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Planning Procedures for Improving Transit Station Security

Virginia Univ.
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Planning Procedures for Improving Transit Station Security

FINAL REPORT

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16. Abstract

This document describes the procedures and concerns in designing safe and secure transit stations. The report is divided into five parts. Part I introduces the problem of transit security, distinguishes between safety and security and between objective and perceived security, and presents background information on design issues and security. Part II reviews the statistics on transit crime - comparing bus versus rail systems, various U. S. cities, and types of crimes. Descriptions of the circumstances and nature of three frequent transit crimes (assault and battery, vandalism, and robbery) were developed; and the criminal's perspective on transit crime is described. Part III describes transit security from the passenger's point of view, the variables affecting perceived security, and the passenger's activities within the transit station and their relationship to security. In Part IV, crime countermeasures appropriate to transit environments are discussed, and the bases for evaluating countermeasures for a particular application are outlined. Finally, Part V describes the security planning procedure for transit station design. This step by step procedure is outlined for use by the transit planner.

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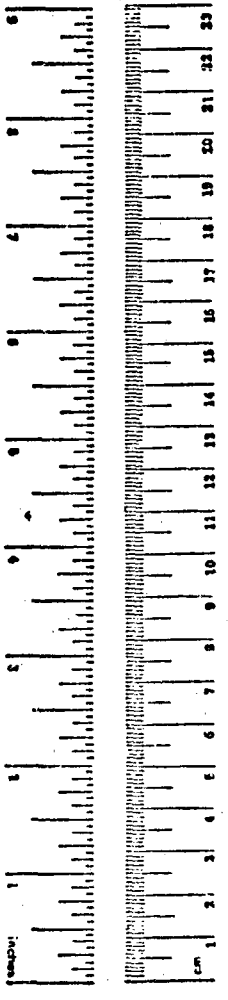
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

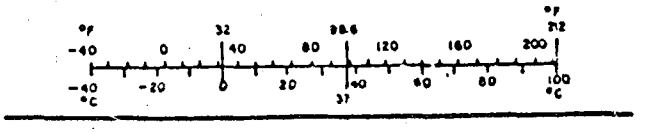
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	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

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



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	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



EXECUTIVE SUMMARY

A. INTRODUCTION

As a result of increasing crime in our large cities, both in general and in transit environments, transit users have become more aware of and concerned about their safety and security. People's beliefs about security help determine whether they will use public transportation at all, and how, where, and when they will use it - if they decide to do so. Personal security is one of several important criteria for transit use from the passenger's point of view.

Since most transit crimes occur in the stations, this is the most critical element in the transportation system for the reduction and control of crime. Designers must be concerned with creating transit stations which are actually and perceptually safe and secure.

B. PROBLEM STUDIED

The purpose of this research was to develop the procedural steps that should be followed in planning transit stations using security as a measure of effectiveness. Proposed crime countermeasures were identified and evaluated in terms of their costs and benefits. Crime statistics and the characteristics of crime occurrences were reviewed and compared with possible approaches for thwarting, deterring, or apprehending criminals. The final product of this effort is a report describing the procedures and concerns in designing safe and secure transit stations.

C. RESULTS ACHIEVED

This document describes the procedures and concerns in designing safe and secure transit stations. The report is divided into five parts. Part I introduces the problem of transit security, distinguishes between safety and security and between objective and perceived security, and presents background information on design issues and security. The literature relating to security design, both in general and specific to transit stations, was reviewed and evaluated. Part II reviews the statistics on transit crime -comparing bus versus rail systems, various U. S. cities, and types of crimes. Descriptions of the circumstances and nature of three frequent transit crimes (assault and battery, vandalism, and robbery) were developed; and the criminal's perspective on transit crime is described. Part III describes transit security from the passenger's point of view, the variables affecting perceived security, and the passenger's activities within the transit station and their relationship to security. In Part IV, crime countermeasures appropriate to transit environments are discussed, and the bases for evaluating countermeasures for a particular application are outlined. Counter-

measures are arranged by type: hardware and equipment; personnel and operations; design and environment; or community and judicial countermeasures. Criteria for evaluating countermeasures include effectiveness, acceptance costs, monetary costs, design implications, feasibility and flexibility. Finally, Part V describes the security planning procedure for transit station design. This step by step procedure is outlined for use by the transit planner.

The seven step planning procedure for transit station security includes (1) assessing the initial situation, (2) anticipating station crime problems, (3) establishing security goals and selecting possible countermeasures, (4) evaluating possible countermeasures, (5) considering limits and constraints, (6) considering tradeoffs with other user acceptance factors, and (7) establishing a countermeasure and design strategy for the target station. Sources of information relevant to each step are identified in the report, and a comprehensive list of security design goals and means of achieving them is presented.

D. UTILIZATION OF RESULTS

The information on transit crime presented in this report will provide the designer of transit facilities with an appreciation of the conditions which facilitate or hinder the commission of crimes. The discussion of crime countermeasures will provide security personnel and policy makers with the criteria for evaluating proposed security measures. The planning procedure will guide designers and planners in considering the security implications of their proposals and help insure the design of facilities which provide high levels of actual and perceived security for transit users.

E. CONCLUSIONS

This report describes a planning procedure for improving transit station security. It outlines seven steps to be followed in planning transit stations using security as the measure of design effectiveness.

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I. INTRODUCTION

A. PURPOSE

An important consideration in the design of transit stations is the level of security furnished to the traveler. Since most transit crimes occur in the stations, this is the most critical element within the transportation system of the reduction and control of transit crimes. The purpose of this report is to develop the procedural steps that should be followed in planning transit stations using security as the measure of effectiveness. The methodology developed for transit security is compatible with the comprehensive planning and design procedures developed for transit stations (1-6). This comprehensive methodology has been applied in case studies of both new and renovated transit stations (7,8).

The present report is an elaboration of one component of the overall station design process - that concerned with passenger security. As a result of increasing crime in our large cities, both in general and in transit environments, transit users have become more aware of and concerned about their safety and security. Peoples' beliefs about security help determine whether they will use public transportation at all, and how, where, and when they will use it if they decide to do so (9). Personal security is one of several important criteria for transit use from the passenger's point of view. Thus designers must be concerned with creating environments which are actually and perceptually safe and secure.

This report provides a detailed analysis of security design issues. Proposed security countermeasures are identified and evaluated. A review of crime statistics serves to indicate the types of occurrences common to transit stations and these are compared with possible approaches for thwarting, deterring or apprehending criminals. Environmental factors which influence both actual and perceived security are described and reviewed in terms of their implications for design. Finally, a planning procedure for improving transit security is developed.

The report is divided in to 5 parts. Part I introduces the problems of transit security, describes the distinction between safety and security and the perceptions of security for transit users, and contains a background discussion of security issues. Part II discusses types of crime occurrences committed on transit systems, comparisons between bus and rail, transit crime comparisons for U. S. Cities, a summary of what is presently known about transit crimes, particularly assault, robbery and vandalism, and crime occurrences from the criminals perspective. Part III describes transit security from the users point of view, the variables affecting transit security, recent studies of perceptions of security by transit patrons, and passenger activity within a transit system and its relationship to security. Part IV discusses various countermeasures that can be employed in a transit system to improve security, evaluates the effectiveness of those countermeasures and their relative costs. Finally Part V develops a security planning process for transit stations. A step by step procedure is outlined for use by the transit planner.

B. SOME NECESSARY DISTINCTIONS

In discussions of the factors which influence user acceptance of transportation systems, safety and security are often treated as a single factor with no distinction made between them. However, they are quite different: a particular transit system may have a good safety record and a bad security situation, or vice versa. Safety refers to the environment or system being free from accidents and injuries; designing for safety means protecting people from mishaps. Security design involves protecting people and property from other people.

It is also necessary to distinguish between actual and perceived security in the transit system. While the two are often strongly related, they are not always. Sometimes a station with a high crime rate is thought to be secure, and conversely, stations with little actual crime are sometimes believed to be dangerous. Perceived

security, not actual security, is what influences ridership and transit use patterns. In designing security procedures for transit stations, both aspects of security must be considered. The designer should aim to maximize both actual and perceived security - to alleviate both crime and fear of crime in the transit environment.

The factors which influence perceived security may or may not affect actual security. Usually though, some influence would be expected: if the situation fosters high perceived security, then even a criminal should feel it is secure and therefore be less likely to attempt a crime. Crimes are more likely in those situations perceived by the criminal to be conducive to crime. It should also be true that factors which enhance perceived security influence ridership levels and that this in turn influences actual crime levels.

In general, three types of measures are usually advocated for improving security and perceived security; there are (1) official presence (manpower, police and transit employees), (2) technological countermeasures (hardware, electronic devices), and (3) environmental design.

Police deployment strategies are discussed in detail in Siegal et al. (10). They conclude that large increases in police patrol activity generally lead to reduced crime, but that the effect is often temporary and the size of the effect is not always evident - some displacement of criminal activity may occur. Systematic comparisons of different types of patrol (continuous, regular, random, covert operations, etc.) have not been done, and little empirical data is available to demonstrate the effectiveness of police activity. Siegal et al. suggest a set of measures to be collected to assess the success of various policing strategies.

Technological countermeasures are reviewed in detail by Jacobson, et al. (11). Current transit security practices, police perspectives on crime and anti-crime measures, and possible security problems on Automated Guideway Transit (AGT) systems are reviewed in Hawkins and Sussman (12). A comprehensive discussion of

transit security issues has also been compiled by the APTA security committee (13). An annotated bibliography of key articles on transit security is also presented in (11).

The issues of environmental design for security have been addressed in several books by Newman (14-16) and form the basis of the crime prevention through environmental design (CPTED) program discussed by Bell (17). These ideas are discussed in detail below.

This report is concerned primarily with station design and with built-in security features, not with policing strategies or operational decisions. However, design features can facilitate surveillance and police patrols and optimize equipment use.

C. BACKGROUND LITERATURE

The influences of the physical and social environments on human behavior have been widely studied by psychologists and sociologists. The everyday environments of modern life have been extensively investigated by Barker (18), Sommer (19), and Craik (20). The specific problems of designing for security have been covered by Newman (14-16, 21) and Becker (22) for public housing projects and by Harris (23) for urban transit systems.

In his many publications, Oscar Newman has developed and supported the concept of defensible space, and has shown convincingly that design features can influence crime rates. The concept of defensible space depends on a community's sense of territoriality. It involves arrangements of buildings and spaces to foster a sense of control and cohesiveness among the residents of a community and to give the impression of community solidarity and property to outsiders. This is accomplished by arranging a residential area so that certain regions are delineated by barriers (physical and psychological) and are naturally under surveillance by community residents. These spaces convey the impression of belonging to the residents, and thus entering them will make an intruder uncomfortable and conspicuous. Such territorial definition helps create the distinction

between people who belong in an area and those who don't. Community residents are then able to watch intruders and take action (i.e., call the police) if necessary. The intruder, sensing his visibility, will probably not enter or linger long in such places.

Newman (14) describes design features which foster the perception of zones of territorial influence and which provide natural surveillance opportunities. The forms, arrangements, and grouping of buildings can define the zones of influence of those buildings. Barriers and markers can be used to define private zones and to differentiate them from semi-public and public areas. Amenities and facilities can be provided within the zones of influence of a buildings' residents, thus giving residents both control over and responsibility for these facilities.

Defensible space requires surveillance. Residents should be able to survey exterior areas from high activity places within their apartments. The lighting, materials and spatial arrangements of surrounding public areas and access lanes should promote visibility and enhance surveillance by residents and police. Both interior and exterior design should permit visual prescanning of routes one is about to enter or travel.

Newman contends that security can be improved by juxtaposing building entrances and public zones with safe areas or areas with a safe image. Thus building entrances should face safe public streets rather than an isolated area interior to the housing project. As examples of safe areas, Newman cites "heavily trafficked public streets and arteries combining both intense vehicular and pedestrial movement; commercial retailing areas during shopping hours; institutional and government buildings" (14, p. 78). Such areas may not always objectively be safe, but they seem safe to most people because of the availability of potential witnesses to any incident.

The final element of defensible space is to avoid design features which convey stigma, vulnerability or isolation. Especially in public housing projects, the buildings have tended to be "institutional" and easily distinguished from "normal" apartment complexes. Materials,

layouts, building heights and amenities all tend to differ from commercial multiple family dwellings. In addition, public housing is often spatially isolated from the neighboring areas, and removed from the activity patterns of urban life. All this creates a negative impression of the project occupants, both to outsiders and to themselves. A sense of property and individuality can be instilled in residents if their unit has unique features; yet typical housing projects emphasize uniformity of materials, colors, and designs. Newman notes that vandal-proof materials often provide a challenge rather than deterrent to vandalism.

These four main themes

1. territorial definition,
2. natural surveillance,
3. interface to safe zones, and
4. nonstigmatizing design forms and features

provide the basis for defensible space. Although his work focuses primarily on the design of crime-free environments in residential developments, some of Newman's suggestions are appropriate for the selection and design of transit facilities. Newman's concepts are empirically well supported. As a result of his studies, he has developed recommendations (15), guidelines (16) and a model security code (21).

Becker (22) also examined the determinants of perceived security among the residents of public housing projects, as well as other aspects of resident satisfaction with multi-family housing. He found that people felt least safe in public areas with poor lighting and limited visual surveillance. Their fears were primarily focused on non-daylight hours, and security was strongly related to lighting in the minds of these respondents.

Becker contends that perceived security depends on the residents feeling in control of particular spaces. Like Newman, he believes that by arousing the sense of territoriality in the residents of a building or project, they will be more responsible for their own security and that outsiders are less likely to violate clearly "defensible space". Becker found that residents in buildings with single access points, locked doors, glass doors (for easy surveillance) and guards felt that those who don't belong would be discouraged from entering, while residents of multiple access buildings were less likely to feel so - even with more guards. He concluded that a major contribution of security design was that it permitted effective use of guards. In the multiple-access, high-rise units, more guards were unable to provide the level of surveillance that a single guard could in a limited access building. Becker draws the conclusion that "money spent initially on good territorial definition and security design in the long run should result in lower operating costs." (p. 119).

Becker also asserts that the physical environment (here, the apartment building and grounds) can be thought of as a communication medium through which the residents and housing authorities send messages to each other. In particular, the physical environment is used to convey attitudes and opinions. He asserts that many standard practices in public housing convey to the residents that management has a negative image of them. Vandalism is then interpreted as sending a message back to management. He cites studies at college dorms showing that student vandalism was directed "at the establishment" by destroying property perceived to belong to that establishment. When students were given more control of their living space, vandalism decreased.

When a housing unit is built like a prison - to discourage vandalism -it may incite vandalism instead. There is always the urge to break the unbreakable, or deface the vandalproof wall. Becker and Newman both argue that structures and policies should convey a posi-

tive evaluation of tenants by management. Their data from housing projects suggest that both vandalism and crime are reduced by design features which create defensible space, instill a sense of territoriality in residents, and convey a positive message to the residents.

These notions have been developed and tested in housing projects. They appear to work for spaces people live in and around. Some of these ideas and design features should apply in transit station settings. But it is important to test them there to insure their relevance. Whether it is possible to use the notion of territoriality in this context is questionable, but clearly natural surveillance, 'high visibility' and 'design to instill a positive attitude of the user' are concepts that should transfer to the transit situation. Transit stations differ from the kinds of settings studied by Newman and Becker in that they are truly public spaces, they are used for short periods of time, and the population of users is constantly changing. Further, transit stations are enclosed and users are confined once the station is entered.

Harris (23) identified a large number of factors that might influence crime and vandalism in the transit environment, and proposed a set of three surveys to be used in collecting data to isolate those factors strongly correlated with the occurrence of crime. His survey I records the details of criminal incidents; survey II deals with station design - assessing in detail the physical environment provided by the station, as well as features of the surrounding neighborhood, and survey III similarly assesses the features of subway trains. Harris proposed a regression methodology for isolating the key factors in transit crime. Data on a large number of incidents and transit stations would be required, and to date no one has actually applied the methodology.

The Institute of Urban and Regional Development of the University of California at Berkeley (24) developed a procedure for assessing security levels for stations in the BART system. The

scoring procedure is based on summing the values for each of several indicators of station security. Those values depend on explicit assumptions about the design features that improve or diminish security. Some of those assumptions are: (1) the presence of an area limited to paid users improves security, (2) the fewer exits there are from the paid area, the better the security, (3) proximity (closeness) to a station agent's booth, a courtesy phone, or a major user path enhances security, (4) if an area is visible from a station agents' booth or under CCTV surveillance, security is improved, (5) poor lighting and areas which could be used for hiding both severely diminish the security of the station, (6) higher passenger volume is associated with greater security, (7) fewer station levels provide better security, (8) surface and aerial stations are more secure than subways, (9) suburban stations are more secure than urban stations, (10) residential area stations are more secure than those in commercial areas, (11) the lower the land use density surrounding the station, the better station security will be, and (12) the absence of parking facilities improves security.

Station security is assumed to be directly related to these indicators. Each station in a system is evaluated and receives a score on a scale of one (relatively hazardous) to three (relatively secure) on each variable. The nine scores are summed for each station; then the stations can be ranked according to the magnitude of the aggregated scores. A high score indicates a relatively safe station and a low score indicates a security problem.

Richards et al (9) developed a model to predict the level of perceived security felt by the transit user. The model involves variables representing (1) the person, (2) the station, (3) the situation, and (4) the security response provided by the transit system. Perceived security was assumed to be a function of composite indices for these four types of variables and a score expressing the general security reputation of the transit system.

Variables representing aspects of the station environment which appear to influence perceived security were included in the model. The variables, their levels, and scores for each level are shown in Table 1 (higher numbers reflect poorer security). Most of the variables are obviously related to perceived security. People will feel less safe in stations that are old, dirty, poorly maintained and poorly lit than in modern, clean, well maintained and well lit ones. The negative features represent cues that are associated with crime occurrence and with lack of care and attention by the transit authority. They convey a negative message to the transit user. The positive features are associated with safety and security and with transit system commitment to the facilities and therefore the users.

The degree of sensory aggravation is related to some of the other variables. If the station is dirty, smelly, noisy, and filled with graffiti, then users will view it as less secure because these cues are generally associated with unsafe environments. Further, sensory aggravation itself leads to discomfort and annoyance, which may lead to hostility and aggression.

The area surrounding a transit station will influence how a station itself is perceived: a station in a high crime neighborhood will generally be assumed to be unsafe.

In the model, a composite station score is derived by taking the mean of the scores on all the variables. This mean value can range from 1 (very secure) to 6+ (very insecure). Since each of the variables realized as a rating scale can be used in evaluating any particular station, the model provides a tool for assessing stations as well as predicting user responses to the station.

D. SUMMARY

Three schemes for assessing station security have been discussed. In each case, an assessment method has been proposed, but not widely applied to actual station evaluation. These proced-

Table 1

Station Variables Related to Perceived Security*

Variable	Values	Scores
Internal lighting	Bright	1
	Adequate	3
	Dim	5
	Very poor	7
Age of station	New	1
	Old	5
Cleanliness	Clean	1
	Dirty	7
Level of maintenance	Good (well maintained)	1
	Bad (poorly maintained)	7
Degree of sensory aggravation	Non-intrusive	1
	Noticeable	3
	Annoying	7
Visibility throughout station interior	Good	1
	Some obstructions	3
	Limited	5
Neighborhood surrounding station	Low crime area	1
	High crime area	5

*Source: Richards and Jacobson (9)

ures will be meaningful only if applied to a variety of stations so that comparisons between them can be made. In all three cases, the scales are useful for assessing the conditions actually present in transit stations, but further research is necessary to relate those station features to actual and perceived security.

II. TRANSIT CRIME

Security design depends in large part on the types of crimes likely to occur in a particular environment. In order to design transit stations for maximum personal security, it is necessary to know (1) how much crime is likely to occur in a station, (2) what types of crimes are likely to occur, and how frequently, and (3) under what conditions these crimes typically occur.

A. TRANSIT CRIME STATISTICS

The first attempt to determine the amount of crime on public transit was reported by Thrasher and Schnell (25). In 1970-71, they contacted authorities in 50 U. S. and Canadian cities to obtain information on crime and vandalism in their transit systems. Useable data were obtained from 37 U. S. and 4 Canadian systems, including most of the major urban rail systems operating at that time. The 37 U. S. systems were found to represent about 60% of the total vehicle miles and passenger revenues for all transit systems in the United States. For 1971, 20,899 criminal incidents were recorded on those 37 systems - of which 1,623 were classified as violent crime. The greatest number of violent crimes occurred in Chicago (714), followed by New York (305), Boston (163), and Philadelphia (102). These same systems had also displayed high levels of violent crime in 1969 and 1970. Both New Orleans and Los Angeles reported high levels of violent crimes in 1969; however, such crimes decreased drastically by 1970 for Los Angeles (from 217 incidents to 45 incidents). For New Orleans, there was an increase in violent crime in 1970 followed by a steep drop in 1971 (from 154 to 514 to 28 incidents). Nonviolent transit crimes were most frequent in New York City (10,619) in 1971, followed by Chicago (2,410), Boston (1,966) and Los Angeles (1,108). Toronto reported almost no violent crime in any of the three years, but did report moderately high levels of nonviolent crime.

Based on the observed 20,899 criminal incidents in these 37 U. S. transit systems, Thrasher and Schnell estimated that between 33,000 and 39,000 crimes actually occurred on all U. S. transit

systems in 1971. The authors note that this estimate is based on reported incidents and may therefore be a lower bound on actual crime levels. On the other hand, if there were a bias in the actual data such that those transit systems with crime problems had data available, while those who failed to provide information did so because they had no crime problem, these estimates would be exaggerated. Thus, the extrapolated data are open to question, but the actual counted incidents are, if inaccurate, an underestimate of crime levels for these 37 U. S. transit systems.

Vandalism costs were also obtained from these transit systems for the years 1969, 1970, and 1971. The actual cost of vandalism in the 37 U. S. transit systems amounted to $5,258,139 in 1971; the estimated costs for the total national transit system were in the range from $7.7 to $10 million. These are only the direct costs of vandalism; adding indirect costs would greatly increase these values. The most frequent acts of vandalism were breaking vehicle windows, damaging seats, damaging stationary facilities, and graffiti.

The data presented by Thrasher and Schnell strongly suggest that crime levels are greater on rapid rail transit than on buses. But those data do not allow separating the effects of type of system from city size. Johnson (26) compared crime rates for bus versus rail transit within a single city (Chicago) for 1971 and the first six months of 1972. Crimes on rapid rail represented 84% of all CTA robberies, 92% of all crimes against persons, but only 53% of battery incidents. Overall, 75% of the crimes recorded by the Chicago Transit Authority occurred on the rapid rail system. When the crime data for rapid rail versus bus are expressed as incidents per million riders, the ratio of incidents is 10 to 1: 7.2 crimes per million for rail, .7 for bus.

Siegal et al. (10) interviewed security authorities in each of twelve major transit systems and identified the major crime problems of each. Vandalism was a problem for almost all transit systems. PATCO and BART both have extensive parking facilities and the

resultant auto crimes. Robbery and related crimes for personal gain were also common to most transit systems. Fare evasion and internal theft plagued some.

The Southeastern Michigan Council of Governments (SEMCOG (27)) surveyed 66 transit systems to obtain statistics on crime occurrence in 1977 and information regarding transit security measures and services. They received 59 replies and thus achieved an 89% return rate. The systems responding to the survey were separated into three groups on the basis of passenger volume: 12 systems handled 100 million passengers or more during 1977; 18 systems carried between 20 and 100 million passengers, and the remaining systems had 20 million or fewer passengers during the year. Of the 12 largest systems, 9 represented either rail only or a combination of bus and rail vehicles; the WMATA data reported by SEMCOG for 1977 involved predominantly bus crime - only a small segment of the subway system was open during that year. Of the 18 transit systems in the second size category, 4 involved only rail vehicles or rail-bus combinations. Two rail systems, PATCO and MVRTA (Miami Valley Regional Transit Authority), were in the third category.

Tables 2 and 3 summarize selected results of the SEMCOG study. These tables were constructed using data from the SEMCOG report, but they differ in several respects from the presentations in that report. First, we have grouped transit systems by whether they involved a rail component or were exclusively bus services. Second, except for PATCO and MVRTA, all data in Tables 2 and 3 represent systems with 20 million or more passengers in 1977. Third, data for Los Angeles, California (SCRTD) were deleted entirely. The SEMCOG report cited known reporting errors in those data and the L. A. results were so unusual and unique that including them would give a distorted picture of the transit crime situation nationally. The New York City data were also problematic - only crimes not immediately cleared by arrest were reported - but these data were at least in line with those from other transit systems.

Further, the New York data would represent underestimates of crime levels, while the L. A. data clearly overestimates minor crimes - but to an extent that cannot be determined from the data.

In the SEMCOG report, crimes were divided into three categories - roughly on the basis of severity. PART I offenses were murder, rape/criminal sexual conduct, robbery, burglary, larceny and motor vehicle theft; PART II offenses were simple assault, arson, fraud, embezzlement, forgery and counterfeiting, possessing stolen property, vandalism, minor sex offenses, drug law violations, drunkenness and disorderly conduct. The third category involved local ordinance violations, fare disputes, smoking aboard coach, etc. Several transit properties apparently don't bother to record incidents in this third category.

Table 2 shows the frequency of crimes in each of these three categories -separately for rail or rail and bus systems and bus only systems. Of the 60,402 crimes summarized in this table, 70% occurred on rail or rail/bus systems. However, these systems are the ones that have the greatest passenger volumes. Eight of the 15 systems in the rail or rail/bus group carried over 100 million passengers in 1977, while only 2 of the bus systems did. Within the two groups, there is considerable variation in overall crime levels. Among the rail systems, NYCTA reported 9,409 open complaints and Maplewood, New Jersey (TNJ) reported only 22 total crimes. The Milwaukee bus system had 6,347 criminal incidents, while Dallas reported 111. The mean crime level for rail or combination systems was 2,807.6 crimes; that for bus only systems was 1,143.

The column totals for the two groups of transit systems shows that the distribution of types of crimes is different for the two situations. Twenty-nine percent of the crimes on rail-type systems are PART I offenses, while only seven percent of those on bus systems are. For both types of system, local ordinance violations account for less than 20% of recorded incidents. Thus the number and pattern of crimes differs for bus vs rail-type systems, but the

effects of type of system can't be distinguished from those of passenger volume.

For both Chicago and New York City, over half of the recorded crimes were PART I offenses; Milwaukee also reported a predominance of the more serious crimes.

Table 3 shows the frequency of occurrence of selected crimes on these transit systems. The crimes shown are the most frequently occurring PART I and PART II offenses. Robbery, larceny, and serious assault account for most PART I offenses on all systems. The remaining PART I offenses are largely motor vehicle theft and burglary. Murder and rape are very infrequent transit crimes: all U. S. and Canadian systems reported a total of 10 murders and 13 rapes in 1977.

Among the PART II offenses, vandalism if clearly a major problem for both bus and rail systems. Drunk and disorderly conduct also constitutes a major security problem in both situations. Both of these offenses contribute to passenger perceptions of insecurity in the transit environment.

Thus, security design features should focus on preventing larceny and robbery, vandalism, and drunk and disorderly conduct. They should also help prevent situations in which serious assaults can occur. The appropriate countermeasures will surely differ depending on whether a bus or rail system is being considered.

The following sections will review what is known about transit crime in general and about the specific crimes of assault, robbery and vandalism. This information can then be used to help select appropriate crime countermeasures and station design features.

B. SOME FACTS ABOUT TRANSIT CRIME

Several well-documented generalizations about transit crimes (see references 9, 10, 25, 26, 28, 29, 30, 38, 39, 41) are summarized below:

Table 2

Total Transit Crime for Selected U. S. and Canadian Transit Systems, 1977 (data from SEMCOG, 1978)

	PART I Offenses	PART II Offenses	Local Ordinance Violations	Row Totals
Rail only or bus and rail				
MBTA	1,660	5,123	---	6,783
CTA	2,208	1,107	---	3,315
MUCTC	207	1,927	1,428	3,562
NYCTA	4,864*	3,984*	561*	9,409*
SEPTA	230	573	90	893
Pittsburgh	76	1,632	---	1,708
MUNI	648	1,538	---	2,186
TTC	410	969	650	2,029
New Orleans	179	332	42	553
PATH	122	424	2,004	2,550
BART	1,262	2,508	2,814	6,584
Seattle	58	1,235	71	1,364
MVRTA	3	85	27	115
PATCO	236	786	19	1,041
TNJ	22	---	---	22
Column Totals	12,185	22,223	7,706**	42,114
Bus Only				
Baltimore	136	1,914	---	2,050
Atlanta	28	681	204	913
Buffalo	61	850	80	991
Dallas	0	47	64	111
Detroit	175	812	286	1,273
Kansas City	2	64	55	121
Miami, Florida	227	321	292	840
Milwaukee	22	5,725	600	6,347
Minneapolis	236	117	0	353
Oakland (AC)	118	1,237	550	1,905
Ottawa	1	43	225	269
Portland	195	659	64	918
Quebec	1	325	70	396
Rochester	1	304	27	332
San Diego	0	1,112	127	1,239
WMATA	101	121	8	230
Column Totals	1,304	14,332	2,652**	18,288

* NYCTA data is in terms of open complaints only.
**Totals based on incomplete data

Table 3

Frequency of Occurrence of Selected Crimes on U. S. and Canadian Transit Systems in 1977 (data from SEMCOG, 1978)

	Robbery	Serious Assault	Larceny	Van-dalism	Drug Laws	Drunken-ness and Disorderly Conduct
Rail only or rail and bus						
MBTA	221	147	1,106	300	36	2,995
CTA	472	82	1,638	---	---	---
MUCTC	37	6	143	397	8	273
SEPTA	62	0	71	297	0	124
Pittsburgh	13	0	8	555	25	377
MUNI	46	36	508	480	24	746
TTC	15	98	272	272	62	188
New Orleans	16	17	141	156	11	37
PATH	39	13	65	68	46	96
BART	37	16	890	549	57	379
Seattle	4	27	25	971	10	87
MVRTA	0	0	0	75	1	0
PATCO	27	8	134	329	0	0
TNJ	13	0	0	---	---	---
Column Totals	1,002	447	5,001	4,449	280	5,302
Bus only						
Baltimore	6	3	127	561	6	1,232
Atlanta	2	11	15	151	218	231
Buffalo	3	18	39	683	6	124
Dallas	0	0	0	15	0	29
Detroit	54	63	50	552	34	209
Kansas City	0	0	2	51	0	0
Miami, Florida	18	73	135	189	4	104
Milwaukee	0	5	15	5,400	100	200
Minneapolis	3	26	137	14	0	59
Oakland (AC)	14	50	50	371	30	595
Ottawa	---	---	---	0	0	15
Portland	1	4	190	244	2	149
Quebec	0	1	0	300	0	10
Rochester	0	0	0	215	2	50
San Diego	0	0	0	339	19	480
WMATA	28	19	46	58	3	24
Column Totals	129	273	806	9,143	424	3,511

1. Crime levels vary for different parts of the transit system. Crime in transit stations is related to neighborhood crime: stations in high crime areas generally experience high levels of transit crimes.

2. Crime levels vary over time. There are certain times of the day, days of the week, and periods of the year when crime levels are high. Assaults are most likely during the evening rush hour; robberies are most common on Friday and Saturday nights; and suicides are prevalent during holiday periods -especially, the Christmas season.

3. Most transit criminals are young, and most commit their crimes in their own neighborhoods. Transit crimes usually involve two or more perpetrators.

4. The risk of transit crime to the individual varies from one city to another, as does the likelihood of being a victim in or out of the transit system. Thrasher and Schnell (25) computed the risk of being involved in a criminal incident to be twice as great while using an urban transit system as in a non-transit situation. Shellow et al. (29) found the likelihood of being victim to a robbery about 1/3 as great in the Chicago transit system as in the rest of the city. A SEPTA study found the risk of crime in the Philadelphia subway to be at about the same level as walking the streets of the city (13).

5. Most crimes in urban rapid rail systems occur in the transit station, not on the vehicles. If a crime is committed in a station, the offender leaves the transit system at that station - the train is rarely used to make an escape. If an incident does occur on a train, the criminal exits the system through the next station.

6. Different crimes occur in different situations. Crowded stations facilitate picking pockets, while isolated, empty stations permit muggings or rapes to occur. A station may have adequate protection against robbery, but not against assault.

In the next few sections, information on types of crime and specific crimes that often occur in transit environments is reviewed. The station planner may select different design alternatives depending on the particular crime problem anticipated at a given station site.

C. TYPES OF CRIME

Jacobson, Richards, Leiner, Hoel, and Braden (11) reviewed four categories of crimes likely to occur in rapid transit systems:

1. Crimes against persons (assault, battery, rape, murder, mugging, etc.)

2. Crimes against persons' property (picking pockets, purse snatching, robbery, etc.)

3. Crime against system property (burglary, vandalism, fare evasion, trespassing, etc.)

4. Crimes against the public (drunkenness, disorderly conduct, drug law violations, sex offences, suicides, etc.)

Each of these types of crime has a different method of operation and a different eliciting situation. For each category, Jacobson et al constructed examples of typical and extreme situations in which the crime could occur. These descriptions ("scenarios") were evaluated by transit police chiefs, and revised in light of their comments. The scenarios provide a basis for security planning. They are the situations one must plan to prevent in designing a station or planning security procedures.

The crimes within categories vary in seriousness and likelihood of occurrence. Rape, for example, is very serious, but is quite rare. Nuisance offenses -kids running in the trains and on the platforms, disorderly conduct, harassment, smoking, graffiti, etc. - are very frequent but not serious. However, these latter offenses convey the impression of disorder and insecurity. Their occurrence suggests to users that aspects of the system are not under control by the authorities. If minor offenses are allowed to happen, major ones could also occur.

Another important distinction between crimes is in terms of their motivation or the eliciting situation for them. There are crimes of intention (someone sets out intent on committing a crime) and those of opportunity (a situation develops in which the crime is possible). There are also crimes for profit and those of passion or impulse. Picking pockets is generally premeditated and is done as a living (for profit). Purse snatching is more impulsive and opportunistic, though still for monetary gain. Crimes of violence and aggression are usually impulsive and situation-specific, although some, like rape, are probably planned or at least contemplated before the appropriate situation presents itself.

All crimes require a conducive situation in order for them to occur at all. Some criminals seek out these situations, others are just tempted when the appropriate situation develops. Crimes for profit usually involve the perpetrator looking for an opportune situation: both pickpockets and purse snatchers tend to seek crowded environments. Mugging and rape would be facilitated by isolation; ideally, only the victim and criminal(s) would be present. Aggressive acts (assault, etc.) are often triggered by crowded situations; the violence or aggression seems to be released in such situations and the crowding often leads to frustration and physical discomfort - both of which may lead to aggression.

Crimes of aggression and crimes of opportunity can probably be controlled by appropriate environmental engineering. Those crimes whose perpetrators are likely to circumvent countermeasures are the ones which are profitable. In the following sections, more detailed descriptions are given of three common transit crimes.

1. Assault and Battery

Assault and battery are the most frequently occurring crimes against persons. The Carnegie-Mellon University study of batteries in the Chicago transit system (30) reached several conclusions: (1) Batteries occur most frequently during the evening rush hour (5-6 p.m.) and are common during the period from 4 to 10 p.m. Few

batteries occur in the morning or early afternoon. (2) Over half of the reported batteries involved a single offender, but a substantial fraction of the remainder involved gangs of four or more offenders. (3) Batteries are fairly uniformly distributed over days of the week, but there is a slight peak on Wednesdays and Thursdays. (4) Batteries occurred most often on station platforms. (5) Most batteries did not involve weapons.

There appear to be two types of assault and battery incidents - one involving altercations between passengers (lone perpetrator, lone victim) during periods of high congestion (rush hour), the other apparently a youth gang phenomenon (four or more perpetrators, a single victim). The first type of incident often doesn't involve people who would usually be identified as criminals, but rather normal people who become aggressive in frustrating situations.

There is a large literature on the psychology of aggression, and a variety of factors have been identified which promote aggressive behavior. Goldstein (31) distinguishes between long term and short term factors associated with aggression and nonaggression, and between characteristics of the environment or situation and those of the person or actor. People differ greatly in their propensities toward violence and aggression. Nonviolent people are generally able to delay gratification; they have positive regard for others and can take the perspective of another person; they view aggression negatively, and have a well-developed sense of self (individuation) and an inclusive sense of group ("we"); and they function at a high level of moral development. People predisposed toward violence are impulsive, function at a low level of moral development, have positive feelings about aggression and negative views of the targets for that aggression, and have a limited regard for self-or-social evaluation (deindividuation). These long term attributes of people help explain why different people react to the same situations in different ways.

The situational and environmental factors which promote or prevent aggression and violence are important for design purposes.

Aggression is frequently a result of frustration, other aggression, and annoyers (32). Frustration results from thwarting or interferring with some behavior, from removing sources of reinforcement, and from conflict. Missing one's train, encountering a malfunctioning fare card machine, or being pushed aside at a turnstile are all sources of frustration.

Aggression frequently results from prior aggression. If someone shoves you out of the way, you may well retaliate. An individual who has been involved in one altercation is likely to participate in another.

The third class of factors promoting aggression are annoyers. These may be either physical or social factors. Thus, an array of irritants like noise, heat, intense light, unpleasant odors, dirt, vibrations, and extreme motions help to develop a tendency toward aggression. Social factors promoting aggression include crowding, being close to disliked or negatively-valued persons, being exposed to objectionable behaviors and appearance by others. These physical and social annoyers help create a predisposition or tendency toward aggression.

A transit user comes into the station environment with some tendency toward aggression (perhaps none, perhaps a great deal). The transit environment and the user's interactions with others in that environment can help prevent or promote an aggressive encounter. If the environment is pleasant, uncrowded, and nonintrusive, and if people are friendly and cooperative, then even if the user is initially hostile, no incident will result. However, if the transit environment adds onto the frustrations and irritations of the day, then a minor incident may release the user's aggressions.

This account of aggression is a threshold model: a critical level of aggressive tendencies must be reached before an overt act of violence occurs. Contributing to one' tendency toward aggression are the long term personal predispositions discussed above, immediately previous experience, and physical- and social-situational

factors. Assaults are rare in transit environments early in the day; the users are fresh and few frustrations have developed; the situational factors don't matter much. In the evening, however, the environmental factors add onto the frustrations and problems of the day. It is then that minor incidents are elevated into major problems. Another factor facilitating aggressive behavior late in the day is the consumption of alcohol - through the reduction of a person's normal inhibitions. The anonymity of being in the rush hour crowd also functions to reduce inhibitions and foster aggression. Finally, darkness functions as a disinhibitor (33); poorly lit stations encourage aggression.

Against all these forces propelling aggression, the designer must develop counterforces - factors promoting nonaggression. Two major factors influencing nonaggression are the presence of an authority figure (e.g., a police officer) and the awareness by the individual that he can be identified. Both of these factors argue for a well lighted and easily surveyed station interior. Police officers, if present, should be visible, and they should be able to see throughout the station. Other means may be used to convey a sense of identifiability and of available authority; prominently placed CCTV cameras may function in this manner - if station users know they are being watched and believe that an effective response can be made.

In general, transit designers should strive for simple, pleasant stations. They should create environments which minimize conflict, crowding, frustration, and uncertainty.

2. Vandalism

All transit systems appear to have problems with vandalism. For most systems, vandalism costs are minor - representing a small fraction of the total system operating costs. But for several of the major transit systems, vandalism has reached epidemic proportions: SEPTA in Philadelphia and the New York City transit authority have experienced the most extensive vandalism damage.

The major types of destruction of system property are (1) broken windows, (2) graffiti, (3) damage to stationary facilities, and (4) damaged seats. Stoning moving vehicles, shooting at vehicles and attempts to derail trains are also problems in some cities. Seat damage is usually due to slashing, cutting, or tearing of the seat fabric; less frequently, the seat is burned with cigarettes or lighters. Occasionally, seats are disassembled or torn from the floor.

In their survey of crime and vandalism problems on urban transit systems, Thrasher and Schnell (25) found that total vandalism costs for 37 U. S. and 4 Canadian transit systems exceeded five million dollars in 1971. From this observed figure they estimated that total vandalism costs for U. S. transit systems probably fall in the $7.7 to $10 million range. New York City alone reported over $2 million in vandalism costs; SEPTA, $976,000; and Chicago, $696,496. These three systems however, reported quite different patterns of vandalism contributing to these costs: for New York, 63% of the total costs were involved with graffiti damage while 21% were for damage to stationary facilities. SEPTA attributed 38% of their vandalism costs to damage to stationary facilities and 27% to broken vehicle windows. In Chicago, 39% of vandalism costs involved broken vehicle windows and 25% covered damaged seats. Boston, with $257,581 in vandalism costs, spent 44% of that on damage to stationary facilities. Thus while vandalism is a problem for most transit systems, the nature of the problem differs according to the particular system and probably to specific subparts of any given system (i.e., certain stations or routes).

Vandalism is predominantly a youth crime; offenders are typically 11 to 15 years old. It is most often a gang activity and is frequently thought of as a form of play. Forms of vandalism become socially acceptable to a specific peer group, and become fads which are popular at specific times and places. The second common motive for vandalism is revenge for some real or imagined wrong doing or injustice. Thus, it may be committed as a reaction against prejudice by members of minority groups.

Wade (34) has analyzed the social processes involved in the acts of vandalism committed by 50 boys in Kansas City, Missouri. He has distinguished five stages in an act of vandalism: Stage 1 involves the group of youths coming together and searching for something to do. This situation often develops at a gathering place or hangout which is important to the group members. Stage 2 is when the suggestion of an act is made - someone comes up with a daring activity. Stage 3 requires converting the rest of the group to the activity. Stage 4 is characterized as "joint elaboration of the act". Here a sort of behavioral contagion takes place with the gang participation leading to hign levels of destruction and damage. Stage 5 involves the participants giving meaning to the act and assessing it. They may regret it or decide that it was appropriate (depending in part of the consequences). At Stage 2 the importance of other acts of vandalism is apparent, if the group members know of prior episodes of destruction, they are more likely to engage in similar acts. If one group receives media coverage for "painting" a subway station, other groups are encouraged to do the same -often more elaborately. Vandalism often serves as a test of skill and/or daring, and frequently involves competition. At Stage 3, the activity may be stopped by the group if it is resisted or belittled by group members. Thus, if the belief "vandalism is kid stuff" were voiced, that would probably abort the episode. Once the episode is underway, it may escalate rapidly beyond the original intentions of the group and have consequences not intended by them.

Zimbardo (35) also studied the stages involved in acts of vandalism and the conditions which foster these acts. He abandoned cars on the streets of New York City and Palo Alto, California, and then observed the activity around them. In New York, he witnessed the rapid and total destruction of the car in a few days, while in Palo Alto, the car was untouched a week later, except that someone rolled up the windows when it started to rain. These two cities experience different "natural frequencies" of vandalism. Zimbardo noted that in New York, one has a greater level of social anonymity

than in Palo Alto. This facilitates the commission of acts of destruction and aggression. According to Zimbardo's theory, an individual will be less likely to commit a crime or act of vandalism under circumstances which emphasize his individuality and identifiability. Conversely, situations leading to deindividuation and anonymity will reduce inhibitions and promote criminal activity.

Acts of vandalism will result if this general feeling of anonymity is coupled with some releaser cues. In New York, such releaser cues were the mere presence of a car with no one around it. In Palo Alto, destruction of the car required explicit modeling for aggression to be released - when some people were seen smashing the car with various tools, other people joined in. This more extreme situation - seeing others behaving destructively and the presense of a crowd - was sufficient to elicit vandalism even where it was rare behavior.

"Releaser cues" can include reports of vandalism in the media, evidence of previous vandalism in a transit station or vehicle, graffiti "marking" a station as part of the territory of a certain gang, and so forth. Such cues serve to incite vandalism in certain youths and to make passengers uncomfortable. Thus, transit authorities should repair, clean up, and remove evidence of vandalism as quickly as possible. An obviously vandalized station is an invitation to further vandalism.

Attempts to prevent the destruction of system property have focused mainly on installing indestructible fixtures and surfaces. Thus, vehicle windows made of acrylic and polycarbonate materials are now available. These are more resistant to breakage than standard safety glass. Traditional soft, padded seats are being replaced with hard, molded fiberglass seats. Such seats are hard to destroy but are often targets for graffiti. Some manufacturers are offering fabrics which are resistent to cutting and tearing and are hard to deface. Attempts to control graffiti have included developing new materials, coatings, and solvents.

In a transit system with a particularly acute graffiti problem (SEPTA) special police units have been deployed to deal with the "graffiti artists". The resulting arrests and convictions have greatly reduced the production of graffiti - at least temporarily. Other municipalities have tried community relations programs, school presentations, and cooperation with school and court authorities in dealing with vandalism.

The Southeastern Pennsylvania Transportation Authority (SEPTA) has also dealt in an innovative manner with the problem of stoning and attempted derailments of trains (36). Helicopter surveillance of the tracks and system property has helped locate potential offenders and direct ground patrols to them. This demonstration project resulted in the apprehension and arrest of several youths trespassing on SEPTA property and/or stoning the trains.

Extreme anti-vandalism measures are quite expensive. Clearly, the system planner must evaluate how serious vandalism will be and decide whether the costs of special materials and fixtures is justified. Since vandalism, like other crimes, tends to be focused on particular stations and routes, extreme countermeasures should be necessary for only part of the transit system.

3. Robbery

There are two main classes of robbery in the transit system:

1. robbery of passengers
2. robbery of toll booths

These are separate offenses and are committed by different kinds of criminals.

The Rand Corporation study of crime in the New York subway system (37) found that passenger robbers tend to be school age children, operating in the hours just after school lets out, whereas toll booth robbers tend to be older, more experienced criminals. A toll booth robber is likely to use a weapon (usually a gun) in com-

mitting his offense, but generally the robbery is accomplished with no violence. However, robberies of passengers often involve violence.

As a result of the Chicago study of transit crime (30), several conclusions were reached concerning robberies: (1) Most robberies occur on the station platform; few occur on the trains. (2) Robberies generally occur in the evening. They are most frequent on Friday and Saturday nights. (3) Robbery victims tend to be alone; robberies are often committed by 2 or 3 youths. (4) Passenger robberies involve small amounts of money (usually around $20), credit cards and jewelry; toll booth robberies typically involve over $100 in cash. (5) Weapons were used in the majority of reported robberies.

Transit robbery clearly has financial gain as its incentive. The toll booth robber plans his crime and has thought out his timing, approach, and escape. Passenger robberies may be more impulsive and opportunistic, and thus more dependent upon a conducive situation. An especially attractive target (a passenger who is known to have lots of cash) may precipitate a robbery.

D. THE CRIMINAL'S PERSPECTIVE

People in general have beliefs about the conditions which facilitate crime; so do criminals. The criminal seeks an environment in which he can perform a series of activities with relative ease and without interference. These activities include (1) locating a target (person or machine, source of gain or gratification), (2) surveying the environment to assess risk and probable success, (3) assessing escape routes and relative ease of escape, (4) lining up the victim, preparing for the crime, (5) actually committing the crime, (6) escaping the premises, and (7) if necessary, getting rid of evidence or incriminating possessions (i.e., credit cards, identification material).

The criminal thus needs to act on a series of perceptions and decisions. He will assess the situation and decide to commit the crime if (a) he thinks he can pull it off (based on his analysis of the situation), (b) he thinks it will be worth the effort (analysis of the victim, what is the probability of gain?), (c) he thinks there is little or no chance of his getting caught (analysis of security response), and (d) he thinks there is a small chance of later identification, apprehension, conviction, or other bothersome consequences. A related analysis of criminal decision processes was presented by the Westinghouse group in their OTREP model in which an opportunity for committing a crime is viewed in terms of the target, risks, effort, and payoff (42).

If it is assumed that there are conditions which, through their effects on the criminal, facilitate the commission of a crime, then by eliminating or reducing such conditions, it should follow that the probability of crime occurrence will be reduced. A basic premise in several views of crime is that the criminal does not wish to be identified. If this is so, then any countermeasure designed to emphasize his visibility and identifiability will be effective in preventing crime. Good station lighting, easy surveillance, and CCTV monitoring (or police presence) will serve these goals.

III. THE PASSENGER'S PERSPECTIVE

A. PERCEIVED SECURITY

What determines how secure a passenger or user feels while using the transit system? Richards and Jacobson (9) have developed a procedure to represent the various factors influencing perceived security. Those factors were classified as (1) person factors, (2) station factors, (3) situational factors, (4) security response factors, and (5) general system reputation. Perceived security is seen as resulting from the combination of all these factors, as represented in Figure 1. The particular function developed by Richards and Jacobson is a simple linear combination of all the input factors. In the present context, the form of the combination rule is not critical, but only an awareness of the kinds of variables that influence perceived security.

Characteristics of the person who is using the transit system will influence their level of felt security: men in general feel more secure than women, younger persons more than older ones; persons in poor health or with handicaps worry about security more than the able-bodied; and persons who use transit rarely are more concerned with security than those who use it frequently. Thus, perceived security may depend on the sex, age, health, and experience of the passenger. System designers and planners can't control the type of people using the system, but certain design features could be incorporated if a station were likely to be used by predominantly older persons, or by a large number of handicapped travelers, or foreign visitors, etc. The designer can anticipate special groups of users likely to pass through any particular station and make the necessary design adjustments.

Variables which describe the environment of the transit station were discussed in section IC. They included physical aspects of the station (lighting, cleanliness, maintenance, age of station, level of sensory aggravation, and visibility) and characteristics of the area and neighborhood surrounding the transit station.

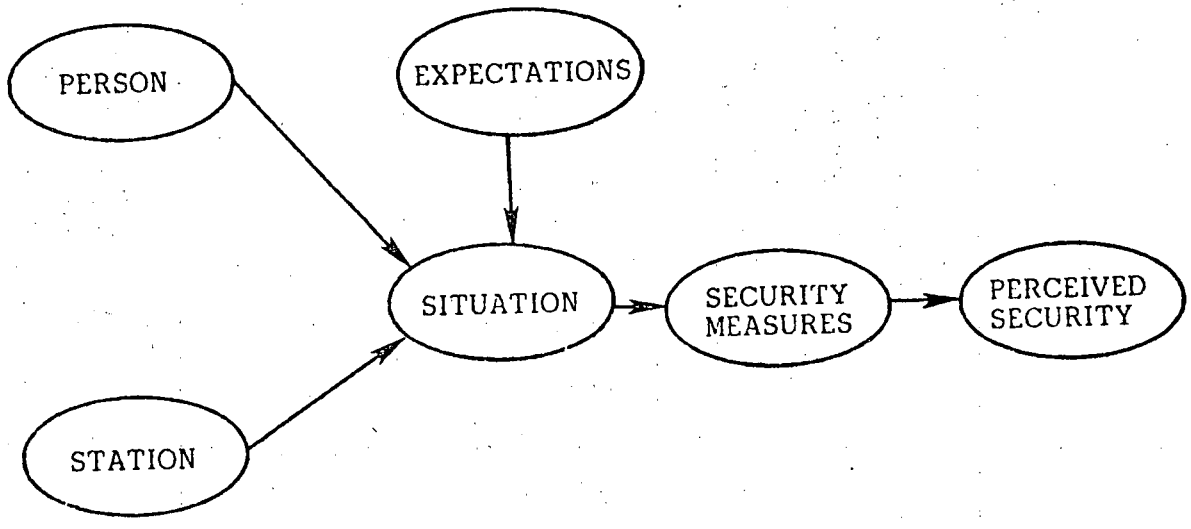

Figure 1. Components of a Model of Perceived Security (Source: Richards and Jacboson (9))

Situational variables characterize the temporary interaction of the person with the transit environment. Such variables may be personal, social, or physical. Personal variables refer to the situation as perceived by the person; the station may be familiar or unfamiliar, the trip may be novel or habitual, and the person's general concern for security may be high or low. Passengers generally feel more secure in familiar stations than in unfamiliar ones, and are more secure making habitual trips than novel ones. Awareness of, or concern for, security also influences the person's level of perceived security in particular situations.

Social variables are party size - how many people are travelling with the person - and passenger density - how crowded the station is. A moderate passenger density would make passengers feel most secure - either too many or too few other individuals in the station will lead to insecurity. Finally, the procedure includes the variables time of day and length and uncertainty of wait time.

These eight situational indices are combined into a single component reflecting how secure the passenger feels as a result of the situation he is in.

The SECURITY RESPONSE provided by the transit system also helps determine how secure patrons feel. There are basically two kinds of security responses transit authorities might implement: official presence (manpower) or countermeasures (technology and hardware). Official presence might include armed police - continuous presence or patrols, other system employees - ticket agents, maintenance staff, or none. Countermeasures could include CCTV, alarm and communication systems, audio monitors, or emergency phones. How secure a person feels in response to countermeasures depends on whether he is aware of their presence and of how they work. If the traveler doesn't know the devices are there, he won't feel any safer as a result of them.

The final component influencing perceived security is the general security reputation of the transit system being used. This

reputation will depend on the past history of the system as well as current media coverage.

These five components are combined to yield a measure of the perceived security expected of a particular person in a given station under certain circumstances.

The procedure incorporates and systematizes a large number of findings regarding perceived security. These findings have been reported by Thrasher and Schnell (28), Ferrari and Trentacoste (38), Olsen et al. (39) and Feldman and Vellenga (40). Siegel et al. (10) summarized and evaluated the results of previous studies of perceived safety and security. They concluded that (1) transit crime does seem to affect passenger perceptions and ridership; (2) the importance of perceived security varies with the volume of crime in an area, the availability of alternative modes of transportation, and time of day; (3) within a travel mode, there are differences in perceived security for different parts of the system; and (4) perceived security does not always reflect the objective crime situation for a system. However, Siegal did note that people are generally correct in attributing risk to different types of systems, different times of day, and different parts of the same system.

Aspects of this procedure were tested in a major study involving an older transit system in a large metropolitan area (9). Two transit stations were selected for physical similarity, location, and neighborhood socioeconomic characteristics. At one station, changes in security procedures and equipment were instituted: CCTV surveillance of the station was undertaken while creating low employee density in the station itself. This was the experimental station. At the matched control station, no changes were made.

Surveys were distributed to randomly selected households in the areas surrounding these two transit stations. A pretest survey was conducted at each site before any security changes were initiated or announced. Another survey was done at each site shortly after the installation of the equipment and new procedures. In both surveys,

the target population included both users and nonusers of public transit and various levels of age, sex, and income. In addition to testing aspects of the model of perceived security, the results of these surveys replicated, extended and formalized prior conclusions about the role of security in user reactions to transit.

The major reason given by people for not using the transit system was that it was unsafe (insecure). Perceived security differed for men and women (men rated the transit system as more secure than women did) and frequency of transit use (frequent users viewed the system as more secure than infrequent users and both rated it better than did nonusers). Personal security was a major factor in deciding whether to use the transit system for one third of the men and half of the women responding to the surveys.

Transit users felt more secure in their home stations than in a central business district station, and they felt using transit at night was less safe than in the evening which was less safe than day. Eighty percent of the men and 90% of the women said that there were times they were reluctant to use public transportation for reasons of personal security: the period from 7 p.m. to 6 a.m. was so identified by most of the respondents.

Respondents were asked about their personal experiences with crime on the transit system: overall, about 14% of them had been victims of a crime while using transit, 28% had witnessed a crime, over 70% had friends who were victims of transit crime, and over 80% feared that they would be victims.

There were changes in perceived security as a result of the CCTV installation. Women reported that they felt more secure in the evening and at night following the change, while men felt somewhat less secure. These findings were interpreted in terms of the initial salience of security as an issue for men and women: before the experiment, women were concerned with security as an issue and they were aware of security problems in the system. When changes were made to control crime, women felt safer as a result. For men,

however, security is not initially an issue, they felt secure already. The effect of the experimental change was to make security salient for them - they discovered it as a problem.

This study clearly demonstrates the importance of perceived security in modal choice and in transit use patterns. It has also identified some of the determinants of perceived security. Comprehensive parametric studies of the procedure discussed above are now needed.

B. USER ACTIVITIES IN THE STATION

The user of public transportation engages in a sequence of activities while in the system. Each of these activities have associated with them a certain level of risk, and of perceived risk. According to one report (30), perceived security is least while entering and exiting the transit station; waiting for and riding the vehicle were perceived as relatively safe. Actual levels of risk are greatest while waiting for the vehicle or when riding in it. Entering and exiting the station are relatively secure activities.

Table 4 was adapted from the Carnegie-Mellon report. The objective data concerning crime were used to develop the security ranking for each of eight passenger activities. Those activities which are objectively safest (ranks = 4-8) all involve purposive, directed movement on the part of the passenger. The three relatively insecure activities require the user to pause, hesitate, or wait. Waiting time is exposure time, and the less the wait, the safer the passenger - in general. Fare collection involves handling money, but also usually involves interacting with another person. Transit criminals may use this activity to identify targets for later crimes - on the platform or in the train.

The transit designer should facilitate the rapid, purposive movement of people through the station. Whenever the user must pause because he is confused, uncertain, or frustrated, he is a potential target for a criminal incident.

Table 4

Security Ranks for Various Passenger Activities*

Passenger Activity	Objective Security Rank**
Travels to station	Not ranked
Arrives at station	6
Enters station	4
Pays fare	3
Waits for vehicle	1
Boards vehicle	5
Rides on vehicle	2
Exits vehicle	7
Exits station	8
Travels to destination	Not ranked

*Source: adapted from Carnegie-Mellon University, 1975
**Ranked as 1 = most dangerous to 8 = least dangerous

The passenger needs control and predictability in the transit station. He should know, or be able to find out rapidly, what to do to accomplish each activity. Automated information aids and fare equipment must work - reliably and correctly. If not, passengers will be confused, frustrated, and angry.

While on the train or in the station, the passenger should experience a minimum of sensory aggravation. The environment should be as nonobtrusive as possible: pleasant, adequate lighting, minimal noise, no odors or smoke, comfortable temperature and humidity, etc. The trains and stations should be well maintained and kept in good working order. Poor maintenance, obvious vandalism and graffiti, and nonworking equipment all convey to the passenger a lack of concern by transit authorities. If the transit authority can't maintain its facilities, it is unlikely to provide adequate security.

IV. CRIME COUNTERMEASURES

A. TYPES OF COUNTERMEASURES

There are many possible procedures, policies, design features, and technological devices which can function as crime countermeasures. The purpose of a countermeasure is to prevent crime and/or the fear of crime. Countermeasures may be divided into classes according to their focus: thus, they may focus on hardware and equipment, or personnel and operations, or design and environment, or community relations and judicial policy (11). Examples of countermeasures of each type are shown in Table 5.

The countermeasures of primary interest in this report are those that have implications for station design. Items from three of the categories in Table 5 impact on station design. The key questions for security planning in station design are:

1. Interior design: What should be the interior configuration of the station? What materials and construction techniques should be employed, what features should be included?

2. Exterior environment: Where should the station be located? How should it be placed? How should its surroundings be designed and arranged?

3. Hardware and equipment: What hardware and physical components should be built into the station or planned for? What design features are necessary for effective use of the hardware?

4. Manpower deployment: How can the station be designed to insure effective and efficient use of personnel and security patrols? Can station design minimize the manpower required to protect and secure the system?

The optimal set of countermeasures to provide for a particular transit station will depend on several considerations, including probable crime problems, available financial and manpower resources, user acceptance, community acceptance, relevance, appropriateness, and effectiveness. Most of the countermeasures listed in Table 5

seem to relate to the occurrence of crime. They are reasonable precautions in view of our ideas about crime and criminals. However, only a few of them have been tested empirically - that is, most have not been subjected to experimental test to determine their effects on actual and perceived security. In some instances, the relevance of a countermeasure will follow from our knowledge of the circumstances typical of crime occurrences as discussed in Section 2. Some countermeasures are appropriate because of their influence on perceived security whether or not they actually affect crime rates. There are some proposed countermeasures whose relevance is conjectural.

The next two sections of this report discuss the effectiveness and acceptability of selected countermeasures and outline the goals that packages of countermeasures should address. The design implications of these security goals will be noted.

B. COUNTERMEASURE EVALUATION

Few studies have examined the actual effects of countermeasures on transit crime. Experiments are in progress in Chicago and New York to assess the impact of CCTV on transit crime. CCTV has proven effective in providing security in industrial and military installations, and electronic security devices tend to suppress criminal activity in stores and banks. Screening devices have had marked success in airports for disarming and deterring potential hijackers. Street lighting has helped reduce crime in several cities, and adequate lighting in shopping center parking lots has cut criminal incidents and auto-related offenses. The New York City crackdown on fare evaders reduced other crimes in the system, led to the arrest of many offenders wanted for previous crimes, and apparently thwarted some more serious criminal activities.

The lack of data concerning countermeasure effectiveness is unfortunate, and hopefully transit authorities will perform the experimental and statistical comparisons necessary to evaluate newly implemented procedures and equipment.

Table 5

CRIME COUNTERMEASURES ARRANGED BY TYPE

I. Hardware and equipment countermeasures
- A. Alarm systems
- B. Communication devices - phones
- C. Surveillance equipment
  - 1. Closed circuit television (CCTV)
  - 2. Visual and auditory monitoring
  - 3. Teleview alert system (TVA)
- D. Evidence gathering equipment
  - 1. Alarm activated cameras
  - 2. Videotape
- E. Entry control
  - 1. Turnstiles, gates
  - 2. Prescreening riders
  - 3. Automatically sealed exits
- F. Fare Hardening
  - 1. Exact change systems
  - 2. Sealed farebox
- G. Detection devices
  - 1. Metal detectors
  - 2. Intrusion detectors

II. Personal and operations countermeasures
- A. Manpower deployment
  - 1. Visible uniformed security force
    - a. Police always in station
      - (1) Fixed location
      - (2) Station patrolled
    - b. Police patrol the system
      - (1) Random patrols
      - (2) Regular patrols
      - (3) Saturation patrols
      - (4) K-9 patrols (dog/man team)
    - c. Plain clothes police officers
    - d. Decoy teams
  - 2. Transit employees in station
    - a. Ticket sellers
    - b. Concession operators
    - c. Maintenance people
- B. Operations
  - 1. Station under constant surveillance
  - 2. Selective deployment of police
  - 3. Frequent scheduled service
  - 4. Fare collection policies
    - a. Multiple trip fare cards
    - b. Time limited fare cards
    - c. Exact change systems
  - 5. Variable vehicle size
  - 6. Nonscheduled stops
  - 7. Rerouting capability
  - 8. Preventing fare evasion
  - 9. Aerial surveillance

III. Design and environment countermeasures
- a. Interior design considerations
  - 1. Area easily surveyed by camera or person
    - a. Good lighting
    - b. Open space
    - c. No barriers or visual obstructions
    - d. Height-limited fixtures
    - e. Transparent exterior walls
  - 2. Controlled passenger movement
    - a. Fare collection at entrance
    - b. Single entrance/exit area
    - c. Specified traffic flow patterns
    - d. Adaptive space
    - e. Central platform or loading area
    - f. Floating platforms; elevated guideways
  - 3. Control passenger convenience services
    - a. Eliminate restrooms
    - b. Control access to restrooms
    - c. Single person restrooms
    - d. Eliminate concessions
    - e. Cluster concessions
  - 4. Manage environment
    - a. Attractive, clean property
    - b. Vandalproof surfaces and fixtures
    - c. Easy maintenance materials
    - d. Climate control
  - 5. Minimize number of station levels
- B. Exterior design issues
  - 1. Site selection
    - a. High or low crime area
    - b. Proximity to activity centers
  - 2. Use integrated with neighborhood activities and surrounding environment
  - 3. Ease of access
    - a. Pick up and delivery zones
    - b. Parking facilities
  - 4. Lighting
  - 5. Landscaping
    - a. Perimeter barriers
    - b. Natural fences
    - c. Open area between building and outer perimeter

IV. Community and judicial countermeasures
- A. Public relations
  - 1. Media programs
  - 2. Control publicity about incidents
  - 3. Community relations
  - 4. School programs
- B. Judicial policies
  - 1. "Swift and certain justice"
  - 2. Prosecution of incidents
  - 3. Rapid processing of court cases
  - 4. Judicial disposition of incidents

Jacobson et al. (11) convened a panel of ten judges to help evaluate a set of crime countermeasures. There were six men and four women on the panel, and they varied in age and their familiarity with transit security issues. All judges were well acquainted with at least one major urban transit system.

The panelists were asked to evaluate the potential effectiveness of various countermeasures against a set of target crimes. The judges did their ratings independently, and then the experimenter aggregated the data using the most frequent rating as the consensus of the group. In fact, 8 or more of the 10 judgments usually agreed for a particular countermeasure-crime combination. Table 6 shows the resulting ratings of the effectiveness of each countermeasure in combating each crime. An "X" indicates that the countermeasure would be very effective against the crime, a "/" means it would be moderately effective, and a "0" means it would have no effectiveness in preventing the crime.

The ideal countermeasure would be one that had a strong effect on many crimes of different types. Unfortunately, most countermeasures are effective against a few crimes - usually of a single type. The countermeasures which are highly effective against many crimes are mostly manpower intensive (visible, uniformed security force, presence of transit personnel, saturation patrols, and K-9 patrols). The exception is CCTV which is both widely effective and requires relatively little manpower. Various other communication and alarm systems would be moderately effective against a wide range of crimes, as would the design features: good lighting, open space single exits and adaptive space. Prescreening riders would also be moderately effective in preventing most crimes and very effective against some.

Active surveillance is the key to the effectiveness of the manpower countermeasures and of CCTV. The problem with an alarm system is that someone has to activate it. Either through ignorance or through fear, many people will fail to trigger an alarm in an

TABLE 6

JUDGED EFFECTIVENESS OF CRIME COUNTERMEASURES*

	CRIMES	GOOD LIGHTING	"OPEN" DESIGN	CLIMATE CONTROL	ADAPTIVE SPACE	VISIBLE, UNIFORMED SECURITY FORCE	MEDIUM-VOLUME TRAFFIC FLOW	SCHOOL/COMMUNITY PROGRAMS	ATTRACTIVE, CLEAN TRANSIT PROPERTY	REDUCE NO. OF CARS DURING OFF-PEAK HOURS	PRE-SCREEN RIDERS	ELIMINATE STATION RESTROOMS	TRANSLUSCENT DOORS IN RESTROOMS	PNEUMATIC TUBES TO COLLECT END-OF-DAY RECEIPTS	VOICE MONITORS	CCTV	PASSENGER-ACTIVATED ALARMS	ALARM-ACTIVATED VIDEO-TAPE	BURGLAR-TYPE ALARMS	PUBLIC ADDRESS SYSTEM	TELEVIEW ALERT SYSTEM	METAL DETECTORS	K-9 PATROLS	PRESENCE OF TRANSIT PERSONNEL	PLAIN-CLOTHES DETECTIVES	SATURATION PATROLS	POLICE DECOYS	NON-SCHEDULED TRAIN STOPS	AERIAL PATROLS	NON-BREAKABLE WINDOWS	VANDAL-PROOF SEAT COVERINGS	CLEANABLE, GRAFFITI-PROOF SURFACES	AUTOMATICALLY SEALED EXITS	SINGLE EXITS	PREVENTION OF FARE EVASION
AGAINST PERSON	ASSAULT	/	/	/	/	X	/	0	0	/	/	0	0	0	/	X	/	/	0	/	/	/	X	X	/	X	/	/	0	0	0	0	/	/	0
	BATTERY	/	/	/	/	X	/	0	0	/	/	0	0	0	/	X	/	/	0	/	/	/	X	X	/	X	/	/	0	0	0	0	/	/	0
	HOMICIDE/ MANSLAUGHTER	/	/	/	/	X	0	0	0	/	/	0	0	0	/	X	/	/	0	0	/	/	X	X	/	X	/	/	0	0	0	0	/	/	0
AGAINST PERS. CARRIED PROP.	ROBBERY	X	X	/	/	X	/	0	0	/	/	/	/	0	/	X	/	/	0	/	/	/	X	X	/	X	X	/	0	0	0	0	/	/	/
	PURSE-SNATCHING	/	/	0	/	/	0	0	0	0	/	/	0	0	/	X	/	/	0	/	/	0	X	X	/	/	/	0	0	0	0	0	/	/	/
	POCKET-PICKING	/	/	0	/	X	0	0	0	0	/	0	0	0	0	/	/	/	0	/	/	0	/	X	/	X	/	0	0	0	0	0	/	/	/
AGAINST STATION PROP.	STATION BURGLARY	/	X	0	0	X	/	0	0	0	/	0	0	X	/	X	/	/	X	/	X	/	X	X	/	X	/	0	0	0	0	0	/	/	/
	FARE EVASION	/	/	0	/	X	/	/	0	0	X	0	0	0	0	X	0	/	X	/	/	0	X	X	/	X	0	0	0	0	0	0	/	/	X
	VANDALISM	/	/	0	/	X	/	/	/	/	/	/	/	0	/	X	/	/	/	/	/	0	X	X	/	X	0	0	/	/	/	/	/	/	/
	PETTY THEFT	/	/	0	/	X	0	/	0	0	/	0	0	0	0	X	/	/	/	/	/	0	X	X	/	X	0	0	0	0	0	0	/	/	0
	TRESPASSING	/	0	0	/	X	0	0	0	0	/	0	0	0	/	X	0	/	X	/	/	0	X	X	/	X	0	0	/	0	0	0	/	/	0
	ARSON	/	/	0	0	X	/	0	0	0	/	0	0	0	0	X	/	/	X	/	/	0	X	X	/	X	0	0	/	0	0	0	/	/	0
	MISSILINGS	0	0	0	0	X	0	/	/	0	0	0	0	0	0	0	0	0	0	0	0	0	/	/	/	/	0	0	/	0	0	0	0	0	0
AGAINST PUBLIC	DRUG LAW VIOLATIONS	/	/	0	/	X	0	0	0	0	X	X	/	0	0	/	0	0	0	0	/	0	X	/	/	X	/	0	0	0	0	0	/	/	0
	SEX CRIMES	X	/	0	/	X	/	0	0	/	/	/	/	0	/	X	/	/	0	/	/	0	X	X	/	X	X	0	0	0	0	0	/	/	0
	DRUNKENNESS	0	0	0	0	/	0	0	0	0	X	/	0	0	/	0	/	/	0	0	0	/	0	/	/	/	/	0	0	0	0	0	0	0	0
	DISORDERLY CONDUCT	/	/	0	/	/	/	0	0	/	/	0	0	0	/	X	/	/	0	/	X	0	/	/	/	X	0	0	0	0	0	0	0	0	/
	CONCEALED WEAPONS	0	0	0	0	/	0	0	0	0	X	0	0	0	0	0	0	0	0	0	0	0	X	/	/	/	/	0	0	0	0	0	0	0	0

* X = very effective against the crime, / = somewhat effective,
0 = no effect.

emergency. CCTV is a passive system from the passenger's perspective, he doesn't have to do anything to benefit from it. Continuous CCTV surveillance of a station is the best countermeasure other than having police present in the station.

A second set of questions about countermeasures is whether they are acceptable - both to transit users and to transit management. The panel discussed above also rated the "acceptance costs" associated with various countermeasures. A countermeasure would have high acceptance costs if it were objectionable and low acceptance costs if it were acceptable. Table 7 shows the group results for various countermeasures. Thus, good lighting is not objectionable to either interest group; prescreening riders is highly objectionable to both; and restroom restrictions are somewhat objectionable to riders but acceptable to management. CCTV and police patrols have low acceptance costs; neither riders nor managers find them objectionable.

Several studies have reported results from surveys asking transit users what security measures they would favor or thought would increase their perceived security. Ferrari and Trentacoste (38) asked people to rank eight possible transit security improvements. "Increasing the number of police at the stations" and "increasing the number of police in vehicles" were the two most preferred alternatives. The third choice was initiation of a communication network, followed (in rank order) by an alarm system and improved lighting.

Respondents in the Broad and Columbia Subway Development study (41) felt their personal security would be most enhanced by a full time security guard. CCTV and an alarm system on the platform would also provide a high level of perceived security. Several design features (better lighting, open design, and eliminating hidden corners) would result in significantly improved security, but not as much as with the above three countermeasures.

TABLE 7

JUDGED RELATIVE COSTS OF CRIME COUNTERMEASURES*

COUNTERMEASURE	Acceptance Costs		Monetary Costs	
	Objectionable to Transit Riders	Objectionable to Transit Operators	Capital Costs	Operating Costs
Pre-Screen Riders	H	H-	M+	H
Alarms & Sensors	L	L	M	M
CCTV	L	L	M	M
Voice Monitors	L+	L	M	M
Barriers	L+	L	M	L
Sealed Exits	M	L+	L+	L
Fare Box Hardening	L	L	M	L
Good Lighting	L	L	M	L+
Open Station	L	L	M	L
Climate Control	L	L	M	M
Adaptive Space	L	L	M	L+
Attractive Environment	L	L	M-	M
Restroom Restrictions	M+	L+	L	M-
Single Exits	H	L	L	L
Community Relations	L	M-	L	M
Police Patrols	L	L	L	H
Vehicle Deployment Strategies	L	L	M-	M
Canine Patrols	L+	M-	L+	H
Aerial Surveillance	L	M	H	H
Reduced Service	H	L+	L	L
Legal Sanctions	L	L+	L	M+
Land Use Considerations	L	M		L
Televiewer Alert System	L	L	H	M

H = high M = medium L = low/little
+ better, - worse

*Source: Jacobson, Richards, Leiner, Hoel, and Braden (11).

Shellow, Romualdi, and Bartel (29) also found that police patrols are viewed by transit users as the most effective security measure. They concluded that the key to perceived security is the ability to get help quickly in an emergency. If the passenger feels he can get assistance when it is needed, he will feel secure.

All of these studies suggest that user acceptance is greatest for security measures involving either personnel in the stations or continuous surveillance of the stations coupled with a response capability. The transit rider wants security measures which insure (1) a high probability of detecting an incident, (2) a high probability of getting help when it is needed, and (3) a fast response time if action is needed. With police or transit employees in the station, the help is already there - response time is minimum. With a communication or surveillance system, help is available but removed. The success of such a system depends on (1) the response time to incidents and (2) the frequency and rapidity with which incidents are detected.

Monetary costs must also be considered in selecting countermeasures and designing a comprehensive security system. Exact cost figures will depend on the specifications for a particular installation. Changing economic conditions and rapid technological development make precise cost figures obsolete rapidly.

Jacobson et al. (11) asked their panel of judges to provide estimates of the relative costs of the various countermeasures (as of 1978). The judges related initial capital costs separately from operating costs. The results are presented in Table 7. Ideally, one would like to implement countermeasures with minimum costs of both types. Unfortunately, the most preferred security measures are not the ones lowest on both kinds of cost. CCTV has moderate capital and operating costs. The personnel intensive measures are low in capital costs, but high in operating costs. These judgments were made relative to each other - comparing the various countermeasures. The real question for the security planner and system

management is how these costs compare to those due to the real or anticipated crime in the transit system. A serious crime problem will justify major expenditures to combat it.

V. PLANNING FOR STATION SECURITY

The considerations which should guide security planning and design have been discussed in detail in the previous four sections. The present section ties those considerations together into a unified set of procedures for directing and aiding the design process. Depending on when in the overall planning process security design is considered, these procedures can be either a set of guidelines to influence design or a set of standards for evaluating the alternatives or plans developed by others. Security design should be considered from the beginning of the overall planning process. It is both easier and less costly to incorporate security measures in the initial design phases. Design features which may lead to crime and vandalism can be eliminated early on rather than designed around or compensated for later.

The security planning process is represented as a linear sequence in Figure 2. However, each step in the process involves coordinating diverse information, and various interactions and iterations between steps may be necessary in practice.

STEP 1. ASSESSING THE CURRENT SITUATION

For either an existing or planned station, the first step is to collect or generate the relevant information about actual or proposed design features, neighborhood characteristics, and the status of the station in the overall transit network. Design evaluation for an existing station can be accomplished using one or all of the procedures proposed by Harris (23), the University of California (24), or Richards et al. (9). Crime statistics and reports of incidents in the station should also be examined. Surveys of users, employees, and area residents can also reveal important problems and concerns. The design evaluation for a proposed or planned station should focus on the issues and features raised in the Harris, BART, and Richards surveys. Thus, station characteristics which could contribute to security problems can be identified (see Table 8).

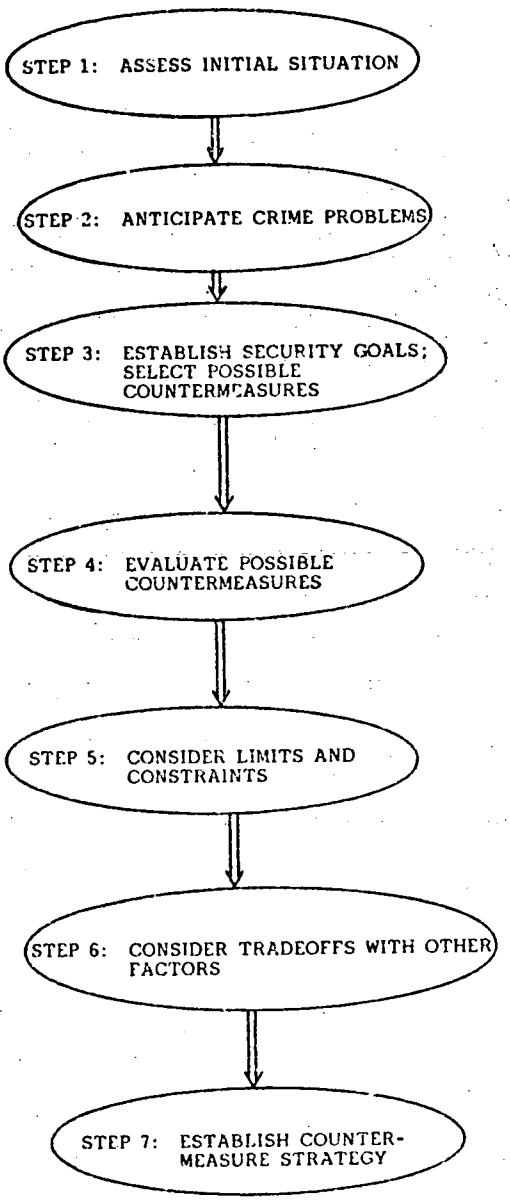

Figure 2 Steps in the Planning Procedure for Transit Station Security

Table 8

Assessing the current situation

Existing Station	Planned Station
1. Design features	1. Design features
2. Neighborhood characteristics	2. Neighborhood characteristics
3. Functional requirements	3. Functional requirements
4. Crime statistics for neighborhood for station	4. Crime statistics for neighborhood
5. Expert input police transit employees community leaders	5. Input from potential users community residents police businessmen
6. User interviews	
7. Incident reports	

The station location can contribute to or help minimize crime problems. Both the neighborhood crime rate and the manner in which the station interfaces with the community will influence the amount of crime to be expected in the station itself. The security designer should obtain information regarding

1. Demographic characteristics of the area; census information: population density; ethnic, age, and sex distributions; socio-economic indices - including patterns of changes over time; level of unemployment.

2. Neighborhood crime situation; as reflected in police records, crime statistics; the perceptions, impressions and opinions of police, residents, and business people in the area.

3. Special area characteristics; is the area urban, suburban, rural; is the neighborhood primarily residential, business, industrial; are there special facilities which will be served by the transit station: schools, hospitals, a stadium, civic center, or coliseum, a factory? Special problems can be anticipated for certain facilities: Hospitals have personnel arriving at all hours with some shifts coming in at night. Schools cause predictable morning and afternoon peak traffic periods. Stations near junior and senior high schools may have special problems. Factory sites will have special security needs on paydays, and may cause changes in system use patterns during periods of extensive overtime work. Station security procedures must be designed to handle peak traffic periods as well as be adjustable for reduced traffic at other times.

4. Interface: how does the station integrate with the surrounding area? Station entrances should connect to safe areas. The entrance should not connect to a place people are afraid to go. Proximity to juvenile hangouts, bars, skid row, and areas of known professional crime activity should be avoided. Entrances near stores and shopping centers, busy streets, etc. are usually desirable.

The status of the station in the overall transit network will influence its potential security. Is the station a primary interface with other travel modes? Is it a major transfer terminal? Is it an end of the line station or an intermediate stop? Is it a major activity center, a primary collection or distribution point for a key business or industry?

What points are connected to the station; do the connections present any inherent problems?

STEP 2. DOCUMENT OR ANTICIPATE CRIME PROBLEMS

The security designer must identify probable or actual crime problems and thus isolate potential security needs. For existing stations, these problems should be evident from actual data. For planned stations, they must be anticipated from knowledge of the conditions for crime and the characteristics of the station neighborhood. An area with a large teenage population and a high unemployment rate will likely have problems. A neighborhood of mostly retired people is unlikely to experience much vandalism or graffiti. Area police can often provide valuable information about what crimes might be expected at various potential station sites.

STEP 3. ESTABLISH SECURITY DESIGN GOALS AND SELECT POSSIBLE COUNTERMEASURES

The security design goals will be statements of what the designer wishes to accomplish via countermeasures. These goals will in part depend on the crime problems which are anticipated at a given station. Table 9 presents a list of security design goals and possible means of achieving them. The ideal strategy is to assemble packages of countermeasrues which complement each other and mutually permit the achievement of multiple goals. The designer will generate sets of countermeasures and station design features to combat various high probability patterns of criminal activity. The countermeasures may be general (aimed at reducing several types of crime) or specific (to combat a particular problem like graffiti).

TABLE 9

SECURITY DESIGN GOALS AND MEANS OF ACHIEVING THEM

I. Insure adequate surveillance of station interior

- A. Police or CCTV in station
- B. High visibility
  1. Users should be aware that they can be seen
  2. Police should be visible
  3. Security equipment should be visible
- C. Good lighting - well-lighted interior and exterior areas
- D. Direct line of sight to all areas of station
  1. No obstructions
  2. No separate spaces, secluded areas, or cul de sacs
  3. No dark corners, isolated regions, or places to hide or jump out from
- E. Transparent or translucent doors and/or walls wherever possible

II. Control access and egress

- A. Limit station access to passengers
  1. Require payment to enter station
  2. Maximize proportion of station that is paid area
  3. Deter entry of nonusers
  4. Prevent fare evasion
- B. Have entrances and exits under surveillance
  1. By CCTV
  2. By transit police
  3. By fare collectors
- C. Provide detection devices
  1. For unwarranted intrusion
  2. For unwanted objects: weapons, spray cans
- D. Minimize the number of entrances and exits
  1. Single access/egress area
  2. Absence of multiple escape routes
  3. Prevent easy exit by criminal
- E. Insure easy access and egress by police
  1. Pass cards
  2. Special opening devices

III. Minimize exposure time

- A. Minimize walking time and distance
- B. Limit processing time
  1. Working fare card machine
  2. Presorted change
  3. Well rehearsed information
- C. Minimize waiting time
  1. Provide frequent service
  2. Let passenger know when the next vehicle is expected (eliminate uncertainty about length of wait)

IV. Insure adequate communications

- A. Communication points on vehicles and in stations. These must be easy to find, identify and use. Their purpose and operation must be understood by passengers.
- B. Equipment for police use - to insure contact between police, and with outside personnel and emergency services.

V. Secure property; design against vandalism

- A. Use vandal resistant materials
  1. Special window materials
  2. Hard or special fabric seats
  3. Coated walls and doors
- B. Keep attractive equipment out of reach
  1. Cameras on high ceiling
  2. No loose fixtures or devices
- C. Design for easy maintenance
  1. Modular construction - for easy repair or replacement
  2. Easily cleaned surfaces; compatible solvents
  3. Policy of immediate cleanup and maintenance

VI. Insure comfort and ease of use of station

- A. Process passengers pleasantly, smoothly, and efficiently
  1. Familiar, uniform, standardized equipment
  2. Easy to use equipment
  3. Understandable user aids
  4. Easy to follow directions and signs
- B. Aesthetic and sensory adequacy

VII. Enhance perceived security

- A. Incorporate positive factors
  1. Good lighting
  2. High visibility
  3. Clean, well maintained station
  4. Design for easy maintenance
- B. Eliminate negative factors - remove cues associated with lack of security; also minimize annoyance in station environment.
  1. Minimize annoyance factors
     a. Reduce sensory aggravation (noise, odors, vibration, dirt)
     b. Prevent graffiti
     c. Keep out loiterers or bums and youth gangs

STEP 4. EVALUATE POSSIBLE COUNTERMEASURES

Countermeasures must be evaluated in terms of their

1. effectiveness
2. costs
   - monetary costs (capital; operating)
   - acceptance costs (to users; to operators)
3. design implications
4. feasibility and flexibility

The bases and procedures for making these evaluations have been presented in the previous sections of this report. Countermeasure effectiveness can be determined by (1) empirical evidence (demonstrated effectiveness) or (2) functional relevance - that is, the countermeasure must do something clearly related to security goals. Thus design features enhancing visibility and surveillance foster security. That adequate lighting is necessary for perceived security is obvious. The evaluation of proposed countermeasures will be done using information like that in Section IV (Tables 6 and 7). These tables could be used or updated versions of them generated by the experts of a particular transit property. Monetary costs have been changing rapidly and the recent trend has been for high technology communication and surveillance equipment to decrease in price. Vendors can often put together novel equipment configurations which meet functional specifications at reasonably low costs - especially when faced with competitive bidders. Acceptance costs will vary as a function of what the users and operators have as a standard or frame of reference: acceptable improvements in New York may not satisfy the users of a newer system, and procedures which authorities in Chicago approve of may not be acceptable to Boston (12). The basic concern will be with user acceptance: How much inconvenience, bother, or delay will proposed security procedures cause the user? How likely are they to be so objectionable as to drive the user from public transit?

Clearly, in existing stations, the design implications of a countermeasure may rule it out. Thus, surveillance equipment requires high ceilings and reasonable light levels. If an existing system has all low ceiling stations, then surveillance technology is ruled out unless the stations can be appropriately renovated.

The final evaluation criterion involves the potential for change in the face of changing times or conditions. What degree of flexibility exists after installing a particular countermeasure to later upgrade or improve the station? One must consider whether a decision will rule out whole classes of future improvements: you don't want to install a system that will become obsolete but be difficult to replace.

Not all transit stations in a given system will require the same countermeasures. Selective treatment of transit stations is a reasonable strategy. The user will appreciate security precautions where they are clearly necessary, but may resent them where they are not. Or, at worst, he may think they are needed when they are not and therefore attribute a greater degree of danger to the entire transit system than it deserves.

The system should not be overfortified. Massive fortification (lots of security equipment) will give the impression it is needed; if it is not needed, it is better not to have it. People like to feel their home stations are safe and secure, and generally those in residential areas are. So residential and suburban stations shouldn't need much security response - if they do, the residents probably won't use the transit system anyway. Strong security response would be expected and appreciated in downtown or central city stations.

STEP 5. CONSIDER LIMITS AND CONSTRAINTS

Security design does not occur in a vacuum. It takes place in the context of the total design process. Thus, it is influenced and constrained by finances, politics, community needs and system functions. Prior decisions regarding station function and size will provide constraints for the security designer. Population density and the distribution of work sites will determine station locations, as will local politics and community preferences.

Some typical prior constraints are:

1. an existing station. Here almost everything is given. The security designer must determine how to best protect an existing facility. His options will usually be quite limited. Technological countermeasures will be necessary unless the station is to be redesigned.

2. a given volume of users, a specified station size. Here the security designer has more flexibility and can help choose from possible station designs that can handle the volume those which would be most secure.

3. an established traffic flow pattern.

In general the greater the initial flexibility in the design, the cheaper and better security procedures will be. The more constrained the security planner, the less flexibility in how to protect and the greater the cost. For example, at early planning stages, the security planner will suggest minimizing the areas requiring surveillance. This will require a few cameras or a single employee. If the planner is presented with a convoluted design with many units or subareas, designing for security will be more costly and more difficult.

STEP 6. CONSIDER TRADEOFFS WITH OTHER FACTORS

There are various situations in which security goals can conflict with other system goals - both in general and for specific user

groups. Two examples involve security versus safety, and security versus convenience. Safety considerations often conflict with security goals. Few (or only one) exits from a station are desirable for security, but not for safety. As a matter of safety, the more ways to get out, the better. High turnstiles and hardened entrances facilitate security, but not safety. There must be adequate escape provisions for emergency situations. Exact fare or subscription user services are ideal for security, but present convenience problems for many users.

Persons with handicaps or health problems may experience difficulty with certain countermeasures. A variety of special design problems exist with mainstreaming physically and mentally handicapped persons.

For a proposed countermeasure or design feature, it is necessary to consider (1) how it will affect each of the factors of user acceptance (safety, convenience, dependability, scheduling, etc.), and (2) how it will affect the number of users the station can handle and the system's ability to accommodate special user groups.

STEP 7. ESTABLISH DESIGN AND COUNTERMEASURE STRATEGY

1. Design key features into the system. Provide a minimum set of countermeasures: lighting, an alarm or communication device, and a means of identifying one's location. The minimum set of countermeasures should insure adequate levels of perceived security.

2. Provide selective treatment, target hardening in high crime areas. Focus major security efforts where they are needed.

3. Rank possible countermeasures for each site; assess economic limits on their installation; develop best combination for the money.

The security designer should propose both an optimal configuration and a minimal configuration of countermeasures for a particular site. Where the optimal is not accepted, he should be prepared to propose additions to the minimal set which achieve the greatest effectiveness within the fiscal and political constraints which exist.

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