., reported by victims). A supplementary measure, which affects the system's ability to observe criminal incidents, is the number of hours per day that the system is fully operational.

7.3.2 Assessing Detection of Safety Hazards

Virtually the same system factors as described for the detection of criminal incidents applies as well to the detection of safety hazards. The measures of the safety hazard detection capability would likewise be comparable. That is, the practical measures could include: (1) the percentage of "staged" or simulated safety hazards that are detected correctly; (2) the number or percentage of false hazard alarms (both negative and positive) produced by the system; (3) the correctly detected percentage of all transit station safety hazards known to the police (e.g., reported by witnesses or victims); and (4) the number of hours per day that the system is fully operational.

7.4 ASSESSMENT OF THE ADEQUACY OF OPERATING PROCEDURES

7.4.1 Assessing Responses to Emergency Situations

For purposes of these guidelines, the adequacy of operating procedures is addressed in terms of the most critical activities—the system's responses to emergency situations. The system designer or administrator may wish to expand this viewpoint to address any other activities considered appropriate for assessment in a given system. Responses to emergency situations should be assessed in several ways, including adequacy (or appropriateness) and expediency (or timeliness) of the responses. The measures for each are not always mutually exclusive.

7.4.2 Adequacy or Appropriateness of Responses

This assessment consists of a comparison between the situational demands and the system's response. It implies the existence of performance criteria in terms of resources to be utilized (e.g., videotape recorder, public address system, police officer, etc.), procedures or standards for utilizing those resources (e.g., a manual of standard operating procedures), and time limits to carry out the major steps in responding to particular incidents. The actual resources, procedures and time utilized are compared to those specified, and a judgment can then be made. Some typical response steps are described in an earlier chapter of this document, and can be used as an initial guide in preparing more comprehensive criteria for evaluating a given CCTV transit station security system. To help in making response comparisons, some transit security organizations prepare videotape recordings of "ideal" responses, and compare those with similar videotape recordings made of actual responses to real or simulated emergencies. If no performance information is obtained during an emergency, it may still be possible to conduct a retrospective examination of events based on operator and victim recall and routine records kept by the system staff or outside agencies involved in the incident. In any case, this activity requires some kind of recorded standard operating procedures for the most frequent (e.g., fare evasion) and the most critical (e.g., bomb threat, fire, hostage taking) types of incidents.

7.4.3 Expediency or Timeliness of Responses

The assessment of timeliness is also conducted by making a comparison between the demands of the emergency situation and the actual performance of the system. Response time is a measure which can be made in the absence of detailed procedural assessments, though this is not always recommended. For example, one can measure the time between detection of a criminal incident and arrival of an officer. One can also measure the time between recognizing a potential suicide victim and the initial rescue response. The evacuation of an unattended station in the event of a fire emergency can be measured in terms of time, as can the arrival of an emergency medical team after detection of a possible cardiac emergency. Unfortunately, the time measurement alone may not be sufficient to assess any one particular situation, since there are so many elements which can affect response time. However, in the long term, accumulated statistics of response times can provide one overall measure of system effectiveness. It is always advisable, though, to examine the elements which contributed most to the response time, so that a continuing effort can be made to reduce this often crucial factor.

7.4.4 Indirect Measures of Adequacy and Expediency

There are additional measures which are less direct, but which could be used to assess appropriateness and timeliness of responses. Often these measures are easily made and, as a group, can be indications of the system's operating effectiveness. For example, the percentage of time that the CCTV surveillance system is in full operation reflects its ability to respond at or not respond at different times of the day, week or year. Anything less than constant 24-hour coverage means that a random emergency incident may not receive a response simply because the system is not in operation. Some hours (or days) can be more significant than others for measurement purposes.

Other measures of operating effectiveness can be derived from available records and statistics. For example, changes in the severity and types of incidents may be assignable to changes in the effectiveness of the system (or they may be due to something else, and that must be carefully determined). Also, one can make inferences about operating effectiveness by examining the number and types of errors that occur in trying to follow standard operating procedures, as when observing the response to a simulated emergency incident. Even the standard operating procedures themselves can be reviewed to determine if they are conducive to optimum performance (e.g., if appropriate priorities are assigned to critical incidents and response elements). In addition, a measurement of personnel knowledge and skill levels, outside of simulated incidents, can prove useful, especially in detecting trends toward improvement or degradation. Personnel knowledge and skills can be checked out on a scheduled basis, and could even include other indicative traits, such as attitude toward the job and attendance record. Finally, the system administrator should try to determine the passengers' and operators' perceptions of system responses and capabilities. These subjective reactions can sometimes provide important insights for giving the system more meaning to those who come in contact with it daily. Formal and informal methods are available to determine the perceptions of people, and they should be used. (7, 8)

7.5 ASSESSMENT OF THE CCTV SYSTEM AS A CRIME COUNTERMEASURE

7.5.1 Perceptions and Deterrence

The assessment of the operational system as a crime countermeasure requires measurements in addition to those described earlier for evaluating items like the system design, its ability to correctly detect incidents, and its ability to respond adequately. The notion of a crime countermeasure also relies heavily on the deterrence effect, arising from how potential criminals perceive the operational effectiveness of the system. Perceptions on the part of passengers and criminals can result in actual localized reductions in the amount and seriousness of crimes and vandalism, perceived reductions in those incidents, and geographical displacement of incidents to areas perceived as being less protected by security forces.

7.5.2 Actual Reductions in Criminal Activity

For many, the ultimate measure of worth for a CCTV transit station security system is the degree to which incidents of crime and vandalism are reduced in quantity and seriousness. These actual reductions can be measured directly by counting the number of reported incidents, or apprehensions, or convictions associated with the CCTV system and comparing those counts with equivalent figures from similar stations without CCTV or from the same station before CCTV was installed. As in all comparisons of this type, it is essential to rule out changes that occur for any reason other than the presence of the CCTV system. A somewhat subtler measure of actual improvements in security operations (and, thus, countermeasure value) is the change in the ratio of convictions to incidents. An improvement in that ratio could reflect the CCTV's ability to improve reaction time (leading to more apprehensions), and the use of videotape recordings as evidence (leading to more convictions). Another measure of actual reductions in crime are the comparative levels of losses with and without the CCTV security system. Examples of such losses include dollars of vandalism damage, value of property taken, the medical costs of injuries, and the number of lives lost. Some of those reductions may reflect a shift to less serious crimes, another measure which suggests the effectiveness of the CCTV system as a crime countermeasure. Comparative levels for each type of crime, for each station and surrounding neighborhood, and for different times of day are appropriate for this assessment. (4)

7.5.3 Perceived Reductions in Criminal Activity

Through the use of various direct and indirect methods, it is possible to measure the subjective impressions of people with regard to such feelings as security and safety. One method that has been used recently in a "repeated measures" design (with a control station), involved mailing questionnaires to a total of 4,000 households, in the neighborhood of two "matched" transit stations (only one of which acquired the CCTV station surveillance system). Half the households at each location received questionnaires before plans for CCTV were announced to the public, and the others received questionnaires some time after the CCTV system was operating in the one station. Among the questions asked were some dealing with the respondents' perceived changes in crime levels, personal experience with crime, the influence of perceived security on riding habits, and perceptions of security for different times of the day and different locations in and around the stations. While this can be a fine technique, the reader is once again cautioned that the proper design of a survey and the questionnaire is crucial to insuring the validity and reliability of results. Anyone considering this kind of venture should seek the services of an expert to consult, or guide, or actually conduct the survey. That individual should be concerned with selecting the proper sized representative samples of the population (no minor task), enlisting their cooperation, asking the right questions in the right way so as to minimize misunderstandings and biased results, and finally analyzing the responses and making the appropriate statistical inferences and the fullest interpretations possible. In addition to the public's own reported level of ridership, it is possible, of course, to examine the daily (and hourly) station statistics for differences in riding habits (level and time of use) between the "CCTV" and "no-CCTV" conditions. Finally, the administrator should keep in mind that the perceptions of transit police and other system employees can also be helpful in putting together a complete assessment of the CCTV role as a crime countermeasure. Administering questionnaires to those individuals is a considerably easier task than surveying the general public, for many reasons. Some of those individuals may even perceive instinctually what the statistical analysis later demonstrates to be the case. (4, 8)

7.5.4 Geographical Displacement of Crimes

This indicator of countermeasure effectiveness is familiar to most security personnel. They know that, by strengthening security in one area, crimes may drop there, but will increase elsewhere as the criminals move to avoid the countermeasure. These effects can be demonstrated for the CCTV countermeasure by examining the comparative levels for each type of crime at each station (and surrounding neighborhood). The displacement from a given station can be to other stations, or to the surrounding neighborhood. Consequently, it is necessary to obtain the crime statistics from local city police, if a thorough assessment is to be made.

7.6 ASSESSMENT OF THE CCTV SYSTEM AS A SAFETY AND CONVENIENCE TOOL

7.6.1 Safety Measures

The safety of a transit system is measured primarily by the rate at which accidents occur. It is usually expressed as a fraction (or ratio), the denominator being the risk exposure (e.g., passenger-miles, exposure-hours, etc.). In transportation safety work, the most frequently used measure is "accidents per passenger-mile," while the most universally applicable measure is "accidents per exposure-hour." Here again, it is important to distinguish between actual and perceived effectiveness. Among the system data measures that can be used to reflect the role of the CCTV system as an actual aid in safety services are: (1) the comparative number of safety incidents detected with and without CCTV; (2) the comparative response times in safety incidents with and without CCTV; (3) the comparative number and severity of injuries or medical complications; (4) the comparative life and property losses due to fire, accident and other safety emergencies; and (5) the comparative costs of claims and repairs resulting from accidents, fires, injuries and medical emergencies. Among the survey measures that can be used to reflect the perceived value of the CCTV system in safety services are: (1) comparative (with and without CCTV) passenger feelings of their own overall safety in different system locations (e.g., on platforms, vehicles, stairways, waiting rooms, etc.); (2) comparative passenger impressions of response times for fire, medical and other safety-related services; and (3) comparative passenger impressions of the life and property losses due to safety emergencies. Similar perceptions can be sought from transit police, other transit system employees, and members of external emergency services. (2)

7.6.2 Convenience Measures

The assessment of the CCTV system's role in aiding passenger convenience services can require a very wide diversity of measures, because there is such a wide diversity of possible services. Keeping in mind that the changes can be actual or perceived, some of the more universal measures include: (1) comparative waiting times for such events as vehicle arrivals, turnstile access, change machine access, toilet access, exiting the station, and parking lot departure; (2) comparative availability of transit system information from the system facilities and employees; and (3) comparative condition of the station in terms of cleanliness, graffiti, lighting, and general comfort. Another indicator of CCTV's role in aiding passenger convenience services is the comparative numbers and types of complaints received by inconvenienced passengers. Increases in the amount of use given to newly enhanced services (such as passenger information phones connecting to the control center) also indicate that a previously unmet need is being filled. (3)

7.7 REFERENCES

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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.

In the event that several projects are to be compared, it may become necessary to adjust all future costs to a single point in time. These techniques, involving the time value of money (interest rates, inflation, etc.) are beyond the scope of this document, but can be applied by economic or accounting experts available to the planner. Standard formulas and tables exist for bringing all life-cycle costs back to their "Present Value," as a function of some assumed interest and inflation rates. (4, 9)

Special problems may have to be considered in making cost calculations and decisions for some systems. These could be problems of cash flow, capital vs. operating expense budgets, available employee skills (e.g., maintenance capabilities, existing equipment in the system (for compatibility purposes), training requirements, or any others that must be determined by the planner. To help in estimating the costs of interest, the following sections provide some specific guidance.

8.2 REPRESENTATIVE EQUIPMENT COSTS

8.2.1 GSA Prices

The prices noted for equipment on the following pages are only a sampling of typical prices at the time of this writing (Fall 1979). However, most of them are considered close to the lowest prices one can expect, because they are taken from authorized Federal supply schedule price lists that have been negotiated between the suppliers and the General Services Administration (GSA). Generally a little higher than prices paid by equipment distributors, the GSA prices are significantly (30% to 50%) below the usual recommended retail list prices. Where GSA prices were not found, published retail list prices are given, and appear with an asterisk (e.g., $995*). This sampling of prices is intended only as a general guideline for developing preliminary cost estimates. Precise cost estimates should be based on current quotations from specific equipment suppliers.

8.2.2 Cameras, Monochrome (Black and White) Television

	Description	Price
a.	600 line resolution, 2/3" vidicon, 24/117/220 VAC, 16 mm F/1.6 lens, 10,000:1 ALC	$150
b.	Outdoor weatherproof version of "a," with tamperproof, lockable outdoor housing	204
c.	Same as "a," with 2 to 1 interlace and increased vertical resolution	213

	Description	Price
d.	Outdoor weatherproof version of "c," with tamperproof, lockable outdoor housing	$266
e.	700 line resolution, 1" vidicon, 24/117/220 VAC, 20,000:1 ALC; less lens	193
f.	Same as "e," with 2 to 1 interlace and increased vertical resolution; less lens	252
g.	850 line resolution, 1" vidicon, 40,000:1 ALC	546
h.	Low light version of "a"	434
i.	Low light version of "c"	554
j.	Low light version of "e"	582
k.	Low light version of "f"	645
l.	Low light version of "g," 750 line resolution	938
m.	Outdoor version of "l," with tamperproof outdoor housing	1048
n.	Low light camera with image intensified vidicon; less lens	4542
o.	Same as "n," with 14 mm - 140 mm F/1.9 zoom lens, automatic iris, remote zoom and focus functions	5795
p.	Low light camera with silicon intensifier tube	5686
q.	Same as "p," with 14 mm - 140 mm F/1.9 zoom lens, automatic iris, remote zoom and focus functions	6937

8.2.3 Cameras, Color Television

	Description	Price
a.	3-tube, broadcast quality, prism optics, 6x zoom lens, AC/battery operated, battery belt, charger	$14,812
b.	Same as "a," with 10x lens, 10 mm to 100 mm F/1.8	17,833

8.2.4 Monitors, Monochrome (Black and White) Television

	Description	Price
a.	5" video monitor	$170
b.	5" video monitor, accepts external sync	177
c.	6" video monitor, solid state	285*
d.	10" video monitor, 700 line resolution	145
e.	10" video monitor, accepts external sync	162
f.	12" video monitor, solid state	325*
g.	14" video monitor, solid state	415*
h.	17" video monitor, solid state	435*
i.	17" video monitor, 800 line resolution	353
j.	17" video monitor, accepts external sync	375
k.	19" video monitor	430*

8.2.5 Monitors, Color Television

	Description	Price
a.	Color Monitor/Receiver, 13", for CCTV, includes reception of broadcast audio and video	$675*
b.	Same as "a," 19"	875*

8.2.6 Video Recorders and Tapes (Cassette)

	Description	Price
a.	1/2" video cassette, time lapse, 50 dialable speeds, up to 200 hours unattended recording, color or monochrome	$2795*
b.	Same as "a," with built in Time/Date Generator, Alarm Time Memory and On Tape Alarm Identification	3090*

	Description	Price
c.	3/4" video cassette, time lapse, recorder/player; 1 hour (real time) to 72 hours record or playback	$3750*
d.	Tape, video cassette, 3/4", 20 minutes playing time	24*
e.	Same as "d," 60 minutes playing time	35*

8.2.7 Lenses and Automatic Iris Controls

	Description	Price
a.	6.5 mm F/1.8 lens, extreme wide angle	$183
b.	12.5 mm F/1.4 lens, wide angle	99
c.	25 mm F/1.4 lens, general purpose	63
d.	50 mm F/1.4 lens, telephoto	100
e.	75 mm F/1.4 lens, telephoto	135
f.	25 mm F/1.4 lens, motorized iris	188
g.	12.5 mm to 75 mm F/1.8 zoom lens, manual control, 2/3" format	144
h.	Automatic lens control for low light level cameras, less lens	84
i.	12.5 mm F/1.4 lens, motorized iris, for low light level cameras	267
j.	25 mm F/1.4 lens, motorized iris, for low light level cameras	220
k.	50 mm F/1.4 lens, motorized iris, for low light level cameras	249
l.	18 mm to 90 mm F/1.8 zoom lens, remote control, 2/3" format	723
m.	12.5 mm to 75 mm F/1.8 zoom lens, remote control, 2/3" format	756
n.	14 mm to 140 mm F/1.9 zoom lens, remote control	1285

8.2.8 Switchers, Generators and Consoles

	Description	Price
a.	Video switcher, 4 positions	$35
b.	Video switcher, 6 positions	49
c.	Video switcher, 8 positions	60
d.	Video switcher, 15 positions	172
e.	Sequential video switcher, 4 positions, 1-20 seconds per camera position, manual override	134
f.	Sequential video switcher, 8 positions, 1-20 seconds per camera position, manual override	257
g.	Sync Generator, 2:1 interlace, horizontal and vertical outputs	184
h.	Color Sync Generator, gen-lock, color-lock	1580
i.	Time-Date Generator, produces single row of clock and calendar information	420
j.	Special effects generator, provides fade in/out, lap dissolve, superimposition, six wipes; includes sync generator for 4 cameras	550
k.	Modular control console, sloping panel, desk surface, 1 bay	360
l.	Same as "k," 2 bays	571
m.	Same as "k," 4 bays	1008
n.	Same as "k," 6 bays	1446

8.2.9 Tubes, Cables and Connectors

	Description	Price
a.	2/3" or 1" vidicon tube	$33
b.	2/3" or 1" silicon diode array tube	392
c.	2/3" or 1" newvicon tube	392

	Description	Price
d.	1" plumbicon tube, green or blue channel	$1159
e.	1" plumbicon tube, extended red channel	1477
f.	Coaxial cable, RG-59U, 75 ohms, 50 ft., with connectors	8
g.	Same as "f," 500 ft., less connectors	33
h.	Coaxial cable, RG-59S, includes RG-59U plus 2 No. 18 stranded wires for power or sound, 50 ft., with connectors	13
i.	Same as "h," 500 ft., less connectors	96
j.	Video line amplifier, equalization for up to 2500 ft. of coaxial cable, self-contained power supply	129

8.2.10 Environmental Housings, Pan and Tilt, Controls and Other Accessories

	Description	Price
a.	Camera housing, indoor, tamperproof, lockable	$31
b.	Camera housing, outdoor, weatherproof, lockable	63
c.	Heater-cooler kit for "b," thermostatic control	63
d.	Pan unit, automatic scanning from 0 to 360 degrees, automatic or manual control, 12 lbs. capacity	154
e.	Pan and tilt unit, indoor, requires separate joystick control, 20 lbs. capacity	360*
f.	Pan and tilt unit, similar to "e," 40 lbs. capacity	540*
g.	Pan and tilt unit, heavy duty, indoor or outdoor, remote control	548
h.	Same as "g," with automatic scanning	610
i.	Pan and tilt unit, outdoor, requires separate joy-stick control, 40 lbs. capacity	660*
j.	Pan and tilt unit, similar to "i," 100 lbs. capacity	1100*

	Description	Price
k.	Video sensor/Motion detector, motion in surveillance area sets off alarm	$420
l.	Video motion detector, 4 channels, adjustable sensing "windows"	995*
m.	Dummy camera, including dummy lens	29
n.	Wall or ceiling mount for camera, heavy duty, aluminum	30
o.	Wall or ceiling mount, swivel, tilt and angle adjustment	54
p.	Wall mount for pan and tilt units, heavy duty	139
q.	Eraser, video cassette, bulk type	49*
r.	Intercom, simple audio 2-way system	22
s.	Resolution chart, 18" x 24", mounted, Electronic Industries Association	28*

8.3 PERSONNEL COSTS

8.3.1 General

The experience of many security administrators is that the major expense item in their system is that of salaries and wages. For planning and budgeting, therefore, the rate of personnel-related expenditures should be examined in considerable detail across the entire system life cycle.

8.3.2 Typical Factors to Be Considered

Each transit system has its own wage structure, governing regulations and collective bargaining agreements, and the planner must relate any estimates to those constraints. However, there are some general categories of personnel cost factors that may face planners anywhere during the lifetime of a system. These include the effects of separations and additions resulting from personnel turnover, other unusual additions or reductions in staff, provisions for merit increases and promotional increases, changes in the length of the work day (or week), changes in basic wage scales, bonuses and incentive payments, provisions for temporary employees (e.g., vacation replacements, summer hirings for resort areas, etc.), and any other changes that may be foreseen in personnel remuneration. Adequate provision for these factors must be included in any personnel cost estimate.

8.3.3 Unique Factors to Be Considered

Because transit security can be a 24-hour-a-day, 7-day-a-week operation, the effect of adding "one" person to the staff can actually result in the addition of up to four or five persons, if one accounts for three shifts, five-day work weeks, vacations and sick days. Consequently, such decisions as to select highly trained (more expensive) police officers rather than lower level (less expensive) civilians to become operators can have a very significant impact on the system cost. However, one may decide after careful assessment that the administrative and productivity advantages of the more costly approach outweigh the disadvantages. This is a highly individual decision for each system, and it depends on many other unique factors, such as the anticipated availability of skilled personnel and, of course, money.

Although transit organizations tend to employ only transit personnel in CCTV security operations, there may be a possibility in certain cases to obtain personnel from other sources. For example, an outside security firm can be hired, as is done in some private organizations employing CCTV. This can remove certain costs from the transit system, replacing them with a contractual expense and possibly less control over personnel selection and practices. If circumstances allow for the option of contracting with outside security support services, the advantages and disadvantages are probably worth examining, and direct inquiries of potential suppliers are appropriate.

8.3.4 Sources of Personnel Staffing and Related Cost Data

The sources from which a planner obtains anticipated dollar figures for personnel costs are as varied as the factors which influence those costs. Certainly, the starting point is the historical data within the existing organization or parent organization. The wage history of existing personnel and recent collective bargaining agreements can often provide an indication of cost trends for the near future. If available, the historical experience of other more mature CCTV transit security systems may provide the planner with a basis for anticipating trends.

For use with the historical cost data, estimates for staffing can be derived from the system plans and schedules as developed for each stage in the life cycle. For example, in the Concept Selection, System Definition and Planning stages, one would expect relatively few (e.g., one to four) people to be involved, but they would likely be the senior technical, operational and administrative individuals of the organization who may devote only a portion of their time to this effort. Consequently, personnel cost estimates would reflect the known higher wages and wage trends for those senior people, and the part-time nature of their efforts. It is advisable to hire or otherwise bring in a CCTV expert at this stage to serve as a consultant on call throughout system development and indefinitely thereafter.

In the Detail Design and Development stage, estimates would reflect a shift to slightly lower level individuals who devote a higher percentage of their time to the system. Depending on the size of the system and the amount of work done "in-house" versus the amount given to outside experts (or even potential suppliers), the number of people involved at this stage could vary from a few (e.g., two to four) to many (e.g., eight to twelve). For very large systems, involving extensive mechanical and electrical design efforts, formal drawings and documentation, even more people could become involved, and for longer periods of time due to delays for reviews, approvals, and other organizational or governmental processes. A reduction of designer personnel effort would accompany the next move into contractor solicitation activities, and a small number of senior technical, operational and administrative personnel would participate in that process. Those individuals could be the same ones as were involved in the Concept Selection, System Definition and Planning stages, with support from a small number of senior people who participated in the Detail Design and Development stage.

Once contracts are executed and construction begins, and until the installed system is tested and checks out as being capable of full operation, there is likely to be a project manager within the transit security organization, with several part-time support people, who will devote most of his/her time coordinating all of the required purchasing, construction, assembly, testing and checkout activities. Another individual should begin to acquire operators (and possibly maintenance technicians) through a selection and training procedure developed along with the rest of the system.

Finally, the planner must estimate the costs of personnel associated with long-term Operation and Maintenance. Here, one depends upon prior estimates of the number of operators required to view the selected number of CCTV monitors, the number of hours per day the system (or parts thereof) will be scheduled for operation, maintenance policies, the organizational structure within which CCTV security operations will take place, and many of the other factors identified earlier in this chapter. Estimates of system lifetime, growth, technological modifications, and wage trends during the Operation phase must be made if the personnel cost estimates are to appear reasonable. For example, a period of 10 years is not unrealistic before technological obsolescence starts to become apparent in the system. Significant replacements or modifications can be expected to occur in about that time. More detailed notions of equipment lifetimes are described in the next section on maintenance costs.

8.4 MAINTENANCE COSTS

8.4.1 Development of a Maintenance Philosophy

The importance of keeping the CCTV surveillance system in good operating order cannot be overemphasized. Its value as a crime countermeasure and safety aid depends upon the certain observation of critical incidents and subsequent rapid responses. Because equipment failures or malfunctions are inevitable over the course of time, the system must be planned in advance for high reliability and ease of maintenance at the most reasonable possible cost. Several design and operating guidelines are offered in keeping with this approach and, clearly, these will affect maintenance costs.

First, in order to minimize outages for critical system components, the design must include redundancy, basically reliable apparatus, fast fault locating, and unit replacement. Redundancy can be created by having spare equipment and using overlapping camera coverage. Reliability of apparatus can be assured by having all critical equipment and components fully guaranteed or subjected to reliability testing in order to be approved for purchase. Fast fault locating requires that equipment be designed with accessible fault location aids, such as indicators, test points or built-in test equipment. Unit replacement is accomplished by the use of plug-in printed circuit boards or major assemblies that can be easily replaced in the field, while the defective board or assembly is returned to the service facility for more time-consuming repair.

Once the system is assembled and operating, it is usually advantageous to have initial maintenance performed under contract with the installing contractors. The advantages of using contractor maintenance in this initial period include: (1) the incentive for the contractors to do a better installation job since they will otherwise be burdened with their own defects later on; (2) the opportunity for the contractor to make small changes readily as installation proceeds, in the event that a better design or newer technological development becomes available; (3) the opportunity to observe the contractor's maintenance procedures, and to thereby develop and document maintenance procedures for the system; (4) the opportunity to learn how large a maintenance staff is required, from observing the real tasks to be done and the real time required to do them; and (5) the provision of time so that the maintenance staff can be built up and trained in an orderly fashion.

In general, the maintenance technicians will carry out rearrangements of equipment, conduct preventive and routine maintenance, conduct alignments and adjustments for optimizing system performance, replace equipment and repair failures. The three former tasks can be carried out as time permits, while the two latter tasks would require more immediate response. A maintenance capability, at least for field replacement of critical components, should be available whenever the system is in operation. The priorities for various maintenance tasks should be established in advance. For example, the highest priority for repairs should go to main video and audio transmission links and to platform cameras. A lower priority can be given to cameras in locations other than platforms (e.g., fare collection areas), to intercoms and to passenger convenience telephones. Still lower priority can go to monitors in the control center. Finally, the lowest priorities could go to equipment alignment, equipment rearrangement and routine maintenance.

8.4.2 Replacement Components

The major variable cost associated with long-term maintenance is the cost of replacement components. It has been reported that 75% to 85% of all maintenance costs of a basic CCTV system are due to the cameras, and these in turn are due to required replacement of the light-sensing elements and image intensifiers. Certain steps can be taken to significantly extend the life of some light-sensing elements. One way is to invest in automatic light-compensating devices to protect against target burn. A second method, for those light-sensing elements that use filaments, is to specify that the filaments be powered from regulated voltage supplies. (7)

An analysis of lifetime costs based upon initial design decisions and maintenance policies can also provide insights into the cost implications of such decisions and policies. They can be very significant, as suggested by one published example for the replacement of various light-sensing elements, and adapted here for Table 8-3. In that table, the annual replacement for the conventional antimony trisulfide vidicon and the sensitive vidicon are predicated on their tendencies to degrade in resolution over a two-year period even under proper use, plus their susceptibilities to target burn (which could require several new vidicons per year). On the other hand, the silicon diode vidicon is impervious to burn and, therefore, requires less frequent replacement. Although the two intensified vidicons incorporate antimony trisulfide light-sensing elements, they often come with automatic iris control devices and 1-year factory warranties, so a 2-year period is used in computing costs for these two tubes. Experience with the SIT suggests that it will require replacement every 2 to 3 years, and the shorter period is used in Table 8-3. The newer ISIT is similar to the SIT except for an additional image intensifier, so a 1-1/2 year replacement period is used in the table. Finally, solid-state cameras (being completely solid state) do not need vidicon replacement. Although Table 8-3 is a simplified example of computing the cost of ownership over a life cycle, it should make the potential user aware of the continuing costs and their sensitivity to maintenance factors. (7)

8.4.3 Preventive vs. Remedial Maintenance

One of the classical questions in maintenance theory is: Should we repair and maintain the equipment regularly on a scheduled basis, or should we wait for equipment failures? The answer, of course, is: It depends. By calculating the costs of each alternative over the long term (if not over the whole Operation phase), one can compare the amount of money involved and choose the least expensive approach. The calculations depend upon developing an accurate mathematical model to describe each of the two replacement philosophies. A discussion of such models is beyond the scope of this document. However, one may call upon the services of an expert in the subjects of replacement models and economic analysis to help in such a calculation. If done properly, say for the replacement of vidicon tubes, a minimum-cost policy can result. That policy may show remedial maintenance of tubes to be the best approach or, if preventive maintenance is found preferable, it would indicate how frequently all tubes should be changed. The factors entering into these calculations include: the cost of providing preventive maintenance to one piece of equipment (e.g., a camera), the average cost of servicing a failure, the probability that the equipment will fail in each particular month after it has been serviced, and the number of pieces of the same equipment in the system being serviced. (8)

TABLE 8-3. CUMULATIVE COST OF OWNERSHIP (7)

Based Only on Expected Tube Replacement

Camera Type	Replacement Tube (Retail Cost)	Cumulative Retail Cost					
		Initial Cost	End Year 1	End Year 2	End Year 3	End Year 4	End Year 5
Vidicon	$ 75	$ 300	$ 375	$ 450	$ 525	$ 600	$ 675
Sensitive Vidicon	400	800	1,200	1,600	2,000	2,400	2,800
Silicon-Diode Vidicon	450	1,200	1,200	1,650	1,650	2,100	2,100
1-Stage Intensified Vidicon	1,325	10,000	10,000	11,325	12,650	13,975	15,300
2-Stage Intensified Vidicon	2,000	12,000	12,000	14,000	16,000	18,000	20,000
Silicon Intensified Target Tube Camera	2,000	6,000	6,000	8,000	8,000	10,000	10,000
Intensified Silicon Intensified Target Tube Camera	3,300	9,000	9,000	12,300	15,600	15,600	18,900
Solid-State Camera	No replacement required	2,000	2,000	2,000	2,000	2,000	2,000

8.4.4 Cost Implications of Other Maintenance Issues

If it is determined, for rapid response purposes, that maintenance capabilities should be "close" to the critical components of the system, then the notion of a field maintenance staff and workshops (in addition to a main servicing facility) must be considered. Those additional shops should contain an adequate supply of plug-in and replaceable components. With such an arrangement, service personnel and equipment can be dispatched for rapid arrival at the scenes of an equipment problem. Clearly, this kind of maintenance operation may prove economical only on relatively large systems. To further improve maintenance response time, the service personnel can be provided with two-way radios or telephone alert "beepers." Each of these concepts should be assessed on a cost-benefit basis.

8.5 RENT/LEASE/PURCHASE CONSIDERATIONS

8.5.1 Acquisition Alternatives

There are various alternatives in addition to the outright purchase of equipment (including test equipment for maintenance) that the planner should consider in the overall development and financing of a CCTV security system. They include: (1) purchase; (2) rental; (3) rental with purchase option; (4) cancellable lease; and (5) full-payout lease. Assuming that electronic equipment rental firms have or can obtain the desired items, and that they offer those options for equipment acquisition, the planner should be familiar with the appropriate conditions for the use of each acquisition alternative.

8.5.2 Criteria for Selecting the Optimum Acquisition Plan

In choosing the best acquisition plan, one should consider the duration of equipment need, rate of use, obsolescence potential, reliability of the equipment, familiarity with equipment, maintenance capabilities, delivery requirements, type of funds (i.e., capital, operating) available, and amount of funds available. In general, low or infrequent utilization and high costs of acquisition and ownership (purchase, maintenance, taxes, insurance, capital) often justify renting or leasing rather than outright purchasing of equipment. Obviously, there is a break-even point beyond which it is more economical to own than to rent or lease. (1, 2)

8.5.2.1 Direct Purchase - This alternative is appropriate when there is a certain and long-term need for the equipment, a low risk of obsolescence, availability of capital funds, and availability of an adequate maintenance program (either "in-house" or under contract with an outside organization). In calculating the immediate acquisition costs and the long-term costs of direct ownership, one must determine: the actual purchase cost, discounts or other benefits available, the percentage cost of capital (if loans are required), the percentage of depreciation (if the equipment can be written off over the years), the annual cost of maintenance and calibration (which can be 10-22% of purchase cost, according to one electronic equipment rental company), property taxes (if applicable), and miscellaneous annual costs like insurance, storage and others (which can be 2-5% of purchase cost, according to that same rental company). The long-term ownership costs, of course, are incurred continuously, regardless of equipment activity level. Previously owned equipment can sometimes be purchased at reduced prices, and one may find such an option appropriate in a given situation.

8.5.2.2 Rental - If the need for equipment is clearly very brief (several days to several months) and immediate, or the long-term need is either nonexistent or uncertain, then rental of equipment should be considered. Compared to a direct purchase, relatively little cash is required, and it comes out of operating funds on a periodic basis. Maintenance and calibration are provided by the equipment supplier, and one can obtain use of the latest in equipment technology. The rental rate is lower for longer rental periods, and is often stated as a percentage of the equipment's list price. A one-month rental fee can be as much as 10% of the list price. Rental periods typically run from about 2 weeks to 6 months. One can expect a 6-month rental to be accompanied by about a 20% reduction in the basic monthly rate.

8.5.2.3 Rental with Purchase Option - The advantage of this alternative is that one can build up equity in the equipment should later purchase be desired. Maintenance and calibration are also provided by the equipment supplier. Depending on the plan obtained, a percentage of the monthly rental fee is credited toward optional purchase at the end of the rental period. For example, a "special" plan offered by one company consists of a monthly rental fee of 10% of the list price, of which 75% may be credited toward optional purchase, provided there is a 3-month minimum rental commitment. These arrangements and percentages can often be tailored to one's expected needs, so that uncertain long-term needs can be accommodated with lower rental rates and lower potential rebate. One should not ordinarily choose this alternative if there is a high risk of equipment obsolescence, or if the long-term need is very certain.

8.5.2.4 Cancellable Lease - Leasing is appropriate for intermediate to long-term applications. The advantages of leasing include low initial capital outlays, relatively flexible payment schedules, potential tax benefits (if applicable), and the options of purchase or renewal at the end of the leasing term. Maintenance is generally the customer's responsibility. Since leasing includes a commitment for a relatively long term (2-5 years), expected equipment utilization should be high. However, the long-term commitment results in lease rates that are much lower than rental rates (e.g., 25-45% of equipment costs, per year). A cancellable lease is typically a 2-3 year plan with an option to cancel at the program midpoint or thereafter. This may be desirable if there is some reason to believe the equipment may become obsolete or long-term needs are uncertain. In leasing, as in outright purchasing, there is also the possibility of acquiring previously owned equipment should one be willing to forego the benefits (real or imagined) of new equipment in return for lower costs.

8.5.2.5 Full Payout Lease - Except for the fact that these agreements are non-cancellable and often run longer (typically up to 5 years), the full payout lease provides the same advantages as the cancellable lease. Because of the longer periods involved and the greater commitment, one can expect the rate to be lower than that obtained for a cancellable lease. This alternative is appropriate when the risk of equipment obsolescence is low and the long-term need is reasonably certain. There may be different financial accounting and disclosure requirements for this option as compared with the cancellable lease, in that capital (as well as operating) funds may become involved and balance sheet disclosure may be necessary. No matter which lease or variation is obtained, the administrator is urged to read the document, right down to the last clause, to see what is the transit system's responsibility and what is the lessor's. The total cost should be assessed (not just the monthly payment) to decide if the benefits are worth the cost. These are all issues to be addressed with the help of the financial specialist in the planner's organization.

8.6 REFERENCES

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APPENDIX A. PRODUCT INDEX, REPRESENTATIVE SUPPLIERS AND MISCELLANEOUS SERVICES

In this section an index of the various kinds of equipment that are used in a CCTV transit security system is presented, together with the names of representative suppliers.

Following this index is an alphabetical list of these suppliers with their addresses and telephone numbers. A miscellaneous list of information that could be useful as a reference completes this section.

These lists are intended for planning purposes only. They are merely representative and do not purport to include every qualified supplier, nor do they endorse any specific product or service. The reader must decide which supplier or service best meets the system requirements in terms of technical capabilities, financial considerations and long-term needs.

A.1 PRODUCT INDEX

A.1.1 Cable, Coaxial and Transmission

Alpha Wire Corp.
Belden Corp.
Columbia Electronic Cables
Consolidated Wire
Dearborn Wire and Cable Co.
Jerrold Electronics Corp.
Systems Wire and Cable
Times Wire and Cable Co.

A.1.2 Cameras, CCTV (Color, black and white, low-light level, and surveillance)

Cohu, Inc.
Dage-MTI, Inc.
G.B.C. Closed Circuit TV Corporation
General Electric Co. Closed Circuit TV Operation
Hitachi-Denshi America, Ltd.
Javelin Electronics
Lear Siegler, Inc.
Motorola Communications and Electronics, Inc.
MTDI
NEC America, Inc.
Panasonic Co.
Philips Audio Video Systems Corp.

RCA Closed Circuit Video Equipment
Sanyo Electric, Inc.
Sharp Electronics Corp.
Sony Corporation of America
Telemation, Inc.

A.1.3 Camera Housings and Mountings (Environmental, ceiling, wall, etc.)

G.B.C. Closed Circuit TV Corporation
Javelin Electronics
KLM Associates, Inc.
Listec Television Equipment Corporation
MTDI
Panasonic Co.
Pelco Sales, Inc.
Quick-Set Inc.
RCA Closed Circuit Video Equipment
Vicon Industries, Inc.
Visual Methods, Inc.

A.1.4 Consoles, CCTV and Audio Control

Amco Engineering Co.
Broadcast Electronics, Inc.
Bud Industries, Inc.
Engineered Security Systems, Inc.
G.B.C. Closed Circuit TV Corporation
Industrial Sciences, Inc.
Modular Audio Products
Panasonic Co.
Pelco Sales, Inc.
RCA Closed Circuit Video Equipment
The Winsted Corporation
Vitex Co.

A.1.5 Equalizers, Clampers, Line and Distribution Amplifiers

Cohu, Inc.
Telemation, Inc.
3M Datavision Video Products
Vicon Industries, Inc.

A.1.6 Generators, Time/Date

Engineered Security Systems, Inc.
G.B.C. Closed Circuit TV Corporation
Javelin Electronics

Panasonic Co.
Pelco Sales, Inc.
Philips Audio Video Systems Corp.
Quick-Set, Inc.
RCA Closed Circuit Video Equipment

A.1.7 Intercom Systems

Altec Corporation
Atlas Sound
Audio Designs and Mfg. Inc.
Bogen Division - Lear Siegler, Inc.
Clear-Com Intercom Systems
Custom Audio Electronics
Delta Electronics, Inc.
Electro-Voice, Inc.
Fisher Berkeley Corp.
Paso Sound Products Inc.
Shure Brothers, Inc.

A.1.8 Lenses and Accessories (Video, camera)

Canon USA, Inc.
Fujinon Optical, Inc.
G.B.C. Closed Circuit TV Corporation
General Electric Co. Closed Circuit TV Operation
Hitachi-Denshi America, Ltd.
Javelin Electronics
JVC Industries, Inc.
NEC America, Ltd.
Panasonic Co.
Pelco Sales, Inc.
RCA Closed Circuit Video Equipment
Sanyo Electric, Inc.
Sharp Electronics Corporation
Sony Corporation of America
Vicon Industries, Inc.
Video Components, Inc.
Visual Methods, Inc.
Zolomatics
Zoomar

A.1.9 Lighting Apparatus

General Electric, Lighting Systems Business Department
Halophane/Johns-Manville Sales Corporation
Sterner Lighting Systems
Westinghouse Electric Corp., Outdoor Lighting Division

A.1.10 Microwave Systems

Communication Carriers, Inc.
International Microwave Corporation
RCA Closed Circuit Video Equipment

A.1.11 Motion Detection Equipment

Colorado Video, Inc.
G.B.C. Closed Circuit TV Corporation
Information Processing Systems
Pelco Sales, Inc.
RCA Closed Circuit Video Equipment
Setchell Carlson
Vicon Industries
Videotek, Inc.

A.1.12 Optical Transmission Systems

American Laser Systems, Inc.
Motorola Communications and Electronics, Inc.

A.1.13 Pan and Tilt Equipment

Dage-MTI, Inc.
Diamond Electronics
G.B.C. Closed Circuit TV Corporation
Javelin Electronics
MTDI
Panasonic Co.
Pelco Sales, Inc.
Quick-Set Inc.
RCA Closed Circuit Video Equipment
Vicon Industries, Inc.
Video Components, Inc.

A.1.14 Recorders (Videotape, video time lapse, cassettes, discs)

Echo Science Corporation
Eigen Video
Engineered Security Systems, Inc.
G.B.C. Closed Circuit TV Corporation
JVC Industries, Inc.
NEC America, Inc.
Panasonic Co.
RCA Closed Circuit Video Equipment

Sanyo Electric, Inc.
Sony Corporation of America
VAS Corporation

A.1.15 Slowed-Down Video Transmission Systems

Security Resources, Inc.

A.1.16 Switches, Manual and Sequential

American Data
Cohu, Inc.
Dage-MTI, Inc.
G.B.C. Closed Circuit TV Corporation
Javelin Electronics
Panasonic Co.
Pelco Sales, Inc.
Philips Audio Video Systems Corporation
RCA Closed Circuit Video Equipment
Sony Corporation of America
Telemation, Inc.
3M Datavision Video
Video Components, Inc.

A.1.17 Sync Generators and Distribution Equipment

Broadcast Video Systems Ltd.
Cohu, Inc.
Lenco, Inc.
Telemation, Inc.

A.1.18 Video Maintenance and Evaluation Equipment

Cohu, Inc.
Hewlett Packard
Lenco, Inc.
Panasonic Co.
Sony Corporation of America
Tektronix, Inc.

A.1.19 Video Monitors (Black, white and color)

Cohu, Inc.
Conrac Corporation
Dage-MTI, Inc.

Diamond Electronics
Engineered Security Systems, Inc.
G.B.C. Closed Circuit TV Corporation
Hitachi-Denshi America, Ltd.
Ikegami Electronics, Inc.
Javelin Electronics
JVC Industries, Inc.
NEC America, Inc.
Panasonic Co.
Philips Audio Video Systems Corp.
RCA Closed Circuit Video Equipment
Sanyo Electric, Inc.
Setchell Carlson
Sharp Electronics Corporation
Telemation, Inc.
Video Components Inc.
Videotek, Inc.

A.2 REPRESENTATIVE SUPPLIERS

Alpha Wire Corporation 711 Ledgerwood Avenue Elizabeth, NJ 07207	(201) 925-8000
Altec Corporation 1515 S. Manchester Anaheim, CA 92803	(714) 774-2900
Amco Engineering Co. 7333 West Ainslie St. Chicago, IL 60656	(312) 867-8500
American Data 401 Wynn Drive, Northwest Huntsville, AL 35801	(205) 837-5180
American Laser Systems, Inc. 106 James Fowler Rd. Goleta, CA 93017	(805) 967-0423
Atlas Sound 10 Pomeroy Rd. Parsippany, NJ 07054	(201) 887-7800
Audio Designs and Mfg. Inc. 16005 Sturgeon Roseville, MI 48066	(313) 778-8400
Belden Corp. Box 1327 Richmond, IN 47374	(317) 966-6661
Bogen Division/Lear Siegler, Inc. Box 500 Paramus, NJ 07652	(201) 343-5700

Broadcast Electronics, Inc. 4111 North 24th St. Quincy, IL 62301	(217) 224-9600
Broadcast Video Systems, Ltd. 1050 McNicoll Ave. Agincourt, Ontario, Canada	(416) 497-1020
Bud Industries, Inc. 4605 E. 355th St. Willoughby, OH 44094	(216) 946-3200
Canon USA, Inc. 10 Nevada Drive Lake Success, NY 11040	(516) 488-6700
Clear-Com Intercom Systems 759 Harrison St. San Francisco, CA 94107	(415) 989-1130
Cohu, Inc., Electronics Division P.O. Box 623 San Diego, CA 92112	(714) 277-6700
Colorado Video, Inc. P.O. Box 928 Boulder, CO 80302	(303) 444-3972
Columbia Electronic Cables 11 Cove Street New Bedford, MA 02744	(617) 999-4451
Communication Carriers, Inc. 33 River Road Greenwich, CT 06830	(203) 661-7655
Conrac Corporation 3 Landmark Square Stamford, CT 06901	(203) 348-2100
Consolidated Wire 1635 S. Clinton Chicago, IL 60615	(312) 421-4441
Custom Audio Electronics 2828 Stommel Rd. Ypsilanti, MI 48197	(313) 482-6568
Dage-MTI, Inc. 208 Wabash Street Michigan City, IN 46360	(219) 872-5514
Dearborn Wire and Cable Co. 9299 Evenhouse Ave. Rosemont, IL 60018	(312) 696-1000
Delta Electronics Inc. 5534 Port Royal Rd. Springfield, VA 22151	(703) 321-9845
Diamond Electronics, Div. of Arvin Systems, Inc. P.O. Box 200 Lancaster, OH 43130	(614) 756-9222
Echo Science Corp. 485 E. Middlefield Rd. Mt. View, CA 94043	(415) 961-7145

Eigen Video (916) 273-0067
P.O. Box 1027
Grass Valley, CA 95945

Electro-Voice, Inc. (616) 695-6831
600 Cecil St.
Buchanan, MI 49107

Engineered Security Systems, Inc. (201) 625-3232
25 Bloomfield Ave.
Denville, NJ 07834

Fisher Berkeley Corp. (415) 655-9696
5800 Christie Ave.
Emeryville, CA 94608

Fujinon Optical Inc. (914) 472-9800
672 White Plains Rd.
Scarsdale, NY 10583

G.B.C. Closed Circuit TV Corporation (212) 989-4433
315 Hudson St.
New York, NY 10013

General Electric Closed Circuit TV Operation (502) 926-8600
316 E. 9th St.
Owensboro, KY

General Electric (704) 692-1431
Lighting Systems Business Department
Hendersonville, NC 28739

Halophane/Johns-Manville Sales Corp. (303) 979-1000
P.O. Box 2598
Denver, CO 80201

Hewlett Packard Co. (415) 969-0880
1507 Page Mill Rd.
Palo Alto, CA 94304

Hitachi-Denshi America, Ltd. (212) 898-1261
58-25 Brooklyn - Queens Expressway
Woodside, NY 11377

Ikegami Electronics, Inc. (201) 368-9171
37 Brook Avenue
Maywood, NJ 07607

Industrial Sciences, Inc. (904) 373-6783
3521 Southwest 42nd Ave. (P.O. Box 1495)
Gainesville, FL 32602

Information Processing Systems (415) 592-1742
70 Glenn Way
Belmont, CA 94002

International Microwave Corp. (203) 661-6277
33 River Road
Cos Cob, CT 06807

Javelin Electronics (213) 641-4490
6357 Arizona Circle
Los Angeles, CA 90045

Jerrold Electronics Corp., Distributor Sales Division (215) 674-4800
200 Witmer Rd.
Horsham, PA 19044

JVC Industries, Inc. (212) 476-8010
58-75 Queens Midway Expressway
Maspeth, NY 11378

KLM Associates, Inc. (301) 299-7259
11810 Charen Lane
Potomac, MD 20854

Lear Siegler, Inc., Electronics Instrumentation Div., (714) 774-1010
Video Systems Products
714 N. Brookhurst St.
Anaheim, CA 92803

Lenco, Inc., Electronics Division (314) 243-3147
319 West Main St.
Jackson, MO 63755

Listec Television Equipment Corp. (516) 694-8963
39 Cain Drive
Plainview, NY 11803

Media Concepts, Inc. (813) 821-2122
559 49th Street S.
St. Petersburg, FL 33707

Modular Audio Products (a unit of Modular Devices, Inc.) (516) 567-9620
50 Orville Drive, Airport International Plaza
Bohemia, NY 11716

Motorola Communications and Electronics, Inc. (312) 576-7000
1301 E. Algonquin Rd.
Schaumburg, IL 60196

MTDI (201) 694-7917
P.O. Box 3038
Wayne, NJ 07040

NEC America, Inc. (312) 640-3750
160 Martin Lane
Elk Grove Village, IL 60007

Panasonic Co., Division of Matsushita Electric Corp. of (201) 348-7000
America (Video Systems Division)
One Panasonic Way
Secaucus, NJ 07094

Paso Sound Products Inc. (914) 738-4800
14 First Street
Pelham, NY 10803

Pelco Sales, Inc. (213) 321-5591
351 East Alondra Boulevard
Gardena, CA 90248

Philips Audio Video Systems Corp. (201) 529-3800
91 McKee Drive
Mahwah, NJ 07430

Quick-Set Inc. (312) 498-0700
3650 Woodhead Drive
Northbrook, IL 60062

RCA Closed Circuit Video Equipment (717) 397-7661
New Holland Pike
Lancaster, PA 17604

Sanyo Electric, Inc., Communications Products/ Electronics Division 1200 West Artesia Boulevard Compton, CA 90220	(213) 537-5830
Security Resources, Inc. 616 Riverside Avenue (P.O. Box 331) Westport, CT 06880	(203) 226-7431
Setchell Carlson 530 5th Avenue NW/New Brighton, MN 55112	(612) 633-3131
Sharp Electronics Corp. 10 Keystone Place Paramus, NJ 07652	(201) 265-5600
Shure Brothers, Inc. 222 Hartney Avenue Evanston, IL 60204	(312) 866-2200
Sony Corporation of America 9 West 57 Street New York, NY 10019	(212) 371-5800
Sterner Lighting Systems Windsted, MN 55395	(612) 485-2141
Systems Wire and Cable 3500 S. 30th St. Phoenix, AZ 85040	(602) 268-8744
The Winsted Corporation 8127 Pleasant Avenue South, Dept. 1TR Minneapolis, MN 55420	(612) 888-1957
Tektronix, Inc. P.O. Box 500 Beaverton, OR 97077	(503) 644-0161
Telemation, Inc. P.O. Box 15068 Salt Lake City, UT 84115	(801) 972-8000
3M Datavision Video Products, Minicom Division 3M Center St. Paul, MN 55101	(612) 733-7603
Times Wire and Cable Co. 358 Hall Avenue Wallingford, CT 06492	(203) 265-2361
VAS Corp. 2525 Maricopa St. Torrance, CA 90503	(213) 320-8334
Vicon Industries, Inc. 125 E. Bethpage Rd. Plainview, NY 11803	(516) 293-2200
Video Components, Inc. 601 South Main Street Spring Valley, NY 10977	(914) 356-3700
Videotek, Inc. 125 North York Street Pottstown, PA 19464	(215) 327-2292

Visual Methods, Inc. (201) 391-7383
5 Wortendyke Avenue
Montvale, NJ 07645

Vitex Co. (904) 377-8900
3700 N.E. 53rd Avenue
Gainesville, FL 32601

Westinghouse Electric Corporation, Outdoor Lighting Div. (216) 579-2121
Cleveland, OH 44101

Zolomatics (213) 463-4835
6565 Santa Monica Boulevard
Hollywood, CA 90038

Zoomar (516) 676-1900
55 Sea Cliff Avenue
Glen Cove, NY 11542

A.3 MISCELLANEOUS SERVICES

A.3.1 Equipment Rental and Leasing

Continental Resources, Inc. (617) 275-0850
175 Middlesex Turnpike
Bedford, MA 01730

United States Instrument Rentals, Inc. (415) 592-9230
2121 South El Camino Real
San Mateo, CA 94403

Rental Electronics, Inc. (617) 862-6905
99 Hartwell Ave., P.O. Box 223
Lexington, MA 02173

Leasametric/Metric Resources Corp. (415) 574-1114
1164 Triton Drive
Foster City, CA 94404

A.3.2 Video Consultants, Organization of

PSA International (203) 226-6682
616 Riverside Avenue
Westport, CT 06880

Note: Addresses and telephone numbers have been taken from published sources but have not been independently verified.

APPENDIX B. GLOSSARY OF TERMS

B.1 CCTV AND ASSOCIATED EQUIPMENT

Aberration - Degradation of image formed by a lens. Most aberrations are corrected to a tolerable level in a compound camera lens. The only aberration of noticeable magnitude in a practical CCTV lens is distortion.

Active Lines - Scanning lines in the makeup of the total television signal which contain actual visual information about the picture to be presented. (Refer to Scanning)

Align - To adjust or tune a circuit to the proper operating characteristics.

Alternating Current - A repetitive surging or pulsating flow of electrons in alternating directions along a conductor. Normal house current is 120 vac (volts of alternating current).

Alternating Current or Direct Current - This term is applied to equipment designed to operate on either kind of current. Usually abbreviated: ac/dc.

Ambient Temperature - The temperature of the surrounding medium, such as gas or liquid, which comes into contact with the apparatus or operators.

Amplifier - A device or circuit which increases the strength of a signal.

Analog Communication - Technically, the alternative to digital communication consisting of a continuously varying waveform—the electrical signal on a telephone circuit is typically an analog waveform.

Antenna - A metallic structure, usually an arrangement of rods or wires, used for receiving or radiating radio signals.

Aperture - The lens opening which determines the amount of light that will pass through onto the recording medium.

Aspect Ratio - The ratio of width to height for the frame of the television picture; four units wide by three units high in standard systems.

Audio Frequency - Any frequency corresponding to a normally audible sound wave. Audio frequencies range roughly from 20 to 20,000 Hz.

Auto-Iris Lens - A lens whose aperture is controlled by monitoring the video signal amplitude and adjusting the iris to maintain a constant video output.

Automatic Brightness Control (Display Devices) - The self-acting mechanism which controls brightness of the display device as a function of ambient light.

Automatic Frequency Control - An arrangement whereby the frequency of an oscillator is automatically maintained within specified limits.

Automatic Gain Control - A process which automatically maintains a signal at a certain desired level even though the source or input signal may vary in level.

Automatic Light Control - Automatic light control is the process by which the illumination incident upon the face of the pickup device is automatically adjusted as a function of scene brightness.

Automatic Sensitivity Control - The self-acting mechanism which varies system sensitivity as a function of the specified control parameters. This may include Automatic Iris Control, Automatic Volume Control, etc., or any combination thereof.

Background Noise - The total system noise, independent from the presence or absence of a signal. The signal is not included as part of the noise.

Balanced Telephone Line - A telephone line which is electrically floated with respect to ground so that the impedance measured from either side of the line to ground is equal to that of the other side to ground.

Band - A range of frequencies between two definite limits. For example, the AM broadcast radio band includes all frequencies from 535 to 1605 kHz. Citizen Band includes the frequencies between 26.965 and 27.255 MHz.

Bandwidth - The number of cycles per second (Hz) expressing the difference between the limiting frequencies of a frequency band. For example, the 2.5-3.5 MHz band has a bandwidth of one MHz.

Barrel Distortion - Distortion that makes the televised image appear to bulge outward on all sides like a barrel.

Baseband - The band of frequencies, generally below 10 MHz, containing all video signal information that may be used to modulate a higher carrier frequency, or may be distributed as is.

Base Station - A station used as the central or control station of a group of stations.

Bezel - The rim framing the picture tube faceplate and obscuring the perimeter of the picture tube from view.

Black Level - The level of a television picture signal that corresponds to the maximum limits of the black component of the picture.

Blanking - The process of cutting off the electron beam in a camera or picture tube during the retrace period.

Blanking Level - That level of a composite picture signal which separates the range containing picture information from the range containing synchronizing information.

Blanking Signal - A signal composed of recurrent pulses, related in time to the scanning process, and used to effect blanking.

Bleeding White (Beam Starved) - An overloading condition in which white areas appear to flow irregularly into black areas.

Blinding - The reduction of scene information as the result of relatively high light levels entering the lens.

Bloom - An increase in spot size caused by very bright image points.

Blooming - The defocussing of regions of the picture where the brightness is at an excessive level, due to enlargement of spot size and halation of the fluorescent screen of the cathode-ray picture tube; also, charge migration on video camera image tubes from high illumination sources may produce a similar effect.

Bounce - Sudden variations in picture presentation (brightness, size, etc.) independent of scene illumination.

Breathing - Variations similar to "bounce" but at a slow, regular rate.

Brightness - The attribute of visual perception in accordance with which an area appears to emit more or less light. The term luminance is recommended for the photometric quantity which has been called "brightness". Luminance is a purely photometric quantity. Use of this name permits "brightness" to be used entirely with reference to the sensory response. (See Luminance)

Bulk Eraser or Degausser - A device used to erase an entire roll of magnetic tape without removing it from its reel. Generally employs a strong alternating magnetic field to which the tape is exposed in a manner which neutralizes all previously recorded magnetic patterns.

Burned-In Image - An image which persists in a fixed position in the output signal of a camera tube after the camera has been turned to a different scene.

Camera Tube - An electron tube for the conversion of an optical image into an electrical signal by a scanning process.

Candela (cd or lm/sr) - The luminous intensity of 1/60 of 1 cm^2 of the projected area of a black body radiator operating at $2045^{o}K$ (solidification temperature of platinum). A point source of one candle power emits one lumen into a solid angle of one steradian. A source of one candle intensity which radiates uniformly in all directions emits 4π lumens.

Candle - The photometric unit of intensity; a source which uniformly emits 4π lumens, so that one candle equals one lumen per unit solid angle (Steradian). (See Candela, Foot-Candle)

Carrier - High frequency energy that can be modulated by voice or signaling impulses.

Carrier on Microwave - A means of transmitting many voice messages on one microwave radio channel. Transmission is point-to-point by microwave antennae mounted on towers or tall buildings.

Carrier on Wire - A means widely used by the telephone companies to transmit many voice messages on a single pair of wires.

Carrier System - A means of conveying a number of channels over a single path by modulating each channel on a different carrier frequency and demodulating at the receiving point to point restore the signals to their original form.

Cartridge - Generally represents a one-reel pre-packaged unit of tape, often erroneously referred to as "cassette."

Cassette - A pre-packaged self-enclosed tape format; generally designates a two-reel module.

Cathode Ray Tube - An electron tube assembly used in all video monitors, containing an electron gun arranged to direct a beam upon a fluorescent screen. Scanning by the beam can produce light at all points in the scanned raster.

Channel - In broadcast television it refers to the spectrum space, usually 6 MHz wide, used for the transmission of associated video and audio signals.

Chroma (also "chrominance" or "saturation") - The color quality relating to the intensity or purity of a hue; the saturation of a hue is reduced by mixing in white light.

Clamper - A device which functions during the horizontal blanking or sync interval to fix the level of the picture signal at some predetermined reference level at the beginning of each scanning line; used primarily for common mode noise (hum) rejection.

Clamping - The process of restoring the dc component to a video waveform in which pulses separate from the video signal initiate the restorer action, usually during signal blanking intervals. The purpose of the restoration is to stabilize the blanking level at a fixed value.

Closed Circuit Television - Refers to a confined television system in which the signal is distributed usually, but not always, by cable.

Coaxial Cable or Coax - A particular type of cable capable of passing a wide range of frequencies while maintaining interference immunity. Such a cable, in its simplest form, consists of a hollow metallic shield with a single wire accurately placed along the center of the shield and isolated from the shield.

Color - The aspect of objects and light sources that may be described in terms of brightness (luminance), dominant wavelength (hue), and saturation (chroma).

Color Picture Signal - The electrical signal which represents complete color picture information, excluding all synchronizing signals. One form of color picture signal consists of a monochrome component plus a subcarrier modulated with chrominance information.

Communication - The transmission of information from one point, person, or piece of equipment to another.

Communication Channel - A signaling channel having two or more terminal locations and a suitable information-handling capacity depending on the characteristics of the system used. One terminal location can be the central station and the other terminal location or locations can be sources from which are transmitted video signals, supervisory signals, trouble signals and such other signals as the central station is prepared to receive and interpret.

Composite Video Signal - The combined picture signal, including vertical and horizontal blanking and synchronizing signals.

Conductive Coatings - Magnetic recording tape coatings that are specially treated to reduce the coating resistance, and thus prevent the accumulation of static electrical charge. Untreated, non-conductive coatings may become highly charged, causing poor tape packing on the reels, noise, and dust-attraction problems during high speed winding.

Contrast - Ratio of light and dark portions of TV picture.

Control Track - For videotape recorders, the area on the tape containing a recording used by a servo-mechanism primarily to control the longitudinal motion of the tape during playback in some systems and to control the speed of the drum in other systems.

Crosstalk - An undesired signal from a different channel interfering with the desired signal.

Crystal - A piezoelectric natural (quartz) or synthetic crystal that has been ground to the proper size to produce a natural vibration at the desired frequency and to produce that frequency when set into vibration.

Crystal Control - The use of a crystal to maintain a transmitter (or receiver) on its assigned frequency.

Cycles Per Second (The current term is Hertz (Hz)) - Cycles per second is the number of times per second an electronic event is repeated.

Decibel (db) - A logarithmic measure of the voltage or power ratio of two signals.

Degree of Impairments - Television picture impairments may be present in varying degrees. The following terms are in common usage for indicating the magnitude of impairments:

> Detectable - Impairment is not readily noticeable in a normal picture display but can be discerned by a minute inspection of the signal, it sometimes being necessary to vary picture-monitor brightness or expand presentations.
>
> Noticeable - Impairment is readily observed in the viewed display.

Objectionable - Impairment interferes with the viewing of the display.

Unacceptable - Impairment is present to such a degree that the presentation or portion of the presentation is not usable.

De-Multiplexing - The process of separating multiplex signals, that have been changed in form for the purpose of transmission, back to their original form (also known as decoding or demodulating).

Depth of Field - The span of distance from the nearest object to the farthest object from the camera within which all objects are in focus.

Diaphragm - The element in a microphone which is vibrated by sound waves entering the unit. The vibrations of the diaphragm are converted into voltage variations to produce the audio signal. (Also used in lens (see F-Stop.)

Differential Gain - In a video transmission system, the difference in the gain of the system in decibels for a small high-frequency sinewave signal at two stated levels of a low-frequency signal on which it is superimposed.

Differential Phase - In a video transmission system, the difference in phase shift through the system for a small high-frequency sinewave signal at two stated levels of a low-frequency signal on which it is superimposed.

Digital - Characteristic of data in the form of electrical impulses. Digital refers to discrete, noncontinuous quantities (usually multiples of some elementary unit) as contrasted with continuous quantities.

Digital Communication - The transmission of intelligence by the use of encoded numbers—usually uses binary rather than decimal number system.

Direct Current - A steady flow of electrons along a conductor in one direction. Batteries are a source of direct current, such as the 12 vdc battery used in most cars and trucks.

Disc Recording - Magnetic information put down on disc rather than tape.

Distortion - Any deviation of the received signal waveform from that of the original transmitted waveform.

Dustproof - A quality of construction or protection such that dust will not interfere with successful operation.

Dust-Tight - A quality of construction such that dust will not enter the enclosing case.

Echo (or Reflection) - A wave which has been reflected at one or more points in the transmission medium with sufficient magnitude and time difference to be perceived in some manner as a wave distinct from that of the main or primary transmission. Echoes may be either leading or lagging the primary wave and appear in a TV monitor as reflections, or "ghosts".

Effective Radiated Power - The antenna input power times the gain of the antenna expressed in watts. A measurement of effective signal power being radiated from an antenna. It may be more or less than the input provided by the transmitter.

EIA Sync - The signal employed for the synchronizing of scanning that is specified in EIA Standard RS-170 or subsequent issues.

Electronic Industries Association - An industry association that has prepared standards which are in common use throughout the television industry.

Equalization - The process of correcting frequency-related loss and delay characteristics of a signal so as to be within overall system objectives. Usually applied at the receiving terminal in order to minimize the possibility of excessive noise being introduced as a result of low signal levels.

Erase Head - A small electromagnet in a magnetic tape recorder, over which the tape passes before being recorded upon, and as a result of which previously recorded signals are removed. (See Bulk Eraser)

Erasure - A process by which a signal recorded on a tape is removed and the tape made ready for re-recording. Erasure may be accomplished in two ways: in ac erasure, the tape is demagnetized by an alternating field which is reduced in amplitude from an intially high value; in dc erasure the tape is saturated by applying a primarily unidirectional field.

Explosion-Proof - Constructed in a manner to prevent the surrounding atmosphere from being exploded by the operation of, or the results from, operating the item so classified.

Explosion-Proof Apparatus - Explosion-proof apparatus is apparatus enclosed in a case which is capable of withstanding an explosion of a specified gas or vapor which may occur within it. It must also be capable of preventing the ignition of a specified gas or vapor surrounding the enclosure by sparks, flashes, or explosion of the gas or vapor within. Finally, it must operate at such an external temperature that a surrounding flammable atmosphere will not thereby be ignited.

Federal Communications Commission - A board of commissioners appointed by the President which has the power to regulate all electrical communications systems originating in the United States.

Field - One of the two equal parts into which a television frame is divided in an interlaced system of scanning.

Field Effect Transistor - A semiconductor whose application is similar to a vacuum tube. Typically used in high-performance receivers.

Field Frequency - The number of fields transmitted per second in a television system. The U.S. standard is 60 fields per second. Also called field-repetition rate.

Field Strength Meter - A measuring instrument for determining the relative strength of radiated energy (field strength) from a transmitter.

Filter - An electronic circuit element which reduces interference and unwanted signals, or allows certain desirable signals to pass through.

Focal Length - The distance from the optical center of a lens to the camera tube target; it is indicative of the image size produced.

Focus - Referring to a sharp, clear picture on a monitor screen; for camera lenses, the point behind the lens where parallel light rays converge.

Foot-Candle - A unit of illuminance when the foot is taken as the unit of length. It is the illuminance on a surface one square foot in area on which there is a uniformly distributed flux of one lumen, or the illuminance at a surface all points of which are at a distance of one foot from a uniform source of one candle.

Foot-Lambert - A unit of luminance equal to one candle per square foot, or to the uniform luminance of a perfectly diffusing surface emitting or reflecting light at the rate of one lumen per square foot. A foot-candle is a unit of incident light and a foot-lambert is a unit of emitted or reflected light. For a perfectly reflecting and perfectly diffusing surface, the number of foot-candles is equal to the number of foot-lamberts. (See Lambert)

Fuse - A protective device, usually a short piece of wire which melts and breaks when a current which exceeds its rated value flows through it.

Frame - The total area, occupied by the television picture, which is scanned while the picture signal is not blanked.

Frame Frequency - The rate at which a complete frame is scanned, nominally 30 frames per second.

Free-Running Frequency - The frequency at which a normally synchronized oscillator operates in the absence of a synchronizing signal.

Freeze Frame - To continuously display a single frame so that it appears as if the scene has stopped in motion. (See Stop Action)

Frequency Band - A range of frequencies arbitrarily designated by international or other conventions to carry some convenient letter, number, or other descriptor. For example, international convention has assigned descriptors to certain broad frequency bands as follows:

Frequency Band	Descriptors
3 - 30 kHz	VLF (Very Low Frequency)
30 - 300 kHz	LF (Low Frequency)
300 - 3,000 kHz	MF (Medium Frequency)
3 - 30 MHz	HF (High Frequency)
30 - 300 MHz	VHF (Very High Frequency)
300 - 3,000 MHz	UHF (Ultra High Frequency)
3 - 30 kMHz	SHF (Super High Frequency)
30 - 300 kMHz	EHF (Extremely High Frequency)

Frequency Division Multiplexing - A signaling method characterized by the simultaneous transmission of more than one signal over a communication channel. Signals from one or multiple terminal locations are distinguished from one another by virtue of each signal being assigned to a separate frequency or combination of frequencies.

F-Stop - The lens calibration to indicate relative diaphragm opening or aperture diameter.

Full Duplex - A communication system that can simultaneously transmit in both directions on a transmission line.

Gain - Any increase in power.

Gain Control - A device for varying the gain of an amplifier or system.

Ghost - A shadowy or weak image in the received picture, offset either to the right or to the left of the primary image, the result of transmission conditions which create secondary signals that are received earlier or later than the main, or primary signal. A ghost displaced to the left of the primary image is designated as "leading," and one displaced to the right is designated as "following" (lagging). When the tonal variation of the ghost are the same as those of the primary image, it is designated as "positive" and when the reverse condition occurs, it is designated as "negative."

Gray Scale - Variations in 10 steps from white through shades of gray to black as an established portion of the standarized industry calibration charts, used in qualitative measurements of video camera parameters.

Ground - A metallic connection with the earth to establish a relative zero electrical potential.

Grounded - Connected to earth or to some conductor which takes the place of earth.

Ground Loop - The path in a circuit including two or more ground reference points intended to be at the same voltage (zero) but which are not because of ground impedance. It can result in hum and other undesirable disturbances in circuits particularly where relative signal strength is low.

Half Duplex - A communication system that can transmit in both directions on a transmission line but not at the same time.

Halo - Most commonly, a dark area surrounding an unusually bright object caused by overloading of the camera tube. Reflection of lights from a bright object might cause this effect.

Hard Wire - A colloquialism meaning a circuit with electrical continuity. It is a full pair of copper wires from one point to another. Often used in contrast to "soft-ware" by which functions are carried out through a computer program, rather than a special purpose hard-wire circuit.

Harmonic - A signal, the frequency of which is an integral multiple of the fundamental frequency from which it is derived or related.

Head - A small electromagnet which pulses magnetic signals onto a video tape moving past it or induces these signals off a recorded tape. Audio heads are usually stationary, video heads move in reverse of the tape's direction in most VTRs. (See also Erase Head)

Head Alignment - The positioning of the audio or video heads so that they describe the correct path at the correct angle across the video tape. Heads that are out of alignment will not record or play back properly.

Head Demagnetizer or Degausser - A device to neutralize residual or induced magnetism in heads or guides made from ferro-magnetic materials. Unless the recorder has an automatic head demagnetizing circuit and non-magnetic guides, periodic use of a head demagnetizer may be necessary to avoid addition of noise to, or partial erasure of, tapes.

Head-To-Tape-Speed - The relative speed between tape and head during normal recording or playback.

Height - The size of a video monitor picture in the vertical direction.

Helical Scan - A method of recording video onto tape in which the signal is recorded diagonally on the tape in adjacent strips.

Hertz - A term meaning cycles per second, used to describe the frequency of a signal. (e.g., 60 Hertz)

High Resolution - Descriptive of a camera or monitor capable of displaying a great number of scanning lines (1,000 - 2,000) which produce a picture that is very detailed, defined, and sharp.

High Frequency - The frequency band between 3 and 30 MHz.

Horizontal (Hum) Bars - Relatively broad horizontal bars, which may appear on a video monitor screen, as a result of hum interference. They may be stationary or may move up and down.

Horizontal Blanking - The blanking signal at the end of each scanning line, occurring at the rate of (nominally) 15,750 Hz.

Horizontal Retrace - The return of the electron beam from the right to the left side of the raster after the scanning of one line, occurring while the screen is blanked or cut off.

Hue - The attribute of color quality that subjectively corresponds to the psychological term "dominant wavelength;" that is, the quality by which we distinguish one color from another. Black, gray, and white do not have hue.

Hum - Electric disturbance at the power supply frequency or harmonics thereof.

Hum Modulation - Modulation of a radio frequency or detected signal by hum.

Illumination or Illuminance - The luminous flux per unit area incident upon a surface. One foot-candle (ftc or fc) is one lumen incident per square foot. One lux (lx or lm/m^2) is one lumen incident per square meter, also called one meter-candle. One phot is one lumen per square cm.

Image Dissector Tube (Dissector Tube) - A camera tube in which an electron image produced by a photo-emitting surface is focused in the plane of a defining aperture and is scanned past that aperture.

Image Iconoscope - A camera tube in which an electron image is produced by a photo-emitting surface and focused on one side of a separate storage target which is scanned on the same side by an electron beam, usually of high-velocity electrons.

Image Orthicon - A camera tube in which an electron image is produced by a photo-emitting surface and focused on one side of a separate storage target which is scanned on its opposite side of an electron beam, usually of low-velocity electrons.

Image Retention - The vidicon pickup tube's tendency to retain an image on its target area after it has stopped scanning that image. Extreme image retention results in the image being burned into the target area. (See Lag)

Image Tube - An electron-beam tube used in a television camera where an electron current or a charge-density image is formed from an optical image and scanned in a predetermined sequence to provide an electrical signal; also called "pickup tube" or "image converter tube."

Impedance - The opposition to the flow of alternating current in an electrical circuit, generally categorized as either "high" or "low." It is expressed in "ohms" or millions of ohms (megohms). Commonly used to characterize the input or output termination of components so that proper "match" can be made when inter-connecting two or more devices or for matching with the proper transmission cable. Power loss, frequency discrimination, or ghosting can result from incorrectly matched impedances.

Impedance Match - The condition in which the impedance of a component or circuit is equal to another impedance to which it is connected, for example, the antenna coaxial cable and transmitter of a TV system. With proper impedance match there will be maximum transfer of energy.

Inches Per Second - The customary way of measuring tape speed on an audio or video tape recorder.

Indoor (Used as a prefix) - The prefix indoor means not suitable for exposure to the weather.

Insertion Loss - The signal strength loss when a piece of equipment is inserted into a line signal path.

Integrated Circuit - A very small electrical component, containing a photoetched miniature circuit.

Inteference - In a signal transmission path, extraneous energy which tends to interfere with the reception of the desired signals.

Interlaced Scanning (Interlace) - An interleaved scanning process for reducing image flicker, in which the distance from center to center of successively scanned lines is two times the nominal line width, and in which the adjacent lines belong to different fields.

Ion - A charged atom, usually an atom of residual gas in an electronic tube.

Ion Spot - A spot on the fluorescent surface of a cathode-ray tube which is somewhat darker than the surrounding area because of bombardment by negative ions which reduce the sensitivity of that surface.

Ion Trap - An arrangement of magnetic fields and apertures which will allow an electron beam to pass through but will obstruct the passage of ions. Usually used on the neck of a cathode ray tube.

Iris Diaphragm - An adjustable set of metal leaves over the aperture of a lens, used to control the amount of light passing through the lens. Iris openings are measured in f-stops.

Jitter - Small rapid variations in a waveform due to mechanical disturbances or to changes in the supply voltages, in the characteristic of components, etc.

Kilohertz - 1000 cycles per second.

Lag - A result of image tube persistence, usually expressed as a percentage of signal remaining 3 fields (50 milliseconds) after the signal has been removed. This produces image smearing and resolution loss when relative motion exists between the camera and scene. (See Image Retention)

Lambert - A unit of luminance equal to one candle per square centimeter, and therefore, equal to the uniform luminance of a perfectly diffusing surface emitting or reflecting light at the rate of one lumen per square centimeter. (See Foot-Lambert)

Laser Communication Link - Same as microwave link except that the basic channel is provided by a laser beam rather than a microwave beam.

Light Emitting Diode - A semiconductor which emits light when an electrical current is passed through it. Used for panel lights and digital readouts in electronic equipment.

Light Level - The intensity of the light measured in foot-candles or lumens/meter^2.

Line Amplifier - An amplifier installed at an intermediate position in a CCTV system connected to a main cable run to compensate for loss; generally a broadband amplifier.

Line Fault Protection - A means of eliminating or reducing the effect of faults which occur on a transmission line such as a telephone circuit. Such faults include momentary losses of transmission due to signal outages or high noise levels.

Line Filter - A device inserted in series with the power line to block noise or other interference from devices such as motors.

Line of Sight - The distance from an elevated point to the optical horizon or to another elevated point which may be beyond the optical horizon. Because of the additional refraction or bending of radio waves, the radio horizon is slightly beyond the optical horizon. (See Radio Horizon)

Line Splitter - A term given a device to provide two or more isolated branch cable runs from one cable run in RF distribution systems.

Line Supervision - A continuous means of determining that a transmission line is functional.

Load - Any energy or power consuming device which is connected to another device that is supplying it with power or energy. An antenna serves as a load for the power output of a TV transmitter.

Lumen (lm) - The photometric unit of radiant power. One lumen is the amount of luminous flux emitted into a solid angle of one steradian by a point source whose luminous intensity is 1 candela.

Luminance - The luminous flux emitted from a surface. One foot-lambert is $\frac{1}{\pi}$ candles per square foot, or the luminance resulting from one foot-candle of illumination falling on a "perfect" diffusing surface. One lambert is $\frac{1}{\pi}$ candles per square centimeter. (See Brightness)

Luminance Signal - That portion of the NTSC color television signal which contains the luminance or brightness information.

Lux - See Illumination.

Magnetic Tape - A ribbon of paper, metal or plastic, coated with material sensitive to electromagnetic fields, and used for recording and replaying information. (See Videotape)

Matching - The obtaining of like impedances to provide a reflection-free (optimum) transfer of signal.

Matching Transformer - A device to transform signals from one impedance to another. In video transmission systems, usually 75-ohm unbalanced to 124-ohm balanced.

Megahertz - One million cycles per second.

Meter - An electrical or electronic measuring device, usually comprised of a movable pointer in front of a calibrated scale or set of markings.

Microphonics - Audio-frequency noise caused by mechanical vibration of elements in a system or component.

Mobile Radio - A two-way radio that is either portable or installed for use in a car, boat, truck or other vehicle.

Modulation - The process, or results of the process, whereby some characteristic of one signal is varied in accordance with another signal. The modulated signal is called the carrier. The carrier may be modulated in three fundamental ways: by varying the amplitude, called amplitude modulation; by varying the frequency, called frequency modulation; by varying the phase, called phase modulation.

Moisture-Resistant - So constructed or treated that exposure to a moist atmosphere will not readily cause malfunction.

Monitor - TV set without tuner used to display directly the composite video signal from a camera, videotape recorder, or special effects generator.

Monochrome Signal - In black-and-white television, a signal wave for controlling the brightness values in the picture. In color television, that part of the signal wave which has major control of the brightness values of the picture, whether displayed in color or in monochrome.

Multiplexer - A unit used for combining signals, thus reducing the required number of transmission paths.

Multiplexing - A signaling method using wire path, cable carrier, radio carrier or combinations of these facilities characterized by the simultaneous and/or sequential transmission and reception of multiple signals in a single communication channel including means for positively identifying each such signal.

National Television Systems Committee - A committee that worked with the FCC in formulating standards for the present day United States color television system.

Negative - A designation of electrical polarity, usually associated with an excess supply of electrons (negatively charged particles) or the portion of a waveform pictured below the horizontal axis. (See Positive)

Negative Image - A picture signal having a polarity opposite to normal polarity, as in a picture in which the white and black areas are reversed.

Neutral Density - Having uniform attenuation characteristics for varying light wavelengths.

Noise - Any unwanted disturbance within a dyamic electrical or mechanical system; random electrical variations generated internally in electronic components; in a television picture, often characterized by a "salt-and-pepper" pattern, or "snow".

Octave - The interval between two frequencies of sound or electrical energy having a ratio of 2:1.

Omnidirectional Antenna - An antenna which radiates or receives signals equally well in all directions.

Orthicon - A camera tube in which a beam of low-velocity electrons scans a photo-emissive mosaic capable of storing an electrical-charge pattern.

Outdoor (Used as a prefix) - The prefix outdoor means designed for outdoor service.

Oxide - The ferro-magnetic particles which, when properly dispersed in a plastic binder and coated on a backing or base, form the magnetic portion of magnetic tape. Conventional oxide particles are chemically known as gamma ferric oxide, are brown in color, acicular or needle-like in shape, and about 1 micron in length. All oxides used in magnetic tape are magnetically "hard", maintaining magnetism induced in them until demagnetized by external magnetic fields of sufficient intensity.

Oxide Build-Up - The accumulation of oxide or, more generally, wear products in the form of deposits on the surface of the heads. Oxide build-up causes a loss in output and accelerates both tape and head/guide wear.

Pairing - A partial or complete failure of interlace in which the scanning lines of alternate fields do not fall exactly between one another but tend to fall (in pairs) one on top of the other, thus reducing vertical resolution.

Pan - To rotate a camera in a horizontal plane.

Pan/Tilt - The dual capability of panning and/or tilting a camera.

Peak-To-Peak - The amplitude (voltage) difference between the most positive and the most negative excursions (peaks) of an electrical signal.

Phase - The relative timing of a signal in relation to another signal; if both signals occur at the same instant, they are in phase; if they occur at different instants, they are out of phase.

Picture Signal - That portion of the composite video signal which lies above the blanking level and contains the picture information.

Picture Tube (Kinescope) - A cathode-ray tube used to produce an image by variation of the beam intensity as the beam scans a raster.

Plumbicon Camera - Electronic camera using a lead oxide image tube, producing minimum lag; not in general use for CCTV applications.

Positive - A designation of electrical polarity usually associated with a deficiency of electrons (negatively charged particles) or the portion of a waveform pictured above the horizontal axis. (See Negative)

Power Output - Usually refers to the power, in watts, delivered by a transmitter to the antenna. The power available at the output of any electrical or mechanical device.

Power Supply - A unit or circuit which supplies electrical power to another unit or to the rest of a circuit.

Preamplifier - An amplifier, the primary function of which is to raise the output of a low-level source to an intermediate level so that the signal may be further processed without appreciable degradation in the signal-to-noise ratio of the system.

Projection Television - A system which projects an enlarged television picture on a remote screen.

Proof (Used as a suffix) - Apparatus is designated as splashproof, dust-proof, etc., when so constructed, protected, or treated that its successful operation is not interfered with when subjected to the specified material or condition.

Quadruplex - Refers to a standardized method of video magnetic tape recording which uses four magnetic heads mounted around the rim of a head wheel. The head wheel rotates in a plane perpendicular to the direction of the tape motion; not in use for CCTV applications.

Radio - A general term referring to the use of electromagnetic waves. In particular, communication by electromagnetic waves transmitted through space.

Radio Frequency - A frequency at which coherent electromagnetic radiation of energy is efficient for communication purposes. Generally below the frequency of infrared light.

Radio Horizon - The line beyond which direct radio waves cannot continue along the earth's surface. This distance is affected by atmosphere refraction; hence it is not constant and does not necessarily equal the optical horizon.

Raintight - So constructed or protected that exposure to a beating rain will not result in water entering the device.

Random Interlace - A technique for scanning often used in closed-circuit television systems in which alternate fields are not precisely timed, resulting in unequal scan line spacing. This technique provides somewhat reduced precision to that used in commercial broadcast service.

Range - The maximum distance at which reliable communications may be maintained.

Raster - The area of the picture tube scanned by the electron beam; also generally refers to the illuminated area produced by the scanning lines on a television picture tube when no signal is being received.

Real Time - Refers to the time of actual event occurrence.

Receiver - Any device capable of receiving a message. Examples of messages include an alarm from a remote sensor or an "all's well" signal from an unstimulated sensor as well as ordinary voice messages and video images.

Reference Black Level - The picture signal level corresponding to a specified maximum limit for black peaks.

Reference White Level - The picture signal level corresponding to a specified maximum limit for white peaks.

Refresh Rate - The rate at which display information is rewritten; a low refresh rate produces flicker.

Repeater - The equipment used for receiving and/or amplifying, and retransmitting a signal in a very long transmission line. It restores the signal to sufficient amplitude and correct shape to operate the receiving equipment satisfactorily. Generally used in conjunction with transmit and receive terminals.

Resolution (Horizontal) - The amount of resolvable detail in the horizontal direction of a picture. It is usually expressed as the number of distinct vertical lines, alternately black and white, which can be seen in a distance equal to picture height. If the picture is soft and blurred and small details are indistinct, it has poor, or low, resolution.

Resolution (Vertical) - The amount of resolvable detail in the vertical direction in a picture. It is usually expressed as the number of distinct horizontal lines, alternately black and white, which can be seen in a test pattern. Vertical resolution is primarily fixed by the number of horizontal scanning lines per frame.

Resolving Power - The ability of an object to distinguish picture detail.

Retained Image - See Image Retention, Lag.

RF Pattern - A term sometimes used to describe a fine herringbone pattern in a picture. May also cause a slight horizontal displacement of scanning lines resulting in a rough or ragged vertical edge of the picture. Caused by high frequency interference.

Ringing - An undersirable oscillatory transient occurring in the output of a system as a result of a sudden change in input. May occur as a result of lead inductance, interconductor capacitance and/or impedance mismatching.

Roll - A loss of vertical synchronization which causes the picture to move up or down on a receiver or monitor.

Satellite Station - A normally unattended location remote from the central station and linked by communication channel(s) to the central station.

Saturation - Refer to Chroma.

Scanning - The process of moving the electron beam of an image tube or CRT across the target or screen area of the tube.

Screen Splitter - A device which combines partial (e.g., left, right, upper. lower) video signals from two sources to be displayed on one monitor.

Selectivity - The characteristic which determines the extent to which the desired frequency can be differentiated from other frequencies.

Sensitivity (of a Camera Tube) - The signal current developed per unit incident radiation density, (i.e., per watt per unit area). Unless otherwise specified, the radiation is understood to be that of an unfiltered incandescent source of 2870°K, and its density, which is generally measured in watts per unit area, may be expressed in foot-candles.

Shielded Cable - A cable in which the insulated conductor (or conductors) is enclosed in a conducting envelope which is grounded to reduce the effect of external magnetic or electrical fields. (See also Coaxial Cable)

Signal Strength - The intensity of the television signal measured in volts, millivolts, microvolts, or db using zero db as a reference. The reference signal strength is equal to 1000 microvolts in RF systems; generally 1 volt in video systems.

Signal-To-Noise Ratio - The ratio between the useful television (or other) signal and disturbing noise or snow. This ratio is often expressed in decibels, and it may be a function of the bandwidth of the transmission system.

Simplex - A communication system that can transmit in only one direction on a transmission link. (Wire or Radio.)

Simulator - A device for training operators through a representation of the the actual operating conditions.

Simultaneous Transmission - A full duplex system where transceivers communicate with each other simultaneously.

Skew - Zig-zag pattern on screen, often an indication of poor time-base stability on the part of a video recorder, or an excessively long automatic frequency control (AFC) time constant in a monitor.

Sleetproof - So constructed or protected that the accumulation of sleet will not interfere with successful operation.

Snow - Visible random noise in a video picture.

Solid-State - Devices that can control current without moving parts, heated filaments, or vacuum gaps. Semiconductors or transistors are typical solid state devices.

Speaker - A device which converts electrical signals back into sound.

Splashproof - So constructed and protected that external splashing of liquids will not interfere with successful operation.

Splashresistant - So constructed or protected that exposure to external splashing of liquids will not readily cause malfunction.

Splashtight - So constructed or protected that exposure to external splashing of liquids will not result in the entrance of moisture.

Squelch Circuit - A circuit in a receiver for reducing the background noise in the absence of signals.

Standing Wave Ratio - A measure to determine how well matched a system (transceiver, antenna, antenna cable) is. A low SWR measurement (1.5:1 or better) is an indication that the system is operating efficiently, with a minimum of loss.

Stop Action - In videotape recording systems, the process of electronically holding the picture at one field or frame. (See Freeze Frame)

Streaking - A picture condition in which objects appear to be extended horizontally beyond their normal boundaries. This will be more apparent at vertical edges of objects when there is a large transition from black to white or white to black. If the total degradation is an opposite shade to the original figure (white following black), the streaking is called negative. If the shade is the same as the original figure (white following white), the streaking is called positive.

Switch - A mechanical or electrical device which breaks or completes a path for electrical current.

Sync Generator - A composite of three basic functional units - a pulse generator, a timing reference, and a comparator/control unit to lock the pulse generator to the time reference.

Synchronization - The control over one signal to keep it in time coincidence with another.

Synchronizing (in Television) - Maintaining two or more scanning processes in phase.

Sync Signal (Synchronizing Signal) - The signal employed for the synchronizing of scanning. In television, this signal is composed of pulses at rates related to the line and field frequencies.

Tape Skew - The deviation of a tape from following a linear path when transported across the heads. This causes a time displacement between signals recorded on different tracks, and amplitude differences between the outputs from individual tracks, owing to variations in azimuth alignment.

Target - In a camera image tube, a structure employing a storage surface which is scanned by an electron beam to generate an output signal current corresponding to the charge-density pattern stored thereon.

Tearing - A term used to describe a picture condition in which groups of horizontal lines are displaced in a irregular manner. Typically caused by lack of horizontal synchronization.

Television - A system which picks up, transmits, and displays images by electrical scanning.

Termination - A term used in reference to impedance-matching the end of cable runs by installing a non-inductive resistor or complex reactive network having the same impedance value as the characteristic impedance value of the cable over the frequency range to be used.

Test Pattern - A chart prepared for checking the overall performance of a television system. It contains various combinations of lines and geometric shapes. The camera is focused on the chart, and the pattern is viewed at a monitor.

Tight (Used as a suffix) - Apparatus is designated as watertight, dust-tight, etc., when so constructed that the enclosing case will exclude the specified material.

Time Division Multiplexing - A signaling method characterized by the sequential and noninterfering transmission of more than one signal in a communication channel. Signals from all terminal locations are distinguished from one another by each signal occupying a different position in time with reference to synchronizing signals.

Time Sharing - A means of making more efficient use of a facility by allowing more than one using activity access to the facility on a sequential basis.

Totally Enclosed - Totally enclosed means so enclosed as to prevent circulation of air between the inside and the outside of the case, but not necessarily sufficient to be termed airtight.

Tradeoff - A term which describes the analysis undertaken to determine the best compromise which can be made between conflicting requirements or alternate configurations.

Traffic - Messages handled by communications stations.

Transceiver - A combination transmitter and receiver housed in a common cabinet and employing some common circuit components for both transmitting and receiving.

Transients - Signals which endure for a brief time prior to the attainment of a steady-state condition. These may include overshoots, damped sinusoidal waves, etc., and, therefore, additional qualifying information is necessary.

Transistor - A solid-state device made from semiconductor material which is typically used to amplify signals.

Transmitter - The equipment used to generate and amplify an RF carrier signal and modulate this carrier with intelligence.

Transmitter/Receiver - A device capable of maintaining two-way communication with another similar device.

Transport - In tape recorders, refers to the mechanical system that moves the tape.

Trap - A frequency selective circuit used to attenuate undesired signals while not affecting desired signals.

Two Way Radio - A radio channel wherein both terminals are equipped with both transmitting and receiving equipments to permit two-way message traffic or conversations.

Ultra High Frequency - In television, a term used to designate channels 14 through 83. (See Frequency Band)

Uncompensated Telephone Line - Typically, a standard hard wire pair, Compensation of such a pair involves the addition of electronic components to improve the frequency response of the line and hence its quality of transmission.

Vertical Blanking - Refers to the blanking signals which occur at the end of each field, used to cut off the CRT electron beam and avoid unwanted lines appearing on the screen.

Vertical Retrace - The return of the electron beam to the top of the picture tube screen or the pickup tube target at the completion of the field scan.

Very High Frequency - In television, a term used to designate channels 2 through 13. (See Frequency Band)

Vestigial Sideband Transmission - A system of transmission where the sideband on the lower side of the carrier is transmitted only in part; used in all commercial television broadcasts in the U.S.

Video - A term pertaining to the bandwidth and spectrum position of the signal resulting from television scanning. In current usage, video means a bandwidth in the order of megacycles, and a spectrum position that goes with a dc carrier. This portion of a baseband television signal typically extends to 4.5 MHz for broadcast purposes; may be as high as 10 MHz for CCTV applications.

Vide Amplifier - A wideband amplifier used for passing picture signals.

Videocassette - A self-contained video module played on a specially designed video tape recorder and similar in design to an audio cassette. The videocassette houses two reels—supply and take-up—with the tape running between them and connected to both.

Videotape - Magnetic tape that records the complete intelligence of a TV signal, both video impulses and synchronized audio impulses, and is available for instant replay. (See Magnetic Tape)

Vidicon - A camera tube in which a charge-density pattern is formed by photoconduction and stored on the surface of the photoconductor, which is scanned by an electron beam usually of low-velocity electrons.

Visual Acuity - The capacity of the eye to resolve picture detail.

Voice Grade - A telephone circuit suitable for transmitting signals from 300 to 1700 Hz or greater with certain standards of noise and interference such that intelligible speech can be transmitted.

Volt - The unit measurement for electromotive force.

Volume - The intensity of a sound.

Walkie-Talkie - A two-way radio communication set designed to be hand carried and operated.

Waterproof - So constructed or protected that water will not interfere with successful operation. This does not imply submersion to any depth or pressure.

Watertight - Provided with an enclosing case which will exclude water applied in the form of a hose stream for a specified time.

Watt - The unit of measurement for electrical power.

Wave - A physical activity that rises and falls, or advances and retreats periodically as it travels through a medium, such as a radio wave.

Weatherproof (outside exposure) - So constructed or protected that exposure to the weather will not interfere with successful operation.

Weather-Resistant - So constructed or treated that exposure to a moist atmosphere will not readily cause malfunction

Weathertight - So constructed or protected that exposure to weather will not result in the entrance of moisture.

Wow and Flutter - Terms used to describe undesired changes in signal output frequency caused by tape speed variations.

Zoom Lens - Lens with a variable focal length.

B.2 TRANSIT SYSTEMS, SECURITY AND OTHER RELEVANT TERMS

Accident - Any incident involving an unplanned collision between a bus and another vehicle, a pedestrian, or a stationary object.

Astigmatism - The optical condition in which the refractive power of the eye is not uniform in all meridians and cylindric rather than spheric correction lenses are needed.

Assault - An unlawful physical attack by one person upon another, including both aggravated and simple assault. Excludes rape and attempted rape, as well as attacks involving theft or attempted theft, which are classified as robbery.

Automated Guideway Transit (AGT) - New public transportation concepts which use vehicles capable of automatic operation on separate roadways or guideways.

Biological Rhythm - A physiological and behavioral response cycle, such as a diurnal cycle or circadian rhythm.

Burglary - Unlawful or forcible entry of a home or business, usually, but not necessarily, attended by theft. Includes attempted forcible entry.

Census Tract - Geographic areas used in the 10-year Federal census. The tracts are generally designed for internal uniformity with respect to population characteristics, economic status, and living conditions. The average tract has about 4,000 residents.

Circadian Rhythm - Based on or involving approximately a 24-hour period. Recurring at approximately 24-hour intervals.

Conscientiousness - An internal attribute which motivates an individual to perform well.

Convergence Insufficiency - The muscular condition in which the two eyes cannot simultaneously be directed towards near objects.

Crimes of Violence - Homicide, rape, robbery of persons and assault.

Defensible Space - A surrogate term for a range of mechanisms that combine to bring an environment under the control of its residents. The term was popularized by architect Oscar Newman.

Disorderly Passenger(s) - Passenger(s) acting in a loud, rowdy, boistrous, threatening or assaulting manner.

Diurnal Cycle - Pertaining to day, or belonging to the daytime (opposed to nocturnal). Recurring every day. Having a daily cycle.

Drunk - An intoxicated person who is either creating a nuisance or not able to exercise self-care—often asleep or unconscious.

Extrinsic Motivation - Motivation induced by external influences of the task such as rewards, punishment and coercions.

Extrovert - An individual who tends to be outgoing, impulsive and uninhibited, having many social contacts and frequently taking part in group activities.

Fare Evasion - Knowingly failing or avoiding payment of fare.

Free Area - Common area open to unpaid patrons.

Grand Theft - Larceny of possessions valued at over $200.

Grand Theft Auto - Stealing or unauthorized taking of a motor vehicle.

Group Rapid Transit (GRT) - Systems utilizing automated vehicles on more extensive networks than shuttle-loop transit (SLT) systems. They tend to have shorter headways than SLT systems, use switching and may or may not employ off-line stations. Vehicles with a capacity of 10 to 70 passengers, operating singly or in trains with headways of 3 to 90 seconds, characterize such systems. State-of-the-art GRT Systems (e.g., Airtrans, Morgantown) operate at headways of 15 seconds or greater.

Heterophoria - The muscular condition in which there is a latent tendency of the eyes to deviate, which is prevented by fusion.

Homicide - Unlawful killing of a human being.

Hyperopia - The optical condition in which the refractive power of the eye is "too weak." Far-sightedness.

Incident - A specific safety or criminal act involving one or more victims and offenders.

Injured Passenger - A patron who is injured while using the transit vehicle or related facilities.

Intrinsic Motivation - Motivation induced by some inherent characteristics of the task or situation which cause an individual to try to "do well."

Introvert - A quiet retiring person. Introspective, reserved, and distant. An introvert tends to plan ahead, is not impulsive, dislikes excitement and takes matters seriously.

Lost Passenger - A passenger who does not know where he is. Sometimes a child, more often an older, disoriented person.

Malicious Mischief - The willful destruction of any real or personal property not belonging to the person committing the act.

Monotony - The prolonged repetition of simple acts or tasks. Wearisome uniformity or lack of variety in a situation.

Motivation - An inner urge which prompts or moves a person to action.

Myopia - The optical condition in which the refractive power of the eye is "too strong." Near-sightedness.

Neurotic - Psychological condition involving emotional instability and over-reactivity. Such individuals have difficulty in returning to a normal state after emotional experiences. They often tend to complain of vague medical symptoms.

Paid Area - Section of transit facility open to paid patrons only.

Personal Rapid Transit (PRT) - Systems characterized by small vehicles (2-9 passengers) carrying parties travelling together by choice. Such systems generally feature off-line stations and an extensive guideway network. Most proposed systems call for vehicles to be operated at headways of three seconds or less.

Platform - The boarding area of a bus or train station. The edge of the platform is where the passenger waiting area meets the road or guideway.

Presbyopia - The optical condition in which there is a diminished power of accommodation, arising from impaired elasticity of the aging eye lens.

Rape - Unlawful sexual intercourse through the use of force or the threat of force, including attempts. Statutory rape (without force) is excluded.

Reporting District - Geographic areas used by the police and sheriff's departments to record crime statistics.

Risk - The amount of threat one faces.

Robbery - Theft or attempted theft from a person or a business, of property or cash, by force or threat of force, with or without a weapon.

Safety - Provision of freedom from threat of harm or loss of property through natural or accidental occurrences. Used in relation to health and well-being.

Security - Provision of freedom from threat of harm or loss of property through the conscious efforts of other persons. Used in relation to crime.

Shuttle-Loop Transit (SLT) - The simplest type of Automated Guideway Transit Systems, characterized by vehicles moving along short linear segments or loops with few or no switches. The vehicles may operate singly or trained. Bypasses may be permitted in the shuttle to accommodate intermediate stations.

Simple Display - Characteristics of the "simple display" are defined as: (1) signal parameters (intensity and duration) above threshold; (2) no visual scanning necessary other than between signal and constant background; (3) no sensory-cognitive acts necessary other than "yes-no" decision; (4) time to detect not critical because of (1) and (2).

Theft - Unlawful taking of property or cash, either with contact (but without force of threat or force) or without contact between victim and offender.

Vandalism - Willful or malicious destruction or defacement of public or private property.

Vigilance - The state or quality of watchfulness, awareness or attentiveness.

B.3 SYMBOLS AND ABBREVIATIONS

Å or A	angstrom
ac	alternating current
ac/dc	alternating current or direct current
AFC	automatic frequency control
AGC	automatic gain control
AGT	Automated Guideway Transit
AGTT	Automated Guideway Transit Technology
ALC	automatic lens control
AM	amplitude modulation
amp	ampere
APTA	American Public Transit Association
ART	Automated Rail Transit
ATA	American Transit Association
BART	Bay Area Rapid Transit District (San Francisco, CA)
c	centi- (prefix)
CCTV	closed circuit television
cd	candela
CDTA	Capital District Transportation Authority (Albany, NY)
CITRAN	City Transit Service (Ft. Worth, TX)
COTA	Central Ohio Transit Authority (Columbus, OH)
cp	candlepower
cps or Hz	cycles per second
CRT	cathode ray tube
CTA	Chicago Transit Authority (Chicago, IL)
CTS	Cleveland Transit System (Cleveland, OH)
d	deci- (prefix)

da	deca- (prefix)
db	decibel
dbm	decibel referred to 1 milliwatt
dc	direct current
DOT	Department of Transportation
DPM	Downtown People Mover
EIA	Electronic Industries Association
EHF	extremely high frequency
EMI	electromagnetic interference
ERP	effective radiated power
FCC	Federal Communications Commission
FET	field effect transistor
FRA	Federal Railroad Administration
ft^2	square foot
ft-c	foot-candle
ft-L	foot-lambert
G	giga- (prefix)
GRT	Group Rapid Transit
h	hecto- (prefix)
HF	high frequency
hr	hour
Hz	hertz
IC	integrated circuit
IEEE	Institute of Electrical and Electronics Engineers
IF	intermediate frequency
in.	inch
$in.^2$	square inch
in./sec	inches per second

IPS	tape speed in inches per second
IR	infrared
IRE	Institute of Radio Engineers (Now IEEE)
ISIT	Intensifed Silicon Intensified Target
K	Kelvin
k	Kilo- (prefix)
kc	kilocycles per second
KCATA	Kansas City Area Transportation Authority (Kansas City, MO)
kHz	kilohertz
km^2	square kilometer
kMc	kilomegacycles per second
kMHz	gigahertz (kilomegahertz)
LAX	Los Angeles International Airport
LED	light emitting diode
LF	low frequency
lm	lumen
lm-hr	lumen-hour
lm/watt	lumens per watt
lx	lux
M	mega- (prefix)
m	milli- (prefix)
m	meter
m^2	square meter
ma	milliampere
MARTA	Metropolitan Atlanta Rapid Transit Authority (Atlanta, GA)
MBTA	Massachusetts Bay Transportation Authority (Boston, MA)
Mc or Mc/s	megacycles per second (megahertz)

MF	medium frequency
MHz	megahertz
mi	mile
min	minute (time) and (-) latitude
mL	millilambert
msec	millisecond
MTA	Metropolitan Transit Authority
MTA of MD	Mass Transit Administration of Maryland (Baltimore, MD)
MUCTC	Montreal Urban Community Transit Commission (Montreal, PQ)
mv	millivolt
mw	milliwatt
NAB	National Association of Broadcasters
NOPSI	New Orleans Public Service, Inc. (New Orleans, LA)
NTSC	National Television Systems Committee
NYCTA	New York City Transit Authority (New York, NY)
NYCTP	New York City Transit Police
OC Transpo	Ottawa-Carleton Regional Transit Commission, Ottawa, ON
PAT	Port Authority of Allegheny County (Pittsburgh, PA)
PATCO	Port Authority Transit Corporation, (Camden, NJ)
PATH	Port Authority Trans Hudson (NY-NJ)
pm	phase modulation
pps	pulses per second
PRT	Personal Rapid Transit
R	resistance
Ref	reference
RETMA	Radio Electronic Television Manufacturers Association, (now EIA)
RF	radio frequency

SLT	Shuttle-Loop Transit
VTR	videotape recorder
w	watt
WMATA	Washington Metropolitan Area Transit Authority (Washington, DC)
yr	year

APPENDIX C. BIBLIOGRAPHY

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APPENDIX D. REPORT OF NEW TECHNOLOGY

The work performed under this contract has summarized current and preferred practices for the application of closed circuit television (CCTV) technology in transit stations. Guidelines have been developed for planning, installing and evaluating CCTV systems. Several new concepts are introduced (as described in Sections 3.3, 5.3, 6.3 and 7.2), which apply and extend existing technology and procedures to the transit station context.

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