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ELECTROMECHANICAL TRANSIT SECURITY EQUIPMENT

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16. Abstract

This study documents current experience with electromechanical security devices in combating transit crime, and assesses and evaluates the implications of this experience for automated transit security planning efforts in the future. Security issues and devices for both grade-separated rail and surface bus transportation systems are examined as they apply to automated transit. This examination also includes a review of both station and on-vehicle applications of transit security devices. This work was accomplished using a case study approach, examining the use of electromechanical security equipment at 10 major transit systems throughout the United States and Canada.

The overall consensus of the case study transit operators interviewed was that radio communications equipment rates highest, or "very effective," in terms of both station and on-vehicle applications. Six additional electromechanical security devices--photocameras, closed-circuit television, emergency phones, equipment for altering system operations, automatic vehicle monitoring, and public address systems--all were rated as "moderately effective," with considerable variability on a site-to-site basis.

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Preface

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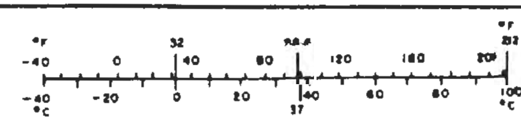
METRIC CONVERSION FACTORS

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	5	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

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)	2.5	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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LIST OF ABBREVIATIONS

AFC	Automatic Fare Collection
AGT	Automated Guideway Transit
ATC	Automatic Train Control
ATO	Automatic Train Operation
BAPERN	Boston Area Police Emergency Radio Network
BART	Bay Area Rapid Transit District
CCTV	Closed-Circuit Television
CTA	Chicago Transit Authority
MARTA	Metropolitan Atlanta Rapid Transit Authority
MBTA	Massachusetts Bay Transit Authority
MPM	Morgantown People Mover
NYCTA	New York City Transit Authority
PATH	Port Authority Trans. Hudson
SCRTD	Southern California Rapid Transit District
SDT	San Diego Transit Corporation
SEPTA	Southeastern Pennsylvania Transit Authority
TTC	Toronto Transit Commission
TVA	Teleview Alert System
WMATA	Washington Metropolitan Area Transit Authority

Executive Summary

Statement of the Problem

The issue of passenger and system security may be critical in determining the extent to which automated transit systems can be implemented in urbanized areas. Security concerns stem primarily from the fact that these systems require few attendant employees. While vehicle and station operators on existing rail and bus transit systems are generally ineffective in dealing with criminal incidents, their physical presence is of psychological value and a perceived deterrent to crime. The lack of transit personnel, the use of more numerous, smaller stations and more extensive guideways, and the inability of passengers to select companion riders in many proposed automated systems may create problems with respect to both surveillance and access control.

Study Purpose and Scope

The purpose of this study is to document current experience with electromechanical security devices in combating transit crime and to assess and evaluate the implications of this experience for automated transit security planning efforts in the future. Security issues and devices for both grade-separated rail and surface bus transportation systems are examined as they apply to automated transit. This examination also includes a review of both station and on-vehicle applications of transit security devices. This work was accomplished using a case study approach, examining the use of electromechanical security equipment at 10 major transit systems throughout the United States and Canada.

Study Organization

The study provides the automated transit system planner with current information on the types of electromechanical security devices available and their application within the transit industry. The report is organized in five chapters with two appendices.

Chapter 1 introduces the study with a statement of the problem and a discussion of the extent and perception of transit crime and its implications for automated transit systems. It also defines the study purpose and scope and provides a definition of terms and study limitations.

Chapter 2 discusses the range of electromechanical security devices that are currently being used in transit systems. Each alternative is discussed in terms of current application, advantages and disadvantages, potential application in automated transit systems, and cost, when available.

Chapter 3 presents information concerning the security programs and experiences of 10 transit system case studies. This information is summarized for each transit system according to system background, the electromechanical security devices in use, other security countermeasures used, and the agency's assessment and evaluation of its security program.

Chapter 4 examines the results of case study interviews and surveys. It discusses the security backgrounds of key security personnel contacts to establish their credibility in making countermeasure evaluations. The chapter also summarizes transit agency security program planning efforts, documents use and evaluation of electromechanical security equipment, provides examples of security equipment costs, when available, and presents recommendations for design and operational improvements in security equipment.

Chapter 5 presents the overall implications of the study for automated transit system planning. It responds to the issue of security hardware effectiveness against transit crime by addressing each of several countermeasure evaluation criteria, such as compatibility with existing transit systems, maintainability, reliability, flexibility, and adequacy of surveillance coverage. In addition, the chapter compares study results with previous research and identifies key research areas requiring further study.

The overall consensus of the case study transit operators interviewed was that radio communications equipment rates highest, or "very effective," in terms of both station and on-vehicle applications. Six additional electromechanical security devices—photocameras, closed-circuit television, emergency phones, equipment for altering system operations, automatic vehicle monitoring, and public address systems—all were rated as "moderately effective," with considerable variability on a site-to-site basis. One of the devices, alarms and sensors, was rated as having limited effectiveness in reducing the perceived or actual risk of transit crime.

Most of the case study transit operators employ multiple security devices, typically five or more devices at either stations or aboard vehicles. The prevailing attitude among the security specialists interviewed is that, regardless of the specialized devices used, the presence of transit police or security guards will continue to be the most significant factor in deterring and controlling transit crime on either automated or conventional bus or rail transit systems.

Appendix A contains a detailed discussion of study methodology. Appendix B presents biographical sketches of the key transit system security personnel contacts for the case study interviews. A bibliography of the major publications and references that were reviewed for this study also is provided.

1. Overview

Statement of the Problem

Within the last decade, crime and vandalism on public transportation systems throughout the nation have become an increasingly serious problem. One impact of this problem is that, despite renewed public interest in the use of mass transit systems due to escalating social, economic, environmental, and energy problems, there is continued consumer resistance to choosing mass transit. While mode choice issues are very complex, high crime rates on transit systems, particularly with respect to violent crime, and vandalism to vehicles, equipment and other property, only help to deter public transit ridership and defeat efforts to promote the use of public transportation.

Another aspect of the transit crime problem is the *increased cost of providing transit services, including increased maintenance and security requirements.* These increased costs include the provision of (1) transit police or security manpower; (2) security hardware and related maintenance functions; (3) repair or replacement of vandalized equipment and property; and (4) administrative costs for the planning, design, monitoring, and ongoing evaluation of a security program.

In addition, while the extent and severity of crimes committed on transit systems have changed, the response from authorities typically has been focused on a change in the number or deployment of transit police or security officers. This response generally has been due to the lack of experience with transit security planning state-of-the-art and technology. Unfortunately, however, the use of security manpower alone has not been effective in combating transit crime.

Despite extensive financial investments in transportation facilities and improvements today, the success or failure of public transportation services may hinge on associated security provisions for transit patrons and property. To help ensure success in the provision of public transportation services, recent advances have been made in transit security planning and technology, including the development and use of electromechanical security devices. These devices are being used and tested to determine their ability to (1) reduce transit crime rates or passenger perception of crime and (2) reduce the cost of providing security by reducing manpower requirements while extending existing surveillance capabilities.

Based on current experience with these devices, electromechanical security equipment could have potential for use in security programs for automated transit systems, especially since such devices are complementary to systems designed to minimize personnel requirements. However, there are few available quantitative or case study analyses which document experience with electromechanical security devices in a transit environment. The purpose of this study, therefore, is to document experience with these devices in order to assist the transit system operator or planner in evaluating their potential for use in existing or future automated transit systems.

Extent and Perception of Transit Crime

Crime on mass transit systems is not a new phenomenon. What has changed over the years are the types of crime which concern transit passengers and the extent to which these crimes occur. Prior to World War II, most concern was expressed over pocket picking, a nonviolent crime. After World War II, concern shifted to acts of violent crime, such as robbery and assault.

It was not until the late 1960s and early 1970s that major studies were undertaken to examine the nature and extent of mass transit crime. However, while these studies have established the characteristics of transit crime, they have failed to consistently define the extent of the problem or the degree of personal risk as compared to street crime. Difficulties with defining the extent of transit crime revolve around such factors as:

- Shifting the responsibility for maintaining detailed crime records from some transit systems to local police authorities, who often do not distinguish between street and transit crimes.
- Jurisdictional or system differences in how transit crimes are defined, recorded, and tabulated, thus complicating the analysis or comparison of data.
- Lack of transit personnel and funds to maintain current and accurate crime incidence reports.

However, these problems are being resolved through the continued development of uniform transit crime reporting practices and the growing awareness of and interest in the potential benefits of transit security planning and data maintenance, including increased transit ridership and reduced facility maintenance and manpower costs.

Also, there have been problems in establishing a consistent comparison of the degree of personal risk of transit crime versus street crime. For example, a 1973 study by the American Public Transit Association (APTA) of 37 U.S. transit systems, which account for 60 percent of total annual vehicle-miles and revenue passengers, concluded that the risk of being involved in a criminal incident is at least twice as great when riding on most major transit systems than it is in non-transit circumstances. (16)

On the other hand, several other studies of transit crime indicate the probability of crime occurring on city streets is greater than on rail rapid transit systems. For example, in the first nine months of 1977, 1,105 murders, 2,976 rapes, and 387,094 felonies were committed in New York City. For the same period in the city's subways, there were 11 murders, 13 rapes, and 10,202 felonies. These numbers reflect a commendable transit security performance record in view of the nearly four million passengers per day carried by the subway system. (21)

The security record of the Washington, D.C., Metropolitan Area Transit Authority (WMATA) is even more impressive. From March, 1976, when the subway opened, through October, 1977, Metrorail trains traveled 2.9 million revenue miles and recorded only 89 criminal incidents—or roughly three crimes for every 100,000 miles. Furthermore, of the 89 crime incidents, only 20 were criminal felonies, mostly robbery and grand larceny. The other 69 incidents were misdemeanors, such as disorderly conduct, drinking in public, or destruction of property. Metro police made arrests in 41 of the incidents, following up with full prosecution in every case. (21)

A comparison of crimes on buses with rail rapid transit indicates that substantially fewer are committed on buses than on rapid transit. A case in point is provided by the Chicago Transit Authority (CTA). An extensive study of transit crime by Shellow, et al. in 1973 revealed that three-fourths of total reported CTA transit crimes occurred on the rail system. (36) Other significant findings of the study include the following:

1. Rapid transit crime occurs largely in stations; 70 percent of crimes occurred in station areas, of which 63 percent were committed on platforms.
2. The character of the neighborhood in which a station is located has a strong effect on crime occurrence. Stations where the crime rate was highest are located in areas with high street-crime rates and high unemployment.
3. Crimes tend to be committed by groups of individuals in a familiar neighborhood. Criminals tend to escape on foot through a station exit rather than by train.
4. Rapid transit crimes tend to occur during off-peak periods. The highest risk period is 8:00 P.M. to 5:00 A.M., and the peak risk time is between 1:00 and 4:00 A.M. Assault and battery tend to occur during more heavily-traveled periods.
5. For robberies only, the annual transit crime rate is 332 per 100,000 persons, whereas the on-street robbery crime rate is 954 per 100,000 persons. Nationally, the comparable robbery crime rate is 187 per 100,000 persons. These figures indicate that rapid transit crime rates tend to be lower than crime rates for the city in which the system is located.
6. Many rapid transit riders are not willing to use the system between 6:00 P.M. and 6:00 A.M. (80 percent), and very few indicate that they would ride after midnight. The fear of riding transit after dark reflects not only the dangers within the system, but also the risk of personal injury when walking to and from a rapid transit station.

7. Perceptions of security for individual modes or elements of a transit trip are (in decreasing levels of security) riding the bus; waiting for the bus; walking to the station; riding the train; waiting at the rapid transit station; and (least secure) station stairs, ramps, or tunnels.
8. Citizens do consider security as a factor in using transit. Most citizen perception of crime risk is confirmed by survey results. Of non-riders, 25 percent cited security as a factor for not using transit, but 80 percent of this group cited ownership and convenience of an available auto as their principal reason.

Public perception of transit crime has as significant an influence on transit ridership and use patterns as actual crime occurrences. In fact, several studies have found that perceived crime levels, not actual crime levels, have the strongest impact on use of transit. (32) For example, although transit use is based on such attributes as travel time, cost, comfort, convenience, and availability, if the system is viewed as dangerous, it is likely that patrons will select another mode or *not make the trip.* Moreover, although the perception of security may or may not fit reality, patrons will avoid situations where they feel threatened or unsafe. (16)

Several factors contribute to public perception of transit crime. First, the news media and overly-zealous or opportunistic crime fighters may play a role in creating fear of crime by associating the idea of "crime" with a few sensational and terrifying criminal acts. (36) Second, the fear of crime is not simply the fear of personal harm due to violent or nonviolent crimes, but rather an underlying fear of strangers. (36) The close personal contact with strangers that is associated with transit use only serves to feed the fear of transit crime.

Third, the typical bus stop or rapid transit station environment, with its dark and shadowy areas, frequent location in high-crime neighborhoods, and frequent absence of security personnel or other security countermeasures, tends to make the problem of crime, as perceived by the public, more serious than statistics of actual crime suggest. (21) Fourth, security personnel are aware of the fact that hundreds of crimes go unreported, but that these cause much of the public's concern for personal safety while riding public transit. These unreported incidents generally fall into the following five categories:

- Minor thefts and assaults. The elderly are most likely to be the victims.
- Loud, boisterous behavior of individuals and groups. Police find that these incidents usually occur on routes near schools in the midafternoon.
- Youths running through vehicles, frightening passengers. Again, a problem that occurs most often near schools.
- Holding of doors, thereby delaying vehicles.
- The shaking down of persons traveling alone. This is different from a minor theft in that the passenger is usually asked to "loan" the offender some money for food, cigarettes, transit fare, etc. Again, the elderly, both men and women, are the most likely victims. (21)

Guideway Transit Hazards

Passenger security is affected by the type and degree of exposure to crime throughout a transit trip. It is important to focus on the potential "hazard areas" in the typical *guideway* transit trip since (1) previous studies (as referenced above) indicate a higher incidence of transit crime on rail versus bus systems and (2) the purpose of this study is to identify and assess the implications of current transit system use and experiences with security devices for future planning of automated guideway systems.

The types of crime which are generally recorded in transit system crime incidence reports are listed in Table 1-1. These include crimes against persons, personal property, the public, and system property. The typical guideway transit trip consists of eight "hazard areas" that represent a potential threat to passenger security. (36)

Arrival at the station presents security problems in those cases where parking lots are provided for park-n-ride services. However, auto thefts or thefts of personal property from autos, as opposed to crimes against persons, typically are the only reported crimes.

Entry into the station poses problems with the use of walkways, stairways, escalators, etc., which cannot be viewed directly or clearly by station attendants, closed circuit television (CCTV), or other transit patrons.

Table 1-1
TRANSIT CRIME CATEGORIES

Crimes Against Persons	*Crimes Against Personal Property*
Assault	Robbery
Battery	Pocket Picking
Rape	Purse Snatching
Homicide	
Abduction	
Crimes Against System Property	*Crimes Against the Public*
Robbery	Drug Law Violations
Burglary	Sex Offenses
Fare Evasion	Drunkenness
Vandalism	Disorderly Conduct
Petty Theft	Carrying Concealed Weapons
Trespassing	Suicide
Missiling (rock throwing)	Terrorism
Theft of System Property	

Source: See Reference 18 in Appendix A.

Fare collection areas present security risks since they provide the only place in which fare booth employees and transit patrons are usually handling currency.

Waiting for a vehicle constitutes the most dangerous segment of the transit trip. The two factors that significantly impact the degree of risk are the length of the waiting time and the number of people waiting per unit area.

Entering the vehicle is an act which places passengers in proximity to one another and is the site of most assault and battery crimes. These crimes are most likely to occur during peak hours when frustration tolerance is low, patron density is high, and crowding takes place.

Riding on the vehicle is the second most likely time for a crime to occur, of the eight activities in the typical transit trip. Analyses of rapid transit crime statistics show that approximtely one-third of all robberies, one-third of all assault/battery crimes, and one-half of all crimes against persons are committed on rapid transit trains.

Exiting the vehicle presents special characteristics during rush hours, when high-density patron traffic may again be the context of assault and battery crimes. However, vehicle exiting is safer than vehicle entry, since exiting patron density is generally lower and patron frustration tolerance higher upon arrival at station destinations.

Exiting the station is the safest portion of the transit trip, even though it takes place over stairs, walkways, etc., which are perceived to be the most dangerous areas of a station. Perhaps, it is the rapid, purposeful movement of most patrons at exit points which is responsible for reducing the risk of crime incidents at this stage of the transit trip.

Security Considerations for Automated Transit Systems

The hazard areas identified above exist on any guideway transit system—rapid rail, light rail, or automated transit. However, automated transit systems pose additional problems in providing passenger security, due to a range of different operating and design characteristics. The relationship of six automated transit characteristics to the various guideway transit hazard areas is summarized in Table 1-2.

One operating characteristic which presents a potential security hazard for transit patrons is, of course, the *automation* of transit system stations and vehicles. For example, since the presence of employees in transit stations is usually thought to help deter crime, their absence in automated transit systems may intensify security problems. Similarly, since automated transit vehicles normally function without on-board operators, the occurrence of criminal acts on-board vehicles may increase, as well as go undetected, unreported, and undeterred.

A potential target for criminal abuse on-board automated vehicles is the emergency passenger evacuation system. With this system, it is possible for an offender to commit

Table 1-2
RELATIONSHIP OF AUTOMATED TRANSIT CHARACTERISTICS TO GUIDEWAY TRANSIT HAZARD AREAS

	Automated Transit Characteristics					
Guideway Transit Hazard	Automated Vehicle Control	Service Characteristics	Vehicle Size	Station Design	Guideway Design	System Design
Arrival at Station				X	X	X
Station Entry	X			X	X	X
Fare Collection	X			X		
Waiting for Vehicle		X	X	X		X
Entering Vehicle	X		X			
Riding on Vehicle	X	X	X		X	X
Exiting Vehicle	X		X			
Exiting Station				X	X	X

X = Significant relationship.

a crime while the vehicle is between stations, stop the vehicle (using the emergency brake), and escape from the vehicle by making an unauthorized exit. In addition, the high-technology components necessary for an automated transit system may be vulnerable to vandalism.

The *service characteristics* of automated transit systems also pose security problems for patrons. For example, a *demand-responsive,* personalized ride minimizes the possibilities of on-board confrontations between transit users and offenders. However, the degree of passenger isolation when waiting or arriving at stations, resulting from such personalized, demand-activated service, may present a security hazard.

Scheduled service also poses a potential threat to passenger security, since passenger waiting or exposure time may be prolonged. In addition, scheduled service assures patron-stranger contacts when vehicles stop at stations to pick up passengers going in the same direction. The *frequency of service stops, distances between stations,* and *vehicle dwell time* also may intensify threats to passenger security.

Vehicle size is another factor which affects the degree of passsenger exposure to strangers or potential criminal incidents. For example, reduced levels of vehicle occupancy (i.e., small vehicle sizes typical of demand-responsive or demand-activated systems) present serious potential security drawbacks, if passengers are obliged to share a ride with strangers without the security of other passengers. Alternatively, however, although high-capacity vehicles may deter robberies, assaults, and rapes, crowd crimes may increase, such as pocket picking, public disturbances, or gold chain snatching incidents.

Station design is another important consideration in providing passenger security. Stations designed with maximum use of transparent walls can provide the security advantages of increased station observability and patron site distances. In addition, the length of station platforms and the size of passenger waiting areas may improve surveillance capability by restricting the viewing area for security guards or CCTV monitors, and by limiting the number of places where potential offenders may find concealment. Moreover, the number of levels of station and guideway construction (i.e., elevated, at-grade, below-grade, including possible multi-level transfer stations) may complicate security access and passenger escape routes, while increasing the number of potential exit routes for offenders who have studied or are familiar with the station design. Thus, crimes could take place on vehicles with perpetrators standing some chance of escape.

Guideway design considerations may include limited at-grade guideway construction to ensure that entrance and exit can take place only at stations. Patron security is also affected by guideway location and environment, such as the character of the surrounding neighborhood, the degree of isolation, or the level of activity in the area.

There are several security issues in *system design* and planning which may need to be addressed. One example is the *extent of system coverage* or size of the service area. Some systems may have problems due to varying jurisdictional laws regarding security enforcement in the service area or security problems due to the sheer size of the service area and the volume of patrons carried by the transit system each day. Other systems may have problems related to low service demand at certain station stops, coupled with the degree of isolation and environment of some transit stations.

Another issue that may arise in system security design relates to *overall system capacity* versus the demand for service. For example, low passenger ridership may result in the isolation of patrons at certain stations or on vehicles, thereby eliminating the sense of security provided by riding or waiting at transit stations with other passengers.

Still another issue relates to the security coverage provided during *peak and off-peak service hours.* Questions that need to be addressed include (1) the extent of coverage necessary and the identification of resources available to develop and finance a security program; (2) the identification or development of special efforts to handle specific problem areas or stations; (3) security planning and program monitoring to help ensure the cost-effective use of security countermeasures, particularly the use of electromechanical security devices; and (4) the coordination of security efforts with area law enforcement agencies and judicial systems to help ensure their support in the enforcement of transit security laws and the apprehension and conviction of offenders.

The automated transit systems that are in service today operate in unique transportation environments. *Shuttle-loop transit,* the simplest class of automated transit service, has been used in six airports, two commercial centers, and eight amusement parks. *Group rapid transit* systems are in operation at Morgantown, West Virginia, and the Dallas-Fort Worth Airport. Currently, there are no *personal rapid transit* systems in commercial use. (8)

If future automated transit systems continue to be used in these specialized contexts, it is doubtful that security will play an important role in determining system design, since crime has been a minor factor on these existing systems. However, this suggests that changing or improving the context or setting of a transit system, including automated transit, in itself, may be a crime countermeasure.

Transit Security Countermeasures

A transit security countermeasure is defined as any policy, procedure, or device whose purpose is to reduce crime, or the perception of crime, within a transit system. Such countermeasures can be useful to (1) deter crime, (2) thwart an ongoing crime, (3) apprehend an offender, (4) provide evidence, and (5) aid in the conviction of criminals. Typically, these countermeasures are focused on some combination of the following:

- Reuse of physical space.
- Efficient allocation of personnel.
- Effective use of technology.

A wide range of transit security countermeasures is available to combat the nature and occurrence of transit crime, including police or security manpower, locational or design techniques, policy guidelines and operating practices, and electromechanical devices. Despite the range of transit security countermeasures available, transit crime problems typically are addressed by a change in the number or deployment of transit police or security officers.

However, this response conflicts with one of the basic objectives of automated transit systems, which is to streamline or simplify system operations by reducing personnel requirements. Moreover, since automated transit vehicles will, by definition, be driverless, and since it is intended that automated transit stations employ a minimum of personnel, there may well be perceived and actual risks of personal danger to transit passengers. Therefore, in the continuing planning and design of automated transit systems, questions have been raised concerning the uncertainties associated with providing passenger security.

Therefore, this study is focused on the current use of transit security devices and the potential they offer to automated transit systems in providing actual and perceived security, while at the same time reducing labor costs.

Among the important background perspectives to maintain in an assessment of electromechanical security equipment alternatives is their role within the full range of transit security countermeasures. The prevailing attitude in the security field is that, regardless of the specialized devices used, the presence of transit police or security guards will continue to be the most fundamental factor in deterring and controlling transit crime. In general, electromechanical security devices are best employed in concert with other security countermeasures, including police activities.

Study Purpose and Scope

The purpose of this study is to document current experience with electromechanical security devices in combating transit crime and to assess and evaluate the implications of these experiences for automated transit security planning efforts in the future. This analysis is accomplished by using a *case study approach,* examining the use of electromechanical security equipment at 10 major transit systems throughout the United States and Canada. This research expands upon previous studies, in that most literature resources to date either document and analyze the nature and extent of mass transit crime and/or discuss the types of security countermeasures available and the state-of-the-art in transit security technology.

However, few studies provide quantitative or case study analyses which document the use and *effectiveness* of security equipment in reducing transit crime. Even fewer studies are available which discuss the potential applications and effectiveness of specific or individual transit security devices. Moreover, no existing studies assess the implications of current experiences with these devices for the future planning of automated transit systems.

Several additional parameters further define the scope of the study. First, the study is concened with issues of transit *security,* as opposed to transit *safety.* Specifically, the emphasis is on the security problems of transit system patrons and property.

The concept of security is the prevention of an act defined as criminal and implies a degree of deliberate action or premeditation to commit the act. The concept of safety is the prevention of an accidental or inadvertent act. For example, transit security problems are typified by such incidents as robbery, fare evasion, and murder, whereas transit safety problems can be characterized by such incidents as fire, equipment malfunctions, and patrons or objects that have fallen onto train tracks. This definition of terms is important in distinguishing between incidents of transit security and safety and in identifying those devices that are most effective in responding to transit *security* problems.

Second, this study examines security issues and devices for both grade-separated *rail* and surface *bus* transportation systems, as they apply to automated transit. This examination includes a review of both *station* and *on-vehicle* applications of transit security devices. In addition, the study reviews experience with security devices not only in reducing *actual transit crime,* but also in improving *patron perceptions* of transit crime as well. Finally, the review of the litrature concerning the state-of-the-art in transit security planning is concentrated on studies completed and published *since 1977.* The methodology for conducting this study is described in detail in Appendix A.

Data Limitations

A key constraint in the conduct of the study has been a paucity of data regarding the *observed* effectiveness of electromechanical security devices. In general, available crime statistics, from either police or transit police departments, are collected in such a manner that it is difficult to relate them to the presence or absence of transit crime countermeasures of any type. For example, statistics on rates of equipment use (such as the number of times transit patrons use alarms or how frequently actual crimes are monitored via CCTV) are not kept. Data on the response time associated with the activation of electromechanical security devices or the arrest rate associated with observed or reported crimes are usually not available. In addition, transit systems have cited difficulties in documenting actual before and after impacts of security countermeasures on criminal activity within their transit systems. Moreover, these kinds of data are very expensive to collect and typically are not now a part of the data collection activities of transit systems.

Very little experience has been gained in documenting either perceived or actual criminal risks associated with automated transit systems operating in conventional urban environments. One of the 10 case studies reviewed in this report—the Morgantown (West Virginia) automated transit system—has been in operation for a sufficient period to provide some insights into criminal behavior patterns associated with automated transit. Still, this system operates largely in a university environment and is not typical of a system operating in a central business district, other major urban activity center, or a corridor.

Because of the lack of actual experience with automated transit system security issues, this study has focused on the experience of nine additional, conventional transit systems, covering both train and bus operations. In assessing these systems, consideration has been given to both on-board transit *vehicle* security issues, as well as rapid transit *station* security questions.

Because of this general lack of data and the "newness" of most electromechanical security devices, an attempt was made to develop comparative information on available devices by calling upon the judgmental opinions of qualified transit security personnel. Among the 10 case study systems investigated, those persons in charge of transit security were interviewed with regard to their experience with and general understanding of the various devices available. While no single transit system has implemented all electromechanical security options, the persons interviewed still displayed a sound understanding of the range of options available and how they might or might not be applicable within their own transit systems. In developing descriptions of how various system options can be implemented, however, emphasis was given to those systems where actual operating experience is available.

Assessment Criteria for Countermeasures

Experience with security countermeasures in the transit environment can be measured in a number of ways. A primary criterion for countermeasure effectiveness is whether it works and how well it does so. Unfortunately, few countermeasures have been empirically evaluated. The actual operation of a countermeasure and its usefulness depend on the state and reliability of the technology on which it is based.

The criteria used to evaluate transit security devices were drawn from a review of the literature and from informal discussions with persons in the transit security field or who have expertise in this area. These criteria cover three broad areas of evaluation:

- Technology.
- Effectiveness (limited available data).
- Acceptability.

For each of these criteria, several salient questions were posed to define the scope of experience to be evaluated. These questions were useful to identify the issues and problems associated with the use of security devices. Thus, the evaluation criteria, as defined by these questions, were expanded as follows:

1. *State-of-the-art.* Does it work? How well does it work? Is it difficult to operate? What are the advantages and disadvantages of its use in a transit environment?
2. *Compatibility with existing transit systems.* Can it be installed easily in most transit systems? Does it have station as well as on-vehicle applications? Can it function in systems with old as well as modern station designs?
3. *Maintainability.* How likely are equipment breakdowns and failures? How difficult and expensive is it to maintain and service the equipment?
4. *Reliability.* How easy is it to overcome or disable a countermeasure? How susceptible is it to vandalism? Are false alarms a significant problem? How useful is the resulting data—i.e., can it be produced in court to facilitate arrest and conviction? Are there hazards associated with its use?—i.e., two-way radios have been used as weapons to attack bus drivers.
5. *Flexibility.* How easily can the technology adapt to future changes in station or vehicle design, the rate or types of crimes committed, budget changes, or ridership?
6. *Adequacy or surveillance coverage.* Does it deter criminals? What type of crime is it effective against? Is the surveillance area adequately covered? Can it impact several types of transit crime effectively, thereby increasing its cost-effectiveness?
7. *Adequacy or appropriateness of response.* Is the security response (change in criminal's behavior) adequate to meet the functions (deterrence, apprehension, conviction) desired of the device? Does it improve passenger perception of transit security? Does it aid or improve response to an emergency, i.e.:

a. Reduce communication delay to police?

b. Reduce police travel time to the scene?

c. Improve apprehension or number of on-site arrests?

d. Aid in tracing suspects or convicting offenders by providing evidence that is admissible in court?

8. *Costs/benefits.* What are the costs/benefits of a device? Costs to be considered include equipment, installation, service and maintenance, and personnel wages. Benefits include those that accrue to both the transit system and the transit patron. Are there other uses or benefits of a device beyond security protection (i.e., the more uses, the most cost-effectiveness to be expected)?

2.
Electromechanical Security Equipment Alternatives

Technological advances in security planning have resulted in the development of several electromechanical devices which can be useful in transit environments. Electromechanical transit security devices are defined as any electrical, mechanical, or technical device, hardware, or equipment whose purpose is to reduce crime or the perception of crime within a transit system.

No existing transit security program relies exclusively on surveillance hardware to protect riders and property. However, such devices can be used to extend the surveillance capabilities of security personnel by:

- Increasing the field of vision in station platform areas or on vehicles.
- Enabling several locations to be monitored, either simultaneously or in rapid succession.
- Improving the response time of security personnel in reaching the scene of a crime or problem incident.
- Facilitating direct communication between patrons and security personnel.
- Aiding in the identification, apprehension, and conviction of criminals.

In addition, the use of electromechanical security devices may help to minimize requirements for security personnel. By providing these and other advantages and capabilities, surveillance hardware has significant potential for use in automated transit systems, which are characterized by having low-manpower utilization.

The range of electromechanical security equipment available on the market today is extensive. The devices most commonly used or considered for use in transit security programs include the following:

- Closed-Circuit Television (CCTV)
- Radio Communications Equipment

- Emergency Phones
- Public Address Systems
- Alarms and Sensors
- Photo Cameras
- Metal Detectors
- Altering System Operations
- Automatic Vehicle Monitoring Systems

The purpose of this chapter is to discuss each of these devices in terms of:

- Current applications in transit security programs.
- Advantages or problems with their use.
- Potential use in automated transit systems.
- Costs, when available.

Closed-Circuit Television

When used as part of a security program for mass transit systems, closed-circuit television (CCTV) can:

- Deter crime and vandalism.
- Reassure passengers of system security and safety.
- Verify alarms or emergency phone calls.
- Provide evidence for the identification of potential offenders through the use of video recordings.
- Monitor station crowd activity.
- Monitor system conditions, operations, and equipment (i.e., lighting problems, litter or weather hazard conditions, equipment malfunctions, etc.).
- Improve response time of police and security officials.
- Aid in the search for lost persons or to assist passengers requiring special assistance (i.e., children, handicapped, elderly, etc.).

Typically, cameras are placed in strategic locations to monitor station areas that are outside the purview of security officers or station attendants or to focus on specific potential crime targets such as fare vending machines. For example, cameras can be installed at station exits so that if a passenger is victimized on a vehicle or station platform, he or she may have an opportunity to press an alarm which simultaneously alerts transit security and activates the cameras which can provide the police with an accurate photograph of the offender leaving the station. In systems with closed station areas (i.e., airports or amusement parks), and in which there is a very controlled environment, CCTV systems are generally used to monitor station crowds or the occurrence of abnormal or unusual events.

The number of CCTV monitors required at central control to view the CCTV cameras may vary considerably, depending on the size and complexity of the system and the primary functions for which the CCTV is installed. Some current operational systems use as many as 32 monitors at central control and require up to three people to constantly monitor TV displays and handle related communications needs. Design considerations for CCTV security systems generally include such factors as:

- Number of monitors per observer.
- Distance from and viewing angle to the monitor TV screens.
- Size of monitor TV screens.
- Constant, sequential, or alarm-activated monitoring capability.
- Fixed or zoom, pan-and-tilt operation.
- Use of dummy and/or active (operating) cameras.
- Purpose of the surveillance function (i.e., security of transit patrons and property or the observation of system operations).
- Scheduling requirements for effective monitoring (i.e., length and number of observation shifts).

Cost estimates for CCTV systems vary widely, according to specific installation requirements or problems and the level of detail and planning in preparing equipment specification orders. A reasonable cost estimate for a three- to 10-camera installation using coaxial cables would be on the order of $1,000 to $1,500 per camera and monitor. (18) Video recording capability could add approximately $1,000 per camera. (18) Since a major part of the cost is installation and maintenance, transit systems could consider leasing rather than purchasing such equipment.

Both technical and human limitations in the use of these devices have been noted by transit systems on which CCTV has been installed. For example, the exposure of the cameras to constant vibration (whether installed at station platforms or in vehicles) deteriorates solid state wiring. Another problem is that CCTV detection rates are a function of the motivation and attentiveness of monitoring personnel. Constant monitoring can result in boredom and fatigue and affect an observer's ability to detect and report a crime in progress.

Another problem is that the likelihood of detecting a crime at all depends on both the presence of an active television scan and the alertness of the central control monitor at the time the crime is committed. Surveillance problems can be compounded if monitors are left unattended while guards perform other required duties. Moreover, CCTV systems are highly vulnerable to vandalism.

Application of and experience with CCTV systems vary widely among the various transit systems that have these devices.

WMATA uses CCTV primarily to monitor ridership behavior on all mezzanines and station platforms. (14, 17) The CCTVs are housed in octagonal metal and glass kiosk booths which are strategically placed just inside the entrances of all Metrorail stations. The booths are manned by civilian station attendants who monitor the CCTVs, the public address system, land-line telephones, fire and intrusion alarms, etc., all of which allow them to sound an early alarm if trouble occurs. With this arrangement, it is essential that the attendants not be required to leave the kiosks, since an offender who plans a crime in advance could create a distraction and then commit a crime while the attendant is preoccupied.

BART uses CCTV primarily to monitor elevator access and to improve passenger safety in stations. (8, 9) For example, if a passenger falls or jumps to the tracks from a station platform, the station master, seeing this on the TV monitor, can shut off the power to that track to prevent a train from coming in until the track is cleared. CCTV monitoring of BART parking lots has had only moderate success. Overall TV scanning of the lot is possible, but there is no zoom lens capability, so that identification of people or license plates is difficult when the monitored object is distant from the camera. In addition to monitoring problems, the response time required for security officers to reach the scene of the crime often minimizes their effectiveness in catching offenders or preventing vandalism or theft of property. As a result, BART security officers prefer human surveillance of the lots from roving police patrols. (8)

The PATCO system has 24 monitors at a central control location. Its surveillance personnel are familiar with all station environments and look only for either motion or abnormalities. (34) However, the security office has found that the CCTV system is only slightly, if at all, more effective than on-site human monitoring. (15) The SEPTA system uses 89 CCTV cameras which are sequentially focused on two sets of 11 monitoring screens. With this sequential system, screen images are in view for only approximately 11 seconds before the next image in the sequence appears. (15)

A unique security system which combines the benefits of CCTV with alarms and communication equipment has been installed and tested by the CTA. The system, known as Teleview Alert (TVA), was designed to counteract the disadvantages of simple alarms and continuous television monitoring by combining the alarm, telephone, and television monitor and public address system into a single unit. The system is an outgrowth of research performed by the city's public works department, which found that more than 64 percent of Chicago's transit crime occurred on rapid transit platforms and that the most needed control unit is an instant and continuing means of alerting the police to platform activity. (44)

In the future, closed-circuit television systems may be invaluable in providing security and operational surveillance capability for automated transit systems because of their high-technology and low-manpower requirements. CCTV is used on the automated transit system in Morgantown, West Virginia. The system employs 32 CCTV cameras and 32 monitors which generally are manned by operators who work as a team to help minimize the problems associated with boredom and fatigue. However, Morgantown uses its CCTV system primarily to improve system safety rather than security. Other key functions provided by the surveillance system include the monitoring of station crowds, equipment, and system operations. In addition, the CCTV observer has other communication-related functons which include public address, radio, and telephone communications.

Another potential application of CCTV systems is to provide surveillance capability on board transit vehicles. This concept is being tested at the Dallas-Fort Worth Airport on the automated terminal shuttle system known as AIRTRANS. (9) If this concept proves to be successful, CCTV installations on board transit vehicles could provide surveillance functions similar to those described previously for station or platform applications.

Radio Communications Equipment

The radio communications equipment available in transit security systems includes various types of voice monitors, intercoms, or two-way radios. These devices generally:

- Provide a fast and reliable means of addressing system-wide problems.
- Reduce the need to dispatch system personnel by corroborating reports of problem occurrences.
- Enable station attendants to answer passenger inquiries and give instructions during emergency situations.
- Permit security officers to monitor public areas outside their viewing range or where CCTV cannot be used.

Two-way radio communication provides a vital security link between headquarters and the officer or mobile patrol team in the field. With radios, security officers are able to call for backup support, notify dispatchers when surveillance or investigation of a problem has been initiated, and alert central control to a potentially dangerous situation.

Typically, each member of a transit security foot patrol unit carries a portable, two-way radio. Mobile units also are often equipped with portable radios in order to allow personnel to maintain communication with headquarters when away from the vehicles. Handie-Talkies have been found to provide the greatest flexibility for coordination between headquarters and dispatched security personnel, although their use may be inadequate for tunnel applications or where large structures may restrict transmission. (10) In addition, access to a separate radio channel, when available, enables transit security personnel to make or receive calls without interference from other transit system employees or visitors who are not placing security or emergency calls. (34)

Voice monitors permit a security officer to eavesdrop on activities outside his viewing range or where CCTV cameras could not be used. When used in conjunction with a public address system, security personnel are able to signal that an incident has been detected. (18)

An example of a sophisticated radio communications network which coordinates these and other communication capabilities is used by MBTA in Boston. In cooperation with the Greater Boston Police Council, the MBTA has installed a comprehensive communication system known as the Boston Area Police Emergency Radio Net (BAPERN). The BAPERN system provides the following capabilities:

- Communication with other members of the transit police.
- Communication with headquarters, including an emergency signal button which, when pressed, signals the dispatcher that the officer is in trouble.
- Communication with the BAPERN Operations Center.
- Communication with all area police departments.
- Communication with individual units in any department. (34)

With this system, potentially thousands of police officers are linked together since each mobile unit and foot patrol is equipped with a four-channel, two-way radio. The cost of the mobile unit radios is approximately $1,750 each, although in smaller quantities, the units might cost $2,200 each. (34) A feature of the unit is a light which will indicate to the mobile unit that a message has been received by headquarters or the dispatcher. While this radio system requires a large initial investment, the MBTA believes that the security and flexibility it affords make it well worth the cost. (34)

Two-way voice communication has potential for application in automated transit systems, since the vehicles and stations in these systems are generally unattended, except for employees responsible for routine maintenance. This type of communication system would allow passengers in vehicles or on station platforms to request and receive information or emergency assistance from central control. Two-way radio systems are designed to provide voice communication between central control and either one vehicle or station or all vehicles and/or stations simultaneously.

Two-way radio communication is employed in WMATA's Metrorail and Metrobus, the Morgantown People-Mover, and the Niagara Frontier Transit System, each of which has equipped its vehicles with intercoms or two-way radios to facilitate communication between passengers and the operating attendant.

In addition to the vehicle intercoms, WMATA uses a telephone patch and telecommunications computer system which serves as central control for information dissemination to and from the field. Metrorail trains, Metrobuses, and transit patrol vehicles are radio-equipped, and all trains have an emergency callbox which passengers can use to sound an alarm to request service. (14) In addition, "blue light" callbox stations are positioned every 800 feet along the rail guideways and can be used to summon help when crimes or transit emergencies occur. Moreover, each patrol officer carries a footman's radio. (14)

Morgantown's MPM system is equipped with a closed-circuit television system which provides radio communication between each vehicle and the central monitoring facility. In addition, viewers at the central monitors can use the public address system to communicate with passengers waiting at any of the station platforms.

The Niagara Frontier Transit System believes that its two-way radio system has been well worth the investment. Armed robbery of operators while on duty has been practically eliminated. Previously, armed robberies averaged one per month. Since radios were deployed, the transit system has experienced only two or three armed robberies per year. Vandalism, "snowballing," and disturbances on buses have also been discouraged by the use of radio equipment. In addition, two-way radio has increased police response to the degree that culprits are often apprehended with the goods. (34)

In view of the experiences of these and other transit security systems, several factors have been identified for consideration in the use of radio communications equipment. Some of these include the following:

- Duplex radio communication systems may be preferable to simplex systems. Unlike the former, simplex systems are designed with a push-to-talk and release-to-listen feature. However, passengers frequently will not release the talk button; hence central control cannot respond to passenger requests. (10)
- Passenger communication controls should be accessible to all potential users, including wheelchair-bound persons and small children.
- Communication systems which automatically provide central control with the identification number and location of any vehicle requesting two-way voice communication provide an important security safeguard for those passengers who panic or are otherwise unable to provide this information.
- Audible voice communication may be precluded in touch-sensitive stripe alarm systems which traverse the entire vehicle interior, depending on the relative distances between the speaker microphone and the stripes. (10)

Experience has shown that two-way radios can aid in detecting, deterring, and apprehending criminals and vandals on transit systems. Unfortunately, this use alone is not always enough to justify costs. However, since two-way radio communication also may be used to increase the reliability of transit system operations, provide public information, and contribute to the safety of passengers in the case of accidents and other emergency situations, the benefits of these combined uses could help justify such investments.

Emergency Phones

Special telephone equipment is available for use in transit system security programs to provide emergency patron assistance. At a minimum, emergency phones provide direct, two-way communication between the passenger and central control or the local police department, and typically are installed in rapid transit stations. (Neither the case studies nor the literature reviewed for this study provided any examples of applications in surface transportation systems or on vehicles.)

In addition, some emergency phones automatically provide the location from which the call is made and are designed with a push button that could be used as an alarm if the victim or witness would like to minimize the risk of retaliation by the offender by not using the handset. (7) As an alternative to the use of special emergency phones, many transit systems have modified their public telephones to permit patrons to "Dial 0" in emergencies without having to use any coins. However, the need for emergency phones separate from public telephones may be justified in large transit systems where heavy use of public telephones may prevent access to telephones during an emergency, if both communication systems are combined.

Emergency phones not only provide direct, two-way voice communication for passenger assistance, but also may help to reduce the time lag between the occurrence of a crime and police notification and arrival at the scene. However, experience has shown that there are some problems which should be considered in the planning and design of emergency phone systems. These include the following:

- A false alarm problem is prevalent among the transit systems that use emergency phones.
- The telephone receiver must be replaced to stop the automatic telephone alarm.
- Telephones are frequent targets for vandalism.
- Victims and witnesses may feel that the actions necessary to use a telephone would attract the offender's attention and further the threat to their safety and well-being. (47)

Several transit systems use emergency phones on their rail station platforms. For nearly 10 years, PATCO has operated a "call-for-aid" telephone at its faregates which is accessible to all passengers on the platform. In addition, PATCO's "call-for-aid" telephones are in view of CCTV cameras whose images are monitored at central control. Similarly, the Toronto Transit Commission completed an emergency phone installation program on its station platforms in June, 1977. Recently, MARTA installed emergency phones on its new rail station platforms.

Public Address System

The use of public address systems (PAs) (in vehicles or on station platforms) in automated transit environments could serve numerous functions:

- Reassure patrons during delays or emergencies.
- Inform patrons of service changes, destination information, system problems.

- Page security or AGT personnel and/or direct them to the location of trouble.
- Warn fare evaders or other system offenders who are detected on CCTV.
- Advise patrons of actions to take during emergencies or when patron problems arise (i.e., locating separated passengers, health problems, etc.).
- Confirm the occurrence of emergencies or problems.

Public address systems have been effective in notifying transit patrons of scheduling or destination information. When used in conjunction with CCTV or other security devices, they could serve as effective security countermeasures as well. Their effectiveness may be increased if central control has the capability to select any one, any combination of, or all station PAs. If at a minimum, PA systems function as described above, they could improve patron perception of transit security as well as reduce the number of crimes.

Two common problems are associated with the use of public address systems. First, PA announcements are often of poor quality or inaudible due to poor station and system design or background noise. Second, the numerous demands and responsibilities of central control personnel during delays or emergencies reduce their ability to provide the advice or information needed to reassure transit patrons.

Cost estimates depend on the details of any particular installation; however, public address systems are relatively inexpensive. (18)

Alarms and Sensors

Alarms are probably the most frequently used and widely accepted hardware countermeasure. In fact, two-thirds of the transit systems in the United States and Canada use some type of alarm mechanism. (34) They are used primarily to attract attention or to summon police or emergency medical assistance. Alarm systems vary in complexity and sophistication, with corresponding variation in price. Overall, these devices are moderate in cost. (18)

A variety of alarms are now in use. For example, "silent alarms" may be used by transit ticket agents to alert police of problems in the station area. "Hidden alarms" are intended to detect intrusion into a guarded area. These alarms can be heard in the immediate vicinity of the protected area (a local alarm system) or only at a remote monitoring center or both. (18)

When response time is the critical factor in apprehending an offender, remote alarms provide the greatest advantage, since they are received directly either by the transit security force or by a dispatcher who telephones the local police. Local alarm systems are not nearly as effective for the following reasons:

- The detection equipment is usually very simple and subject to defect or vandalism.
- Audible alarms can be annoying to neighbors in built-up areas.

- Intruders are not disturbed by audible alarms if the alarm is sounded only when the intruder is leaving the premises.
- On-the-spot alarms may disturb or deter, but rarely result in the capture of the intruder. (18)

Alarms can be activated in two different ways. Sensors detect the presence of an intruder within a protected area and convert the detection into an electrical signal which activates the alarm. Photoelectric beams, microwave/radar, balance pressure, electromechanical switches, vibration, and metal foil are among the types of sensors in use. (18) The second category of alarms is the passenger-activated type which is conspicuously displayed for use by transit patrons. These alarms are often used in conjunction with CCTV and communication devices for direct voice contact. In addition, passenger assistance alarms have on-vehicle as well as station platform applications. For example, Toronto uses passenger assistance alarms in each of its rail cars. (46)

Although alarms may be effective in satisfying public concern for personal security, several problems with their use may restrict their potential, including:

- Witnesses may refrain from using an alarm for fear of drawing an offender's attention.
- Without verification equipment, such as closed-circuit television, alarms may be prone to spurious activation. Inability to distinguish between valid and false alarms could possibly overtax the response capability of the police.
- Response time may be too long.
- The loud noise produced by the alarm may cause an offender to become agitated and harm a victim more seriously than originally intended.
- The exact location of an alarm is not always easily discernible, particularly when there are similar alarms in surrounding areas.
- Because a witness or victim cannot relay information, details regarding an occurrence are not available to police until they arrive at the scene. (47)

Alarms frequently are used by bus systems to aid in crime reduction efforts. Silent alarms or signals such as flashing lights tend to boost drivers' confidence that assistance is available in case of emergencies. However, there are problems with the use of these alarm systems which should be considered.

For example, criminals have the advantage of surprise and, since criminals are well aware that such signals exist, they customarily warn drivers at the outset not to touch anything or make any false motions. The question then becomes whether the driver is willing to activate the signal or alarm at the risk of being injured or killed. Opinion surveys can contribute little to this point because it is not possible to predict how a driver will react under stress.

Another problem relates to the use of a local visual alarm, such as a flashing red light outside or on top of a vehicle. These alarms are the simplest type available for use on a bus and are relatively inexpensive to purchase and maintain. However, their effectiveness is closely linked with the density of police patrols in the vicinity of the bus at any given time.

Photo Cameras

Photo cameras can be used in transit security programs where it is not desirable or appropriate to use CCTV but where some form of evidence could be helpful in identifying and apprehending potential offenders. These cameras are generally hidden and are operated either manually or are triggered by a primary sensing device. Using high-speed film, these cameras have the capability of taking an entire sequence of photos of suspicious or problem occurrences. (34)

An example of their application in transit security programs is the installation of photo cameras on buses as one means of providing driver and passenger security. Typically, such cameras are used in one or more of the following ways:

- To photograph all people who enter a bus.
- To photograph only those pasengers who have aroused the driver's suspicion or who cause problems.
- To photograph persons who enter the bus at night or at the rear of the bus.

At present, the San Diego Transit Corporation successfully uses cameras on three of its buses to provide passenger security and deter vandalism. Since only three of its buses are equipped with cameras, these vehicles are assigned to high-crime routes or, when needed, are assigned as "troubleshooters" on routes where special problems have occurred.

In a different application, WMATA uses photo cameras as part of its revenue protection program. It uses the cameras to monitor unique fare-gate problems or employees suspected of taking money.

Metal Detectors

Metal detectors have two primary functions when used as a security countermeasure: to detect concealed weapons and to prevent theft of protected material. In this capacity, they have been used successfully in airports since the beginning of the 1970s. With the advances in technology, more and different applications of these devices are occurring, including potential use in automated transit systems to detect and deter armed access to public areas.

The detection capabilities of these devices also are improving. The latest detectors have sensors so acute that they can identify a weapon of a certain shape, size, and composition from a collection of other metal objects. (18) Metal detectors also provide a range of detection levels to better respond to changes in the level of real or perceived threat of crime or violence.

The cost of the latest detection systems starts at approximately $5,000 per set and can increase to $30,000 for a central computer-controlled installation. In addition, consulting costs for writing specifications for a special application may run between $600 and $1,500. Maintenance costs may run as high as $100 a month for less advanced systems to as little as $100 a year for the latest detection systems. (18) A completely automated interdiction system could be manned by the regular on-duty security guard, so direct maintenance costs would be nominal. Indirect costs due to false alarms are negligible if only one person out of 20 is delayed, but escalate rapidly when 1,000 or more persons are processed in a short period at a higher detection level. (18)

The potential effectiveness of metal detectors in automated transit environments remains unproved. Their use in busy transit stations could cause many expensive and unnecessary delays. Moreover, the use of these devices may not be warranted since vandalism, petty theft, fare evasion, and rock-throwing are among the most frequent transit offenses and generally do not involve weapons.

Altering System Operations

The ability to respond to emergencies or apprehend offenders on transit systems can be improved by initiating commands that will alter normal system operations. For such situations as abnormal weather, fires, robberies, assaults, etc., commands can be issued to impact the entire system or a small part of the system. The commands may include the following:

- Remote control of exits to stations or to vehicles to open or close doors to prevent anyone from leaving/entering a station or from leaving/entering a vehicle. The potential danger, of course, is bystanders trapped in the company of a criminal. (48)
- Changing route codes or initiating switch overrides to avoid vehicle queues, fires, or to accommodate large crowds. (10)
- Use of vehicle alarms which, when activated or when there is an indication that a criminal has used a vehicle to perpetrate a crime or as a means of escape, would permit the vehicle to be slowed until it is met by security police. (48)
- Removing power from the entire guideway, or appropriate sections of the guideway, when people or foreign objects fall onto the guideway, during evacuation and rescue, or when corrective maintenance dictates the need. (10)
- Issuing stop and start commands to individual vehicles to avoid certain problem areas. (10)

These types of commands are typical of automated transit systems and, in fact, are available for use on the Morgantown People-Mover system.

Automatic Vehicle Monitoring Systems

Automatic vehicle monitoring (AVM) is the electronic technology that gathers data on bus activity by means of a radio link to a central computer. Each bus in the system is "interrogated" at regular intervals, and the equipment on the bus responds automatically with such information as location, distance traveled, and the number of passengers carried. In addition, the system provides an emergency alarm signal and a voice channel for the driver.

Each bus in an AVM system carries a radio transmitter. Beacons, which allow the computer to gather information from each bus, are mounted on poles along the streets of the service corridor. The transmission range of each beacon can be limited so that they do not overlap.

A significant benefit of this new technology system is the easy and accurate collection of data on the daily operation of a transit system. The data are then compiled and analyzed by computer and summarized by day, week, season, weather, or related parameters. These data provide planners with detailed, "real-time" facts, useful for schedule revisions and route changes. However, AVM system effectiveness as a security countermeasure has not been empirically tested.

Several transit systems are experimenting with the use of AVM to improve bus system operation and security. The NYCTA has installed a bus locator in its 220-bus Queens Village Depot. (34) The locator has an emergency button which is placed behind the bus driver's normal foot position on the floor. This signal alerts dispatchers to an emergency condition on the bus. Because of congestion in the radio frequency, drivers have a "request to talk" button on the microphone, which, when pressed, establishes their bus number and a priority list in front of the dispatcher. There also is a *priority push-to-talk* button that the driver may use if he has a more urgent message, which places his bus number at the top of the list of drivers waiting to talk to the dispatcher.

The SCRTD is testing the use of an AVM system in 200 buses over a 400-square-mile sector of its service area. (34) The SCRTD "Multi-User" AVM system is comprised of three primary subsystems. The *location subsystem* consists of all of the on-vehicle electronics, including the silent alarm switch and the priority push-to-talk button. The *communications subsystem* consists of mobile radios, base station radios, and communications links to the central control center, all of which could be used in case of a security problem or emergency. The data processing subsystem includes the AVM minicomputer, display consoles, and a management information element.

The AVM alarm system automatically places buses with *active* silent alarms into a priority polling queue which causes their location and status to be polled once every 10 seconds until acknowledged by central control. By using a polling queue system, up to four buses can have their silent alarm status detected within less than 10 seconds. (34)

3.
Transit Security Case Studies

A case study approach was used to assess the use and effectiveness of electromechanical security devices in various transit environments. This approach was necessary in view of:

- The limited available documentation of experience with the use and application of electromechanical security devices in transit environments.
- The paucity of data regarding observed effectiveness of these devices in reducing crime and improving passenger perception of transit security.
- The lack of information regarding the state-of-the-art of transit security planning in general, and transit security devices in particular, especially since many of the devices used are either relatively new inventions or have only recently been used in transit environments.
- The lack of information with regard to related automated transit system security issues.

Ten transit systems were selected for study, including both rail and bus operations. The case studies are characteristic of medium-to-large urban transportation systems on which crime is a significant problem. The methodology for selecting the 10 transit system case studies and for conducting interviews is presented in Appendix A. The systems selected include:

1. Morgantown People Mover.
2. Washington Metropolitan Area Transit Authority.
3. San Diego Transit Corporation.
4. Port Authority Transit Corporation.
5. Bay Area Rapid Transit District.
6. Toronto Transit Commission.
7. New York City Transit Authority.
8. Southern California Rapid Transit District.
9. Chicago Transit Authority.
10. Metropolitan Atlanta Rapid Transit Authority.

The case studies were conducted using a two-fold approach of literature search and system interviews. The literature search provided:

- Background information on basic characteristics of each transit system.
- General information concerning the state-of-the-art of transit security devices.
- General discussion of possible applications of these devices.

The interviews expand this data base by providing:

- Inventory of devices currently used and their actual applications at transit stations or on vehicles.
- Experience of transit systems in securing programming in general and with security devices in particular, i.e., problems, advantages, disadvantages, etc.
- Assessments of the use and effectiveness of security devices.
- Crime statistics or other data that support the perceptions of effectiveness of the various devices employed.
- Comments and recommendations for improvements in the state-of-the-art.

For each of the transit systems investigated, the persons in charge of transit security were interviewed with regard to their experience with and general understanding of the various devices available. In addition, since a meaningful assessment of electromechanical security equipment also must examine its role within the full context of a transit security program, the case studies discuss the nonmechanical/electrical security countermeasures that are used and how security hardware, manpower planning, and design elements of each program are integrated.

The literature search and case study interviews provided information concerning the security programs and experiences of each of the selected transit systems. This information is summarized for each transit system using the following outline:

- System Background
- Electromechanical Security Devices
- Other Security Countermeasures
- Agency Assessment and Evaluation

Morgantown People Mover

System Background

The Morgantown People Mover (MPM) is unique among the case studies reviewed in this report in that it is an automated transit system currently operating in a transit environment. The MPM project was sponsored as a U.S. Department of Transportation Demonstration Project to determine the economic and technical feasibility of automated transit technology. MPM transportation services were initiated in October, 1975, covering three stations along its service route. The system was closed between June, 1978 and July, 1979 to modify and upgrade equipment, to revise system operations, and to remodel and expand the number of stations.

Today, the people mover system serves the Morgantown metropolitan area by providing reliable and safe transportation services between downtown and the campus of the University of West Virginia. It serves this area with a fleet of 71 vehicles that operate between five stations, one downtown and four in the university area.

The MPM carried a total of 3,038,000 passengers in fiscal year 1979-1980 and provides services for an average of 14,000 passenger-trips per weekday. Much of this ridership consists of university students and employees, campus hospital and medical university staff, and persons who work and live near MPM stations.

The system observes the following operating schedule:

- Sunday — 9:30 A.M. to Midnight
- Monday through Thursday — 6:30 A.M. to Midnight
- Friday — 6:30 A.M. to 1:00 A.M. Saturday
- Saturday — 9:30 A.M. to 1:00 A.M. Sunday

University students may purchase magnetically encoded fare cards that allow them unlimited travel on the system. All other patrons may purchase fare cards from banks, bookstores, or MPM offices for 25 cents per trip or deposit the required amount of money in faregate machines.

Electromechanical Security Equipment

The Morgantown People Mover provides passenger security through an integrated system of surveillance devices. All MPM stations are equipped with 32 fixed-turret CCTV cameras which provide constant monitoring capability over station platform areas. (1) The system uses 32 CCTV screens at central control which are monitored primarily by one operator, but which are generally manned by three operators who work as a team. (10)

In addition, the CCTV system incorporates related communications functions. Two-way radio communication is available between each vehicle and the central monitoring facility. (10) Passengers have two-way voice communication with central control by means of a push-button phone located in every car. (7) Still another component is a public address system which can be used by monitors at central control to communicate with passengers waiting at any of the station platforms.

Another security feature of the MPM is the ability of central control to alter system operations. In other words, MPM central control is equipped with a power distribution control panel which allows a response to emergencies or apprehension of offenders by initiating a command that will alter normal system operations. The types of commands that can be issued via this system include:

- Stop and start.
- Remote control of station or vehicle exits.
- Route changes.
- Activation of alarms.
- Interrupting power to all or part of the guideway.

Security alarms also are installed on all MPM vehicles. These alarms are used primarily for vandalism detection and deterrence, and are wired to interior access panels, lighting fixtures, fire extinguishers, and the like. When the alarm is activated, the vehicle tampered with relays a message back to central control.

Other Security Countermeasures

To provide some means of fare protection for both passengers and the MPM, fare cards can be purchased in advance for 25 cents. However, the faregates are capable of receiving either cards or coins.

The MPM has no transit security or police force of its own. However, when problems do arise, the MPM calls on the university security force or the local police for assistance.

Agency Assessment and Evaluation

Crimes against persons or personal property are not a problem on the MPM. In fact, the integrated CCTV/communications system is used primarily as a safety feature to detect people or animals on the guideway or in station platform areas. In this function, the system is effective in monitoring station crowds, equipment, and system operations. (1)

MPM statistics do show a gradual increase over the years in vandalism, which is the only crime of any consequence on the system to date. Much of this increase in vandalism is attributable to the extension of service operation hours from 9:30 P.M. to midnight. However, the greatest rise in the vandalism rate occurred shortly after the change in operating hours and has since fallen off. Of the vandals apprehended, half have been juveniles from nearby communities or other persons not associated with the university. The vehicle alarm system has proved to be effective in detecting instances of vandalism and, in some cases, has assisted in the apprehension of vandals.

Although the capability for altering system operations has been used in a few cases of suspected imminent security problems, it has been used primarily to carry out routine maintenance or other system operations functions.

Washington Metropolitan Area Transit Authority

System Background

The Washington Metropolitan Area Transit Authority (WMATA) is a public agency created in 1966 through an interstate compact approved by Congress. The Authority has the responsibility to plan, construct, finance, and provide for the operation of rapid rail (Metro) and bus (Metrobus) transit systems for the Washington metropolitan area. Its service area includes the District of Columbia and contiguous areas of Maryland and Virginia.

WMATA initiated rail service on March 27, 1976 with the provision of more than 51,000 free rides on its (then) 4.5-mile, five-station Red Line service route. The first day of revenue service was March 29, 1976, when 19,913 passenger-trips were carried. By 1980, with 37 miles of track, 41 Metro stations, and approximately 292 rail cars in operation, rail ridership averaged 300,000 persons on weekdays. Rail service is provided on the following schedule:

• Monday through Friday	6:00 A.M. to Midnight
• Saturday	8:00 A.M. to Midnight
• Sunday	10:00 A.M. to 6:00 P.M.

Metro headways average three to six minutes during rush hours and six to 12 minutes at all other times. When completed, Metro will have 100.84 track miles, serve 86 stations, and provide 55,259 park-n-ride spaces.

Major bus improvements in the Metrobus system also were made as a result of the creation of the transit authority. The service was refined and expanded, the bus radio communication system was improved, new buses were purchased to replace older vehicles, special services for the elderly and handicapped were initiated, equipment was acquired to accommodate larger passenger volumes, and the transit information system was improved. In 1980, the fleet consisted of approximately 2,000 buses. The weekday ridership for that year averaged 480,000 regular trips and 55,000 school trips, for a total of 535,000 trips. Metrobus operates seven days a week, 24 hours a day.

The high level of demand for service on the transit system appears to indicate that people accept the system and feel reasonably comfortable and safe using it. In fact, since WMATA took over public transit in the Washington area in 1973, overall transit ridership has increased by more than 23 percent. (51)

However, WMATA has experienced some increase in crime on both its rail and bus transit systems. On Metrorail, there was a 33.2 percent increase in crime in 1980 over the previous year or about 851 reported criminal acts for calendar year 1980 as compared to 569 for 1979. Crime on the Metrobus system increased 20.7 percent, representing a total number of criminal acts for 1979 of 318 as compared to 401 for 1980. (50)

However, in the context of increased ridership and the eastward extension of Blue Line stations and parking facilities, this increase in criminal acts is not considered excessive. In fact, the average daily ridership—bus and rail total—was 524,059 in fiscal year 1979. (50) During fiscal year 1980, public transit ridership in the Washington region increased 35.4 percent, reaching an average daily total bus/rail ridership of 810,000.

No murders or rapes have been reported on Metrobus or Metrorail. Of the 675 arrests on Metrorail facilities during fiscal year 1980, 182 were for fare evasion and 60 for disorderly conduct. Of the total arrests, there were only 31 assaults, 15 larcenies, and 25 robberies. On Metrobus for calendar year 1980, there were 1,019 arrests, of which 250 were for fare evasion, 119 for drinking, 197 for smoking, and 84 for disorderly conduct. Of the total arrests, there were only 10 assaults, seven larcenies, and 18 robberies.

Electromechanical Security Equipment

WMATA's electronic and mechanical surveillance network is among the most sophisticated and extensive on any public transit system. All Metro stations are equipped with closed circuit television, which eliminates station blindspots for Metro police or attendants who view the platform areas from monitors at central control. At least eight cameras scan every platform (some have as many as 12) and, because fares are automatically dispensed by machines, transit clerks only have to observe monitors in station kiosks. The cameras provide constant monitoring of platforms and have zoom lens and pan-and-tilt capability. WMATA also employs a portable CCTV, which is used primarily to survey employees as part of its revenue protection program.

Station attendants have direct access to Metro's central control room through a private telephone network that has a 2,000-line capacity. Central control supervisors can notify Metro police officers at the touch of an intercom button. All transit police have two-way radios and are allowed to ride trains and buses free of charge. Should outside help be necessary, Metro police officers can reach any of the region's many law enforcement agencies, including the FBI and Secret Service, at the push of a single hotline button.

Station attendants also have access to a public address system which is operable from either the station kiosks or from central control. The system uses a low-level distribution with many amplifiers which feed sound through hundreds of closely-spaced, low-volume, high-fidelity speakers in each station. When necessary, the system can be used to provide patron assistance information or to advise patrons of security or safety problems or emergency situations.

Trackside telephones are positioned every 800 feet along the Metro right-of-way. Called blue-light stations because of the identifying light over each box, the telephones serve a three-fold function:

- Provide emergency communication to central control by Metro employees.
- Link track maintenance crews with other nearby crews.
- Function as an in-house telephone system for normal operational calls. (51)

Station intrusion alarms and fire alarms also help to maintain WMATA's goals for high security and safety standards. In addition, train dispatchers can slow or even stop trains to gain time for police to arrive.

During calendar year 1980, WMATA installed a microwave alarm system designed to offer additional tampering and burglary protection for the automatic fare collection equipment in nine stations. The Authority will conduct a one-year test of the equipment to evaluate its effectiveness and determine the feasibility of its installation in other stations. At the close of calendar year 1980, WMATA also placed in service a portable fare card verifier (reader) designed to decipher information that is magnetically encoded on fare cards. (50) This instrument will aid the transit police in identifying ticket value, points of entrance/exit, and to assist in the investigation of fare evasion offenses. (50)

Metro's on-vehicle security devices also provide security and emergency assistance for patrons. In the event a problem occurs, passengers have access to an intercom box located at the ends of each train car. At the push of a button, passengers are provided with immediate, two-way communication with the train operator. The operator then relays messages to central control by means of a radio system that provides effective communication both above and below ground. The train operator also can inform and/or instruct passengers via the train's public address system.

WMATA buses also are equipped to provide for the safety and security of patrons and employees. All Metrobuses are provided with silent alarms as well as a toggle ring of flashing lights around the front of the bus that can be activated to alert police in the area. The buses are also equipped with two-way radios to provide direct communication between Metrobus operators and central control dispatchers.

Other Security Countermeasures

WMATA stations were carefully designed with consideration for the safety and security of passengers. Tunnels have coffered arches with recessed walls that are accessible with difficulty to graffiti artists. Platform areas are designed to provide clear sight lines (no concession stands or dark recesses), and most platforms have only one or two exits.

Bullet-resistant station kiosks have been installed in Metro stations. The kiosk attendants have been targets of several robbery attempts. However, since these perpetrators are discovering that attendants do not handle any money, WMATA officials believe that this type of crime will become rare. (20)

Moreover, although trains operate automatically in normal service, a trained operator sits at the control console, opens and closes doors, announces upcoming stations, communicates with central control, and performs numerous other tasks. However, the operator's first responsibility is the well-being of passengers, which may number more than 1,500 on an eight-car train during peak travel periods.

Last, the WMATA security program is concentrated on its transit police force of 280 officers. Each officer must pass a rigorous 26-week training course which includes the FBI firearms program, knowledge of the laws of all 29 jurisdictions served by WMATA, and emergency medical training. The Metro Transit Police Force is a unique police department in that it is the only non-federal, multi-jurisdictional transit police force in the United States with concurrent authority to enforce applicable state statutes as well as local ordinances of municipalities within the transit zone. (14) The department's primary rail security tactic focuses on the use of highly visible patrols for trains and station platform areas to create an aura of passenger security through conspicuous police presence. In addition, since officers are allowed to ride buses and trains to work free of charge, some degree of extra off-duty police protection is provided at no additional cost to the Authority.

To meet the objective of high visibility, security personnel are deployed in a variety of ways, both overtly and covertly. The following deployment strategies are employed to help combat crime on the system:

- Fixed posts or the assignment of patrol officers to a given station.
- Riding posts or train patrols.
- Mobile, random patrol or the coverage of multiple stations.
- Saturation patrol or the substantial increase in patrol manpower at a given location to maximize visibility.
- Decoys or the deployment of officers posing as potential crime victims.
- Stakeouts or covert surveillance.

The transit police department also effectively employs highly-trained decoy officers, referred to as the "power squad." K-9 patrols are used only for specialized problem cases (i.e., in situations involving bombs or narcotics).

Agency Assessment and Evaluation

To date, WMATA has not conducted any studies nor collected any data which directly correlate security program impacts with the use of individual security devices, deployment strategies, or other security countermeasures. Case studies of the effectiveness of various devices now used on the system are presently being conducted, and results are expected sometime in 1982. However, several facts are available which demonstrate the effectiveness of elements of the WMATA security program:

- In response to an increase in burglaries or break-ins involving fare vending machines in calendar year 1980, an increase in transit police surveillance activities on an overtime basis at selected Metrorail stations resulted in 56 arrests. (50)
- As a result of transit police surveillance coupled with electronic surveillance equipment and improvements to the automatic fare collection equipment, arrests on Metrorail for fare evasion decreased by 38 over the previous year. Arrests on Metrobus for fare evasion decreased by 436 over the previous year. This indicates a decrease in this type of crime. (50)

- In several instances, Metro communications have aided in the capture of suspects in robberies committed against local citizens and businesses. (51)
- Intercoms on train cars have been used primarily for medical emergencies. (26)
- The high visibility of Metro police plays an important role in WMATA's low transit crime record. Success in deterring crime is due, in part, to starting out with and maintaining high-visibility patrol forces; it is also due to an excellent decoy police division. (17)

As a result of the experiences of its transit police department with the use of security devices, WMATA officials expressed preferences for specific capabilities or features of these devices. For example, experiments with the use of dummy CCTV cameras has proved them ineffective, since their use incorrectly supports the contention that perpetrators have a low mentality. Since criminals quickly become aware that such cameras are dummies, WMATA does not use them. Moreover, due to the state-of-the-art of on-vehicle camera technology, WMATA does not use them either on its trains or buses. On the other hand, WMATA's experience with portable cameras and fare card verifiers has proved them to be an effective part of a revenue protection program.

San Diego Transit

System Background

The San Diego Transit Corporation (SDT) was established in July, 1967, as a public system owned by the City of San Diego to provide service to the city and, under contract, to other jurisdictions within the metropolitan area. Since its creation, the SDT has been nationally recognized within the industry as an innovator in the implementation of new, more effective service plans and operating techniques. SDT efforts include such programs as a telephone information service, Project Ready Fare, and pioneering efforts with RUCUS (a computerized bus scheduling procedure), bus radio communications and emergency alarm systems, and a telecamera security program.

The SDT service area is roughly 350 square miles and covers nearly all of metropolitan San Diego. The service area population was estimated at 1,238,900 in 1980. During fiscal year 1980, the system carried an estimated annual ridership of 34,303,750 persons or an average weekday ridership of 110,000 passengers. The system provides service to the metropolitan area on a fixed-route, fixed-schedule basis comprised of 33 routes with more than 573.5 route miles. In the 573.5 line-miles of service, there are approximately 3,850 bus stops. As of March 1, 1980, SDT had a total bus fleet of 365 vehicles and operated 241 buses in peak-hour service.

Three primary elements contribute to the system's security program. First, SDT credits its bus operations and maintenance program, in part, for providing improved passenger safety and security on buses. The second element which contributes to passenger security is the two-way radio communications system which includes an operator-activated emergency alarm. Third, SDT initiated a test program of placing film cameras on three buses in fiscal year 1977 to help reduce vandalism costs and increase passenger security. These and other security countermeasures employed by the system are discussed below.

Electromechanical Security Devices

Cameras (both video and film) are now available for use as a crime deterrent in specialized security applications. SDT first proposed the use of these cameras on board buses to help reduce the cost of vandalism and improve passenger security. After numerous stages of testing and development, SDT installed experimental cameras on three transit buses in mid-summer 1976.

The cameras are operated either by a button pressed by the driver, which provides a three-second picture of the passenger area, or by the driver's floor emergency alarm, in which case the camera will run for three minutes and use its entire quantity of film. The camera films are sensitive to a wide range of light levels so that the identity of passengers anywhere in the bus is probable despite extreme variations in light conditions. The telecamera systems are designed to withstand continuous vibration and road shock and are fully encased units with an armored cable to make them vandal-proof. Along with the security warning signs that are strategically located throughout the bus, a continuous red light on the face of the camera enhances its deterrent effect. An indicator light in view of the driver only signals whether or not the camera is recording.

Passengers also are protected by a two-way radio communications system that is installed on all SDT buses. This system also incorporates an operator-activated emergency alarm. Together, these systems enable SDT to summon emergency health care or security assistance. In addition, SDT provides bus flasher lights in the event of emergencies.

Other Security Countermeasures

Like most surface transportation systems, San Diego Transit has no police or security force of its own. Instead, the SDT is provided with emergency assistance by local medical, fire, and police departments with whom they have shared a successful and cooperative relationship. In addition, periodic surveillance is provided by the city police department through random deployment of plain-clothes detectives on buses.

The SDT attempts to improve passenger perception of security by posting signs in its buses which warn riders that surveillance is being conducted by camera and/or plain-clothes policemen.

Agency Assessment and Evaluation

San Diego Transit initiated the telecamera program with two primary goals: (1) to reduce SDT's $54,000 annual cost for seat vandalism repair and (2) to increase passenger security. (33) At the conclusion of the demonstration test program, the telecamera system exceeded all expectations and proved to be an invaluable investment. During the test period, there was virtually no seat vandalism. In addition, many driver reports validated the positive effect the cameras have on behavior problems such as driver harassment, smoking, and loud radios. Although SDT has its share of rowdyism and malicious mischief, there were no reports of problems on the three buses equipped with cameras.

The camera-equipped buses stimulated new passenger enthusiasm by creating an added feeling of security. Several volunteer phone-in and write-in reports have been received from the public praising the transit system for its efforts and expressing the hope for more camera-equipped buses. In fact, since the camera systems have been so well received by the public, have proved effective against vandalism and behavioral problems, and have had no significant mechanical or operational difficulties, SDT is planning to obtain 205 of these cameras as soon as funding permits. (33)

Port Authority Transit Corporation

System Background

The Lindenwold Hi-Speed Transit Line is a 14.5-mile rapid rail system which links areas of Camden, New Jersey, with central Philadelphia. It serves these areas through six suburban stations, four center-city Philadelphia stations, and two Camden stations, all providing convenient pedestrian access in congested areas. The system operates 24 hours a day, seven days a week, 365 days a year. On a normal weekday, it operates 338 one-way revenue trips. From 5:45 A.M. until midnight, the longest interval between successive trains is 10 minutes. During morning rush hours, this headway is closer to three minutes; during evening rush hours, it is two minutes. From midnight until 5:00 A.M., there is a train every 30 to 60 minutes, depending on travel demand.

The Lindenwold Line was constructed by the Delaware River Port Authority and is operated by its wholly-owned subsidiary, the Port Authority Transit Corporation (PATCO) of Pennsylvania and New Jersey. The system began operation on January 4, 1969, between Camden and Lindenwold and on February 15, 1969, to Philadelphia. On its first day of operation into Philadelphia, there were 14,850 paid fares. By the end of four years, PATCO was transporting an average of 42,000 riders per normal weekday. In 1980, it transported a total of 11,333,941 fare-paying passengers. Moreover, convenient parking with good road access is a feature of all six suburban stations which accommodate approximately 7,500 parked cars every weekday.

The Lindenwold Line is unique in that it was one of the first highly-automated rapid transit systems in North America. Pertinent features of this system are as follows:

- Trains are dispatched automatically at terminals at the beginning of each run. Trains are capable of being operated at full performance levels in both manual and automatic modes, assuring dependable service to the user.

- Automatic train control (ATC) always ensures safe maximum train speed and a safe distance between successive trains.
- The automatic signal system sets up routes and signals in advance of each train.
- Automatic change-making machines and ticket vendors supply passengers with magnetically encoded tickets in unattended passenger stations.
- Automatic fare collection (AFC) gates regulate passenger entry and exit to and from stations.
- Trains pass through an automatic car washer twice a week.
- Automatic supervisory control systems monitor central electric power and signal protective systems. (19)

This automated system has been so successful that today it operates efficiently with a small work force of only 309 employees. However, the success of the system has created some problems. Trains which are designed to carry 500 to 550 passengers comfortably are regularly carrying 800 to 850 passengers. Also, parking space is inadequate to receive and store the automobiles of all commuters using the system. For example, it is almost impossible to find a vacant parking space at Lindenwold Station by 8:15 A.M., a station constructed with the capacity to park 2,753 automobiles. All of the station parking facilities have been expanded, and at present, there is no opportunity for further expansion except to construct multistory parking structures.

Electromechanical Security Equipment

PATCO stations are unattended, and fares are collected through an automatic fare collection (AFC) system.

Since there are no station attendants or cashiers, all fare collection areas are under CCTV surveillance 24 hours a day, seven days a week, to protect against vandalism and fare evasion and to assure passenger security. Ticket vendors and change-making machines are built of three-sixteenth-inch steel plate, using safe-type construction and locking mechanisms. In addition, two roving supervisors are employed to ensure that all equipment is functioning properly and to report any defective equipment. One of two TV monitors covers PATCO's 12 stations via CCTV plus a public address system and a private call-for-aid telephone system to communicate with patrons.

Anyone loitering about a station is easily detected and would be advised by the TV monitor through the public address system to move along. The AFC system with its associated CCTV and public address system cost about $1,600,000. For a conventional attended-fare system, cashiers and supervisors would require an annual payroll of well over $600,000. Thus, the AFC would pay for itself in three or four years, after accounting for $100,000 to $200,000 in annual AFC operating costs.

Inquiries or calls for emergency assistance are handled through the call-for-aid telephone. This is a dial phone, painted red, clearly marked, and adjacent to the first gate of each fare control area. It is part of the private dial-operated PAX system and is not connected with the Bell System. The passenger has only to dial 11 for emergency assistance or problems with the AFC system. These calls are answered by the CCTV monitor.

The TV monitor program not only includes the PAX telephone system, the public address system, and the usual Bell Telephone system, but also has access to the PATCO short-wave police-band radio. If vandalism is observed or suspected, PATCO police can be summoned at once. The Center Tower control complex in Camden also has a "hot line" to the Philadelphia Police Department dispatcher. This leased Bell System line is used by pushing a red button on a conventional Bell System phone. The Philadelphia dispatcher responds immediately to these calls.

On its trains, PATCO provides a Trainphone in each cab. The phone has four channels:

1. Intra-train public address system.
2. Train to dispatcher at central control.
3. Train to another train.
4. Dispatcher to passengers using the public address mode.

Thus, the dispatcher can be in constant contact with each train and its passengers.

Other Security Countermeasures

In addition to the above devices, PATCO effectively employs several non-technology oriented security countermeasures. First, all trains are operated by a one-man crew, regardless of the number of cars in the train. PATCO officials recognized from the beginning that it would always be necessary for operators to be aboard every train to take charge in case of emergencies. Second, the cab of PATCO cars is only partially enclosed, much like a PCC streetcar. The train attendant is in constant view of passengers, thereby providing a psychologically reassuring presence.

A third security measure is provided in the design of stations. The six suburban stations are bright and cheerful with good visibility from the outside. A police officer on patrol can see into the lobby of the station and also can see passengers waiting in the headhouse at the top of the escalator. The generous use of glass insures visibility and contributes to the passenger's sense of well-being. In addition, parking lots which serve these stations are all paved and well-lighted, providing apparent safety and convenience.

Fourth, no PATCO employee (other than armed revenue collectors) carries or handles money. The revenue collectors work in teams of two or three. At the same time, they are under full view of the TV monitor when servicing fare collection equipment, thereby providing another measure of security.

Much of PATCO's security efforts, however, are concentrated on a fifth measure—its police patrols. PATCO has a bi-state legislatively-created police department with full police powers on PATCO property in both New Jersey and Pennsylvania. The PATCO force consists of 25 officers who operate on a 24-hour, seven-day week basis. The officers work in squads of four which patrol the line and stations by train, by police car, and on foot.

Each squad consists of a sergeant, two patrolmen, and a K-9 dog handler. In addition to their other duties, these K-9 patrols are effectively used to patrol late night "owl" trains between midnight and 5:00 A.M. The PATCO force deploys both uniformed and plain-clothes or decoy officers in its efforts to prevent crime and apprehend suspects. Officers are equipped with walkie-talkies and have access to a two-channel radio communications system.

Agency Assessment and Evaluation

Crime on the Lindenwold Line is of growing concern to PATCO administrators. Crimes against persons on the system are relatively infrequent. However, the most troublesome security problem is crimes against patron property, particularly motor vehicles. PATCO provides more than 10,000 parking spaces which are filled to an average of 90 percent capacity each weekday and account for more than two million automobiles parked on an annual basis. With this volume of use, PATCO is experiencing an average of about 15 automobile thefts each month, plus other auto-related crimes.

PATCO officials strongly believe they have a good security program. However, they are just now establishing a statistical data base to enable them to evaluate the effectiveness of security measures. There are several cases in point which indicate the effectiveness of the security program. First, thefts of fare receipts or money from change makers have been negligible to date, and only a few change makers have been slightly damaged by would-be thieves. (49) Second, the few instances in which the hot-line radio communication network was used resulted in the arrival of squad cars at the PATCO stations within two minutes of the call. (30)

The effectiveness of PATCO's police force also has been demonstrated in several instances. Vandalism of PATCO property has been kept to a minimum. Two professional car theft rings have been caught in PATCO lots. (30) Moreover, PATCO decoy and plain-clothes officers have been responsible for apprehending hundreds of men charged with indecent exposure, which is the most common crime committed in the subways. (21)

Bay Area Rapid Transit District

System Background

The Bay Area Rapid Transit District (BART) has a service area population of 2,377,800. The transit system links San Francisco and the East Bay via the Transbay Tube with a network of 71 miles of track and 34 stations. Each day, BART riders average greater than 135,000 trips. In fiscal year 1979-1980, BART provided 41,191,566 passenger-trips covering 500,221,000 passenger-miles.

BART has a fleet of 447 vehicles, of which an average of 270 is operated during peak hours. BART's operating hours are Monday through Friday between 5:30 A.M. and midnight plus weekend service. Peak weekday travel hours on the system are between 7:00 and 9:00 A.M. and 4:00 and 6:00 P.M. Forty-eight percent of BART ridership travels the system during these four hours. During the day, 10 trains per hour per direction pass through each station. From 7:00 P.M. to midnight, there are three trains per hour through each station in each direction.

Parking is provided at 26 of the 34 stations in the system. Free parking is available at each except the Lake Merritt Station where parking costs 25 cents. Bike racks are also available at all stations except downtown Oakland, San Francisco, and Berkeley. A BART permit lets cyclists take their bikes on board vehicles during non-rush hours.

Commuting to and from work is the most common trip purpose on BART, involving almost three-quarters of the daily patrons. The number of senior citizens riding BART on a given day equals approximately five percent of daily ridership. (11) Handicapped patrons and children represent less than two percent of daily patronage. Fares are posted on information charts at all stations. Discount tickets are available for senior citizens 65 and older and for children five to 12 years of age.

A gradual increase in crime on the BART system has been of growing concern to the transit police department. Burglaries rose 13 percent, from 288 incidents in the first quarter of 1980 to 325 for the same period in 1981. Robberies have increased from 36 incidents in 1980 to 52 incidents in 1981. There was a 26 percent increase in auto thefts for the first quarter of this year as compared to 1980. In fact, BART statistics reflect the loss of an average of one car per day from station parking lots. (8) Rapes have increased by 250 percent from two incidents in the first quarter of 1980 to seven for the same period in 1981. However, it should be noted that this increase represents a crime rate of only 0.61 per million passenger-trips on the system.

Electromechanical Security Equipment

BART is unique among the case studies because its current security program reflects its early experience with the problems of high-technology security measures. The result of this experience is that instead of increased use of electromechanical security devices, BART is now concentrating its security efforts on its transit police force. The devices that are used primarily serve in a support capacity for transit police as well as in system maintenance and operations functions.

Between April and October of 1978, BART initiated a pilot security program in eight of its stations to test the use of an integrated audio/video communications system, referred to as remotely staffed stations or RSS. BART's RSS program was an operating concept which provided passenger assistance by means of a remotely located agent using closed circuit television monitors, public address and telephone communications, and various remote operating functions.

Because of a range of problems, including security gaps and inefficiencies, equipment malfunctions, union problems, employee sabotage, and station design and architectural problems, the RSS program at all eight stations was abandoned. Some CCTVs are still operable at the downtown and North Berkeley stations and at entrances and exits for the elderly and handicapped. However, the CCTVs are used to make periodic equipment operations checks and not for security purposes. The ineffectiveness identified with the RSS program will be discussed in greater detail in the program evaluation section.

At present, the *on-vehicle* security devices available include push-button intercoms on trains and a public address system to provide passenger service or safety information. BART also has the capability to alter system operations by closing doors or delaying trains. However, this capability is seldom used for security purposes, and in the past, such requests were seldom acknowledged. BART feeder service buses are equipped with an emergency alarm system referred to as MODAT.

Station security devices include the provision of push-button emergency phones to request assistance from station booth attendants. In addition, BART uses a sophisticated data acquisition system (DAS) to protect its fare equipment. DAS is a type of sensor that registers when the system is damaged or broken into, malfunctions, or incurs instances of misuse such as the issuance of too many fare cards of a certain value or quantity. As a further security measure, all station booths are equipped with alarms.

Other Security Countermeasures

Like other rail rapid transit systems, BART's security efforts are concentrated in its transit police force. Initially, the protection and security of BART patrons were to be provided by the local police departments of the various jurisdictions served by the transit system. However, these local police departments contended that they had already inherited parking and traffic enforcement problems in areas surrounding BART stations and refused to accept further responsibility for the security of BART property, system personnel, or passengers. (15)

As a result, the BART administration authorized the creation of a BART transit police department which consists of a 100-man force of police officers.

These officers perform all police functions related to the system, including routine station and train patrol, revenue collection, protection of patrons, employees, and property, and surveillance of station parking facilities. BART police use both uniformed and decoy or plain-clothes officers. K-9 dog teams are no longer used on the system, although recommendations have been made by the BART police force to reinstate K-9 use by 1982.

A radio communications system is available to all officers. Although the radios themselves incorporate the best technology available on the market, the communication network has some problems: dead spots, poor antennae connections, and maintenance difficulties. The transit police department also has recently instituted a public education program in the schools to improve the public's perception and awareness of available transit security measures.

Agency Assessment and Evaluation

When BART initiated its RSS pilot program in early 1978, there was optimism about its success. This was reinforced by a preliminary test of the system which confirmed its effectiveness as a transit security measure. However, unlike the newer systems of WMATA in Washington and MARTA in Atlanta, BART did not have the benefit of prior experience in the planning and design of its RSS system. As a result, the program encountered a variety of problems, not all of which related to the state-of-the-art.

First, the architectural design of stations did not lend itself to the most effective use of audio/video technology. The CCTV could not be used to survey many areas of station platforms, and dead spots were frequently a problem in subway station communication lines. Second, employee sabotage, whether intentional or not, was also a significant problem. All too frequently, alarms were ignored, and requests for assistance were not reported by central control. This problem was compounded when employees began using the alarm system to report that they had arrived for work. Union difficulties also became a problem when members feared they would be replaced by machines.

Unfortunately, the problems with the RSS program did not end here. The design and operation of the system itself resulted in additional operator inefficiencies. First, the RSS operators spent 45 percent of their time talking on the emergency phones, primarily assisting patrons with ticket/money problems. (2) Second, based on a study of monitors' *actual* viewing times and behavior, it was found that:

- There was only a 17 percent chance that a problem occurring in the faregate area would be observed.
- Problems occurring outside the faregate area had only a two percent chance of being viewed.
- Even if a problem were viewed, the monitor often failed to identify it as a problem because he/she was watching four monitors simultaneously and talking to patrons on the phone.
- Equipment failures were frequent, and maintenance proved to be difficult and costly. (2)

Despite these problems and the eventual abandonment of the RSS program, a survey of 1980 BART riders indicated that almost half felt BART was doing a good security job. (11) Moreover, informal police surveys have found that BART patrons respond better to a policeman on the beat than to sophisticated security devices. (8)

To improve security program effectiveness, BART police proposed the following measures for fiscal year 1981-1982:

- Provide radio pagers to all officers.
- Institute a BART-EYE program of anonymous citizen informants providing crime "tips."
- Increase the police force by 31 officers.
- Upgrade the lossy line radio system.
- Reinstate the use of K-9 teams.
- Seek more assistance from the judicial system in backing up arrests with convictions. (8)

Toronto Transit Commission

System Background

The Toronto Transit Commission (TTC) provides public transportation for metropolitan Toronto, which has a population of two and a quarter million and an area of 240 square miles. During 1980, the system had an average weekday ridership of approximately 1.2 million, with total ridership of approximately 360 million passengers for the year. The subway system is 31 miles in length, has 57 stations, and is served by a fleet of 618 subway cars. There are 123 surface routes with a total length of 710 miles. These are served by 1,230 buses, 150 trolley coaches, and 360 streetcars.

Electromechanical Security Equipment

In 1976, the TTC equipped all subway cars with special passenger assistance alarms. These alarms are pressure-sensitive strips, one-inch by seven feet long, located above car windows. When activated, the alarm produces an audible signal in the car in which it is pressed, energizes a light on the exterior of that car, and sounds an audible alarm in both the operator's and guard's cabins. Once the alarm is sounded, the train guard contacts TTC Transit Control by two-way radio and requests police assistance to assess the situation and take whatever action is necessary. The alarm is designed to provide passenger assistance in the event of illness, accident, fire, vandalism, or a security incident. To discourage false alarms, stickers are prominently displayed which warn that improper use could lead to a fine or imprisonment. Although the system was installed primarily for security purposes, records reflect that in most instances, they are used to request assistance in cases of illness or accidents.

To provide additional security on the subway system, all unattended station entrances are monitored by closed-circuit television. Moreover, a telephone installation program was completed in June, 1977, which provides public telephones on all subway station platforms. The phones allow callers needing emergency assistance to dial "0" and contact the operator without the use of a coin. The phones are easily recognizable, marked by the international telephone symbol. In addition, signs indicating the subway station name and platform location are posted immediately above the telephones, so that callers can give the operator precise information about where they are located.

All surface vehicles (buses and trolley cars) are equipped with a driver's distress alarm system. The alarm can be activated by the operator from either his driving position or by using a stop cord if he leaves his seat to investigate a problem occurrence on the vehicle. A micro-switch in the seat cushion automatically transfers alarm activation to the pull cord when the driver's seat is vacated. Once the alarm system is activated on buses, the horn sounds and four-way flashers are energized. On streetcars, a warning gong sounds and stoplights flash. The alarm continues until shut off by the driver. In addition to this alarm, many surface vehicles are equipped with two-way radios.

A recent addition to surface vehicle security systems is the installation of a communications information system (CIS) on approximately 100 buses. This system contains some significant security features, including two-way voice communication, silent alarm, and discrete remote vehicle monitoring. The vehicle tracking system is accurate within 100 feet and has proven to be reliable and effective in quickly dispatching help.

Other Security Countermeasures

The Toronto transit system generally was designed with concern for safety, security, and easy maintenance. Moreover, basic concepts of good lighting, the use of vandal-resistant materials, and a high standard of cleanliness have been retained over the years. New subway stations are designed with the specific objective of eliminating alcoves and other locations which might cause security problems. Older stations also have been retrofitted to improve security by blocking up telephone alcoves. In fact, 26 public telephones formerly located in alcoves were moved to more visible locations and 14 other unused alcoves or passageways were closed. Parabolic mirrors are also used throughout the system to eliminate blind corners on platforms and stairways. Mirrors are also used on subway cars to improve the surveillance capability of motormen and guards.

Concern for passenger security further extends to such basic planning items as the deployment of police and security officers, the location of bus stops, and public education and information programs to improve passenger awareness of the level of security provided by the system, as well as measures patrons can take to further ensure their own security. Typical of the advice given patrons is the warning to female passengers to ride in either the motorman's or guard's cars during late hours or times characterized by reduced ridership (i.e., weekends, holidays, etc.).

Police protection within the transit system is provided by the Police Department of the Municipality of Metropolitan Toronto. This department employs a unit beat patrol in transit stations to counter crime occurrences. (24) In addition to the "beat" approach, the Toronto Police Department also maintains a subway squad of plain-clothes officers deployed to prevent purse snatching, pickpocketing, and assault. (24) The TTC has a security section staffed by approximately 15 security officers. (24) These officers do not have peace-officer status but do have responsibility for investigating all crimes which occur in association with the transit system.

Agency Assessment and Evaluation

The Toronto transit system has a reputation for being one of the safest in the world. This is due in large part to the extended use of security technology in conjunction with the effective deployment of police and security forces. The result is that less than one percent of Metropolitan Toronto criminal activities occur on the transit system. (26) The success and effectiveness of TTC's security program is highlighted in the following general assessments of four components of its security system:

- The Driver's Distress Alarm System has proven to be effective not only in defusing problem situations, but also has resulted in an 80 percent apprehension rate when used. (26)
- Tests of the Communications Information System (CIS) have proven it to be effective in improving the dispatch of police or emergency assistance by reducing the average response time for officers to arrive at the scene of the incident. (26)
- Although the passenger assistance alarm system was installed primarily for security purposes, greater than 50 percent of its use is for assistance in cases of illness or accidents. (26)
- TTC's experience in security planning has demonstrated that of all the security devices and strategies used, the best deterrent against crime and disorderly conduct on the system is the presence of uniformed police officers. (45)

New York City Transit Authority

System Background

The New York City Transit Authority operates an extensive public transportation network. Millions of New Yorkers each day are served by the buses, commuter trains, and subways that span the villages and boroughs of this metropolitan area. The New York subway system, in particular, is the largest subway system in the world. (26) It consists of a 700-mile network which serves 458 stations with a fleet of about 5,000 subway cars. Each weekday, the subway system alone provides transportation for approximately 3.2 million passengers. (20)

Two decades ago, crime on New York's public transportation system was largely confined to pickpocketing, farebeating, and minor acts of vandalism. Recently, however, this public transportation network, especially the subway system, has become the target of increased attacks by violent criminals. For example, felonies on the subway system increased 55 percent in fiscal year 1980 over the previous year. (20) This increase represents an average of 343 felonies committed each week. (20) Similarly, robberies increased by 60 percent over the same period—from 337 to 558. Moreover, the incidence of reported larcenies almost doubled between fiscal year 1979 and fiscal year 1980, with an increase of from 541 to 982. Adding to the occurrence of these violent crimes is the system's serious problem with graffiti and vandalism.

Passenger security on the subway system is the responsibility of the New York City Transit Police Department (TPD). This department is independent of the New York City Police Department (NYCPD) and is staffed by fewer than 3,000 officers. The NYCPD has primary jurisdiction over the surface transportation system. Although the Transit Police Department does have a small bus police unit, it is used primarily in response to extreme emergencies or unusual cases in which the NYCPD may need assistance. Transit security on the commuter trains is the responsibility of the various railroad companies.

Electromechanical Security Equipment

An emergency telephone communications system is available in all station token booths as one means of providing emergency passenger assistance. With the touch of a button, instantaneous communication is provided between each token booth and the central control room. In addition, on January 1, 1981, the transit authority initiated the Dial Free "911" or "0" number for emergency calls made on public telephones located in station platform areas.

Closed-circuit television was installed at three subway stations recently to test CCTV effectiveness in reducing crime and to determine the feasibility of future expansion of such equipment. The 57th Street Station has been monitored by 16 cameras at an installation cost of $125,000. The 59th Street Station has been equipped with 75 cameras at a cost of $550,000. CCTV surveillance was inaugurated in January, 1982, at the Times Square Station which was equipped with 134 cameras at a cost of $1,800,000. Renovations have been made to these and other stations to provide higher ceilings and eliminate columns and passageways which interfere with the ability to monitor station platforms or otherwise limit the field of vision of transit police patrols.

Every police officer has a portable radio which provides instant two-way communication with central control. The radio system operates at all locations on both elevated lines and in underground stations. Since as many as 90 percent of the transit officers patrol alone, this system provides their only communications link in emergencies. In addition, there is a separate radio system for mobile police car units which enables aid to be dispatched without officers having to wait for trains for transportation to the scene of a reported incident. Plans are being made to further upgrade and modernize the present communications system.

All subway cars have two-way radio communication which enables the motorman to alert the Command Center of any crime or unusual condition aboard trains. The Command Center can immediately dispatch assistance to the area and issue instructions as required. Plans are also being made to upgrade and modernize this system as well.

Transit buses are equipped with a two-way radio system that is similar to that used on subway trains. Buses also are equipped with exterior flashing alarm signals located on the roofs. Recently, a new computerized radio system has been installed at the 220-

bus Queens Village bus depot. The system automatically provides the exact location of every bus operating out of the depot by means of beacon signposts that are located along bus routes. The system includes an emergency silent alarm which the driver can activate by foot to alert dispatchers to a problem occurrence on any bus. Because of congestion on the radio frequency, the system has a "request-to-talk" button which identifies the bus and establishes its call priority. There also is a "priority-push-to-talk" button for more urgent messages which automatically gives the call first-priority status.

A public address system also is available to transmit messages to passengers from the Command Center. At present, only 121 of the 458 stations have a public address system. Two-way transmission is not provided on these systems because of the high potential for false alarms and pranks. If a passenger needs assistance, he is encouraged to use the Dial Free "911" or "0" numbers on the public phones or to contact any motorman, token booth agent, or other transit authority official.

The only alarms used in the system are located in the token booths. There are no passenger assistance alarms in vehicles or on platforms, because of the high potential for abuse and vandalism. Part of the problem is related to the fact that the subway system transports approximately 600,000 school children each weekday. (23) Despite their efforts, the transit police have not been able to control the frequency or number of students who pull the vehicles' emergency stop cords as a practical joke. (23)

Other Security Countermeasures

A program for the installation of bullet-resistant token booths is nearly completed. Upon completion, a total of 749 such booths will have been installed to help improve security for station agents. (27) The total cost of this program will be $23.8 million. (27) Because of a recent incident in which two attendants were killed when their booth was set on fire, the installation of fire extinguishers will be tested in 20 token booths. Pending the results of the one-month test program, the fire extinguishers will be installed in all token booths.

The Authority also is experimenting with a program to establish the size and location of platform "waiting areas" for passengers. Under this program, a specific area will be designated for passengers to wait for their trains during off-peak hours or other periods of low travel demand. These areas will be located on the station platforms at or near the token booths, depending on the layout of the station.

Since the subway system is nearly 80 years old, its physical design significantly contributes to surveillance problems of the transit police department. Therefore, as part of a station modernization program, the Authority has been raising ceilings, eliminating steel columns, and removing signs, advertisements, and telephone booths which obstruct or limit the surveillance capability of booth attendants, CCTV, or transit police patrols. This work was initiated as part of the Authority's "face-lift" program, and will continue under its station modernization program which will include nine stations.

Security personnel at the TPD consider manpower to be their most important resource in the fight against transit crime. (23) The TPD staff of 3,000 officers provides all police services for the subway system. Its operational activities are directly related to monitoring the transit system, preventing crime where possible, and apprehending criminals who commit felonies on property controlled by the Authority. In addition, the department has a crime prevention unit which is charged with responsibility for disseminating information regarding crime prevention, property protection, and public safety. To accomplish this purpose, the unit regularly performs three functions:

1. Analyzes crime hazards, potential crime hazards, and existing security procedures in an effort to make recommendations for the prevention of breaches in security.
2. Performs appraisals of security hardware available on the market and/or operational in the system to make recommendations to obtain optimum security.
3. Conducts a crime prevention information and education program for both the public and other law enforcement agencies. (27)

Another TPD security program is Operation Decoy in which officers are disguised as drunks, derelicts, aged persons, women, and bewildered tourists to capture the attention of unsuspecting criminals. (23) The decoy officers work in teams, with one officer posing as the intended victim and one or two backup officers poised to step in at the first instance of assault or robbery.

Operation Fare Cheat is a program designed to stop criminals at the turnstile. The program uses uniformed officers stationed near turnstiles to arrest gate crashers.

After much public controversy, the TPD initiated the use of K-9 patrols in February, 1981. (23) Despite poor public opinion of the program and public fear that attack dogs may harm innocent patrons, the department believes their use will provide an effective means of restoring order, deterring crime, or pursuing and interrogating a suspect.

Agency Assessment and Evaluation

Despite these security efforts, transit crime continues to escalate dramatically from year to year. Whether or not the use of security hardware has kept the percentage increase in crime incidents per year from being even greater than it is at present remains to be established and documented with data or statistics from police records.

An example is the recent experience with the use of parabolic mirrors. In 1979, crimes in stairwells represented 10 percent of all station crimes. (23) To help combat this problem, the Authority installed parabolic mirrors to increase patrons' viewing distances. A year later, crime in stairwells represented 12 percent of all station crimes or an increase of two percent over the previous year. The TPD has not been able to determine whether:

- The mirrors had no impact on stairwell crimes.
- The mirrors kept the crime rate from being even higher.
- The mirrors alone provided the only measure of added security.

The increasing problem of crime throughout the transit system is related in part to declining transit ridership over the last several years. The fewer riders there are, the less revenue the system takes in; the less revenue it receives, the more difficult it becomes to staff and properly equip the transit police force. One of the problems the TPD faces now is that it has fewer than 3,000 officers to protect a daily subway ridership of 3.2 million persons. Moreover, it costs the City of New York an average of $112 million annually to maintain a staff which TPD considers too small to adequately protect the system's riders.

The Far Rockaway Suburban Station is the only station that has had CCTV long enough to provide any statistical results on its effectiveness (since 1978). However, this station is located in a low-crime, upper-middle-class neighborhood. The result has been that no impacts on crime or other indications of system effectiveness have been determined to date from the information available.

The TPD's special programs to divert graffiti artists from despoiling trains has also been unsuccessful. (20) As a result, graffiti is a serious problem, one which the TPD has essentially given up trying to combat, especially in view of the costs involved and the fact that compared to other offenses, this crime is only visually offensive. (23)

The communications system also has been found to be unreliable. Some features of the network are 25 years old. Radios frequently do not work, either because of dead spots in transmission lines or because the volume of incoming calls is simply too great. (20)

The effectiveness of the undercover police force also appears to have been diminished, when the percentage of undercover officers was decreased from 45 percent to eight percent of the police force. (20) With this cutback, plain-clothes officers are primarily limited to beat patrols which appear to provide a limited deterrent to crime. (23)

Operation Fare Cheat was one of the most effective, yet controversial, anti-crime strategies used by the transit police force. (21). One criticism of the program was that it took the officer away from the platform and protection of riders to the turnstile and the protection of receipts. However, the department defends the program by noting that after the campaign began, some 3,000 persons arrested as fare cheaters were later found to be wanted on warrants and some 4,000 others were charged with additional crimes, such as carrying weapons or stolen property. (21)

Finally, several policing problems have been found to be the result of the deployment strategies that must be used when staff and budget are limited. (20) For example, late night tours typically consist of 175 to 200 officers scattered among 458 stations and 5,000 subway cars. Backup help is usually unavailable or unreliable, since most command districts have only one serviceable squad car. As a result, in 1979, more than 400 patrol officers were assaulted and more than 700 sustained on-duty injuries that necessitated some hospital care.

On the bus system, the NYCPD has found that the exact fare policy has resulted in the greatest reduction in bus robberies. (23) In addition, the police have found that although the bus two-way radios and flashing alarm signals are helpful in speeding assistance to drivers, these devices do not appear to provide any significant deterrent to crime. (23)

Southern California Rapid Transit District

System Background

The Southern California Rapid Transit District (SCRTD) is a public agency created in 1964 by the California State Legislature. It is empowered to carry out two legislative mandates:

1. Operate and improve the existing bus system.
2. Design, construct, and operate a rapid transit system which meets the needs of the people of Los Angeles County.

SCRTD achieves this mandate by providing transportation services to 185 cities and communities in the Counties of Los Angeles, Orange, Riverside, San Bernardino, and Ventura. This service area covers approximately 30,000 passenger stops over some 2,280 square miles and has a fleet of 2,910 buses. The scheduled number of buses operating in the peak hour is approximately 2,000. The total number of passengers carried by SCRTD annually approximates 400,000,000. The average weekday passenger trips total 1,340,000. SCRTD service is provided up to 24 hours a day on selected high-demand routes. The base passenger fare within Los Angeles County is 65 cents.

The District has a long history of program activities to combat crime and vandalism on its bus system. These efforts were initiated in 1969, when the locked fare box program was instituted as a result of an increasing number of assaults and robberies of bus drivers. (40) This program was followed in 1975 by the implementation of two community relations programs dealing with crime prevention and vandalism: (1) Operation Teamwork and (2) Community Youth Corps. (40)

Operation Teamwork was a two-year program designed to inform primary school students of the value of transit services to the community and the contributions all persons can make to maintain and improve the safety, security, and attractiveness of the system. The Community Youth Corps (CYC) program was also conducted for two years; its major purpose was to employ youth from various communities in the District's service area to assist in promotions, plans, and services for SCRTD. A secondary goal was to expose participants to the transportation field as a potential career opportunity.

The District's efforts continued into January, 1978, when it sought and received state authorization to establish its own SCRTD Transit Police Department. (40) The District is unique in the United States in that it is the only all-bus property to have a transit police force.

In addition to the above, SCRTD has had an ongoing series of community outreach and security specialist task force meetings to help plan and coordinate its anti-crime efforts. Descriptions of these programs and specific security devices currently used on the system are given below.

Electromechanical Security Equipment

All SCRTD buses are equipped with a silent alarm system which allows the driver to notify the dispatch center of a serious incident on the bus, without being detected or having to use the bus radio. The dispatcher responds immediately to these alarms by contacting the transit police, the Los Angeles Police Department, or other local law enforcement agencies. The silent alarm system is a component of the two-way radio communications equipment which allows the priority transmission of a silent alarm whenever conditions warrant its use.

Flasher lights are also installed on all buses as an external signal to nearby law enforcement officers that the driver needs assistance. In addition, SCRTD has received some new buses which feature electronic messages on the front and side capable of announcing "emergency on bus, call police."

SCRTD recently instituted a 90-day test program of on-vehicle surveillance cameras to measure their effectiveness in reducing bus crime. It was believed that these cameras would provide a psychological deterrent to crime, and in those cases where an incident occurs, film could be used as evidence against the perpetrator. Unfortunately, the test program was only half completed when all of the Grumman buses on which the cameras were mounted were taken out of service. Plans are under way to remount the cameras on other buses and possibly to utilize these cameras on high-crime or problem routes in the San Fernando Valley service area. (41)

SCRTD is testing the use of an automated vehicle monitoring (AVM) system for its buses. (5) The AVM system is designed to determine the location of vehicles and has the added capability of providing scheduling and silent alarm functions. The system is installed on approximately 200 buses and 20 road supervisory vehicles to test and evaluate the prototype system.

Other Security Countermeasures

The District is involved in a number of community crime prevention programs to help reduce the number of criminal incidents aboard buses. One such program is "Project Heavy," a federally-financed program whose purpose is to resolve and/or reduce gang-related transit violence, crime, and vandalism. Another program is project "We Tip" in which a nonprofit, voluntary group of individuals supplies anonymous information to police authorities regarding transit crime or any crime which may occur. It also includes an anonymous witness program in which victims and witnesses are given cash rewards of up to $500, when information leads to the successful arrest and prosecution of a criminal.

Other SCRTD activities undertaken to combat bus crime and vandalism include regularly-scheduled task force meetings. Anti-crime task force meetings are sponsored by the SCRTD Board to provide a forum for community leaders and law enforcement agencies to discuss crime and vandalism prevention. The Transit Security Task Force consists of members of the Los Angeles City Police Department, Los Angeles County Sheriff's Office, the United Transportation Union, and SCRTD, who meet regularly to coordinate efforts and exchange information related to crime on buses.

Additional security measures implemented by SCRTD include an exact fare policy, in which drivers neither carry or handle any money, and the use of bus numbers painted on bus roofs to aid police helicopters in locating buses from the air. As a further deterrent, the SCRTD Marketing Department designs and places posters on buses that advertise that all vehicles are radio-equipped, and that undercover transit police ride SCRTD buses. SCRTD also recently authorized the voluntary use of tear gas protective devices for its bus operators. Two types of state-approved tear gas units were approved, with the District reimbursing all operators who complete a certified training program in their use. SCRTD is presently conducting a chemical shield training program to license its employees to carry tear gas devices.

SCRTD considers its most effective security countermeasure to be its Transit Police Department (TPD). (5) The department uses a combination of uniformed and plainclothes or decoy officers to survey both its stations and buses. In addition, officers respond to calls for help on a concurrent basis with the various police departments in the service area, with whom excellent mutual working relationships have been established.

The TPD has strengthened its basic security program with the addition of three recent project activities. The first is participation on the Anti-Crime Task Force to develop plans to combat crime on buses. Second, representatives from the TPD conduct training seminars at police academies and police stations to create a greater awareness among patrol officers of the problems aboard SCRTD buses. Last, a part-time police officers program was initiated in October, 1980, to hire off-duty police officers as part-time transit police officers.

Other recent SCRTD efforts to fight crime on buses include the following:

- The SCRTD Board of Directors authorized an additional $1.5 million to hire 45 more transit security personnel. (39)
- SCRTD increased the number and frequency of patrols by transit police, including random boardings of buses to establish a high profile for the transit police force. (39)
- SCRTD obtained the cooperation of other police agencies which now deploy additional undercover officers on District buses. (39)

Agency Assessment and Evaluation

Since its creation in 1978, the Transit Police Department has been in a constant state of organizational and administrative transition. As a result, many of its administrative and bookkeeping functions have suffered. Therefore, the TPD has not maintained any detailed transit security crime data, especially as it relates to the effectiveness of individual security programs or devices. However, several problems and accomplishments of its security planning efforts have been identified.

The intent of the silent alarm system installed on all SCRTD buses was to notify the dispatch center of *imminent danger of great bodily harm to driver or passengers.* Instead, the alarms have been used all too frequently for any violation or problem to circumvent use of the two-way radio. (5) As a result, many problems were responded to inappropriately, thereby presenting a situation in which transit and other police authorities may have been prevented from effectively responding to an immediate emergency situation. Compounding this problem is the location of the alarm switch which results in numerous accidental or false alarms. (5) Plans are being made to relocate the alarm switches.

SCRTD's experiences to date with CCTV have shown that the attention span of operators or monitors seriously limits the effectiveness of these devices. (5) Therefore, for the time being, CCTV cameras are only used in limited applications at SCRTD headquarters.

The part-time police officers program has proven to be the most beneficial of all the crime prevention programs instituted by SCRTD. (41). Since the program's inception, there have been 1,116 arrests, 167 of which were for felonies. The public's improved perception of safety that has resulted from the additional deployment of police officers can best be summed up by a comment by one of its patrons: "You better have your act together before you board a bus.... Either you will walk home or you'll ride to jail." (41)

Chicago Transit Authority

System Background

The Chicago Transit Authority (CTA) is a self-regulating municipal corporation established in 1945 by legislative action of the Illinois General Assembly. It was created with the express purpose of providing adequate bus and rapid rail services to meet the transportation needs of Chicago area residents. With this charge, the CTA was given a 50-year franchise with exclusive rights to operate both the bus and rail transit systems for the 3.9 million people in its service area.

The rapid transit network consists of 191.6 track miles of passenger revenue line, 3.7 track miles of freight revenue line, and 48 track miles of nonrevenue line, including track in yards, crossovers, and unused track. The total revenue-producing network is almost 90 route miles. The rail network is divided into six routes plus the CBD loop portion. Rail service is provided 24 hours a day, every day of the year at all but a few stations. In addition, a few stations on the Ravenswood and Skokie service line do not have "owl" and Sunday service. The rail transit service is operated with a fleet of approximately 1,100 rail cars. In fiscal year 1979-80, 150,710,497 passenger trips were made—a total of 1,099,200,000 passenger-miles.

The bus system includes both local and express service. Local bus service consists of about 135 routes operating over 2,050 miles of city streets. This system operates on the grid of existing arterial streets, with routes spaced about one-half to one mile apart. Bus stops are approximately one-eighth of a mile apart, or an average walking distance of two minutes between stops. Express bus service includes several routes which operate on the Chicago highway network. The major express bus routes constitute about one percent of total route mileage. In addition to these longer express routes, there are several shorter exclusive bus lanes in the local street network. The CTA owns and leases a fleet of approximately 2,500 buses. In fiscal year 1979-80, the CTA served 560,905,036 passenger trips—a total of over 1,402,300,000 passenger-miles.

The CTA has pioneered in transit security planning with the testing and demonstration of two major anti-crime systems: a bus monitoring system, which consists of a radio communications system that includes silent electronic alarm capabilities and an audio/video electronic surveillance network with combined passenger-activated alarm devices and telephones for the rail system. These anti-crime measures were designed to utilize state-of-the-art technology to combat transit crime, improve patron perception of transit security, and minimize the necessity of maintaining a large, intensive transit police force. These and other security countermeasures currently available on the CTA transit system are discussed in the following sections.

Electromechanical Security Equipment

The Chicago Transit Authority has a unique electronic surveillance system which combines the benefits of CCTV with alarms and communications equipment. Popularly known as Teleview Alert (TVA), the principle of the system is to overcome the limitations attributable to the separate use of its component anti-crime devices. The system was dedicated and placed into preliminary operation on May 8, 1980. The purpose of the one-year demonstration project was to determine the effectiveness of state-of-the-art technology in reducing crime on the CTA's rapid transit line and the feasibility of future TVA expansion to other transit stations. (43)

The equipment was installed at four high-crime stations (35th, 40th, 43rd, 55th Streets) on the Englewood/Jackson Park elevated routes, at a total cost of $1.7 million. Each station is equipped with nine closed-circuit television cameras (four focused on the platform, four focused on the stairwells, one focused on the ticket agent), supplemented by push-button alarms, emergency telephones, and a public address system. The entire system is monitored at a nine-screen control console located in the Communications Section of the Chicago Police Headquarters at 11th and State Streets.

The TVA system is not designed to be monitored continuously, but only when an alarm button is pushed. However, the system has an optional surveillance feature which permits the monitor to view stations even when no alarm has been activated. When operated in this mode, the system monitor will scan each station for 11 seconds in continual succession. Activation of the alarm preempts any routine, sequential surveillance of the stations.

Passengers may signal for assistance from any of the red alarm boxes located in the stations (ground-level), stairways, or on the platforms. The alarm boxes are within viewing range of a CCTV camera and include a telephone/intercom system which allows the console operator and persons at the alarm box to communicate with each other through the use of telephone handsets. The system also permits the console operator to hear and monitor incidents on the platforms or make announcements at one or more station locations.

The alarm and the two-way feature of the intercom system are activated when the alarm button is pushed. Once activated, the control console automatically switches to the station involved. The computer selects the camera covering the activated alarm. As a result, the console operator can observe the station on the central monitor screen, activate the videotape recorder, and dispatch appropriate emergency assistance. A unique feature of the system is that persons responsible for false alarms or tampering with the equipment also can be recorded on videotape.

Passenger assistance also is available through the use of public telephones located on station platforms within view of the CCTV camera. The use of the Dial-Free "911" number was initiated on the public phone system on September 16, 1976. In addition, ticket agent booths are provided with a separate telephone and silent alarm switch.

The CTA also pioneered in bus system security with the installation of a bus locator system for 500 of its coaches in late 1969. (42) The system was designed to automatically keep track of the locations of buses, allowing central control to know where buses are and whether they are operating on schedule. The system has the capability of estimating bus locations to within 100 feet. It operates through the use of fixed "sign posts" which record when buses pass specified locations.

The system also includes a silent alarm that a driver can activate by foot in the event of a robbery or other serious emergency. When depressed, the floor alarm button relays a coded message to the central dispatcher which identifies the bus and gives its location.

Radio equipment is also installed as part of the system. The equipment has two separate channels, one for voice communication and one for routine location data collection. In addition, the radio system has a selective calling feature which preempts the need for an open channel in order to use the system.

The total installation cost of the pilot bus locator system was approximately $2 million. Remaining CTA buses are equipped with a silent alarm and flasher lights as an external signal of a problem occurrence.

Other Security Countermeasures

Under Illinois state statute, municipal police agencies have primary responsibility for passenger security on public transit systems, while transit security agencies may provide supplementary assistance. (7) As a result, CTA passenger security on both bus and rail systems is the primary responsibility of the Chicago Police Department through its Mass Transit Unit. The unit was created in 1974 as part of an expanded anti-crime program. (44) Known as the "Mole Patrol," the unit consists of approximately 200 officers who are assigned full-time responsibility for policing the mass transit system. The officers operate in three general areas: foot patrol, fixed station posts manned by uniformed personnel, and tactical undercover operation. The undercover officers comprise about 50 of the men in the unit and are permitted to dress in civilian clothes and wear beards and long hair.

The Mass Transit Unit makes frequent, random checks of trains and elevated platforms. Officers also board buses at unannounced regular stops, checking with drivers as to conditions and incidents that occur during runs. In addition, buses, bus stops, and rapid transit stations are under the continuous watch of radio-equipped squad cars operating out of district police stations. Moreover, the Chicago transit unit has the distinct advantage over its counterparts in most other cities in that it can borrow officers from the regular police division whenever there is a surge in crime. On infrequent occasions, K-9 dog teams are used, primarily to patrol high-crime subway stations.

Agency Assessment and Evaluation

The intended benefit of the pilot bus locator systems in reducing incidents of robbery and assault was to reduce the response time required for the police to reach the bus involved. However, the CTA concluded from its pilot demonstration of this system that the reduction in police response time resulting from obtaining exact bus location information was not sufficient to result in a significant increase in apprehension rates. Therefore, the CTA suggests that properties contemplating the purchase of such systems should recognize that the main use of the bus locators is in improved system management rather than crime reduction. (42)

Based on partial results of the TVA demonstration program, the CTA has found that an integrated surveillance system alone is not the solution to transit crime problems. Although such systems provide a deterrent to crime, they are functionally part of a "demand-responsive system," and must be supported by the very entity that they are designed to minimize, a dedicated transit police force. (26) The success of a fully integrated electronic surveillance system depends on its ability to improve police response time. (18)

Moreover, like other transit system counterparts, the Chicago pilot TVA program has experienced frequent equipment failures, including one in May, 1980, that foiled detection of a highly-publicized ticket booth robbery. (29) In addition, no integrated audio/video system is able to survey every cranny of a platform or station, especially when security equipment is added to an existing, older transit system like Chicago's. Furthermore, crimes of opportunity continue despite TVA system capabilities. In fact, a series of gold chain robberies in the Summer of 1980 were not detected by surveillance systems at the TVA demonstration stations. (29) Finally, the results of a patron survey taken in September, 1980, indicated that passengers' first choice in reducing negative security perceptions would be to increase the number of security officers patrolling the system. (26)

Similarly, problems exist with the radio communications system used by transit police. The main difficulty is frequent loss of radio contact with headquarters when officers patrol subway stations and tunnels. To resolve this problem, the police department has authorized the expenditure of $3 million for a Lossy Line System to eliminate these dead spots in the radio communications system. (20)

Poor communications capability and too few personnel spread too thinly also reduce the effectiveness of transit police. Police response time to the scene of transit crimes averages five minutes or less for 40 percent of all crimes, six to 15 minutes for 23 percent of all crimes, and 16 to 30 minutes for 13 percent of all crimes. (7) However, a study of crime on the CTA system has indicated that transit crime apprehension rates are highest (about 65 percent overall) if the police arrive at the scene in less than five minutes. (47)

Despite these findings, the Mass Transit Unit has been successful in reducing transit crime. In 1975, robberies, which were the greatest cause for concern on the rail system, were reduced by more than 50 percent. (44) Tunnel walls and trains are kept free of graffiti. Despite a declining city population, rail transit ridership rose from 146 million in 1977 to 151 million in 1980. (20) Moreover, when crime statistics are viewed in terms of the vast scope of the CTA service area and population, the system appears to be relatively safe.

Metropolitan Atlanta Rapid Transit Authority

System Background

The Metropolitan Atlanta Rapid Transit Authority (MARTA) is a state authority created by the Georgia General Assembly. It is responsible for providing bus and rail transportation for a service area population of 1,077,200 people. Since 1971, the Authority's principal source of local revenue has been a one percent property tax which yields about $100 million a year. MARTA uses half of this tax revenue for capital improvements to the bus system and for construction of the rail system. The remainder of the funds is used to support service operations.

MARTA initiated planning and design work for its 53-mile rail system in 1972 and opened the first leg of that system on June 30, 1979. From the beginning, the rail system was designed to "ooze" security when stations were entered. Design plans provide for high light-levels; open areas; the absence of nooks and crannies; and the installation of CCTV, public address systems, and emergency telephones throughout all stations. In addition, each station is individually designed to reflect the community in which it is located. This neighborhood design orientation for each station is considered essential in enabling local residents to develop a sense of pride, ownership, and participation in the transit system. MARTA now has 12 miles and 13 stations of its rail system in operation and hopes to complete the full 53-mile, 40-station system by 1990.

MARTA also provides surface transportation services with a fleet of approximately 840 buses. In 1980, this system operated 33 million vehicle-miles and carried more than 100 million passengers.

The system has had a relatively low crime rate during the two years of rail system operation. Similarly, serious crime on the bus system is almost nonexistent. As a result, the MARTA system has developed a reputation as one of the safest places to be in metropolitan Atlanta. The most frequent crime incidents on the transit system relate to petty vandalism and smoking, eating, drinking, or littering violations.

Electromechanical Security Equipment

The MARTA rail system was designed with consideration for the protection of its patrons, property, and system operations. In addition, the system was designed to offer MARTA users a level of security high enough so that their desire to use the system would not be inhibited by a feeling of insecurity. To achieve both of these security goals, an integrated closed-circuit television network and an intrusion detection and alarm system were selected to provide remote surveillance of specific areas of stations, supplemented by the MARTA Transit Police Force and local police authorities. In addition, the concept of employing zone surveillance centers for each line of the system was established to insure that effective patron/station area surveillance could be provided within reasonable time and cost constraints.

Each zone center is responsible for all security functions on its assigned rail line. The center operators monitor all CCTV cameras, emergency phones, alarms, public address systems, and roving transit police patrols. Direct telephone communication is also provided between each zone center and operations control, local police, and fire departments within that zone.

Based on established surveillance requirements and selected camera locations, the number of cameras per station varies from a minimum of five at the West Lake Station to a maximum of 23 at the Five Points Station. A typical CCTV surveillance plan for each station covers the following areas:

Concourse Area

- Fare Collection Area and Handicapped Access Gates
- Station Entry
- Long Corridors and Secluded Areas
- Patron Assistance Telephone Sites
- Rest Room Access
- Vending Machine Areas (Future)

Platform Area

- Center of Platform
- End of Platform
- Elevator Exit Area
- Escalator/Stairway Base
- Security Telephone Sites

Passenger assistance is provided by means of the white emergency telephones that are located near fare gates and on train platforms. These phones are designed for easy operation under panic situations and are in clear view of CCTV cameras. Phone systems are linked to zone centers for appropriate action or response by the center operator. In addition, phones provide the only means of passenger access to station washrooms, which are opened by an electric strike operated by the zone center operator.

Stations also are equipped with a public address system, which is used to inform the general public of emergencies, special instructions, or service information. The system can be operated either by the zone security center or operations control.

Intrusion detection and other security alarms are located throughout rail stations and platforms, including access corridors, entrance/exit gates, and fare gates. These alarms are audible locally and annunciated at the zone security centers. Finally, emergency intercoms are provided at the ends of each train car, connected to the train operator and Central Train Control.

Security devices are also available on MARTA's surface transportation system. Beginning in 1975, MARTA began equipping all of its buses and vehicles with two-way radios. In addition, buses have a secret alarm system which the driver can activate by means of a floor switch. Once the alarm is activated, it relays a coded signal to communications headquarters, which identifies the bus and approximates its location.

Other Security Countermeasures

MARTA maintains its own Transit Police Department. Its officers are graduates of the Georgia Police Academy and are sworn peace officers. This department consists of a small group of uniformed roving police who are deployed randomly both to deter criminals and to reassure passengers. MARTA police also are responsible for monitoring all security devices. All officers are armed and carry two-way radios for communication with patrolmen in trains, on platforms, or at local and county headquarters.

Officers are provided in each station, as needed, to watch the concourse, administer first aid, write reports, or detain someone until the local police arrive. MARTA police have the full support of local and state judicial systems to back up arrests with convictions and/or penalties. Whenever possible, the department publicizes its record of arrests and convictions as a further deterrent to crime on the system.

MARTA also emphasizes the importance of station cleanliness and regular equipment maintenance as part of its security program. Experience has demonstated that by maintaining equipment and keeping stations clean and free of graffiti and litter, MARTA patrons tend to respect the system and respond in kind.

Design elements of stations and platforms also contribute to the safety and security of the system. Security objectives designed into the system include open space station designs, short access corridors, restricted patron waiting areas, and unobstructed platform sightlines. (25) In addition, station elevators are designed with glass door panels and emergency intercoms that are connected to the public address system in each station. (52)

Agency Assessment and Evaluation

MARTA believes that its success in maintaining a relatively crime-free system is the result of its successful integration of surveillance equipment, public address and emergency phone systems, and its uniformed police patrols. Based on this experience, uniformed police officers are felt to provide the best deterrent to crime on the system. (52) Of the security devices used, the CCTV system is the officers' most valuable tool. However, MARTA has experienced design and operational problems with the use of CCTV cameras, such as frequent system malfunctions and the inability to survey every inch of stations, even with cameras designed with pan and tilt features.

The security device that has proven to be least effective against transit crime has been the intrusion alarm system. (52) The system not only is highly susceptible to false alarms, vandalism, or missed detection of intrusions altogether, but it also has been found that the information provided by the system is of little or no use against offenders in any court proceedings. Despite MARTA's security efforts, crime incidents on the rail system have begun to increase, as offenders devise new ways to foil the use of both security manpower and equipment in the perpetration of crimes.

The silent bus alarm system is acknowledged as the security device that is most useful in maintaining the relatively low incidence of crime on the surface transportation system. (52) This alarm has been effective in speeding the arrival of both MARTA and Atlanta police to the scene, thus resulting in MARTA's high apprehension rate for bus system offenders. However, the major deterrent to crime on the system has been the exact fare program and the hardening of related fare box equipment. (52)

4.
Survey Results

Overview of the Survey Methodology

A key element in the preparation of the transit system case studies was interviews of experienced security personnel. The purposes of the interviews were to:

1. Verify information obtained in a literature search of existing security studies.
2. Expand the documentation of existing research concerning the experiences of transit systems with the application of security hardware.
3. Develop new supporting information concerning the potential use of security devices in automated transit systems.

The major topics covered in each of the security interviews included transit system operational characteristics, security planning and programming efforts, and the extent of security implementation experiences, particularly with regard to the use of electromechanical security devices.

Information concerning the first of these topics was obtained because transit security systems cannot be planned effectively without a working knowledge of not only a transit system's physical characteristics, but also its operating environment. As much of this information as possible was collected from transit system reports or other documents prior to the interviews. The interviews served to verify existing data and allowed more time for the discussion of specific security experiences and countermeasures.

The discussion of transit security planning and programming efforts focused on the identification of the following:

- Descriptions of existing and proposed programs.
- Inventory of the types and ranges of devices used.
- Countermeasure applications/capabilities.
- Factors influencing selection of countermeasures.

This information helped to verify and complete the inventory and descriptions of available transit security devices obtained from the literature search.

The discussion of experiences of each transit system with security implementation revealed (1) the types, frequency, and severity of crime incidence; (2) any unique system characteristics that had some impact on the occurrence of crime; and (3) the effectiveness or impacts of security countermeasures in various transit environments.

To facilitate the collection of the information described above, several survey instruments were developed. The surveys were conducted in two phases, requiring a general assessment of security programs and hardware in Phase I and a more detailed assessment and evaluation of the use of security hardware in the latter phase of the study. The survey forms used to record the information are listed in Table 4-1 and are included in the study methodology provided in Appendix A.

Key personnel responsible for security planning and operations for each of the 10 case study transit systems were interviewed. Both telephone and mail-back procedures were used to conduct the interviews, as well as field visits to four of the selected case study systems.

The purpose of this chapter is to present the findings of the surveys, highlighting transit system assessments and evaluations of the use of electromechanical security devices in transit environments and their impacts on transit crime. The chapter is organized in six sections, including discussion of (1) the background and experience of key study contacts, (2) agency security planning programs and efforts, (3) experiences with implementation of security hardware, (4) equipment costs, (5) system evaluations of security equipment, and (6) agency comments and recommendations for equipment design and operational improvements.

Table 4-1
LIST OF SURVEY FORMS

Phase I: General Assessment

- Form A: Security Countermeasures Used and Their Applications
- Form B: Countermeasure Evaluations
- Form C: Countermeasure Effectiveness Against Crime

Phase II: Detailed Evaluation

- Form A: Extent of Agency Experience with Security Devices
- Form B: Security Equipment Costs
- Form C: Equipment Impact/Use Rates
- Form D: Transit Security Equipment Evaluation

Security Backgrounds of Key System Contacts

Each of the transit systems was asked to identify staff with major responsibility for and experience with the system's security program. Although in many cases, several security personnel from each agency participated in the interviews, a key contact person was selected by each system to coordinate the research and dissemination of information in response to the surveys. The principal study contacts collectively represent an average of 23 years of experience in the police and security field.

The range of experience for the different transit security staffs includes security system planning and design, manpower training and deployment, and hands-on experience, with many of the security devices referenced in this study. The devices employed by individual systems are identified in the case studies in Chapter 3, and in Table 4-3 in a later section of this chapter. Staffs also were generally familiar with the latest research and literature in transit security technology.

In fact, many of the case study agencies have been hosts for research and demonstration programs to test the use of specialized transit security equipment, such as the "Teleview Alert" integrated surveillance and communications system at the Chicago Transit Authority and the use of photo cameras on buses operated by the San Diego Transit Corporation and the Southern California Rapid Transit District.

While no single transit system has implemented all of the electromechanical security options, the persons interviewed displayed a sound understanding of the range of options available and how they might or might not be applicable within their own transit systems. The assessments and evaluations that follow represent the subjective opinions of transit security staffs, based on actual experiences as well as familiarity with and understanding of current literature and available transit security technology.

Table 4-2 provides a list of the principal contacts for the study. Biographical sketches of these study contacts are provided in Appendix B.

Agency Security Program Planning Efforts

For the most part, the transit systems contacted for this study have no formalized administrative program for security planning. Comparatively, there tends to be considerably more planning for the hiring, training, and deployment of security manpower than for the use of electromechanical security equipment. However, aside from security considerations for station design and surveillance equipment when stations were first built, most security planning efforts primarily are reactive—responding to an immediate, specific security problem.

Moreover, with the exception of the collection and analysis of transit crime statistics, case study transit systems have no established criteria or guidelines for monitoring and evaluating security program effectiveness or for the selection and evaluation of the effectiveness of security equipment. The transit system's primary sources of information concerning the state-of-the-art in transit security planning are conferences, current literature, inter-system communications, and professional police and security associations.

Table 4-2
DIRECTORY OF TRANSIT SECURITY CONTACTS

Contact	Rail	Bus	Other
Lieutenant Stojkovic, Lieutenant of Police Chicago Police Department Room 200, Communications Center 1121 South State Street Chicago, Illinois 60602 (312) 744-5447			Teleview Alert System
Inspector John F. Hyde Bureau of Support Operations Metro Transit Police Washington Metropolitan Area Transit Authority 600 Fifth Street, NW Washington, D.C. 20001 (202) 637-1552	X	X	
Sergeant Newlon, Police Services Bay Area Rapid Transit District 800 Madison Street Oakland, California 94607 (415) 465-4100	X		
Mr. James B. Meehan, Chief New York City Transit Police 370 Jay Street Brooklyn, New York (212) 330-3441	X	X	
Mr. John Waters, Assistant Chief MARTA Transit Police 2775 East Ponce de Leon Avenue Decatur, Georgia 30030 (404) 586-5000	X	X	
Mr. Harry Budds, Assistant Police Chief Southern California Rapid Transit District 425 South Main Street Los Angeles, California 90013 (213) 972-6000		X	
Mr. Theodore C. Barker Morgantown People Mover Operations Manager 99 Eighth Street Morgantown, West Virginia 26506 (304) 293-5011	X		
Captain John P. McGinty Port Authority Transit Corporation Ben Franklin Bridge Plaza Camden, New Jersey 08102 (609) 963-8300	X Lindenwold Line		
Mr. Jack Townsend, Director of Safety and Security Toronto Transit Commission 1900 Yonge Street Toronto, Ontario, Canada M4S 1Z2 (416) 534-9511	X	X	
Mr. John Garland, Manager of Safety and Instruction San Diego Transit P.O. Box 2511 San Diego, California 92112 (714) 238-0100		X	

Experiences with Electromechanical Security Equipment

The case study transit systems collectively use a wide range of security countermeasures to combat transit crime. None of the systems is dependent on one security countermeasure alone and most use some combination of security manpower and electromechanical security devices. The security devices most frequently used by transit systems are closed-circuit television, radio communications equipment, public address/intercom systems, and passenger assistance phones. The technology for automatic vehicle monitoring systems and systems with the capability of altering system operations is fairly new and, therefore, operable at only a few transit systems.

In all cases, these devices are employed to augment and extend the surveillance capability and effectiveness of security personnel. All of the transit systems provide some form of police protection for patrons, either through the local police department or a transit police division of the transit authority. Table 4-3 identifies the security countermeasures currently in use at each of the 10 transit systems.

The devices identified above typically are installed either at stations and/or in vehicles. For example, closed-circuit television and emergency phones primarily have station applications, whereas altering system operations and automatic vehicle monitoring systems have vehicle applications. Other devices have applications both at stations and in vehicles, such as radio communications equipment, public address/intercom systems, and alarms and sensors. Table 4-4 indicates the current applications of security hardware at the 10 transit systems.

Although these devices may serve security functions, their primary use within a system may not be for security purposes at all. For example, although BART and Morgantown use closed-circuit television for crowd control and other security purposes, their primary use is to monitor system operations. Similarly, all of the transit systems also have indicated that, in addition to security functions, they use radio communications equipment, public address systems, their capability to alter operations and automatic vehicle monitoring systems primarily to monitor and improve system operations and communication. Table 4-5 shows the primary function served by security devices at each of the 10 transit systems.

One barometer of the effectiveness of electromechanical security devices is their use rate and corresponding impact on transit crime. Unfortunately, most transit systems do not have the staff or budget to collect and tabulate transit crime data at this level of detail. Typically, transit police divisions keep records of crime incidences and manpower deployment in response to a particular problem. However, these records generally do not indicate the use or role of a particular security device in deterring or detecting a crime, or in apprehending a perpetrator. As a result, most transit systems, at best, can provide only estimates of security equipment use and impact rates.

Table 4-3
CASE STUDY INVENTORY OF CURRENT SECURITY COUNTERMEASURE USE

Security Countermeasure	Transit Operator BART	Morgan-town	WMATA	TTC	MARTA	PATCO	CTA	NYCTA	SCRTD	San Diego
Electro-Mechanical Equipment										
Closed Circuit Television	X	X	X	X	X	X	X	X		
Radio Communications Systems	X	X	X	X	X	X	X	X	X	X
Emergency Phones	X	X	X	X	X	X	X	X		
Public Address System/Intercoms	X	X	X	X	X	X	X	X		
Alarms and Sensors	X	X	X	X	X	X	X	X	X	X
Photo Cameras			X						X	X
Altering System Operations	X	X	X	X	X	X	X	X		
Automatic Vehicle Monitoring	X	X		X			X	X	X	
Other Security Countermeasures										
Transit Police	X[1]	X[2]	X[1]	X[2]	X[1]	X[1]	X[2]	X[1]	X[1]	X[2]
Security Officers				X						
K-9 Patrols			X			X	X	X		
Observation Booths/Ticket Kiosks			X				X	X		
Fare Evasion Equipment	X		X	X		X	X	X		
Parabolic Mirrors				X				X		

[1] Division of the Transit Authority.

[2] Service provided by local government.

Table 4-4
PRIMARY APPLICATIONS OF SECURITY DEVICES

Security Countermeasures / Transit Operators	Closed Circuit Television	Radio Communi-cations Equipment	Emergency Phones	Public Address Systems	Alarms and Sensors	Photo Cameras	Altering System Operations	Automatic Vehicle Monitoring
BART	S	S/R	S	S/R	S/B		R	B
Morgantown	S	S/R	S	S/R	S/R		R	R
WMATA	S	S/R/B	S	S/R	S/B	S	R	
TTC	S	S/R/B	S	S/R	S/R/B		R	B
MARTA	S	S/R/B	S	S/R	S/B		R	
PATCO	S	S/R	S	S/R	S		R	
CTA	S	S/R/B	S	S/R	S/B		R	B
NYCTA	S	S/R/B	S	S	S/B		R	B
SCRTD		B			B	B		B
San Diego		B			B	B		

S=Station; R=Rail; B=Bus

Table 4-5
PRIMARY FUNCTION SERVED BY SECURITY DEVICES

Security Countermeasures / Transit Operators	Closed Circuit Television	Radio Communications Equipment	Emergency Phones	Public Address Systems	Alarms and Sensors	Photo Cameras	Altering System Operations	Automatic Vehicle Monitoring
BART	O	O	S	O	O	N/A	O	O
Morgantown	O	O	S	O	O	N/A	O	O
WMATA	[illegible]	O	S	O	O	S	O	N/A
TTC	S	O	S	O	S	N/A	O	O
MARTA	S	O	S	O	O	N/A	O	N/A
PATCO	S	O	S	O	O	N/A	O	N/A
CTA	S	O	S	O	S	N/A	O	O
NYCTA	S	O	S	O	S	N/A	O	O
SCRTD	N/A	O	N/A	N/A	S	S	N/A	O
San Diego	N/A	O	N/A	N/A	S	S	N/A	N/A

S=Security; O=Operations and Communications; N/A=Not Applicable

None of the transit systems studied for this project routinely keeps data on equipment use rates and impacts on transit crime. The data that are available typically were collected in connection with special demonstration programs for the security equipment involved, or as part of a follow-up report on a particular security problem. However, in most of these cases, the available data were incomplete, either because the demonstration program was still in progress or cancelled prior to project completion.

Data on estimated equipment impact and use rates were provided by several transit operators based on their general experiences and observations. These estimates are presented in Table 4-6, and only apply to closed-circuit television, alarms, public address systems, and emergency telephones. Unfortunately, there is not enough information available to compare experiences with the use of these devices or to determine their effectiveness against transit crime. However, despite this lack of information, the prevailing attitude among transit system security personnel is that, regardless of the specialized devices used, the presence of transit police or security guards will continue to be the most significant factor in deterring and controlling transit crime.

Equipment Costs

The *costs* of providing security devices are difficult to estimate. First, the cost of installing a security system depends on the total transit system configuration. (18) Equipment distributors prefer to bid on an integrated system, since the cost of a total system usually will be less than the total of a series of separate parts. Furthermore, a supplier's bid will often depend on who the competition is (or is thought to be).

Second, agency procurement practices often raise the costs of a security system. (18) Some agencies overspecify their acquisitions—often requesting particular pieces of equipment. It may be preferable to write some general performance specifications—stating what the equipment is required to do and then letting potential suppliers suggest ways of meeting these specifications. Novel and inexpensive equipment combinations might result.

Third, specific cost estimates rapidly become obsolete, since most product costs are rising due to inflation. However, the cost of advanced technology in electronics and computers has been declining for several years.

Fourth, without detailed equipment specifications, reliable estimates of costs for security hardware systems are difficult to obtain. Manufacturers are loathe to disclose even approximate cost figures without specifications because of the custom-design nature of surveillance hardware.

Fifth, manpower involvement can be a major operating cost consideration. Therefore, the cost of manpower involvement must be included in the cost computations for any proposed countermeasure.

Table 4-6
EXAMPLES OF EQUIPMENT IMPACT/USE RATES

Security Equipment	Patron Use Rate	Crime Detection Rate	Response Time of Security Staff	Arrest Rate	Conviction Rate	Overall Impact on Crime Reduction
Call-For-Aid-Telephones[1]	300/Day	8/Month	Impact Unknown	21/month	Impact Unknown	Impact Unknown
Closed Circuit Television[2]	NA	.2/Month	Impact Unknown	.1/month	Impact Unknown	Impact Unknown
Intrusion Alarms on Fare Gates[3]	NA	Average 20/Month	Average 1 to 10 Minutes	No Arrests	No Convictions	Impact Unknown
Closed Circuit Television[3]	NA	Average 250/Month	Average 1 to 10 Minutes	Average 10/Month	Average 95 Percent	Impact Unknown
Public Address System[3]	NA	Average 40/Month	Average 1 to 10 Minutes	No Arrests	No Convictions	Impact Unknown
Call-For-Aid-Telephones[3]	Average 300/Day	Impact Unknown	Average 1 to 10 Minutes	Impact Unknown	Impact Unknown	Impact Unknown

(1) Actual counts for November, 1981, Port Authority Transit Corporation.
(2) Estimated counts for 1981, Port Authority Transit Corporation.
(3) Estimated Counts for 1981, Metropolitan Atlanta Rapid Transit Authority.

Sixth, a detailed analysis of the characteristics of a specific system is necessary to be at all precise. The analysis should not neglect the versatility of certain countermeasures in fulfilling additional roles beyond the primary security function. For every additional application within the capability of a device, the unit cost is unchanged and, therefore, the cost-effectiveness of the equipment is enhanced. This provides management with a rationale for spreading cost justification of certain countermeasures over several functions.

Detailed equipment cost information as described above was not available from manufacturers or any of the transit system case studies. In many instances, security equipment costs for transit systems were hidden within the total costs for system construction and renovation, or included in the purchase cost of vehicles. In addition, information concerning equipment bids, procurement practices, and equipment specifications also was not readily available for use in this study. However, Table 4-7 presents some examples of the capital, installation, and operating costs of security equipment at several transit systems. Again, there is not enough information available to adequately report or estimate the unit costs of transit security equipment.

Agency Evaluation of Security Equipment

Each of the 10 transit systems was asked to evaluate its security equipment, using the evaluation criteria discussed in Chapter 1:

1. State-of-the-art.
2. Compatibility with existing transit systems.
3. Maintainability.
4. Reliability.
5. Flexibility.
6. Adequacy of surveillance coverage.
7. Adequacy or appropriateness of response.
8. Costs/benefits.

Applying each of these criteria, transit systems evaluated security equipment types or options using the following judgmental evaluation scale: superior, three points; good/adequate, two points; and poor, one point.

Based on this scale, the lowest possible overall score for each device is eight, the highest possible score is 24. Based on the system evaluations, overall rating scores were tabulated in two groups: (a) devices with station applications and (b) devices with vehicle applications.

In addition to indicating each system's general evaluation of security equipment, tabulation of rating scores in this manner further highlights whether there are any significant differences in countermeasure evaluations, based upon their station or vehicle application in a system. The agencies' evaluations of security devices are detailed in Tables 4-8 and 4-10, and are summarized in Table 4-12. The basis for these evaluations is reflected in Tables 4-9 and 4-11, which show those criteria which significantly contributed to the overall rating of individual security devices.

Table 4-7
EXAMPLES OF SECURITY EQUIPMENT COSTS

Security Equipment	Costs: Capital	Costs: Installation	Costs: Operating
Closed Circuit Television[1] (233 cameras and 219 monitors)	$2,487,000 (1980 dollars)	Not Available	Not Available
Call-For-Aid-Telephones[2] (17 phones)	$2,125 (1969 dollars)	Not Available	Not Available
Integrated Security System[3] Closed Circuit Television Intrusion Alarms Public Address System Emergency Phones	Not Available	Not Available	$90,000 (1980 dollars)
Two-Way Radio System[2] (both walkie-talkie and in-vehicle systems)	$800,000 (1969 dollars)	Not Available	Not Available
Remotely Staffed Stations[4] Closed Circuit Television (64-80) Monitors (8) Emergency Telephones/Intercoms Public Address System Remote Equipment Controls	$833,100.00 (1978 dollars)		$57,600/month for 22 people. $12,000/year for repair parts. $26,000 fare collection/ maintenance. $30,000 process patron refund requests. $213,000 Union Fund contribution--one-time payment.
Teleview Alert System[5] Closed Circuit Television Radio Communications Emergency Phones Public Address System Alarms and Sensors	$1,700,000 (1980 dollars)	Not Available	Not Available

(1) New York City Transit Authority.
(2) Port Authority Transit Corporation.
(3) Metropolitan Atlanta Rapid Transit Authority.
(4) Bay Area Rapid Transit District.
(5) Chicago Transit Authority.

Table 4-8
EVALUATION OF DEVICES WITH STATION APPLICATIONS

Security Countermeasures / Transit Operators	Closed Circuit Television	Emergency Phones	Public Address Systems	Alarms and Sensors	Photo Cameras	Radio Communi-cations Equipment
BART	13	14	13	11		24
Morgantown	14	13	13	10		22
WMATA	17	14	14	11	15	23
TTC	14	14	13	12		23
MARTA	15	14	14	10		24
PATCO	17	12	14	12		22
CTA	14	14	13	11		23
NYCTA	14	14	12	9		19
SCRTD				16		23
San Diego				12		23
Composite Average Scores	15	14	13	11	15	23
Evaluation Scale: 8 to 12—Little or No Effect 13 to 18—Moderately Effective 19 to 24—Very Effective						

Table 4-9
BASIS FOR EVALUATION OF DEVICES WITH STATION APPLICATIONS*

Security Alternatives / Effectiveness Criteria	Closed Circuit Television	Emergency Phones	Public Address Systems	Alarms and Sensors	Photo Cameras	Radio Communi-cations Equipment
State-of-the-Art	2	2*	2	1	2	3
Compatibility with Existing Transit Systems	1	2	2	2	2	3
Maintainability	2	2	2	2	2	2
Reliability	2	1	1	1	3	3
Flexibility	2	1	1	1	2	3
Adequacy of Surveillance Coverage	2	2	2	1	1	3
Adequacy or Appropriateness of Response	2	2	1	2	1	3
Cost/Benefit	2	2	2	1	2	3
TOTAL (Out of Possible 24)	15	14	13	11	15	23
Individual Criterion Evaluation Scale: 1—Poor 2—Good/Adequate 3—Superior						Aggregate Evaluation Scale: 8 to 12—Poor 13 to 20—Good/Adequate 21 to 24—Superior

* Numbers shown represent the composite evaluation scores of all systems having the devices indicated.

Table 4-10
EVALUATION OF DEVICES WITH VEHICLE APPLICATIONS

Security Countermeasures / Transit Operators	Radio Communications Equipment	Public Address Systems	Alarms and Sensors	Photo Cameras	Altering System Operations	Automatic Vehicle Monitoring
BART	24	13	11		13	13
Morgantown	22	13	10		14	14
WMATA	23	14	11		14	
TTC	23	13	12		14	14
MARTA	24	14	10		14	
PATCO	22	14			15	
CTA	23	13	11		14	14
NYCTA	19		9		15	13
SCRTD	23		16	16		15
San Diego	23		12	17		
Composite Average Scores	23	13	11	16.5	14	14
Evaluation Scale: 8 to 12—Little or No Effect 13 to 18—Moderately Effective 19 to 24—Very Effective						

Table 4-11
BASIS FOR EVALUATION OF DEVICES WITH VEHICLE APPLICATIONS*

Effectiveness Criteria \ Security Alternatives	Radio Communi-cations Equipment	Public Address Systems	Alarms and Sensors	Photo Cameras	Altering System Operation	Automatic Vehicle Monitoring
State-of-the-Art	3	2	1	2	2	2
Compatibility with Existing Transit Systems	3	2	2	2	2	2
Maintainability	2	2	2	2	1	1
Reliability	3	1	1	2.5	2	2
Flexibility	3	1	1	2	2	2
Adequacy of Surveillance Coverage	3	2	1	2	2	2
Adequacy or Appropriateness of Response	3	1	2	2	1	1
Cost/Benefit	3	2	1	2	2	2
TOTAL: (out of possible 24)	23	13	11	16.5	14	14
Individual Criterion Evaluation Scale: 1—Poor 2—Good/Adequate 3—Superior						Aggregate Evaluation Scale: 8 to 12—Poor 13 to 20—Good/Adequate 21 to 24—Superior

*Numbers shown represent the composite evaluation scores of all systems having the devices indicated.

Table 4-12
SUMMARY OF COUNTERMEASURE EFFECTIVENESS AS A DETERRENT TO CRIME[1]

Station Applications

Rating	Scale	Score	Devices
Very Effective	19 to 24	23	Radio Communications Equipment
Moderately Effective	13 to 18		
		15	Photo Cameras
		14	Closed Circuit Television
		14	Emergency Phones
		13	Public Address Systems
Little or No Effect	8 to 12	11	Alarms and Sensors

Vehicle Applications

Rating	Scale	Score	Devices
Very Effective	19 to 24	23	Radio Communications Equipment
Moderately Effective	13 to 18		
		15	Photo Cameras
		14	Altering Systems Operations
		14	Automatic Vehicle Monitoring
		13	Public Address Systems
Little or No Effect	8 to 12	11	Alarms and Sensors

[1]Based on composite responses of the transit operators interviewed for this project.

As shown in these tables, most security devices are assessed as moderately effective in combating transit crime. For example, photo cameras and public address systems are evaluated as being moderately effective in both station and vehicle applications. The systems generally rated emergency phones and CCTV as being moderately effective in station applications, whereas altering system operations capability and automatic vehicle monitoring are assessed as moderately effective in reducing transit crime on vehicles.

Radio communications equipment is evaluated as being very effective in both station and vehicle applications, having received the highest rating of all of the security devices. Conversely, alarms and sensors were evaluated as having little or no effect on transit crime, whether or not they are used at stations or on vehicles.

Transit security devices also were evaluated to determine their impacts on certain categories of transit crime. The results of this evaluation are presented in Table 4-13. The table represents composite responses across the 10-case study transit systems. For example, closed-circuit television was rated as very effective in dealing with crimes against personal property and system property, but only moderately effective in dealing with crimes against persons. Similarly, emergency phones were evaluated as moderately effective in dealing with crimes against persons or personal property, but having little or no effect on crimes against system property.

Tables 4-8 through 4-13 illustrate a procedure for evaluating electromechanical security equipment. The results are not intended to be conclusive, since they represent subjective opinions based on the knowledge, experience, and perceptions of a limited number of individuals. However, this evaluation provides a more thoughtful assessment of security equipment effectiveness than is found in previous research, since it was performed solely by a group of transit security specialists.

Agency Recommendations

For the most part, transit agency recommendations for design and operational improvements in security equipment generally focused on three primary areas:

- The modification and/or replacement of existing equipment with the latest available technology.
- The improvement and extension of surveillance capabilities through the increased use of electromechanical security equipment.
- The improvement in the state-of-the-art of available security technology.

However, a few systems recommended more specific changes that could be made to improve the effectiveness of security equipment.

Table 4-13
COUNTERMEASURE EFFECTIVENESS[1] AGAINST TYPES OF CRIME

		Crime Categories (Crimes Against...)		
DEVICES	APPLICATION	VE[2]	ME[3]	LE[4]
Closed Circuit Television	Station	Personal Property System Property	Persons Public	
Radio Communications Equipment	Station/Vehicle	Personal Property System Property	Persons Public	
Emergency Phones	Station		Persons Personal Property	System Property Public
Public Address Systems	Station/Vehicle		Personal Property System Property Public	Persons
Alarms and Sensors	Station/Vehicle		System Property	Persons Personal Property Public
Photo Cameras	Station/Vehicle	System Property	Persons	Personal Property Public
Altering System Operations	Vehicle		Persons Personal Property	Public System Property
Automatic Vehicle Monitoring	Vehicle		Persons Personal Property System Property Public	

[1] Based on composite responses of the transit operators interviewed for this project.

[2] Very Effective.

[3] Moderately Effective.

[4] Little or No Effect.

For example, MARTA recommends that several of its closed-circuit television cameras be changed from "stationary" to "pan, tilt, and zoom" cameras. This change would improve the surveillance capability of their CCTV system by increasing the viewing area of the cameras.

The MARTA intrusion alarm system is monitored by central control. To decrease response time in dispatching transit police, MARTA also recommends that alarms be received instead by the zone center monitors. In addition, MARTA suggests that the zone centers, from which all CCTV cameras are monitored, could become more effective if designed to allow two persons to control all functions on the console simultaneously. Therefore, if one monitor is busy handling a call or emergency, another monitor can continue surveillance of station platforms.

WMATA transit police strongly believe that while security equipment extends the surveillance capability of the police force and no doubt is a deterrent to crime, its real value is directly related to reduction in response time by the transit police force. Their experience has shown that electromechanical security equipment will deter criminals only if they know an adequate timely response will follow an incident.

This is the basis for WMATA's rejection of the use and potential value of dummy CCTV cameras as a deterrent to transit crime. WMATA has found that transit crime perpetrators will very quickly recognize the field of view of CCTV equipment and thus could very likely detect dummy cameras without difficulty. The Chief of WMATA's Transit Police personally believes that the greatest advance in electromechanical security equipment will come with the refinement of fiber optics, which will allow the monitoring of any number of CCTV cameras at one central location.

The staff of the Morgantown People Mover made several recommendations for the modification and upgrading of security equipment. First, staff believe that the replacement of "fixed" CCTV cameras with those having "pan, tilt, and zoom" capabilities could greatly increase their field of view and, thus, the potential for identifying problems or suspects. In addition, it is also felt that CCTV technology should be improved to provide a better quality of picture and, perhaps, the use of color instead of black and white to further enhance the picture's focus and identification of suspects.

MPM staff also believe that their on-vehicle radios could be improved with the addition of automatic vehicle identification as soon as communication is established between the vehicle and central control. Presently, the passenger has responsibility for identifying the vehicle by number; and if panicked, this information is often either inaudible or not provided. The staff further suggests that improvements in the emergency phone system could be realized through its conversion to a digital phone system (i.e., a four duplex system), which would allow patrons and/or central control to dial-up more quickly, and without interference, if more than one vehicle or operator is accessing the line. Such a system also allows for preemption in case of emergencies.

5. Conclusions

Because of the limited data available on the effectiveness of electromechanical security devices in combating transit crime, conclusions based on the case studies and survey described in this report are necessarily tentative. Although substantial additional information has been developed regarding the details of implementing security devices within existing rail and bus transit systems, assessments of these devices are based primarily on the judgmental views of a panel of experts from the case study transit systems. As a result, implications for utilization of devices in automated transit systems are drawn in a generalized way.

Conclusions based on this study are outlined in four areas:

- Relative effectiveness of different security devices, based on the various criteria utilized by surveyed security specialists, as presented in tabular form in the previous chapter.
- Comparison of these evaluative ratings of security devices against previous research, particularly studies completed for UMTA in 1980.
- A review of the policy and planning implications of transit security devices for automated transit system design.
- A brief list of continuing research needs in this subject area.

Summary of Transit Operator Assessments

A generalized impression of the effectiveness of electromechanical security equipment in association with guidway transit—and with implications for automated transit systems—can be drawn from the assessments made by personnel of the case study transit systems presented in the previous chapter. These assessments were made in relation to eight screening criteria, which were presented in Chapter 1. Admittedly, only a judgmental rating of each criterion was provided by each of the security experts who participated in the survey, but this still permits relative comparisons among the different security devices. All of the devices or approaches reviewed in this study appear to have some applicability to automated transit systems, if only because of their unmanned, electromechanical character. Consequently, ratings by transit personnel who have had real-world security experience can help in assessing the carry-over applicability of these devices to transit systems that are completely (or almost completely) unmanned.

A summary of the ratings given to the different equipment types reviewed in this report can be keyed to the eight criteria employed. Not all of the questions raised in relation to the criteria discussed in Chapter 1 were addressed in the interviews and surveys, largely due to a lack of data. Many other questions were answered, indirectly, via the descriptions of specific security devices given in Chapter 2 and the additional details on actual applications given in the case study reviews of Chapter 3. For example, operational details of different equipment types were discussed in Chapter 2, while some of the advantages and disadvantages of use in a transit environment were reviewed, via case study experience, in Chapter 3.

A number of factors make generalizations regarding the eight assessment criteria difficult. For this reason, the reader is referred to the additional details given in Chapters 2 and 3 for a more thorough understanding of individual security devices. Among the factors affecting generalizations are:

- Extent of application of a device in a transit system; how, where, and to what extent it is used—at stations, in vehicles, or both.
- Related elements of system and station design; whether stations and/or vehicles are new or old and whether security devices have been integrated within system design or added as a "retrofit."
- Extent and duration of experience with security devices, including ongoing modifications to improve effectiveness.
- How well a security hardware program has been managed, with regard to adequate funding (ability to purchase the best available technology), routine maintenance practices, and whether security devices are part of an integrated security system or employed as an uncoordinated strategy.
- Extent to which multiple security devices have been employed within a planned, integrated system and extent to which hardware devices have been coordinated with security personnel.

State-of-the-Art. Nearly all of the devices evaluated were found to perform adequately in terms of state-of-the-art technology. In effect, only those devices that had already been "proven" or implemented in existing rail or transit bus environments were included as candidates, reflecting an operational screening at the outset of the study. Radio communications equipment was rated most highly in terms of state-of-the-art capability, reflecting a superior capability to perform remote communications functions under circumstances of criminal threat or activity. Alarms and sensors, on the other hand, received a low rating, generally reflecting a limited capability to assist in deterring criminal activity or increasing apprehension rates, compared to other devices.

Compatibility with Existing Transit Systems. Four devices—public address systems, alarms and sensors, photo cameras, and radio communications equipment—were found to have applicability in stations as well as aboard vehicles. Appropriate equipment modifications would be needed to fit these devices within such varying environments, indicating ready adaptability on the part of these types of equipment. Again, radio communications equipment received the highest rating, indicating that the versatility and small size of radio communication devices permit a wide variety of applications. Closed-circuit television, on the other hand, was found to have serious problems with respect to compatibility within the older rail transit systems of the country, where convoluted station design (presence of columns, corridors, etc.) prevent adequate viewing of an entire station area. Effective incorporation of closed-circuit TV within automated transit systems will require, as a result, a careful integration within station designs from the beginning.

Maintainability. This criterion is probably too detailed and site-specific to permit adequate assessment. Much depends on the specifics of implementation, operation, and maintenance procedures of any given transit system. As a result, nearly all of the devices received an "adequate" rating on this criterion, although details on equipment breakdowns, failures, expense to repair, and general maintenance costs were not available. Two electromechanical techniques, largely because they are primarily related to system operational functions (the movement of train or bus vehicles throughout a system), received a "poor" rating as effective security countermeasures. Moreover, altering system operations and automatic vehicle monitoring are linked directly with vehicle maintainability and performance and, therefore, reflect the failure uncertainties associated with vehicle performance.

Reliability. The security devices varied significantly with regard to this criterion. Several devices—emergency phones, public address systems, alarms and sensors—are highly susceptible to vandalism, pranks, and false alarms, which clearly limit their effectiveness. Photo cameras and radio communications equipment, on the other hand, if properly located (out of reach) or encased within metal compartments or vehicle fixtures, are much less susceptible to vandalism and disablement. The same applies to closed-circuit television cameras if properly mounted out of reach.

Flexibility. Radio communications equipment again received a high rating with regard to flexibility, largely due to the easy transportability of radio equipment components and their ability to function virtually anywhere within a transit system. Emergency phones, public address systems, and alarms and sensors, on the other hand, were found to be less flexible because of their typical location at only a few fixed positions, partly due to cost and partly due to the need for such devices to be centrally located within stations or aboard vehicles. Still, such devices are capable of integrated design and locational flexibility within new stations, such as those that might be designed for automated transit systems. Consequently, flexibility is more a problem of fixed location within existing rail transit operations.

Adequacy of Surveillance Coverage. It is difficult to generalize about this criterion since it relates to effectiveness in combating crime. In general, most systems were found to be "adequate," except for alarms and sensors and photo cameras. Generally, it was felt that the latter two devices provided only limited coverage of specific problem areas at stations and, therefore, are potentially less effective. Radio communications equipment, on the other hand, including two-way radios and vehicle or voice-activated station intercoms, can offer greater coverage—but only in terms of audio (and not visual) communications.

Adequacy or Appropriateness of Response. More devices were rated as "poor" on this criterion than any other. In part, this reflects the inherently limited capabilities of unmanned devices for immediate response in discouraging criminal behavior (deterrence, apprehension, conviction, etc.). Some devices, such as radio communications equipment, alarms and sensors, and closed-circuit TV, have the potential to reduce police response time via direct communication link to transit operations personnel and associated police operations. Some devices, particularly closed-circuit TV, also have been found to improve passenger perceptions of transit security, via their potentially high visibility (at least within new transit station designs). Public address systems, photo cameras, altering system operations, and automatic vehicle monitoring were all found to have highest response capability.

Cost/Benefit. Because of limited availability of cost data for the security devices examined here, it is not possible to draw meaningful comparisons among devices regarding cost and benefits. According to the generalized ratings offered by case study operators, radio communications equipment offers the highest *potential* for favorable benefit/cost ratios, while alarms and sensors offer the least potential.

Based on these criteria, the general consensus of the case study transit operators was that radio communication equipment rates highest, or "very effective," in terms of both station and on-vehicle applications. Alarms and sensors, on the other hand, were rated as having very limited effect. All of the remaining transit security devices were rated "moderately effective," with considerable variability on a site-to-site basis. These ratings apply to either vehicle or station applications.

Most of the case study transit operators employed multiple security devices—typically five or more devices at either stations or aboard vehicles. In addition, each of the experts interviewed stressed that transit security equipment is, regardless of the specialized devices used, most effective in coordination with transit police or security guards who will continue to be the most significant factor in deterring or controlling transit crime. Electromechanical security devices appear consequently best employed in adjunct to transit police or security officers and cannot, alone, provide sufficient security for the patrons of existing bus and rail transit systems.

This significant conclusion appears to have major carry-over to automated transit systems. Although one of the guiding principles of such systems is to minimize the need for system operations personnel, the lack of real-world experience with automated transit systems in crime-prone environments prevents the forming of firmer conclusions. Only one of the 10 systems reviewed here, the Morgantown system, is automated, but operates in a relatively unique university-type environment, without the crime problems associated with major portions of "typical" central cities and other urban areas. Nearly all of the existing automated transit implementations in the United States are at airports or recreation centers, which are also very specialized environments without significant crime problems as related to transit ridership.

Comparison with Previous Research

This research expands upon previous studies in that most literature sources to date either document and analyze the nature and extent of mass transit crime and/or generally discuss the types of security countermeasures available (electromechanical and otherwise). Few prior research efforts provide qualitative or case study analyses that document the experience of transit systems (including evaluations) with security equipment in reducing transit crime. Moreover, few existing studies explore the implications of current experience with these devices for the future planning of automated transit systems.

One recent study (18) does provide a systematic attempt to evaluate the effectiveness of transit security devices, also relying on judgmental ratings of countermeasure effectiveness. However, these ratings were prepared largely by members of the study team, rather than by security specialists with hands-on transit system experience. Only four of the eight electromechanical devices considered in the present study were included in this previous work. The evaluative ratings, when converted to rankings, in the related study were generally comparable to those reported here. As indicated in Table 5-1, the ratings given to closed-circuit television and photo cameras were reversed, but both public address systems and passenger alarms were rated lower than these options. Closed-circuit television did receive a rating substantially higher than that for other electromechanical devices considered in the previous study, although radio communication devices were not included.

Table 5-1
COMPARATIVE RANKING OF SECURITY COUNTERMEASURES

Countermeasure	Evaluative Ranking: Present Study	Evaluative Ranking: University of Virigina Study[1]
Radio Communications Equipment	1	—
Photo Cameras	2	2
Closed-Circuit Television	3	1
Emergency Phones	3	—
Altering Systems Operations	3	—
Automatic Vehicle Monitoring	3	—
Public Address Systems	4	3
Alarms and Sensors: Passenger-Activated	5	3
Alarms and Sensors: Burglar-Type	5	4

[1] See Reference 18.

Generally, the present study provides a more current and detailed inventory of the security hardware available on the market and in use at each of the 10 major transit systems examined. In addition, unlike previous research, the case study approach used to document the application of the devices and the experience of the existing transit systems in providing passenger security with the use of electromechanical security equipment represents a new, more thorough research framework. This approach permitted the study to focus on security hardware instead of on the wide range of manpower, facility design, and technological security alternatives available. As a result, the study expands upon previous discussions of the types of devices available and the potential advantages, disadvantages, and limitations associated with their use.

Implications for Automated Transit

Policy and planning implications for automated transit, which can be drawn from this review of existing rail and bus operations, must necessarily be broad in nature.

In general, any of the devices reviewed here, except for alarms and sensors, could have a significant role in passenger security planning for automated transit systems, depending on the specific details of system implementation. The ratings and conclusions for applicability and effectiveness within existing rail (primarily) and bus transit environments appear to be directly transferable to automated transit system environments. This is because of many basic similarities in terms of service levels and system design—grade-separated guideways and stations, the need for some degree of waiting for vehicles at fixed locations (stations or stops), the need to share vehicle space with others, the need to enter and exit stations from fixed, street-level locations, etc.

However, two important service improvements of automated transit operations would apparently, in themselves, reduce exposure to criminal risks.

First, for those automated transit operations with small and medium-size vehicles, a relatively short wait time is generally expected, usually well under five minutes during peak hours and possibly that short during the off-peak if some form of demand-responsive scheduling is employed. While this more personalized transit service may reduce criminal risk associated with waiting on platforms, it may increase that risk through the sometimes necessary sharing of small vehicles with one or two strangers, particularly during off-peak operations.

Even for large-vehicle automated transit operations, headways and wait times may be shorter than for existing transit operations, due to more frequent scheduling of one- or two-vehicle "trains," as opposed to the six- or eight-vehicle trains commonly employed in conventional rail transit operations. Large-vehicle automated transit operations reduce the risk of riding with one or two strangers, since more passengers will be carried in any given vehicle, both during the peak and off-peak.

Second, smaller-vehicle automated transit operations also typically require smaller platform lengths and a larger number of more frequently spaced, smaller stations.

These smaller dimensions afford less opportunity for criminal exposure and are also easier to supply with surveillance equipment. However, a large number of stations may increase the overall cost of surveillance; for example, via closed-circuit television and radio communication equipment, as well as public address systems and/or special emergency phones. Even large-vehicle automated systems are likely to require significantly smaller stations because of reduced train or platform length. Fewer stations and vehicles in large-vehicle systems also could reduce security equipment costs significantly for this form of automated transit.

Transit stations—automated or conventional—that are located in high-crime neighborhoods will nearly always require special security planning. Periodic saturation patrols may be valuable in this situation, if post-patrol crime levels for a station are reduced for a significant period. An alternative strategy is the use of police substations on a transit line that has several high-risk stations. By decentralizing monitoring of high-risk stations, the link between victims and police could be direct, response times quick, and central control would be relieved of difficult monitoring tasks. In high-crime neighborhoods, the supplementary use of police patrols would appear to be an important adjunct to automated transit operations.

Station platforms can present security risks for the user of any transit system, automated or conventional. Therefore, new system platforms must be designed to allow effective closed-circuit TV monitoring, as well as radio communications and public address/telephone links. All platforms will likely need some monitoring throughout operating hours, and high-risk platforms will need almost constant surveillance during off-peak, low-density hours. Therefore, adapative space is a firm requirement for larger stations.

Since waiting time for a vehicle is the most dangerous segment of a transit trip, adaptive space, i.e., techniques to modify the size of passenger waiting areas (to reflect changing travel demand levels) would help increase transit station security. For example, it appears that if people can wait in groups, they are safer. Thus, when there are but a few people waiting, a smaller waiting area should be provided. Typically, as waiting time or transit demand increases, so could the size of the waiting area to accommodate the increase in the number of people waiting in queue. In general, though, smaller-vehicle automated transit stations would reduce this need for adaptive space; for large central business district stations, this concept could still be of value.

Continuing Research Needs

The limited availability of data on effectiveness, in relation to specific security devices employed by existing transit systems, suggests at least three continuing research topics related to automated transit systems.

- *More precise evaluation methodologies must be defined*, particularly in relation to data needs associated with the separable (if possible) impacts of different approaches to transit security. Even where existing transit systems expressed interest in or concern for evaluating their own transit security hardware, there was relatively poor understanding of how to proceed to structure experimental designs and data collection efforts in order to assess the impacts. This applies particularly to "before and after" data collection efforts when installation of new equipment is anticipated or accomplished.

- Given workable evaluation and data collection methodologies, there is a *major need to document the actual impacts on criminal behavior*, both within stations and on-board vehicles, in association with existing rail and bus transit systems. This documentation should be in a form to permit a structured comparison of costs versus effectiveness and relative impact rates for the different transit security countermeasures. These evaluations should cover both electromechanical security equipment and supporting police patrols.
- *The perception of criminal risk aboard automated transit systems* is still a relatively unknown area. This is largely due to the absence of such systems within high-crime environments, so that real-world experience is quite limited. The unmanned character of automated transit systems in such environments has not been examined adequately with regard to user perceptions of security and safety.

Appendix A
Study Methodology

The study was organized and conducted by using a program of four consecutive work study phases:

- Phase 1: Perform Literature Search
- Phase 2: Prepare Case Study Program Design
- Phase 3: Conduct Case Studies
- Phase 4: Analysis and Evaluation of Data

These phases were undertaken as a more detailed series of 12 tasks. These tasks are summarized below, as they relate to each of the program work phases.

Phase 1: Literature Search

The first phase of the work involved a review of the general state-of-the-art and recent literature in transit security planning. The emphasis of the literature search was on data published since 1977 and involved a series of four work tasks.

Task 1: Identify Countermeasures

The first work task was a composite inventory of electronic and mechanical security devices available for use on both rail and bus surface transportation systems. Emphasis was given to practical systems already in operation, both on board vehicles and at stations. Specific examples of application within existing systems were identified, and literature relating to their effectiveness was obtained.

Task 2: Analyze Transit Crime

Drawing upon recent literature, the second task involved documentation of the basic characteristics of existing transit crime, both on vehicles and at stations. This review concentrated on new material appearing since 1977 to update the already extensive literature review provided in an earlier related study, *Predicting AGT System Station Requirements*. (53) An in-depth analysis of this literature was made which documents the nature and extent of transit crime and identifies its implications for automated transit security planning. In addition, several studies were reviewed to document and analyze the public's *perception* of crime on mass transit systems.

Task 3: Analyze AGT Systems

In this task, the key environmental characteristics of automated transit stations and operating systems which may influence crime potential were identified. Based on the review of available literature, implications for future automated transit security planning also were identified.

Task 4: Review Analysis Methods

Methodologies to evaluate the effectiveness of electromechanical security devices were reviewed, drawing from existing literature. In particular, methodologies were selected for application to the types of data to be generated during the Phase 3 Case Study work. Among the methodologies considered under this task were archival research, field observations, surveys (both perceptual and victim), and a variety of statistical analyses (crime indices, cross-city comparisons, causal analysis). Prior studies dealing with public perception of crime on existing transit systems also were consulted for methodological inputs.

Phase 2: Case Study Program Design

Phase 2 of the study involved the preparation of a program design for conducting multiple transit system case studies. Since the scope of the study called for no original research or new data collection, except that obtained through the case studies, a careful preparation of the program design was essential in obtaining accurate and appropriate case study data. The work required for this study phase was completed in four work tasks.

Task 5: Identify Effectiveness Criteria

Effectiveness criteria were drawn from a review of prior studies. These criteria were selected to cover three broad areas of effectiveness analysis. Several criteria were identified to evaluate the *state-of-the-art* in terms of technology available and experiences with the operation of these devices. Other criteria were selected to evaluate the *crime reduction potential and effectiveness* of security devices, both in terms of actual crime reduction and improved passenger perceptions of security. Finally, the remaining criteria were selected to evaluate the *acceptability* of the security devices in terms of cost benefits to transit users and personnel.

Task 6: Identify Transit Systems for Study

The list of potential transit systems to be reviewed as case studies was derived from the review of the literature and informal talks with persons experienced in the transit security field. The transit systems identified from this list as case studies for the project were selected on the basis of six criteria. The criteria developed for this selection process include the following:

- Comparability to automated transit environments.
- Range of devices deployed/evaluated.

- Unique capabilities/applications of devices.
- Unique security problems.
- Unique system characteristics.
- Extent of transit security experience.

The results of evaluating the candidate transit systems using these criteria are presented in Table A-1. The Washington Metropolitan Area Transit Authority (WMATA) was selected for case study analysis since it was identified as employing the largest number of security measures, having extensive transit security experience, and using security devices in both on-vehicle and station applications. The Morgantown People Mover (MPM) system was selected since it was one of the few existing automated transit systems operating in a "typical" transit environment. In addition, the system could demonstrate the new technology application of "Altering System Capability" as a transit security countermeasure. The Chicago Transit Authority (CTA) demonstration program, with an integrated audio/visual communications system known as "Teleview Alert," was the basis for selecting the CTA for the study.

The evaluation of the New York City Transit Authority (NYCTA) and the CTA transit systems permitted a comparative analysis of the use and effectiveness of electro-mechanical devices in older transit systems, as compared with the newer and more modern designs of the Bay Area Rapid Transit District (BART), the Metropolitan Atlanta Rapid Transit Authority (MARTA), and the Port Authority Transit Commission (PATCO). The Toronto Transit Commission was selected because of its reputation as a "model" transit security program on which several other systems based their designs and because of its successful implementation of a passenger assistance alarm system on its rail cars. Finally, San Diego Transit (SDT) and the Southern California Rapid Transit District (SCRTD) were selected to expand the data available on surface transportation systems that currently employ technological devices on buses as a means of providing passenger and employee security.

<u>Task 7: Identify Security Specialists</u>

This task involved the identification of "key" transit security specialists or personnel whose background and experiences could benefit the study. The specialists were identified in two broad areas: (1) key personnel at the 10 transit systems selected for the study and (2) other persons whose work and/or special interests have contributed to the body of knowledge in the transit security field. Once identified, these specialists were individually contacted by phone and letter to enlist their cooperation and assistance. Table A-2 is a list of the key security contacts for the study.

<u>Task 8: Develop Formats for Security Interviews</u>

Case study transit security interviews were a key element in the process of evaluating the effectiveness of electro-mechanical security equipment. They documented the actual experiences, perceptions, and evaluations of transit security specialists.

Table A-1
SELECTION OF TRANSIT SYSTEM CASE STUDIES

	Case Study Transit Systems									
Case Study Selection Criteria	BART	Morgantown	WMATA	San Diego	MARTA	TTC	PATCO/ Lindenwold Line	CTA	NYCTA	SCRTD
Comparability to Environments	S	A	S	NS	S	S	S	S	S	NS
Range of Security Countermeasures Employed[1]	9/14	6/14	11/14	3/14	6/14	10/14	6/14	11/14	11/14	4/14
Unique Capabilities/ Applications of Devices	On-Vehicle Devices	Altering System Capability	On-Vehicle Devices and Computer Communications System	On-Vehicle Devices	Integrated Audio/Video Communications System	Passenger Assistance Alarm	CCTV	TVA	CCTV	On-Vehicle Devices
Unique Security Problems	Parking Lot Thefts	Vandalism	Robbery	Public Nuisances Robbery	Public Nuisances	Vandalism Pick-pocketing	Car Thefts	Fare Evasion Robbery	Fare Evasion Personal Safety	Public Nuisances Robbery
Unique System Characteristics	Modern Security Design	Operating AGT System	Modern Security Design	All-Bus System	Modern Security Design	Modern Security Design	Modern Security Design	Old Security Design	Old Security Design	All-Bus System
Extent of Transit Security Experience	Moderate	Limited (Crime Has Not Been a Significant Problem)	Extensive	Moderate	Moderate	Moderate	Moderate	Extensive	Extensive	Moderate

[1] Includes the following countermeasures:

Electromechanical Devices

CCTV
Photo Cameras
Alarms and Sensors
Public Address System/Monitors
Radio Communications System
Emergency Phones
Automatic Vehicle Monitoring
Altering System Operations

Other Countermeasures

Transit Police
Security Officers
K-9 Patrols
Observation Booths/Ticket Kiosks
Fare Evasion Equipment
Parabolic Mirrors

A = Actual
S = Similar
NS = Not Similar

Table A-2
DIRECTORY OF TRANSIT SECURITY CONTACTS

Contact	Rail	Bus	Other
Mr. Raleigh Mathis, Director of Security Chicago Transit Authority P.O. Box 3555 Merchandise Mart Plaza Chicago, Illinois 60654 (312) 664-7200	X	X	
Mr. James A. Anderson, Chief Planning Analyst CTA Security Project Research and Development Division Department of Public Works Room 406, City Hall 121 North LaSalle Street Chicago, Illinois 60602 (312) 744-3669			Teleview Alert System
Lieutenant Stojkovic, Lieutenant of Police Chicago Police Department Room 200, Communications Center 1121 South State Street Chicago, Illinois 60602 (312) 744-5447			Teleview Alert System
Inspector John F. Hyde Bureau of Support Operations Metro Transit Police Washington Metropolitan Area Transit Authority 600 Fifth Street, NW Washington, D.C. 20001 (202) 637-1552	X	X	
Mr. Jack Schnell American Public Transit Association 1225 Connecticut Avenue Washington, D.C. 20036 (202) 828-2880			APTA committee work and transit security research of both rail and bus systems
Sergeant Newlon, Police Services Bay Area Rapid Transit District 800 Madison Street Oakland, California 94607 (415) 465-4100	X		
Mr. James B. Meehan, Chief New York City Transit Police 370 Jay Street Brooklyn, New York (212) 330-3441	X	X	
Mr. John Waters MARTA Transit Police 2775 E. Ponce de Leon Avenue Decatur, Georgia 30030 (404) 586-5000	X	X	
Mr. Harry Budds, Assistant Police Chief Southern California Rapid Transit District 425 South Main Street Los Angeles, California 90013 (213) 972-6000		X	
Mr. Robert Bates, Director Morgantown People Mover 99 Eighth Street Morgantown, West Virginia 26506 (304) 293-5011	X		
Captain John P. McGinty Port Authority Transit Corporation Ben Franklin Bridge Plaza Camden, New Jersey 08102 (608) 963-8300	X Lindenwold Line		
Mr. Jack Townsend, Director of Safety and Security Toronto Transit Commission 1900 Yonge Street Toronto, Ontario, Canada M4S 1Z2 (416) 534-9511	X	X	
Mr. John Garland, Manager of Safety and Instruction San Diego Transit P.O. Box 2511 San Diego, California 92112 (714) 238-3004		X	

Much of the existing literature on actual application and experience in the use of security countermeasures is incomplete, outdated, or in need of clarification. The interview process provided a means for verifying or completing the data base information related to transit crime characteristics and the types and current application of security hardware.

Transit security research prior to 1978 dealt on a limited basis with the "effectiveness" of electromechanical devices as security countermeasures. The interviews provided actual case studies of the use and effectiveness of such devices. Finally, based on the experiences, perceptions, and recommendations of transit security specialists, supporting information was obtained concerning potential applications of electromechanical devices in automated transit systems. Written and telephone interviews were conducted as well as "field visits" for review and evaluation of four selected case studies.

The security interviews covered three major topics:

- Transit System Background
- Transit Security Programming
- Security Planning Experience

Table A-3 provides an outline of the interview and analysis areas included under each of the three major topics. Forms A to G supplement the outline by providing the format for recording responses for portions of Sections 2 and 3 of the table.

Phase 3: Case Studies

The purpose of this study phase was to conduct case study analyses for 10 selected transit systems. Of the 10 systems studied, three were all-rail systems (BART, PATCO, Morgantown), two were all-bus systems (SDT and SCRTD), and five systems provide both rail and bus transportation (WMATA, TTC, MARTA, CTA, NYCTA). Two work tasks were required to complete this study phase.

<u>Task 9: Collect System Background Data</u>

System and operating characteristics for the 10 transit systems were collected. The information obtained is outlined in Section 1 of Table A-3 and was important in establishing a comparative analysis of transit operating characteristics. It was obtained primarily through a review of literature on each of the systems. Additional data, as needed, was obtained through phone or mail requests.

<u>Task 10: Conduct Interviews</u>

The security interviews were conducted by phone, mail, and field visits to selected sites. Each transit system was supplied with a packet containing Forms A to G to serve as an outline for the discussion and to provide a consistent format for recording the responses. The interviews with NYCTA, WMATA, BART, and CTA were conducted by a combination of phone and on-site visits. A combination of phone and mail interviews was used for the remaining transit systems.

Table A-3
DISCUSSION OUTLINE FOR SECURITY INTERVIEWS

1. **Transit System Background**
   - A. System Configuration (linear, loop, grid, AGT)
   - B. System Environment (size, urban, suburban, age, condition, etc.)
   - C. Area Demographics (population, growth, employment, etc.)
   - D. System Organization/Administration (regional, city, etc.)
   - E. Uses Served by System (CBD, special attractors, etc.)
   - F. Hours of Operation
   - G. Patron Profile and Patronage
   - H. Operations/Service Description

2. **Transit Security Programming**
   - A. Existing and Proposed Security Programs or Revisions
   - B. Inventory of Electro-Mechanical Security Devices
   - C. Inventory of Other Security Countermeasures (i.e., transit police, K-9 patrols, observation booths, etc.)
   - D. Applications/Capabilities of Countermeasures (i.e., on-vehicle, TVA, BAPERN, etc.)
   - E. Factors Influencing Countermeasure Selection

3. **Security Planning Experience**
   - A. Extent and Range of Experiences
   - B. Unique Problems or System Characteristics
   - C. Evaluation of Countermeasure Effectiveness
   - D. Effectiveness Packaging of Security Countermeasure Alternatives
   - E. Potential Applications for AGT Systems
   - F. General Comments and Recommendations

Form A
SURVEY OF SECURITY COUNTERMEASURES USE

Security Countermeasure	Countermeasures Used and Their Characteristics[1]	Application	
		Station[2]	On-Vehicle[3]
Closed Circuit Television (CCTV)			
• Constant Monitoring			
• Alarm Activated			
• Video-Recording			
• Dummy Cameras			
• Zoom Lens Capability			
• Pan-and-Tilt Operation			
• Fixed-Turret Camera			
• Sequential Monitoring Capability			
• Other			
Alarms			
• Non-Voice			
• One-Way			
• Two-Way			
• Intrusion Detection			
• Line Supervision Devices (alarms to protect alarms)			
• Hidden Alarms			
• Passenger-Activated Features			
• Local Alarm System			
• Remote Alarm System			
• Audible Alarm			
• Metal Detectors			
• Other			
Sensors			
• Photo-Electric Beams			
• Microwave/Radar			
• Balance Pressure			
• Electro-Mechanical Switches			
• Vibration			
• Metal Foil			
• Acoustic			
• Capacitance Proximity			
• Other			
Communications Equipment			
• Public Address System			
• Voice Monitors			
• Emergency Phones			
• Radios			
• Walkie Talkies			
• Other			
Photo Cameras			
Fare Evasion Equipment			
Altering System Operations			
• Power Interruption Capability			
• Slow or Speed-Up Trains			
• Other			
Automated Vehicle Monitoring			
Observation Booths			
Transit Police			
• Division of Local Police			
• Department of the Transit Authority			
• Multijurisdiction Police Force Separate from Police or Authority			
• K-9 Patrols			
• Plain-Clothes Detectives			
• Police Decoys			
• Saturation Patrols/Random Patrols			
• Visible, Uniformed Security Force			

Use the following check marks for the respective entries: (1) = X; (2) = S; (3) = O-V.

Form B
COUNTERMEASURE EVALUATION

Effectiveness Criteria \ Security Alternatives	Closed Circuit Television	Radio Communi-cations Equipment	Emergency Phones	Alarms and Sensors	Photo Cameras	Metal Detectors	Altering System Operations	Automatic Vehicle Monitoring	Public Address Systems
State-of-the-Art									
Compatibility with Existing Transit Systems									
Maintainability									
Reliability									
Flexibility									
Adequacy of Surveillance Coverage									
Adequacy or Appropriateness of Response									
Cost/Benefit									
Total:									
Evaluation Scale 1 - Poor 2 - Good/Adequate 3 - Superior									

Perceived Effectiveness Against Types of Transit Crime

	Against Public					Against Station Property							Against Person-Carried Property			Against Person			
	Concealed Weapons	Disorderly Conduct	Drunkenness	Sex Crimes	Drug Law Violations	Missilings	Arson	Trespassing	Petty Theft	Vandalism	Fare Evasion	Station Burglary	Pocket-Picking	Purse-Snatching	Robbery	Homicide/Manslaughter	Battery	Assault	Rape
Closed Circuit Television (CCTV)																			
• Constant Monitoring																			
• Alarm Activated																			
• Video-Recording																			
• Dummy Cameras																			
• Zoom Lens Capability																			
• Pan-and-Tilt Operation																			
• Fixed-Turret Camera																			
• Sequential Monitoring Capability																			
Alarms																			
• Non-Voice																			
• One-Way																			
• Two-Way																			
• Intrusion Detection																			
• Silent																			
• Line Supervision Devices (alarms to protect alarms)																			
• Hidden Alarms																			
• Passenger-Activated Features																			
• Local Alarm System																			
• Remote Alarm System																			
• Audible Alarm																			
• Metal Detectors																			
Sensors																			
• Photo-Electric Beams																			
• Microwave/Radar																			
• Balance Pressure																			
• Electro-Mechanical Switches																			
• Vibration																			
• Metal Foil																			
• Acoustic																			
• Capacitance Proximity																			
Communications Equipment																			
• Public Address System																			
• Voice Monitors																			
• Emergency Phones																			
• Radios																			
• Walkie Talkies																			
Photo Cameras																			
Fare Evasion Equipment																			
Altering System Operations																			
• Power Interruption Capability																			
• Slow or Speed-Up Trains																			
Automated Vehicle Monitoring																			
Observation Booths																			
Transit Police																			
• Division of Local Police																			
• Department of the Transit Authority																			
• Multijurisdiction Police Force Separate from Police or Authority																			
• K-9 Patrols																			
• Plain-Clothes Detectives																			
• Police Decoys																			
• Saturation Patrols/Random Patrols																			
• Visible, Uniformed Security Force																			

Use the following check marks for the respective entries: (H) = High; (M) = Medium; (L) = Little or no effect.

Form D

EXTENT OF EXPERIENCE WITH TRANSIT SECURITY EQUIPMENT

Instructions: Please indicate the extent of your knowledge of the security devices listed by checking (✓) the appropriate box.

Device	Hands-On Experience	Review of Literature	No Experience or Knowledge
Closed-Circuit Television			
Radio Communications Equipment			
Emergency Phones			
Public Address System			
Alarms/Sensors			
Photo Cameras			
Metal Detectors			
Altering System Operations Capability			
Automatic Vehicle Location or Monitoring			

Form E
SECURITY EQUIPMENT COSTS

Instructions: List the security devices used in your transit system and provide the indicated cost information, if possible, for each device. Supplement this information with any footnotes or additional tables necessary to explain how these figures were derived.

	Costs		
Security Equipment	Capital	Installation	Operating

Form F

EQUIPMENT EFFECTIVENESS RATES

Instructions: List the security devices used in your transit system and indicate the impact of the devices on each of the security criteria shown. If *actual* impact values or rates are not available from file data, please provide your "best educated guess." If "effectiveness" can be better represented in some other discussion format, please indicate and provide accordingly. Moreover, if no information can be provided—either "actual" or "estimated"—please explain why.

Security Equipment	Patron Use Rate	Crime Detection Rate	Response Time of Security Staff	Arrest Rate	Conviction Rate	Overall Impact on Crime Reduction
Example: Passenger Assistance or Emergency Phones	Average of four times/ day	Average of six times/ month	Improved 5% or an average of seven minutes/call	Average of three arrests/ month	One conviction since installation in 1980	Reduced crime by 1.5%

Note: Please indicate whether "actual" or "estimated" data was provided.

Form G

TRANSIT SECURITY EQUIPMENT EVALUATION

Instructions: Evaluate your transit security equipment based on the following criteria. Definitions of the criteria are attached to the form. In addition, for each of the criteria, identify those devices which have the most significant, positive impact on or pose special problems for your transit security efforts.

State-of-the-Art: ______________________________

Compatibility: ______________________________

Maintainability: ______________________________

Reliability: ______________________________

Adaptability: ______________________________

Adequacy of Surveillance Coverage: ______________________________

Adequacy/Appropriateness of Response: ______________________________

Phase 4: Data Analysis and Evaluation

The final phase of the study involved evaluation of the data collected and the preparation of the final report. The tasks required to complete this work are summarized below.

Task 11: Evaluate Research and Case Study Data

Based on the results of the preceding tasks, a review and analysis were conducted of the case study data and information obtained through the literature search. Data summaries for each of the security interviews were prepared which include the following discussion/analysis areas:

- System Background
- Electro-Mechanical Security Devices
- Other Security Countermeasures
- Security Program Effectiveness

These summaries are particularly useful in identifying specific limitations of technological systems and potential operating and maintenance concerns.

Task 12: Prepare Technical Report

The results of all preceding tasks are documented in this final report.

Appendix B
Biographical Sketches

John W. Townsend, Toronto Transit Commission

John W. Townsend was appointed Director of Safety and Security of the Toronto Transit Commission in 1976. As director, he played a key role in the planning and successful implementation of the rail system's Passenger Assistance Alarm Program. Prior to this position, Mr. Townsend served as General Superintendent of Plant Operations and as Plant Coordinator.

Mr. Townsend is a certified engineering technician in the Province of Ontario, as well as being affiliated with the Ontario and Canadian Associations of Chiefs of Police.

Theodore C. Barker, Morgantown People Mover

Theodore C. Barker is Operations Manager for the Morgantown People Mover. His security experience stems from 10 years of employment with this automated transportation system. Based on this experience, Mr. Barker is familiar with the use of closed-circuit television, radio communications equipment, emergency phones, public address systems, alarms and sensors, altering system operations capability, and automatic vehicle locator systems.

John P. McGinty, Port Authority Transit Corporation

John P. McGinty has been Captain of Police of the Port Authority Transit Corporation for 13 years. During this time, he has acquired experience with the use of closed-circuit television, alarms, and radio communications equipment. He also has attended numerous seminars updating the latest in security technology and manpower training and deployment.

Before joining PATCO, Captain McGinty completed 23 years of service with the Philadelphia Police Department.

John F. Hyde, Washington Metropolitan Area Transit Authority

Inspector Jack Hyde commands the Bureau of Support Operations of the Metro Transit Police of the Washington Metropolitan Area Transit Authority. He is currently engaged in operational police and security activities of the Metro Rapid Transit System. The Metro Transit Police work in close coordination with all police and federal law agencies of the Washington Metropolitan Area.

Inspector Hyde has over 40 years of worldwide police, security, intelligence, and investigative experience in staff, command, and operational positions, including over 30 years of service in the United States Army, from which he retired as a colonel. During his military service he served as a senior police advisor to several police agencies of allied nations and was a member of the U.S. Army General Staff. He is a life member of the International Association of Chiefs of Police, the Military Police Association, the Police Management Association, the Police Intelligence Association, the Maryland State Crime Prevention Association, and the Virginia State Crime Prevention Association, and he is a member of the Board of Directors of the International Association of Airport and Seaport Police.

James B. Meehan, New York City Transit Authority

James B. Meehan was appointed Chief of the New York City Transit Police Department in 1978 by the Metropolitan Transit Authority and the Mayor of New York. Prior to his appointment, Chief Meehan was a member of the New York City Police Department for 30 years. During those 30 years, he held two of the department's highest management positions—Chief of Patrol, in which he commanded the department's 18,000-man patrol force, and Chief of Personnel. He also held command positions in the department's detective, intelligence, planning, and training bureaus.

From 1960 to 1965, Chief Meehan taught Police Personnel Management at the Baruch School of City University, the forerunner of the John Jay College of Criminal Justice. He also has authored several publications dealing with police training and crime prevention.

John L. Waters, Metropolitan Atlanta Rapid Transit Authority

John L. Waters is Assistant Chief of Transit Police for the Metropolitan Atlanta Rapid Transit Authority. He began working with the agency in 1972 when MARTA created its transit police and security division. Mr. Waters' responsibilities include the coordination of transit security efforts with local police agencies, and assistance in the apprehension and conviction of persons committing crimes against MARTA property, employees, and patrons.

In 1976, Captain Waters became actively involved with security planning for the MARTA rail system, specifically with regard to the use of intrusion alarms, closed-circuit television, and emergency phones.

Harry Budds, Southern California Rapid Transit District

Harry Budds has been with the Southern California Rapid Transit District since 1980, where he serves as the Assistant Chief of Transit Police. Among his varied responsibilities, he assisted in the planning, implementation, and supervision of the demonstration program to test the use of on-vehicle photo cameras in reducing crime and vandalism on the SCRTD bus system.

Prior to accepting his position with SCRTD, he was a member of the Los Angeles County Sheriff's Department for 19 years. His various assignments included patrol, homicide investigations, and internal affairs.

Mr. Budds is affiliated with the Los Angeles County Peace Officers Association, the International Association of Chiefs of Police, and the American Society of Industrial Security.

Brian Newlon, Bay Area Rapid Transit District

Sergeant Newlon has been with the Bay Area Rapid Transit District since 1972, where he presently serves as Administrative Sergeant of Support Services. His responsibilities include records, supervision, traffic, warrants, procurement, and capital projects.

Sergeant Newlon has been a police officer since 1965, having served in the police department of the City of Sausalito, California, for seven years prior to joining BART. His knowledge of and experience with electromechanical security devices are based on his tours of duty with both BART and the City of Sausalito.

Ernest Stojkovic, Chicago Police Department

Lieutenant Stojkovic has served in the policy and security field since 1949. For the first three years of his career, he was employed by the Illinois Central Gulf Railroad in the Special Agents Department which was responsible specifically for providing station and vehicle security.

Since 1952, Lieutenant Stojkovic has been with the Chicago Police Department nine years, followed by two tours of duty in the Communications Department, for which he is currently employed as the Watch Commander. His responsibilities include the supervision and coordination of all radio dispatch services, as well as operation and manpower training for the Chicago Transit Authority's "Teleview Alert" audio-video surveillance system.

Lieutenant Stojkovic is affiliated with the Fraternal Order of Police, the Illinois Police Association, and the Chicago Police Lieutenants' Association.

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