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TRANSIT STATION RENOVATION: A CASE STUDY OF PLANNING AND DESIGN PROCEDURES

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16. Abstract

The general techniques and procedures for planning and evaluating transit interface facilities are applied comprehensively to the problem of station renovation. The 69th Street Terminal in Philadelphia is evaluated in terms of its performance in accomplishing its transportation function, its effectiveness in relation to transportation policies, development objectives and costs. The planning procedures are employed to develop possible improvement programs. The report identifies modifications to the transit station that will produce operational conformity with policy guidelines and suggests alternative renovation plans to meet system and user objectives. The alternatives are evaluated and compared using factor profiles. Modifications of the selected plans are suggested, and the methodology is reviewed in terms of its performance in the renovation planning process.

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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 mil[illegible]	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^2	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

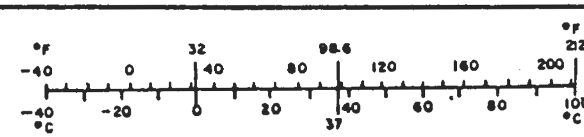

TABLE OF CONTENTS

Table of Contents (Cont'd)

Table of Contents (Cont'd)

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENTS

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EXECUTIVE SUMMARY

Introduction

The public acceptance of transportation services is heavily dependent upon the performance of modal interchange facilities. Travelers generally place greater weight on time spent transferring between modes than on time spent in the vehicle. Thus, abrupt transitions and delays at interface facilities can affect service advantages offered by high speeds, frequent service and advances in line haul technology.

Two recent research reports have developed a methodology for planning and evaluating transit station alternatives. The first was entitled, "Criteria for Evaluating Alternative Transit Station Design" and was concerned with the development of appropriate criteria for the evaluation of alternative station designs. The second document, "Methodology for the Design of Urban Transportation Interface Facilities," provided a basic framework and the necessary tools and techniques for designing and evaluating alternative transit terminal plans. The methods and techniques are summarized in a Procedural Guide that furnishes an overview of the important considerations needed in order to systematically plan and design transit stations (1,2,3).

Problem Studied

The package of general procedures and techniques to define, measure, and evaluate the performance of transit interface facilities is summarized in Figure 1. The problem studied is to test and demonstrate the utility of this methodology through application in specific design settings. Terminal design problems concern the renovation of existing stations and the design of new facilities. Renovation begins with a review of the existing facility and proceeds with the evaluation of changes and modifications. A description of the facility renovation process is depicted in Figure 2.

The purpose of this study is to carry out the process of transit station renovation planning and to illustrate the procedural steps within the context of an existing station that has deteriorated and is not functioning according to modern standards. The general techniques for planning and evaluating transit interface facilities are applied in a comprehensive manner to the station renovation problem, and its performance is evaluated in terms of its effectiveness in meeting system-wide policies for the user and operator.

Criteria Development (Define Performance)

Diagnosis of Interest Groups
Objective Determination
Determination of Impact-interest Interactions
Performance Criteria Determination
Specification of Measures for Performance Criteria
Establish Standards for Performance Criteria

Interface Facility Analysis (Measure Performance)

Policy: System Wide; Site specific
Performance: Pass. Processing, Physical Environment, Passenger Orientation, Safety and Security
Cost Models

Evaluation (Evaluate Performance)

Policy Impacts
Performance Measures vs. Standards
Cost

Evaluation Model

Figure 1. Transit Station Evaluation Process

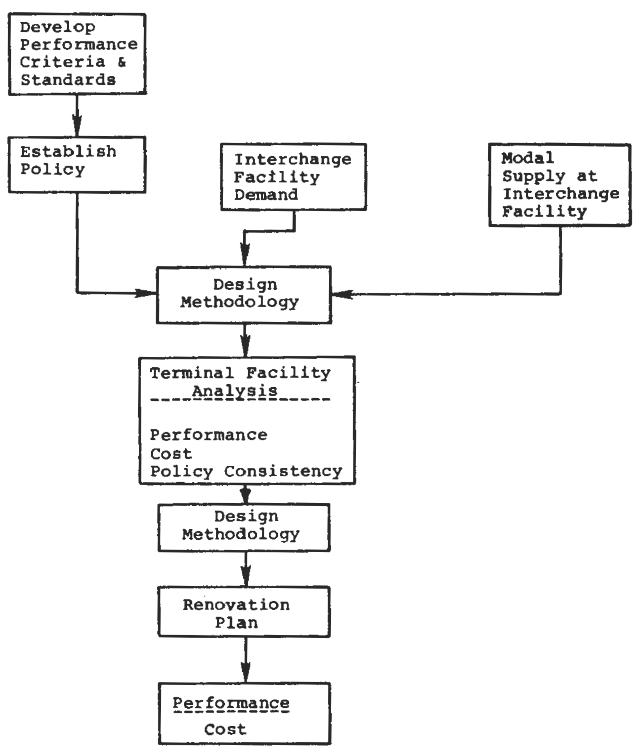

Figure 2. Facility Renovation Process

Results Achieved

The study successfully identified a complex transit terminal, with a variety of system elements, that is badly in need of renovation. The station, built in 1907 with additions made in the 1930s and in 1960, is located in Philadelphia, Pennsylvania and is known as the 69th Street Terminal. It is the western terminus of an elevated rapid transit line and the eastern terminus of a high-speed light rail line. The station also serves streetcar lines and bus feeder routes. Accordingly, the station involves considerable transfer movements and transit vehicle connections.

A set of goals, objectives and criteria were identified for the station. Goals were classified as pertaining to architectural, interchange function, community, and transit authority interests. Objectives were grouped as passenger processing, environmental, fiscal, design and community. Finally a set of criteria and performance measures were identified for each objective. For example, criteria for meeting passenger processing objectives include minimize crowding, travel impedances and conflict, and maximize safety and reliability. Performance measures for each objective would include such things as person-minutes, accidents and down time.

The performance of the existing station was evaluated for each objective and criteria using procedures developed in the general planning methodology. The station was depicted as a node-link network, and the current level of service was determined based on passenger flows between points within the station. The performance for non-passenger flow criteria (e.g., safety, reliability, noise, etc.) was determined by measurement or secondary data sources. Other non-quantifiable criteria were measured by subjective rating scales. The results of the performance of the existing station for the years 1971 and 1985 were depicted on a factor profile chart, as they affect users, non-users and the transit operator.

A review of the existing station was made in light of its conformance with current policy guidelines. For example, if the agency's policy is to require telephones in the station, the present facility is rated in accordance with this policy. It was found that the station failed to meet policy guidelines in the areas of placement of advertising signs, aesthetics (art, music, landscaping, etc.), construction materials, passenger orientation and safety. Policy guidelines were partly met for security, personal care facilities, parking and provisions for special users. The station was noted to be in conformance with policy in the provision of concessions and services, telephones, and the physical environment, as the station areas are enclosed, although not climate controlled. Attention to the items identified as deficient could result in a significantly improved station without the need for extensive redesign of the station layout.

In order to improve the actual processing of passengers through the station by reducing conflicts, trip time and level changes, a series of alternative renovation layouts were produced. These plans included consideration of horizontal and vertical separation, station access for fare collection, passenger volumes on each transit line and accommodations for disabled persons. Plans were developed that emphasized reduction in walking distances and conflicts and the consolidation of bus platforms. Other considerations were to improve weather protection, develop logical layouts and aesthetically pleasant station designs. Five alternatives were developed that represent improvements to the present station layout. The estimated cost ranged from $1.9 to $4.4 million.

The evaluation of each transit station alternative was performed in a manner similar to that used for evaluating the existing station. Performance of each alternative was established for a set of passenger processing, environmental, fiscal, design and community objectives. For each affected group (user, special user, operator and non-user), a factor profile was developed and alternatives compared on the basis of their dominance and tradeoffs. The results indicated the priority of each alternative for each group and showed where conflicts exist. One alternative that represented either the first or second choice of each group was selected for further analysis. Additional design features and modifications were identified that would reduce delay and conflict, improve emergency evacuation, improve equipment reliability, reduce noise and improve orientation. With the completion of the demonstration of the design methodology, the design process can continue with preparation of detailed architectural and structural design plans and specifications, detailed cost estimates, and a financial plan.

Utilization of Results

The results of this study can be used by transit planners, designers, architects, policy makers and citizens to understand the process of developing a renovation plan for a transit station. The results can also be used in the specific station design process as a preliminary guide to its renovation. Professionals presently engaged in rehabilitation projects of this type should benefit from this report.

Conclusion

The study demonstrated the viability of the planning methodology in developing transit station renovation plans. The use of factor profiles for identifying dominance and tradeoffs among criteria proved to be an adequate evaluation technique in the case of renovation planning. Other evaluation methods should be investigated in future research or planning efforts.

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1. Hoel, L. A., M. J. Demetsky, and M. R. Virkler, Criteria for Evaluating Alternative Transit Station Designs, RLES Report No. CE-4142-101-76, Department of Civil Engineering, University of Virginia, Charlottesville, Virginia, February 1976.

2. Demetsky, M. J., L. A. Hoel, and M. R. Virkler, Methodology for the Design of Urban Transportation Interface Facilities, RLES Report No. UVa/59036/CE76/102, Department of Civil Engineering, University of Virginia, Charlottesville, Virginia, December 1976.

3. Demetsky, M. J., L. A. Hoel, and M. R. Virkler, A Procedural Guide for the Design of Transit Stations and Terminals, RLES Report No. UVa 529036/CE77/103, Department of Civil Engineering, University of Virginia, June 1977.

CHAPTER 1

INTRODUCTION

THE PROBLEM

Transit stations, points where passengers board, alight and transfer from one mode to another, are important and integral parts of the transportation network. The smooth and optimal functioning of transit stations is essential for the realization of the full potential of a transportation network.

Transit lines and stations of various designs and eras are not an uncommon feature of our many urban centers. In our northeastern cities, some of these have been in operation since the turn of this century. Many of these transit stations have become less than satisfactory in their operations. This is usually due to a combination of the following reasons:

- physical deterioration with age,
- availability of improved technologies such as new fare collecting systems and people movers,
- changes in travel demand,
- changes in transportation services provided,
- changes in users' or operators' expectations.

Any of the above elements could result in:

- unnecessarily long walking distance and transfer delay,
- inadequate passenger orientation and directional aids,
- an uncomfortable environment,
- accidents, crime or vandalism,
- unnecessary losses in ridership and revenue,
- an aesthetically unpleasant site.

A transit station can be either replaced, eliminated or renovated, depending on the extent and nature of these problems and the various financial, physical, social and political constraints on the transit authority. This study, focused on the process of transit station renovation, is intended as a test and demonstration of a previously developed methodology for the design of urban transportation interface facilities (2,3,4).

PURPOSE

The purpose of this study is to illustrate and test a series of general techniques and procedures prescribed in the above mentioned methodology, by applying them in an existing transit station renovation project. Using the planning procedures and design guidelines of this methodology, options for a possible improvement program can be developed and compared before making a final decision on renovation.

SCOPE

A transit station in need of renovation has been selected to demonstrate the general methodology. The process illustrates the development and evaluation of alternative plans in sufficient detail so that architectural and structural specifications can be produced.

REPORT ORGANIZATION

Following is a brief description of materials covered in each chapter.

Chapter 2: Background

Reasons for renovation of existing urban transit stations in the United States are cited. The various groups affected by or involved in the renovation process are described. The chapter discusses traditional design and planning methods and the systems methodology used in this study.

Chapter 3: Station Selection and Characteristics

The basis for selecting the 69th Street Terminal just west of Philadelphia, Pennsylvania is described. Considerations include its need for renovation, variety of system elements, the availability of information and the cooperation of the operating agency. The chapter also describes the station's physical and demand characteristics.

Chapter 4: Performance and Policy Evaluation

The general methodology is used to evaluate the performance of the present station and its ability to meet the operating agency's policy directives.

Chapter 5: Modifications to Meet Policy

Modifications to the transit station that are necessary in order to have a closer operational conformity with policy directives are identified.

Chapter 6: Generation of Alternatives

After describing the constraints on the station design and the development and analysis of improvement strategies, this chapter then presents the five alternative renovation plans.

Chapter 7: Evaluation of Alternatives

A procedure involving the selecting of objectives, estimation of performance, and the compilation of factor profiles is applied to evaluate the alternatives generated. Modifications and additional details that might improve the performance of the selected alternative are examined.

Chapter 8: Conclusions and Recommendations

Merit of applying the general methodology in a renovation project is discussed. Refinements which would increase the flexibility of the approach are recommended for consideration, and areas where further research may improve the planning and evaluation process are suggested.

CHAPTER 2

BACKGROUND

THE NEED FOR RENOVATION

The transit systems of Boston, Chicago, Cleveland, New York and Philadelphia were either opened or saw their greatest period of growth in the first three decades of the twentieth century. These systems were often placed underground and occasionally elevated in and around the central business district. In their outer reaches they were often at-grade. Accordingly, there are elevated, at-grade and underground stations in most of these systems.

Many of the stations in these systems were built more than half a century ago. As of 1976, 24 out of 58 major stations in Boston's transit system were more than 50 years old, none of which had been renovated during that 50-year period. Replacement or elimination had been proposed for 10 of these stations, leaving 14 as candidates for renovation (6). These figures do not include Boston's numerous commuter rail stations. Comparatively, Boston is noted for its renovation work, unlike New York which has 459 transit stations, of which fewer than one each year are renovated (7, 8).

Public authorities acquired many of these systems from private companies that were in financial trouble. As transit company profits declined along with ridership after World War II, less money was spent on maintenance and renovation. As a result, by the time these systems were acquired by public transit authorities, they had largely fallen into disrepair. The new transit authorities have had only limited success in attempting to deal with the problem of station neglect. Lack of funds has been a major problem, although lack of methodology and experience has not helped the situation either. Although improvements have been made, notably in Boston, much work still needs to be done at many stations.

The existing conditions evoked the following remarks from one transit official:

> . . . Archaic designs created in that era made difficult maintenance and cleaning operations. Barrier designs were cage-like, creating zoo-like or prison atmosphere. Lighting was of poor quality, and antiquated equipment and power distribution had to be

> changed and updated. Station operating personnel were subjected to working conditions long previously recognized as undesirable in a modern society. Passenger conveniences and safety were sorely needed. More efficient means for station cleaning were necessary to cope with the elevating economy. A need to modernize the system that is part of the changing face of the community is mandated by the society it serves. (9)

As of July 1977, the Southeastern Pennsylvania Transportation Authority (SEPTA), in an effort to correct these conditions, had modernized three stations, renovated six stations, and expanded two stations, all in the preceeding five years. SEPTA has plans to start construction on one station and has completed design work on 18 others.

Phase II of Boston's Station Modernization Program, a $14.3 million program scheduled for completion by late 1978, calls for modernization of two stations per year at an average cost of about $2.5 million each (6).

In New York, problems exist in passenger flow, information display, physical condition, lighting, and long queues, as well as in many other areas. In 1977 the City of New York proposed a station modernization plan (10).

Urban transit system stations are not the only interface facilities in need of improvement. Many intercity bus terminals could also be considered for renovation.

REASONS FOR RENOVATION

Reasons for renovation projects vary, but most can be defined by the following set of objectives:

- minimize walking distances, crowding, queues and movement conflicts,
- improve passenger orientation, safety and security,
- provide a barrier-free environment for the elderly and the handicapped,
- improve the station environment,
- improve user services/conveniences,
- decrease maintenance and operating costs,
- increase revenue.

It is from these objectives that priorities in renovation are established. It is important to note that many transit systems have limited funds for station improvement and must often rely on outside sources for funding. Often this funding is granted only when its use meets the objectives of the outside source. Thus, priorities are determined at times by this factor.

GROUPS INVOLVED IN TRANSIT STATION RENOVATION

Various groups and organizations are involved with or affected by a renovation project. Generally, these can be listed as:

- transit users,
- special users,
- transit operators,
- project designers and planners,
- non-users.

The primary function of any transit system is to serve its users. Although not always vocal, current and potential users are usually affected greatly by the renovation project. The ways and the extent to which the users are affected should be considered and evaluated carefully by the renovation authority.

Special users are those who have ambulatory, vision, hearing, reading, or other disabilities that need special attention and/or facilities in order for them to fully utilize the transit system. Turnstiles, level changes, doorways, and information systems are a few of the critical elements that need to be considered for the special users.

Transit system operators are primary interested in the smooth operation of the renovation project both during and after its construction. They seek to reduce costs, accidents, disruptions and breakdowns.

Designers and planners are interested in developing affordable alternatives which meet the desired objectives as well as possible.

Non-users include nearby residents, business people and commuters. They are generally concerned with the renovation project's possible long-term effects, such as increase or decrease in local traffic, general aesthetics, land values, economic and environmental impact and use of local taxes. Short-term effects such as traffic delays and disruptions, noise, air pollution, and their impact on this group during renovation should also be considered.

The interests, or formally stated objectives, and their relative priorities for each group should be carefully determined. Through compromises and tradeoffs, the renovation project should be designed to best meet all these mutually interactive objectives.

DESIGN AND PLANNING METHODS

Most renovation design and planning methods fall into one or more of the following categories:

1. Segmented ("piecemeal" approach)

2. Design Manual ("cookbook" approach)

3. Problem Analysis ("bottleneck" approach)

4. Holistic Analysis ("systems" approach)

In the past, most stations have been designed using the first three methods with "rule of thumb" techniques and special studies of individual problem areas (1,3).

The Segmented Method

The task of planning and design is approached as if the station were a series of segments that can be handled as separate entities. This segmentation is performed in order to simplify the planning problem and facilitate analysis. This process can become risky when there are interactions between the defined segments. For example, if user security were considered a separate entity, many schemes for maximizing security could be devised, such as a single entry or exit, security detectors, constant patrols, armed attendants, audio-visual surveillance and user identification cards. These strategies could, however, hamper passenger processing, invade privacy or cause safety hazards (e.g., locked gates during a rush hour fire). This segmented method therefore tends to be too narrow and assumes that a station is only the sum of its parts. It solves specific localized problems quite well but often creates new problems elsewhere in the total station system.

The Design Manual Method

This method is based on a set of guidelines that has evolved through experience, largely by trial and error. A guideline can be defined as a suggested method for achieving set standards or specific objectives. Because following the guideline to the letter can lead an inexperienced designer into awkward situations, variance from the guideline is often required. This situation occurs more frequently in renovation planning than in planning new stations. Guidebooks can be of help when used judiciously in planning specific aspects of a larger design.

Problem Analysis

In designing renovations it seems logical to first determine the most difficult problem, solve it first, then proceed to the second most difficult problem for solution, and so forth. In the daily operation of a station, this method is likely to be used in solving problems as they occur. It usually works well when renovation consists of correcting only one or two main problems. However, like the segmented approach, there is a danger of creating additional problems or transferring old ones to new locations, thereby effecting little overall improvement.

Holistic Analysis

It is probably impossible to fully comprehend or evaluate as a single entity a system as complex as a transit station; therefore, it is required that the system be divided into segments that can be more fully comprehended. However, in order to avoid the drawbacks of the segmented approach, it is necessary to evaluate the overall performance of the station in view of the interactions between the defined segments. This type of systems approach is termed holistic analysis because it treats the entire system as an entity that is more than just the sum of its components. Holistic analysis incorporates, where appropriate, segmentation, guidelines, and problem analysis in its effort to include all relevant components and significant interactions. Conducted in a systematic manner, this approach insures that the station system is evaluated and planned in accordance with broad societal values.

GENERAL METHODOLOGY

Researchers at the University of Virginia have proposed the use of a "system approach" methodology for improving the transit interface facility planning and design process. This comprehensive General Methodology (2, 3, 4) was designed to be a flexible, systematic method for evaluating, planning and designing both new stations and renovations. The General Methodology incorporates an iterative process to generate alternatives and an evaluation framework based on cost-effectiveness modeling. The General Methodology is presented in flow chart form in Figure 2.1. The renovation problem is slightly different, and its corresponding flow chart is presented in Figure 2.2.

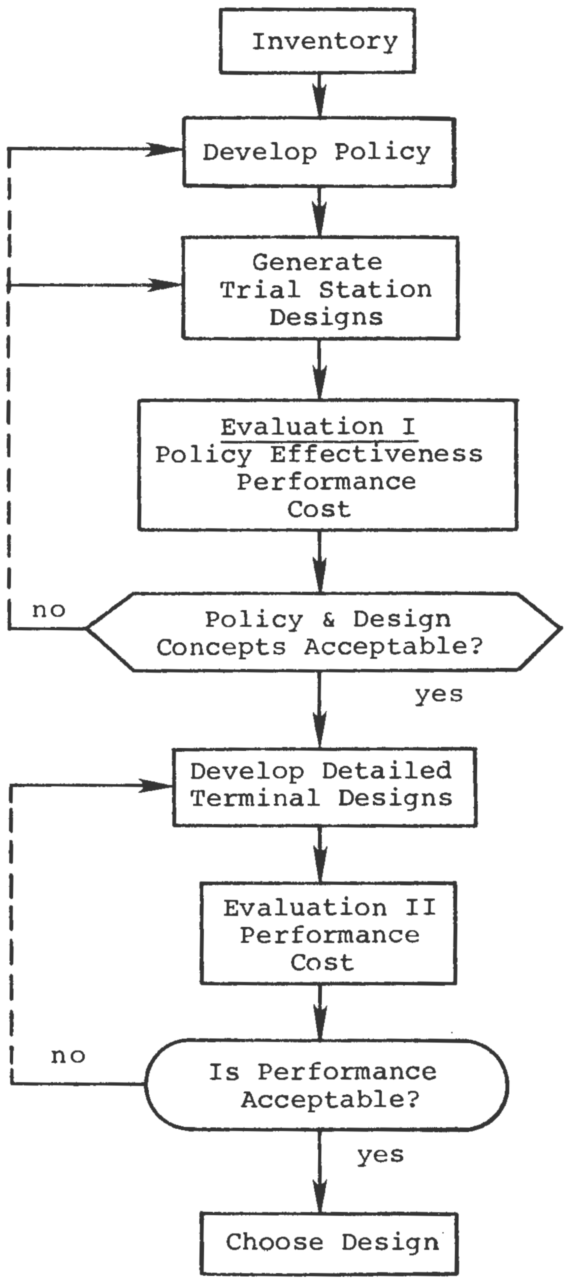


Figure 2.1. Stages in Transit Station Design Methodology

Source: Demetsky, M. J., L. A. Hoel, and M. R. Virkler, Methodology for the Design of Transit Stations and Terminals, U.S. Dept. of Transportation, Report No. DOT-TST-77-53, July 1977.

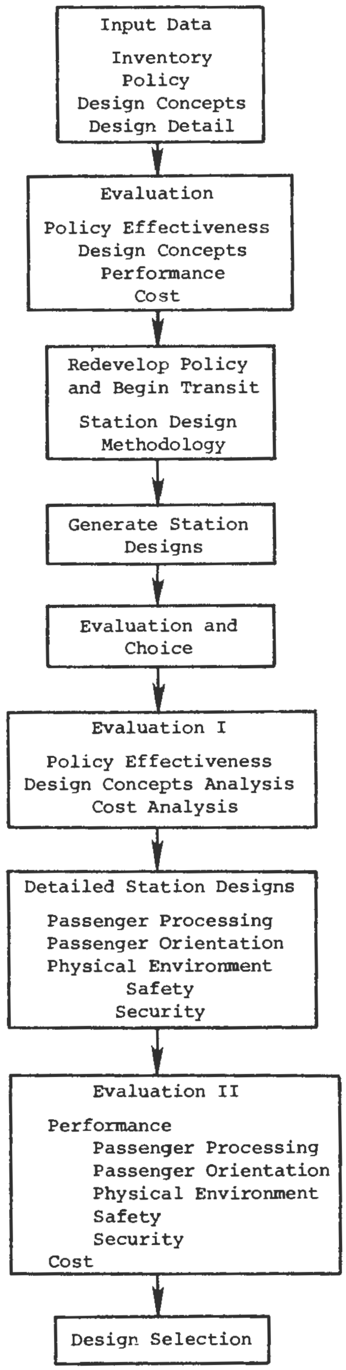


Figure 2.2. Preliminary Tasks for Transit Station Renovation

Source: Demetsky, M. J., L. A. Hoel, and M. R. Virkler, Methodology for the Design of Urban Transportation Interface Facilities, U.S. Dept. of Transportation, Report No. DOT-TST-77-53, July 1977.

CHAPTER 3

TRANSIT STATION SELECTION AND CHARACTERISTICS

STATION SELECTION

The 69th Street Terminal just outside of Philadelphia, Pennsylvania was selected to demonstrate the planning procedure of the General Methodology for transit station renovation. This selection was based primarily on that station's need for renovation, variety of system elements, and availability of information.

Need for Renovation

The following is a general description of the physical condition of the 69th Street Terminal. Areas that need attention in the renovation process are also identified.

The terminal appears to be in good structural condition with the exception of a few concrete arches with exposed reinforcing rods. Peeling paint and extensive graffiti are evident on both walls and signs (see Figures 3.1, 3.2 and 3.3). Information signs, where available, are generally not uniform. There is apparently no public address system.

The terminal has fairly good access provisions for all modes, except for perhaps kiss-n-ride. One major problem with the terminal's circulation system is the excessive walking distances required through the station, in some cases over 200 yards. There are also objects in corridors that impede passenger flow.

Lighting is generally adequate, though rather dim on the subway-elevated platforms. Aesthetically, the terminal is not at all pleasing, due mostly to age and the fact that it is made up of three separate buildings and lacks continuous architectural theme. Although passengers are not always under complete cover, adequate weather protection is provided.

The terminal's restrooms are in poor condition, and there are no lounges or benches for resting purposes. First aid facilities are not evident. There are an adequate number of public telephones, a wide range of concessions and several large stores. Visible security measures are limited to ticket agents and shopkeepers.

The terminal was not designed to serve the elderly or handicapped, and accommodations are lacking for these special users.

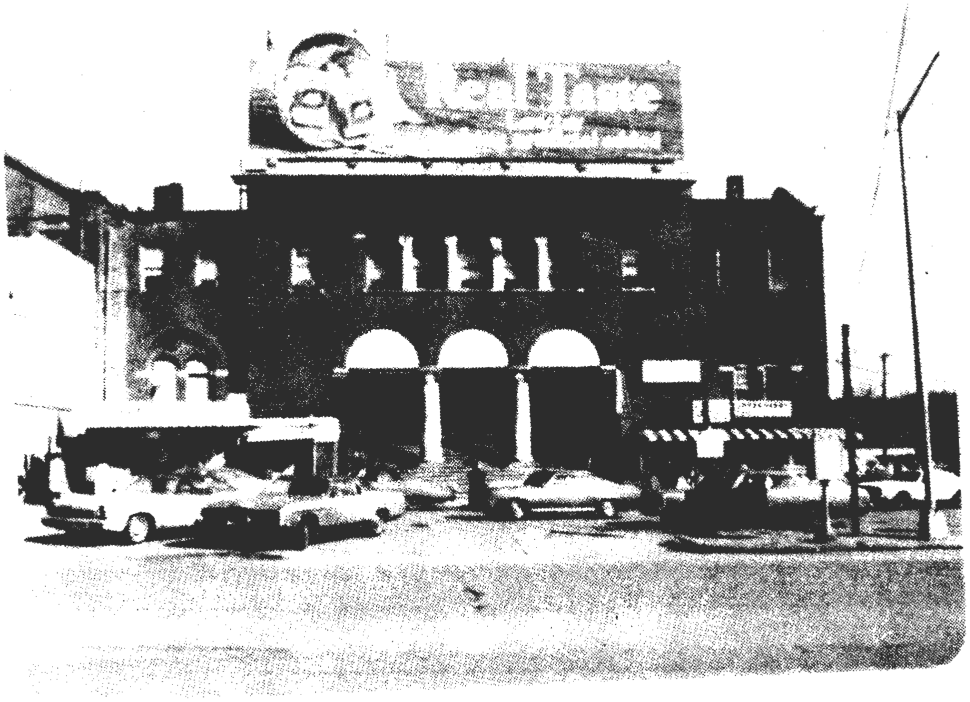


Figure 3.1. Front View of the 69th Street Terminal

Figure 3.2. Peeling Paint

Figure 3.3. Graffiti on Sign

Variety of System Elements

In selecting a suitable station for this study, it was considered important to find a station with a wide range of elements. The following elements, all identified to be significant ones, are found at the 69th Street Terminal:

- large traffic volumes,
- a variety of access modes,
- varied land use in the surrounding area,
- related station elements such as parking, concessions, advertising and provision for the handicapped.

Availability of Information and Cooperation

It is advantageous to select a station on which a great deal of information already exists. In the case of the 69th Street Terminal, planning and volume data were available. Although the original building plans were unavailable, SEPTA has been cooperative in granting permission to gather undocumented data.

STATION CHARACTERISTICS

Regional Setting

The 69th Street Terminal is located just north of West Chester Pike at its intersection with 69th Street, west of the city limits of Philadelphia in the Township of Upper Darby in Delaware County. It is the western terminus of the Market Street-Frankford subway-elevated line and the eastern terminus of a high-speed light rail line from Norristown. It also serves two trolley lines and many bus lines that operate within a well established retail-commercial district in Philadelphia's western suburbs (see Figure 3.4).

Area Travel Patterns

Approximately 50,000 persons per day pass through the terminal. A 1971 study (14) indicated that over 80 percent of the users, about 4,800 persons, arrive at the terminal via public transportation. Of the daily 1,200 users who drive there, about 70 percent approach from either the West Chester Pike or Garrett Road. The morning and evening peak hours each account for about 30 percent of all daily users, totalling 60 percent of the daily traffic.

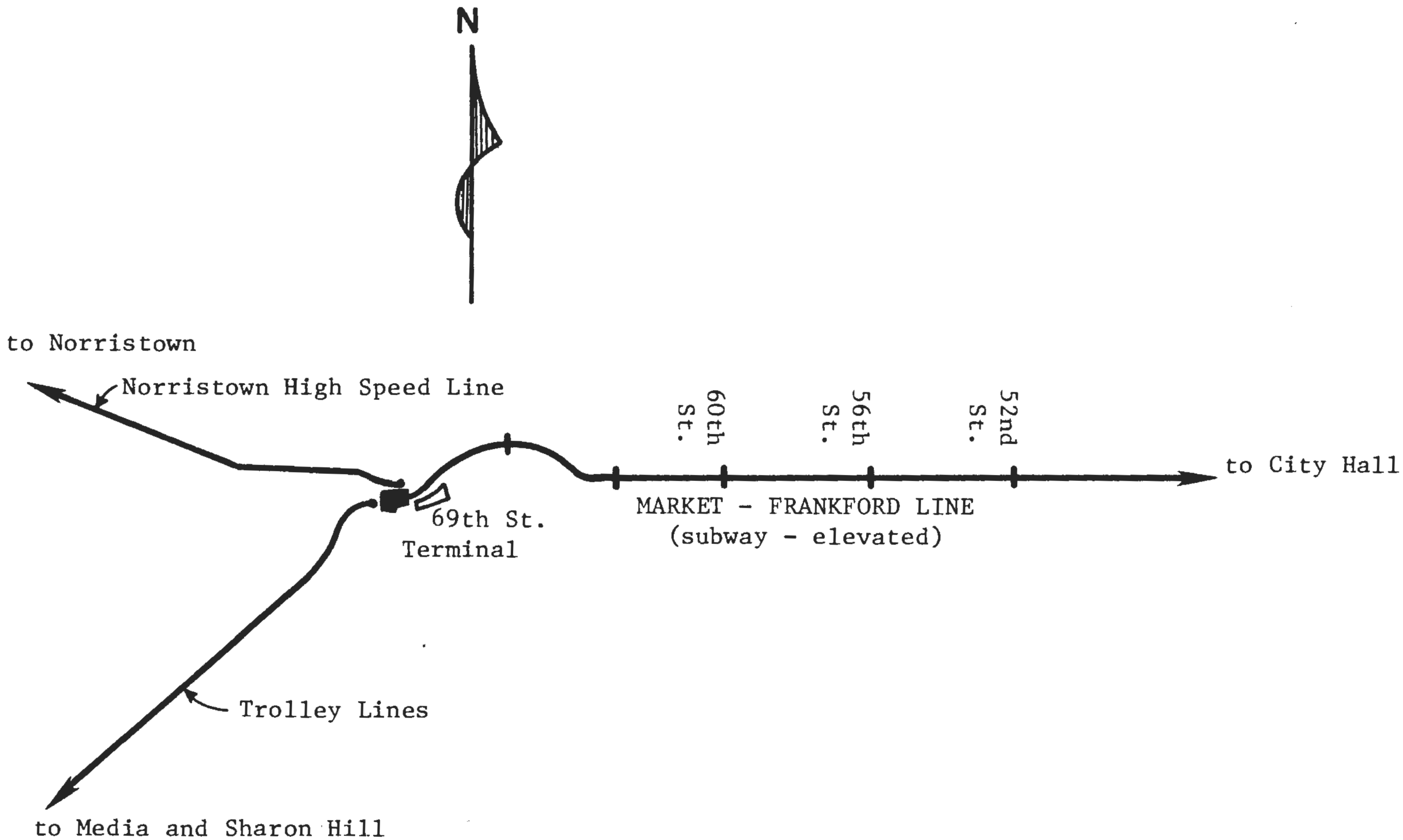


Figure 3.4. Terminal Location

The arterial West Chester Pike, passing in front of the terminal, is a major commuter route into Philadelphia's central business district. It has a typical weekday volume of 25,000 vehicles and a peak hour volume of 1,100 vehicles in peak direction.

Terminal Structures Configuration

The terminal and its associated maintenance shop lie on a site of nearly 35 acres, entirely owned by SEPTA. This terminal is actually three stations, serving three separate transit lines lying adjacent to one another (see Figures 3.4 and 3.5). It consists of three interconnected structures: (1) the old Philadelphia Transportation Corporation (PTC) Building; (2) the Red Arrow Suburban Bus and Tram Line Building; and (3) the Norristown High Speed Trolley Line addition.

The PTC Building (built in 1907) is the oldest structure and provides direct access from the West Chester Pike entrance to the high level subway-elevated platforms situated below and behind its lobby.

The Red Arrow Suburban Bus and Trolley Building is of later construction (1930s) than the PTC building and is located adjacent and west of it. Four platform areas connected to this structure serve the loading and unloading of both buses and the trolley lines.

The Norristown High Speed Trolley Line platforms are located in a structure which was completed in 1963, replacing a 55-year-old "temporary" facility. This structure was an addition to the rear of the PTC building. The structure contains a stub-end, three-track, four-platform layout with roofs over platforms only, and an enclosed waiting room at the east end of the platforms. Access to the waiting room is provided from the lobby level of the PTC building and via stairs ascending from the subway-elevated unloading platform.

Surrounding Land Use

The portion of Upper Darby Township surrounding the terminal is urban in character. Lower to middle income homes dominate the area behind the retail outlets that line both sides of West Chester Pike and 69th Street. There are isolated commercial concentrations and some industrial development. The closest public land is Cobbs Creek Park to the north.

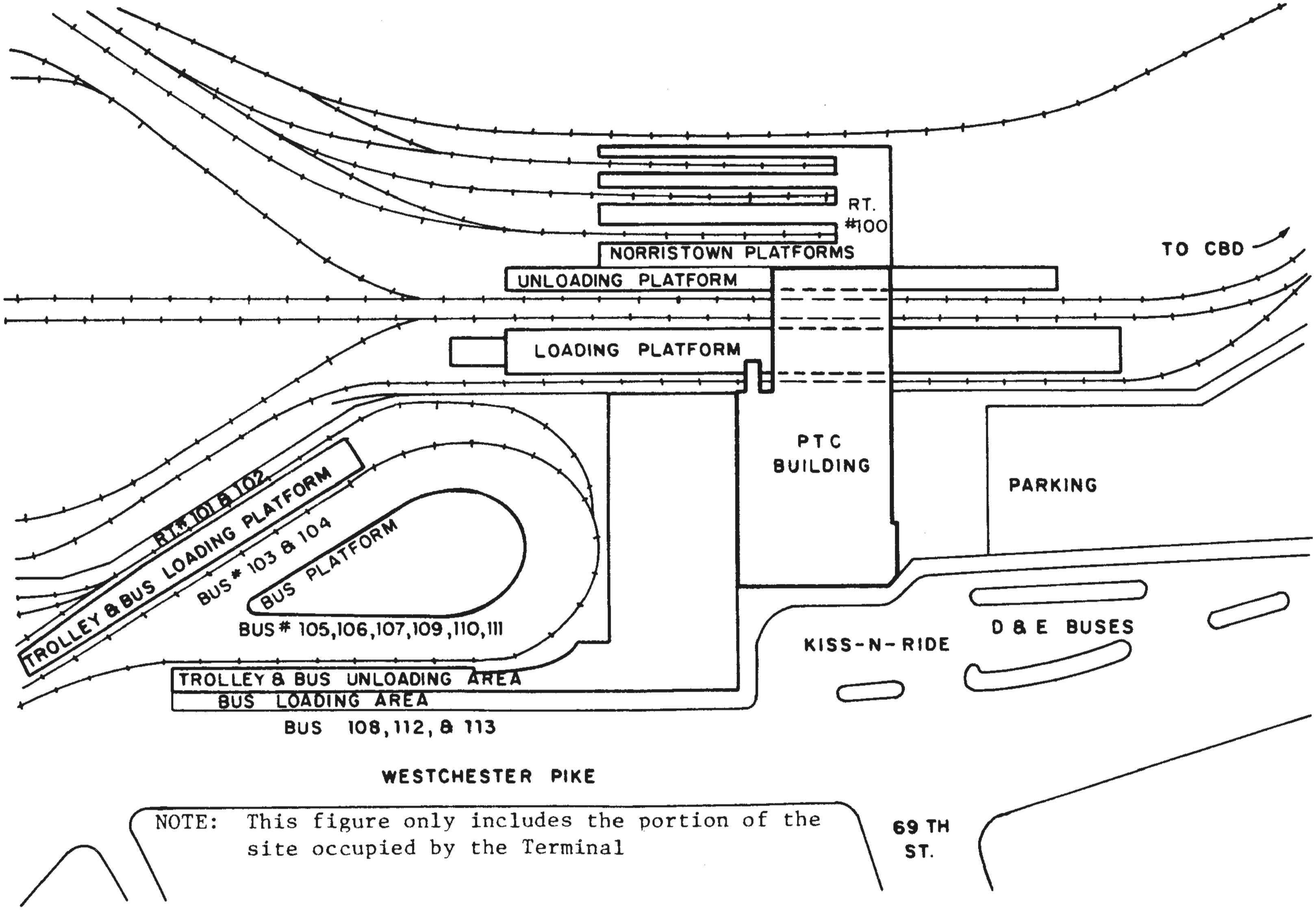


Figure 3.5. Present Terminal

Passenger Demand

The subway-elevated operates 24 hours a day carrying users to the CBD, a 15-minute ride away. Approximately 18,000 subway passengers use the system each day (14). Access modal split for these arrivals in 1970 is shown in Table 3.1. In the May 13, 1971 survey (15), all arrivals during the morning peak (6:30 - 9:30 a.m.) and the evening peak (4:30 - 6:30 p.m.) were recorded (see Figures 3.6 and 3.7).

Transit Vehicles

The Market Street-Frankford subway-elevated is the line-haul mode serving the CBD. This line operates trains of up to eight cars, with headways ranging from three to 30 minutes.

The Norristown High Speed Line operates trolley-like cars which also require high-level platforms. Brill 60-series cars and Brill "bullets" operate as single or tandem cars between the terminal and Norristown. Two four-section articulated "Electroliners" also operate on this line during rush hours. There are 14 arrivals during the peak hour.

The Sharon Hill and Media Trolley lines operate single low-level platform cars. Cars operating on this line include: Brill 80-series, "Brilliners" and PCC-type cars. There are 22 arrivals during the peak hours.

Although the above three lines all run on rails, none of them are interchangeable or compatible with one another.

The buses which serve the terminal are mostly GM standard size coaches. There are 62 arrivals during the peak hour.

TABLE 3.1

ACCESS MODAL SPLIT

Mode of Arrival	Philadelphia Bound Passengers: Peak 15 Minutes[1]	Peak Hour[2]	Daily	% of Daily Total[3]
Auto Driver	145	360	1,200	6.7
Auto Passenger[4]	105	265	880	4.9
Taxi	10	25	70	0.4
Walk	200	510	2,700	15.0
Bus	840	2,100	6,900	38.3
Tram	760	1,900	6,250	34.7
	2,060	5,160	18,000	100.0

[1]Assumes 40% of peak hour traffic arrives in peak 15-minute period.

[2]Peak hour between 5:00 an 6:00 p.m.

[3]DVRPC 1960 Pennsylvania-New Jersey Transportation Survey modal split assumed to be valid for 1970 passenger volume.

[4]Includes 70 car pool and 195 kiss-n-ride arrivals.

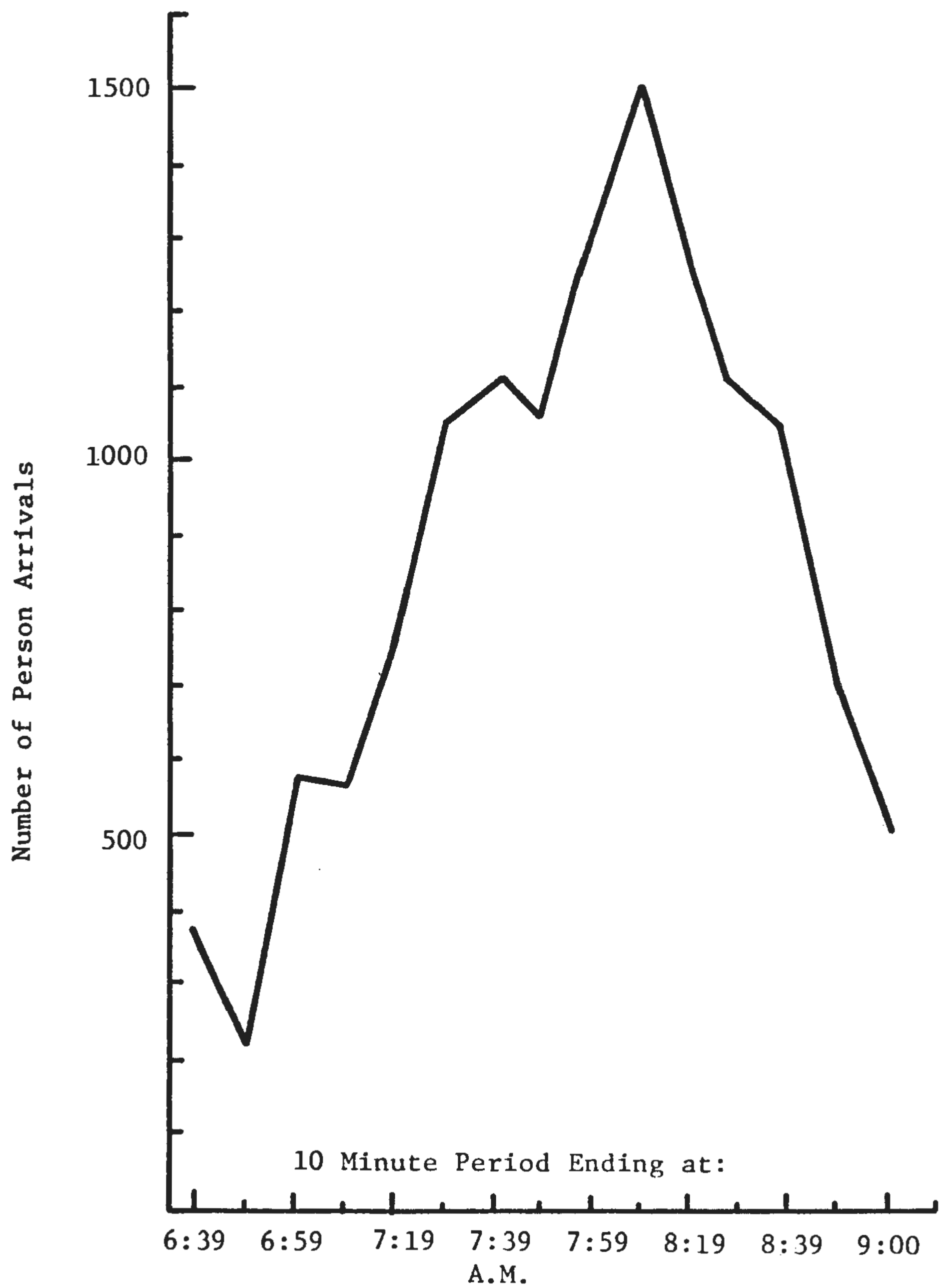


Figure 3.6. Morning Peak Period Arrivals - All persons entering 69th St. Terminal on May 13, 1971

Source: "69th Street Terminal Study Memos No. 1 through No. 9," from Randy Brubacker to Ira Pierce, Delaware Valley Regional Planning Commission, 1971.

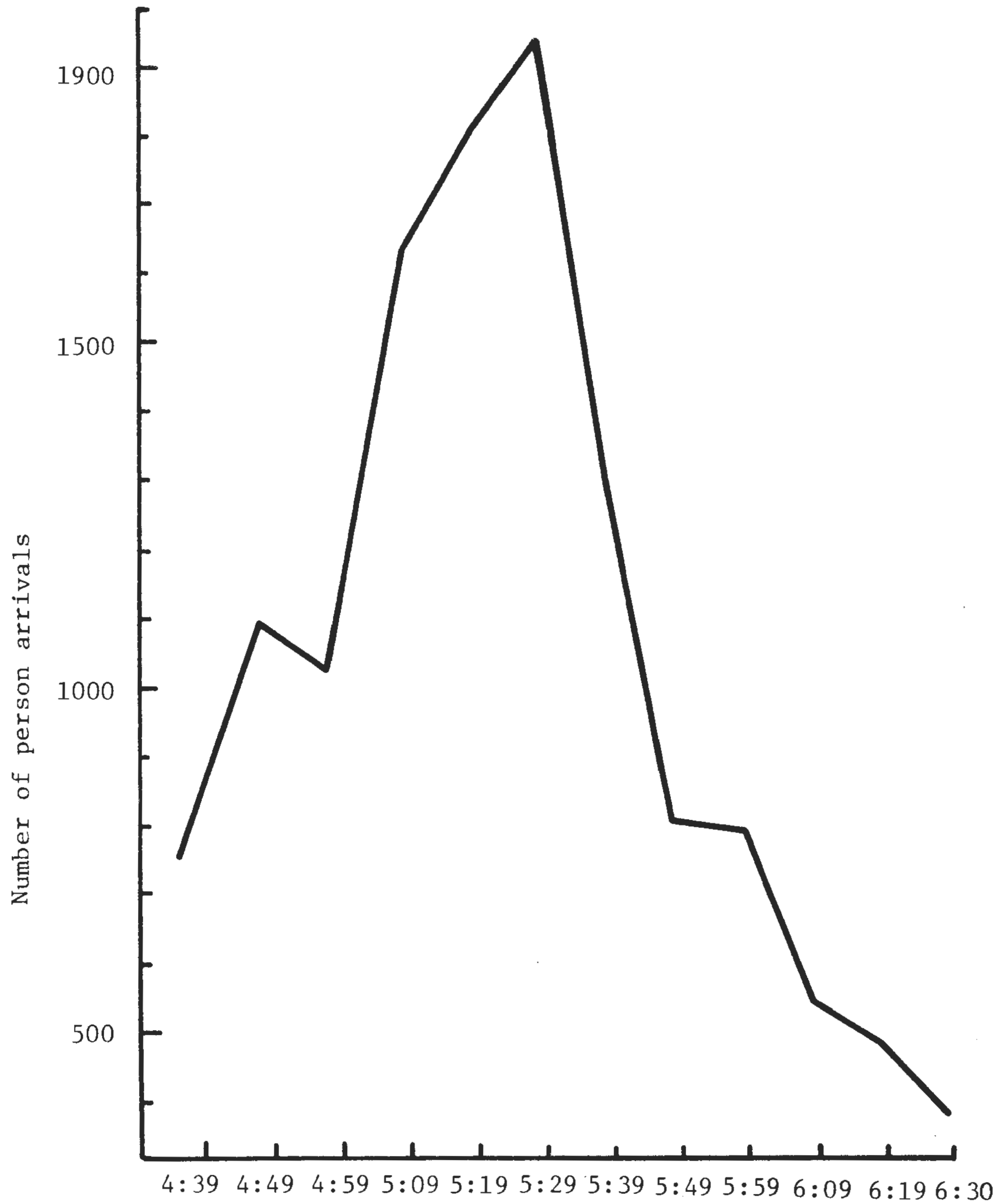


Figure 3.7. Afternoon Peak Period Arrivals - All persons entering 69th St. Terminal on May 13, 1971

Source: "69th Street Terminal Study Memos No. 1 through No. 9," from Randy Brubacker to Ira Pierce, Delaware Valley Regional Planning Commission, 1971.

Chapter 4

PERFORMANCE AND POLICY EVALUATION OF THE PRESENT STATION

EVALUATION STRUCTURE

Goals Definition

The first step in the planning process is the definition of goals. Generally, the goals of a transit station renovation project are defined by the transit authority consistent with society's values. The "Basic Goals" (20) developed by SEPTA are summarized below and adopted as the goals of this renovation study.

Architectural Goals

A-1 to provide information about the service and the facility

A-2 to provide safety

A-3 to remove barriers to the elderly and the handicapped

Interchange Function Goals

I-1 to provide convenient, safe and comfortable transfers

I-2 to integrate intersecting transit lines into a complete and coordinated package

Community Goals

C-1 to reflect the community's characteristics and promote economic development and stabilization of the community

C-2 to promote mixed station use that interfaces but is not congruent with (and therefore hampers) SEPTA operation

Transit Authority Goals

T-1 to provide the best possible service while minimizing costs

Objectives

A comprehensive list of objectives that applies to transit station design is developed by the General Methodology (2). Those objectives appropriate to the above goals are selected and grouped as follows:

1. Passenger processing objectives

2. Environmental objectives

3. Fiscal objectives

4. Design flexibility objectives

5. Community objectives

How these objectives relate to each goal is best described by an interaction matrix (see Figure 4.1).

Each objective has different impacts on different groups. These groups, as identified in Chapter 2, are: users, special users, transit operators, designers and planners, and non-users. The designers and planners, who essentially translate these objectives into reality, are not actually affected once the renovation project is completed and are therefore not considered in the Impact-Interest Matrix (Table 4.1). The Impact-Interest Matrix delineates the group(s) affected by each objective.

Criteria

Criteria and performance measures that can be used to evaluate each objective are presented in Table 4.2. A number of these criteria have been drawn from the General Methodology. Some of these are not applicable at this time, either because the information is unavailable or the procedure for their measurement is not yet sufficiently refined. In this case, another, less refined indicator is given. Since these criteria were developed without the review of the policy makers who had set the basic goals, they should not be considered totally refined but rather an example.

EVALUATION PROCESS

To evaluate the present conditions at the 69th Street Terminal against the objectives outlined, the performance measures for each criterion are either quantitatively calculated or qualitatively described. For example, to see how the station rates in terms of Objective 5: Maximize Safety, GOALS

- A-1 Provide information
- A-2 Provide safety
- A-3 Remove barriers
- I-1 Provide convenient transfers
- I-2 Integrate intersecting lines
- C-1 Reflect community character
- C-2 Promote mixed station use
- T-1 Best service at least costs

Objectives	A-1	A-2	A-3	I-1	I-2	C-1	C-2	T-1
PASSENGER PROCESSING OBJECTIVES								
1. Minimize crowding			X	X				
2. Minimize travel impedances			X	X	X			
3. Minimize conflicts			X	X				
4. Minimize disorientation	X		X	X				
5. Maximize safety		X		X				
6. Maximize reliability				X				
7. Provide for efficient fare collection and entry control				X	X			
8. Minimize level changes			X	X				
9. Minimize physical barriers			X	X				
10. Provide for emergencies		X		X				
ENVIRONMENTAL OBJECTIVES								
11. Provide comfortable ambient environment				X				
12. Provide adequate lighting	X	X		X				
13. Provide for personal comfort				X				
14. Provide aesthetic quality		X						
15. Provide supplementary services				X			X	
16. Provide protection from weather		X		X	X			
17. Provide adequate security				X		X		
FISCAL OBJECTIVES								
18. Minimize costs								X
19. Maximize net income							X	X
20. Utilize energy efficiently								X
DESIGN FLEXIBILITY OBJECTIVE								
21. Provide design flexibility					X		X	
COMMUNITY OBJECTIVES								
22. Minimize impacts on local traffic						X		
23. Promote desired growth						X	X	
24. Minimize Local disruption						X		

Figure 4.1. Goals-Objectives Matrix

TABLE 4.1

IMPACT-INTEREST MATRIX

Impact	User	Special User	Operator	Non-User
Passenger Processing				
1. Crowding	x	x		
2. Travel impedances	x	x		
3. Conflicts	x	x		
4. Disorientation	x	x		
5. Safety	x	x		
6. Reliability	x	x		
7. Fare collection and entry	x	x	x	
8. Level changes	x	x		
9. Physical barriers		x		
10. Emergencies	x	x	x	
Environmental				
11. Ambient environment	x	x		
12. Lighting	x	x		
13. Personal comfort	x	x		
14. Aesthetic quality	x	x		x
15. Services	x	x		
16. Weather protection	x	x		
17. Security	x	x	x	
Economic				
18. Costs			x	
19. Income			x	
20. Energy			x	
Design Flexibility				
21. Design flexibility			x	
Community				
22. Local traffic				x
23. Desired growth				x
24. Local disruption				x

TABLE 4.2

OBJECTIVE-CRITERIA-MEASURES CHART

Objective	Criteria	Performance Measure
Passenger Processing Objectives		
1. Minimize crowding	-Fruin Level of Service	-% C or better
2. Minimize travel impedances	-Path walk times -Path wait times -Aggregate walk time -Aggregate wait time -Aggregate transfer time -Average transfer time	-minutes/path -minutes/path -person-minutes -person-minutes -person-minutes -minutes
3. Minimize conflicts	-Fruin probability of conflict	-number of severe conflict areas
4. Minimize disorientation	-Decision complexity -Availability of directional information	-number of decisions -descriptive
5. Maximize safety	-Accident rate (by type) -Safety features and hazards	-accidents/user* -descriptive
6. Maximize reliability	-Equipment down time -Presence of back up facilities	-ratio of down time to operating time* -descriptive
7. Provide for efficient fare collection and entry	-Crime rate (by type) -Crime potential of technology used	-crimes/user* -descriptive

(Cont'd)

Table 4.2 - OBJECTIVE-CRITERIA-MEASURES CHART (Cont'd)

Objective	Criteria	Performance Measure
8. Minimize level changes	-Changes/path -Aids present	-number and type -descriptive
9. Minimize physical barriers	-Movement ease	-descriptive
10. Provide for emergencies	-Evacuation time -Fruin Level of Service resulting from service interruption	-minutes -minutes to reach Level of Service F
Environmental Objectives		
11. Provide comfortable ambient environment	-Thermal conditions -Noise levels	-temperature and humidity* -dbA
12. Provide adequate lighting	-Illumination levels -Glare	-foot-candles* -brightness and brightness differences*
13. Provide for personal comfort	-Provisions for rest areas	-descriptive
14. Provide aesthetic quality	-Cleanliness -Visual theme and graphics -Landscaping	-descriptive -descriptive -descriptive
15. Provide supplementary services	-Advertising -Concessions -Parking -Others	-descriptive -descriptive -descriptive -descriptive

(Cont'd)

Table 4.2 - OBJECTIVE-CRITERIA-MEASURES CHART (Cont'd)

Objective	Criteria	Performance Measure
16. Provide protection from weather	-Provision of enclosure	-% area fully enclosed, partly enclosed, and open
17. Provide adequate security	-Crime rate (by type)	-crimes/user*
	-Separate spaces	-number in view of attendants/total number
	-Surveillance	-descriptive
	-Avenues of escape	-descriptive
	-Alarm provisions	-descriptive
Fiscal Objectives		
18. Minimize costs	-Capital costs	-$
	-Operating costs	-$/year
	-Maintenance costs	-$/year
	-User costs	-$*
	-Finance costs	-$*
	-Scheduling costs	-$*
19. Maximize net income	-Annual income by type (joint development, advertising, rentals, etc.)	-$/year
20. Utilize energy efficiently	-Total and incremental requirements	-kilowatt hours/year and source*

(Cont'd)

Table 4.2 - OBJECTIVE-CRITERIA-MEASURES CHART (Cont'd)

Objective	Criteria	Performance Measure
Design Flexibility Objectives		
21. Provide design flexibility	-Expansion and reduction potential	-descriptive
	-Joint development potential	-descriptive
	-Service improvement potential	-descriptive
Community Objectives		
22. Minimize impacts on local traffic	-Additional delays	-person-minutes*
	-Additional accidents	-increase in accident rates*
23. Promote desired growth	-Expected development	-descriptive*
24. Minimize local disruption	-Construction caused hazards and delays	-descriptive*

NOTE: *Information was either not available or collected to calculate these measures; or the measure is not applicable in all three evaluations.

the number of accidents per user (performance measure) is calculated for accident rate (criterion), and a description (performance measure) is given on the safety features and hazards (criterion). The steps taken to obtain some of these performance measures, which are very lengthy, complicated and dependent upon many assumptions, are detailed in Appendix A. Following are descriptions of how performance measures are determined for the present terminal for the criteria under each objective.

Passenger Processing Objectives

Objective 1: Minimize Crowding

Objective 2: Minimize Travel Impedances

The performance measures for crowding and travel impedance can be determined only after the terminal's passenger processing system is adequately represented graphically and mathematically. To do so, the Manual Method, presented in the General Methodology and outlined below, is used for this study.

Steps in the Manual Method for passenger processing evaluation include:

1. Define the system as a Link-Node Network
2. Determine pedestrian volumes for each path
3. Determine path choice
4. Load inbound passengers onto the network
5. Load outbound passengers onto the network
6. Determine walk times and crowding on links
7. Determine queuing times and crowding at nodes
8. Determine wait times for transit vehicles
9. Summarize performance measures for criteria

How each step is carried out is explained in detail in Appendix A.1. Essentially, the terminal is reduced to a Link-Node Network (see Figure 4.2). Present passenger volumes, drawn from a 1971 count (15) as well as the 1985 forecast passenger volumes, based on a study completed in 1971 (14), are apportioned, in two separate trials, to each link of the network. The relevant performance measures for crowding and travel impedance can then be calculated and compared for 1971 and 1985.

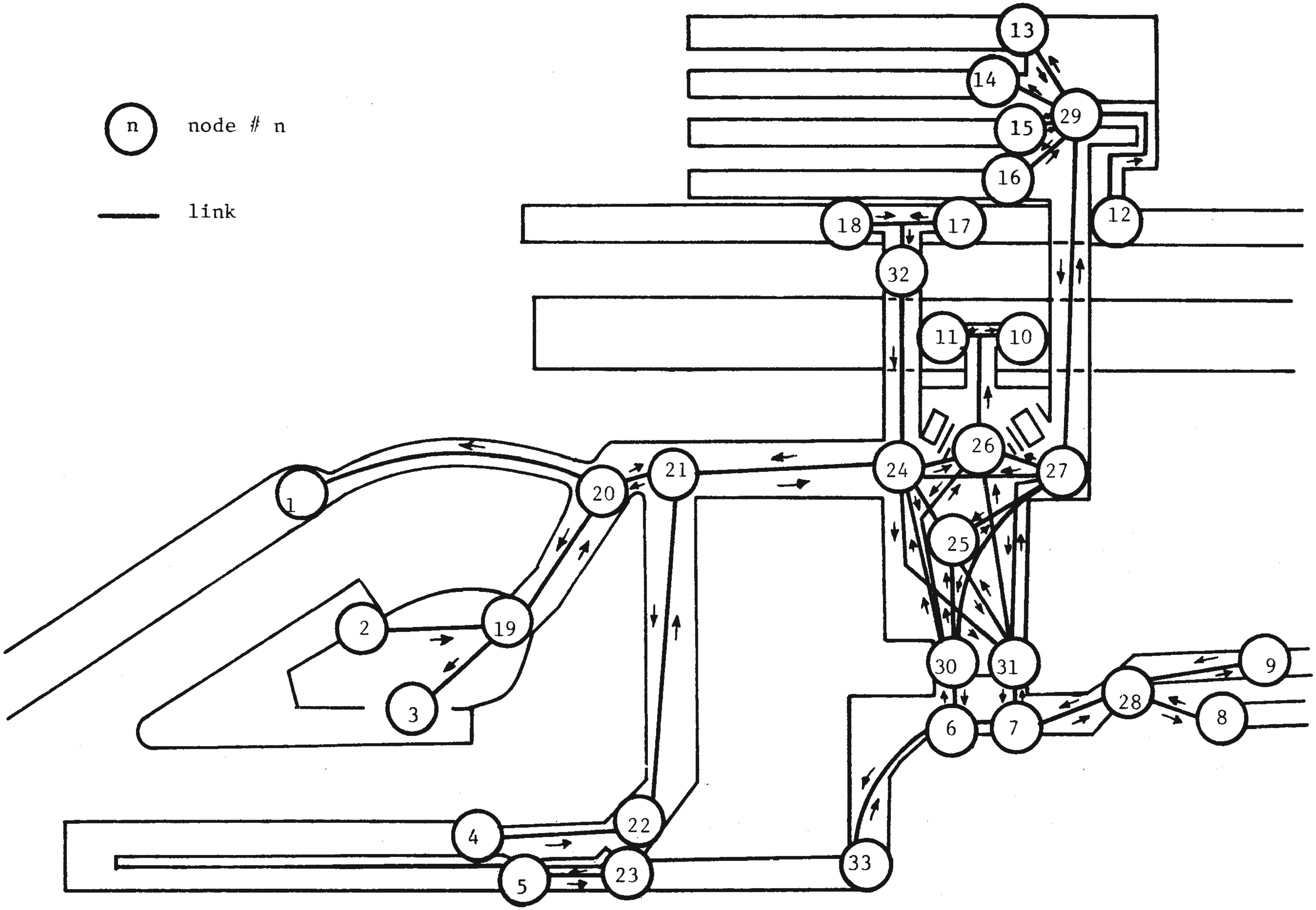


Figure 4.2. Link-Node Network for 69th Street Terminal

It was found that terminal passenger processing was good in 1971. In 1985 three non-bulk arrival links have been projected to have a less than accepted level (Level C) of service. The average morning peak walk time was 1.5 minutes, which is expected to increase 20 percent by 1985. Average afternoon walk times for both 1971 and 1985 were 1.8 minutes. Average morning queuing delays for both 1971 and 1985 were 0.08 minutes. Average afternoon delays were 0.75 minutes for 1971 and 0.94 minutes for 1985. Total average transfer times from platform/entry/exit to platform/-entry/exit were 1.5 and 2.6 minutes for morning and afternoon respectively for 1971 and 1.8 and 2.7 minutes for morning and afternoon respectively for 1985.

Objective 3: Minimize Conflicts

Observation at the terminal indicated that there exists only one severe conflict of two major flows, that at the junction of paths leading from the bus/trolley platform and that leading from the sub-el platform (Node 24) during the afternoon peak. It is calculated (detailed in Appendix A.2) that the probabilities of conflict for the two flows are 57 percent and 80 percent for 1971 and 65 percent and 80 percent for 1985. Probabilities up to about 65 percent are average values for Level of Service C and therefore acceptable, although not desirable, for transit station design.

Objective 4: Minimize Disorientation

The major causes of disorientation are often decision complexity and inadequate informational signing. An indicator of decision complexity is the number of decisions that have to be made, which can be defined as:

$$D_{ij} = \sum^{n} C_n - 1$$

where D_{ij} = the number of separate decisions on the path from Node i to Node j

C_n = the number of choices at decision point n

n = the number of decision points along path ij

On the five most heavily traveled paths during morning and afternoon peaks, D_{ij} ranges from 1 to 5, while the maximum number of separate decisions for any path is 7.

Inadequate informational signing can result when there is too little signing, too much signing, vandalized signs, distractions or non-standard signing. Within the terminal, signage is not standard and is lacking at a number of decision points (see Figure 4.4). Current orientation aids do not meet SEPTA policy standards.

Objective 5: Maximum Safety

The criteria to consider for safety are (1) accident rate and (2) safety features and hazards. Accident rates were not available for this terminal. As indicated in past studies (11), stairs are particularly important for safety considerations. Here handrails are provided on all stairs except for those at the front entrance, though non-slip stair treads are not present. No standard markings are provided at platform edges, and users are permitted to cross the trolley tracks and bus lanes in the bus circle. Although these and many standard SEPTA safety features are not present, safety had not been indicated as a problem by SEPTA.

Objective 6: Maximize Reliability

Statistics on equipment down time were unavailable. The only mechanical devices used by patrons are turnstiles and doors. A problem would arise only at locations where two doors exist and one happens to fail. No data was available on equipment for heating, plumbing or equipment not used directly by patrons.

Objective 7: Provide for Efficient Fare Collection and Entry

Anyone attempting to enter the paid area without paying could be seen by the turnstile operator or change booth attendant. In the event of a robbery, one of the two attendants would see the other being robbed. Statistics on crime rates in the terminal are maintained by the township of Upper Darby and were not available.

Objective 8: Minimize Level Changes

Three level changes are required for four of the five most commonly used paths in the morning. Two level changes are made on ramps. A similar number of level changes is required for three of the five most commonly used paths in the afternoon. Three level changes is the maximum on any of the 99 paths, as the terminal has only two main levels.

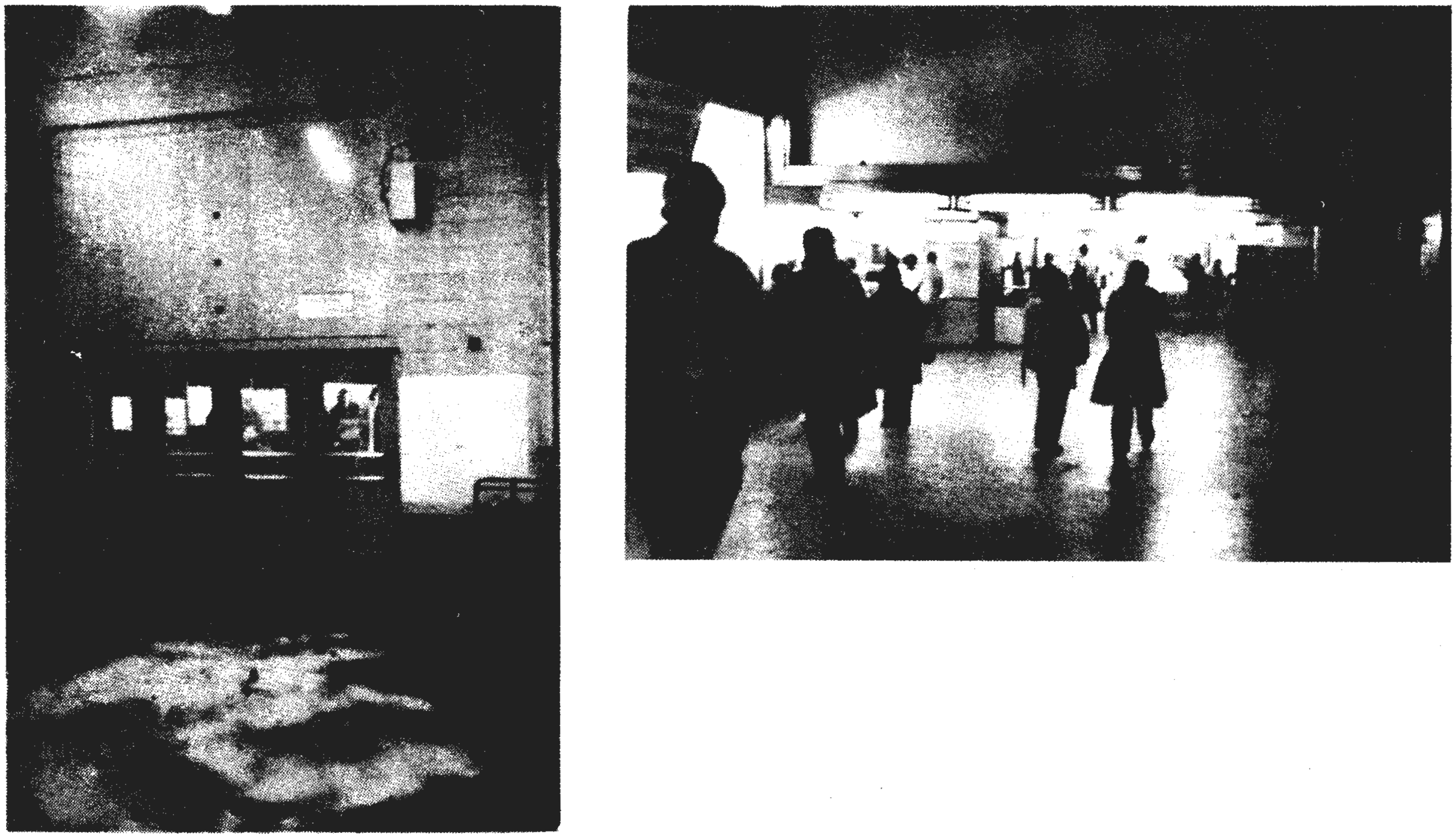


Figure 4.3. Examples of Poor and Inadequate Signing

Objective 9: Minimize Physical Barriers

This terminal, built without considerations for special users, has many physical barriers to this group. Stairs are barriers to all wheelchair users. The only mass transit vehicle--the subway-elevated--that can be used by those confined to wheelchairs is not provided with elevators to access the platforms. The turnstiles and most doors meet SEPTA standards. Semi-ambulatory users would have trouble with stairs and doors. No special provisions have been made for persons with hearing or visual impairments.

Objective 10: Provide for Emergencies

SEPTA standards require that, in case of emergency, such as a fire, the total capacity of a loaded train can exit the station in four minutes (20). The only mode likely to have difficulty meeting this standard is the subway-elevated. To calculate evacuation time, the times necessary to exit the train, walk along the platform, climb the stairs and wait for exit at the doors were added together. Doors were the controlling points with regard to capacity. A train of 500 persons would require 4.3 minutes for evacuation with two exits. With the main exit blocked, evacuation would take 9.0 minutes.

Service interruptions can cause crowding on platforms to the point of possible panic if the platforms are too small. Fruin queuing level of service F (21) provides for no movement and is dangerous, due to panic potential in large crowds. This level of service could be reached for the subway-elevated platform during the peak morning hour if service interruption lasted about 60 minutes in 1971 or about 48 minutes in 1985. All other loading platforms can remain above Level of Service F for longer periods of interruption.

Environmental Objectives

Objective 11: Provide Comfortable Ambient Environment

Air temperature, humidity, flow and pressure data were not available or collected. SEPTA heats the entire terminal, and the ambient conditions are perceived to be quite comfortable.

A sound study was conducted on October 21, 1977 between 4:00 and 6:00 p.m. Taken with a hand-held sound level meter, the maximum reading, the background reading, the duration, and the sound's source were recorded for each location (see Appendix A.3). All sound levels above 80 dbA were from vehicles. SEPTA recommends an upper limit of 80 dbA for trains entering or leaving station (18). Eleven locations exceeded this limit; however, their durations were under 30 seconds. In view of the standards given in the Occupational and Safety Health Act of 1970, the recorded levels are annoying but not harmful. SEPTA recommends the warning noise of entering trains be maintained above 45 dbA for safety reasons. In view of background sound levels ranging between 50 and 70 dbA, this standard should probably be raised, or background noise levels should be lowered.

Objective 12: Provide Adequate Lighting

SEPTA has established extensive recommendations on lighting (see Appendix D). Some of the lighting in the terminal is made of single incandescent light with downward aimed reflectors mounted overhead. This type of lighting is undesirable because it lights only people and floors and casts harsh shadows.

Objective 13: Provide for Personal Comfort

Restrooms are located on the right side of the lobby and are in poor condition. There are no benches in the terminal.

Objective 14: Provide Aesthetic Quality

The terminal is not especially clean on the inside and is neglected on the outside. There is no single architectural theme in the three-building terminal. No uniform guidelines exist for commercial or orientation graphics. No landscaping efforts appear to have been made.

Objective 15: Provide Supplementary Services

There is a profusion of advertising--from the full-size billboards outside to the "sale" signs inside. In many cases, advertising distracts users from directional signs (see Figure 4.4). There is a wide variety of concessions along the major corridors. There are numerous telephones and lockers in several locations.

Users of the terminal park about 1,200 vehicles per day near the terminal, some 950 of them in parking lots. The SEPTA owned and operated lot holds 340 cars. A parking fee of 35 cents per day is charged. Within a five-minute walking distance are 660 spaces in private lots, of which almost 550 are free to shoppers and are closed until 9:30 a.m. to prevent usage by commuters (14).

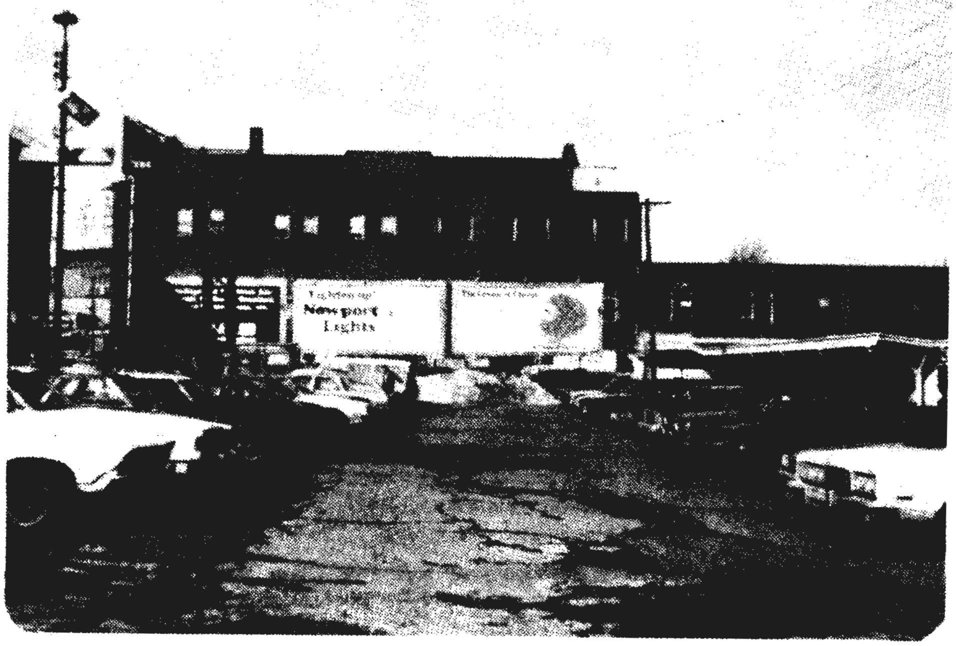


Figure 4.4. Examples of Distracting Advertising

Objective 16: Provide Protection from Weather

Of all pedestrian spaces (by floor area): 43 percent are totally enclosed and heated, 49 percent are partly enclosed, providing protection from rain and some wind, and 8 percent are totally exposed to the weather.

Objective 17: Provide Adequate Security

As stated before, crime rates were not available for this terminal. According to a SEPTA official, criminal acts occur infrequently and are not perceived to be a major problem. About 55 percent of the separate spaces at the terminal can be viewed by an attendant, employee or concessionaire. No security patrols were observed during rush or evening hours There are no video or audio surveillance provisions. Escape is possible on many modes, although there are only two exits to the street. No user operated alarms were observed at the terminal.

Fiscal Objectives

Objective 18: Minimize Costs

The labor operating cost is about $747 per day (see Appendix A.4 for breakdown). The maintenance costs are about $1,852 for labor and fringe and $160 per week for materials. Maintenance and operating costs total $378,000 annually. No user costs have been calculated due to the difficulties involved in establishing a reliable value for travel time during transfers in this specific location.

Objective 19: Maximize Net Income

Annual income from concessions and advertising amounts to about $300,000 (24). There is no other non-transit income.

Due to inflationary pressures, both terminal costs and revenues will be expected to rise in the future. If all these rise at the same rate, the level of objective attainment will remain constant. However, a simultaneous rise in the short run is unlikely, due to the various market forces. The labor cost figures have increased after the 1977 strike threat. Funds from governmental sources vary, due to the nature of the political process. However, SEPTA has better control over fares and non-transit income. Most concession agreements are renegotiated annually. Due to the factors involved and the erratic nature of past short-range trends, no forecasts were attempted.

Objective 20: Utilize Energy Efficiently

No energy consumption data were collected, although it is recognized that the use of such resources is becoming a much more important consideration in transit station operations.

Design Flexibility Objectives

Objective 21: Provide Design Flexibility

The limited flexibility of the terminal for expansion was illustrated in 1922 when it was necessary to relocate West Chester Pike 50 feet to the south to allow for expansion of the trolley building (16). Since travel forecasts indicate an increase in users, reduction potential is of limited importance. Service improvement potential is quite good, especially regarding passenger processing. Joint development potential in the absence of a renovation would be slight.

Community Objectives

Objective 22: Minimize Impacts on Local Traffic

Objective 23: Promote Desired Growth

Objective 24: Minimize Local Disruption

Of the above objectives, the only one applicable to the evaluation of the present station deals with local traffic conditions. The most relevant and readily available data on local traffic conditions were collected in a study completed in 1971 (14). Relevant portions of this study can be found in Appendix C.

EVALUATION SUMMARY

It is rather difficult to comprehend all of the data that have been presented, to achieve an overall understanding. Therefore, in order to summarize this information, it was reduced to graph form. This type of graphic representation is called a factor profile.

The use of factor profiles is part of a decision making process that has been proposed by Oglesby, Bishop and Willeke for evaluating freeway location alternatives (26). Their method was proposed as a means of including in the analysis all factors that cannot be stated in precise monetary terms, due to the lack of either suitable techniques or adequate data. They estimated the percentage of the maximum expected negative or positive effect of each factor.

The factor profiles used here have been modified somewhat in order to show the estimated degree of objective attainment rather than the percent of factor effect. For quantitative data, a value was selected that was judged to be indicative of the limit of non-attainment, and another value was selected that was judged to be indicative of full attainment. These values represent the end points of the scales used in the profiles. For qualitative data, estimates of attainment were made according to SEPTA standards as well as subjective judgments.

The following describes the basis for the values used for best and worst conditions for the objectives shown in Table 4.3.

Objective 1, "minimize crowding." The best expected situation occurs when a Fruin level of service of (C) or better is attained over 100 percent of the station area. Similarly, the worst expected situation will occur when a level of service (C) or better is not achieved anywhere in the station. Thus the estimated level of attainment in 1971 is near 100 percent of station area but is expected to decrease somewhat by 1985.

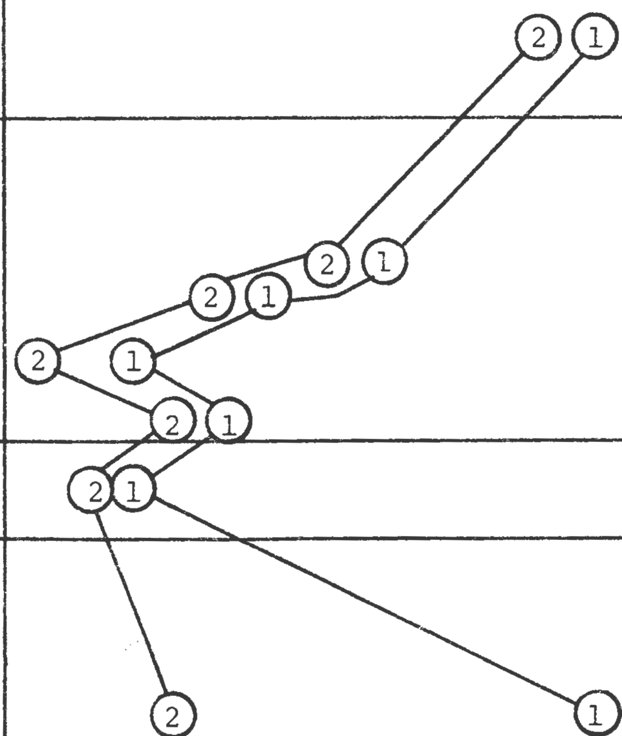
Objective 2, "minimize travel impedances." The unit of measure is the aggregate walking and waiting time per user. This figure will approach zero as waiting time and walking time decreases. The worst expected value theoretically approaches infinity. In this study, a factor was arbitrarily selected that is greater than the current measured value.

Objective 3, "minimize conflicts." The best value that can be expected occurs when the probability of a conflict is zero. The worst expected condition would occur for two flow directions when the probability of a conflict is 100 percent per flow.

TABLE 4.3

USER FACTOR PROFILE

Objective	Worst Expected or Unacceptable Value	← Non-Attainment / Attainment →	Best Expected or Acceptable Value	Unit of Measure
1. Minimize Crowding -links -queues -platforms	0%		100%	Fruin Level of Service C or better
2. Minimize Travel Impedances -avg. transfer time a.m. p.m. -avg. walk time a.m. -avg. wait time p.m.	 4 4 2 2		 0 0 0 0	Aggregate time / number of users
3. Minimize Conflicts	200		0	Sum of conflict probabilities
10. Provide for Emergencies -evacuation time -service interruption	40		60	min. to Level of Service F



NOTE: Attainment values are given only where there is a significant difference between 1971 (1) and 1985 (2) values.

TABLE 4.4

OPERATOR FACTOR PROFILE

Objective	Worst Expected or Unacceptable Value	← Non-Attainment / Attainment →	Best Expected or Acceptable Value	Unit of Measure
10. Provide for Emergencies - evacuation time - service interruption		(2) (1)		

NOTE: 1. There are no significant differences between 1971 and 1985 attainment values in the remaining user objectives.

2. 1971 and 1985 attainment value relationships for special users are similar to those for users.

3. There is no known significant variation in objective attainment between 1971 and 1985 for non-users.

These factor profiles illustrate an information presentation format that can aid in the evaluation of objective attainment over time. The advantages of this presentation format over the commonly used numerical matrix include:

1. Facilitates comparisons between criteria with regard to objective attainment

2. Presents expected limits of attainment

3. Facilitates interpretation of magnitude differences between the present time and the planning horizon.

The main disadvantage is that the actual numerical values for each measure are not given.

A factor profile was developed for each group and is presented in Tables 4.3 and 4.4. These factor profiles present the expected differences in objective attainment between 1971 and 1985 for the existing terminal. A review would indicate the terminal's performance is expected to decline in the years ahead.

IMPROVEMENT POTENTIAL

An evaluation of the present station for planning purposes would be incomplete without estimates of improvement potential. The improvement potential for each objective is estimated, based on the physical possibility of improvement, and is rated either poor, fair or good (see Table 4.5). These are speculative estimates; the actual improvements possible are discussed in the next four chapters.

The improvement potential ratings for each objective are of necessity subjective and based on judgments of the specific situation. They represent an estimate of the difference between the condition in the future and that at present. Thus, if a particular element is in excellent condition at the present time, the potential of improving the facility is poor. On the other hand, if an element performs poorly at present, there is an excellent likelihood that the facility can be improved. What follows is a discussion of the selection process of improvement potential for each objective, as shown in Table 4.5.

Objective 1 Crowding on links and platforms does exist and can be lessened by widening.

TABLE 4.5

IMPROVEMENT POTENTIAL

Objective	Improvement Potential
1. Minimize Crowding	
- on links	fair
- in queues	poor
- on platforms	fair
2. Minimize Travel Impedances	
- for walking	good
- for waiting	good
3. Minimize Conflicts	good
4. Minimize Disorientation	good
5. Maximize Safety	fair
6. Maximize Reliability	poor
7. Provide for Efficient Fare Collection and Entry	poor
8. Minimize Level Changes	fair
9. Minimize Physical Barriers	good
10. Provide for Emergencies	
- evacuation time	good
- service interruption	fair
11. Provide Comfortable Ambient Environment	fair
12. Provide Adequate Lighting	fair
13. Provide for Personal Comfort	good
14. Provide Aesthetic Quality	fair
15. Provide Supplementary Services	fair
16. Provide Protection from Weather	fair
17. Provide Adequate Security	fair
18. Minimize Costs (operating)	poor
19. Maximize Net Income	fair
20. Utilize Energy Efficiently	?
21. Provide Design Flexibility	fair

Objective 2	There are very long walks in the station that could be shortened. There are long waits on platforms that could be shortened substantially.
Objective 3	The main conflict area could be enlarged or eliminated.
Objective 4	Much better signs could be installed.
Objective 5	Stairs could be eliminated.
Objective 6	Reliability is already very good.
Objective 7	A fare collection and entry are already well controlled.
Objective 8	Some stairs could be removed.
Objective 9	Stairs and turnstiles could be made less of a barrier.
Objective 10	Emergency exits could be provided. Platforms could be enlarged somewhat.
Objective 11	Air conditioning could be provided.
Objective 12	Softer fluorescent lighting could replace harsh incandescent lighting.
Objective 13	Benches could be added.
Objective 14	Art work, etc. could be provided.
Objective 15	Advertising could be standardized.
Objective 16	Some additional roofs and wind breaks could be added.
Objective 17	Guards or video monitors could be provided.
Objective 18	Operating costs are already low.
Objective 19	Rental space could be redivided and improved.
Objective 21	The structure's size could be reduced to provide greater exterior use flexibility.

CHAPTER 5

SUGGESTED STATION MODIFICATIONS TO MEET CURRENT POLICIES

This chapter contains a review of SEPTA current policy guidelines and describes how they compare with the results of the evaluation of the present station. Station policies are listed in Appendix D. The station is found to fall short of meeting current SEPTA policies in a number of areas. In this chapter, modifications that would bring the station into compliance with current policy in most areas are suggested. The revision of certain policies was considered in some areas.

Although the previous evaluation indicates that some operating policies should be changed, these changes require only a refinement of SEPTA policy. It is important to note that the terminal was built long before SEPTA existed.

NEEDED STATION IMPROVEMENTS TO MEET POLICY GUIDELINES

The major areas where SEPTA policy is not well met are advertising, aesthetics, construction materials, passenger orientation and safety. Each of these items is discussed in the following sections.

Advertising

Many concession-related advertising signs distract or disorient passengers within the terminal. These should be eliminated by regulating concession advertising with regard to location, size and type. The cost of this is very low, although concession owners may at first resist such regulations.

Non-concession advertising also detracts attention from orientation information. Such advertising should be restricted to a standard, recognizable format and be displayed only at designated areas.

Aesthetics

Music could be provided as part of the public address system for a small additional cost of about $500. This could be tried on an experimental basis and altered according to public acceptance.

The provision of art or historical displays has aesthetic value that is difficult to estimate. If a few local groups seeking space to display material could be found, this would be an economical way to provide exhibits and encourage community involvement.

SEPTA has guidelines concerning landscaping, particularly in parking lots. A site analysis considering landscaping requirements prior to actual landscape planning is suggested (20).

A station washdown system should be provided in the terminal in accordance with SEPTA standards for service systems (see Appendix D).

Materials and Finishes

Criteria to evaluate materials and finishes used in the terminal is specified in detail in SEPTA policy (Appendix D). They include considerations for safety (i.e., non-flammable, non-conducive to personal injury, etc.), maintainability, durability, replaceability and economy.

Passenger Orientation

Providing efficient signing for good passenger orientation is a goal that has been very clearly stated by SEPTA. Three criteria were established for judging graphic efficiency: (1) sufficiency, (2) minimality, and (3) legibility. Three types of information must be displayed within a transit station:

1. Identification of locations within the terminal

2. Directional aid for specific destinations within the terminal

3. Cartographic representation of the terminal (map)

SEPTA has standardized its graphics system-wide to promote economy and user recognition of informational signing and the transit system. These standards should be followed as closely as possible in any renovation. Directional information should be provided at every decision point.

Providing information booths or phones would require expenditures for them, plus a new employee. However, the current ticket/change booth attendant could probably handle this function at no additional cost. A sign should be provided to indicate that information service is provided.

Providing orientation aids for special users could include a wide range of aids and costs. If wheelchair users are to be provided for, signs indicating usable paths and priority parking must be included. SEPTA has standards for handicapped informational signing. Braille directions could be placed on maps, on the wall at a decision point, and on the handrails. Regular users who are blind, though, would probably be guided through the terminal at first and then memorize it. Pictures or symbols for each mode could direct illiterate or foreign users to the mode they wanted.

An installed 12-inch diameter single-faced clock costs about $45, while a double-faced clock costs about $75 (26). It would be advantageous to place clocks in all waiting areas, because users usually perceive time spent waiting to be greater than it actually is. On long platforms it would be more economical to put a double-faced clock in the middle than two single-faced clocks at the ends. Three double-faced clocks and six single-faced clocks would well cover the terminal at a cost of about $500.

An adequate public address system would require 16 or more speakers, at an installed cost of $3,200, to cover each waiting or platform area (26). Public address systems are required in Rapid Rail stations by SEPTA standards (see Appendix D).

<u>Safety</u>

Current below standard treatment of platform edges can be quickly remedied by following those standards specified in SEPTA policy (see Appendix D). The intent of striping the edges is primarily to increase user awareness of potential approaching transit vehicles.

Providing first aid facilities can range in cost from under $50 to well in the thousands. The local emergency medical services organization should be consulted as to what services may be most beneficial to local users. Training attendants in first aid could greatly improve the handling of accidents until trained emergency medical personnel arrive.

The previously recommended public address system would improve safety as well as orientation. Video surveillance in combination with the public address system offers potential for correction of unsafe facility use by patrons.

In addition to the public address system, an evacuation plan is essential for minimizing safety hazards due to panic conditions which may exist in an emergency.

SEPTA standards for fire protection and alarm systems meet all local codes and are described in Reference 18. These should be followed in the event of a renovation.

For stairways, SEPTA recommends abrasive nosings on the outer four inches of each tread. SEPTA also has recommendations on widths, landings, run-offs, tread-riser relationships and headroom clearances (20).

Emergency power provisions should be made in any publicly operated building. At a minimum, this should include emergency lighting to prevent panic and crime and to maintain safety and orientation. At a maximum, emergency power could be provided that would continue normal operation during a power failure. An emergency light unit costs about $135 for a lead battery operated unit and about $230 for a nickel cadmium battery operated unit. A minimum of about 12 units would be required at costs of $1,620 and $2,750, respectively.

POSSIBLE STATION IMPROVEMENTS TO MEET POLICY GUIDELINES

Major areas where SEPTA policy is partly met are in security, personal care facilities, parking facilities and provisions for special users.

All of the above areas could be improved. The important issues regarding decisions on these policy matters are discussed in the following sections.

Security

SEPTA recommends the installation of a video surveillance system in all stations on subway or elevated lines. SEPTA is now experimenting to develop an optimal operative video surveillance system. A minimal system would probably require eight cameras at a system cost of about $4,500 (26). An industrial quality system would cost about four times as much. Special features such as weatherproof cameras, pan and tilt features, and zoom lenses add to the system cost.

Video surveillance offers much potential for reducing crime and identifying suspects after a crime. These surveillance systems should be compared with the cost effectiveness of security patrols. Audio surveillance would complement video surveillance. If chosen as an alternative to video, its lower cost should be considered along with its lowered effectiveness, as victims cannot always make noise.

In theory, as pedestrian densities go down, the probability of crime goes up (e.g., conditions at midnight). User densities during off-peak hours can be increased by closing off unused sections of the terminal, such as platform ends. The costs of such a strategy could be easily calculated; its effectiveness, however, would probably be slight where good video surveillance was provided.

The provision of a pneumatic tube money collection system would eliminate the possibility of robbery of any large sum of collected fares. Such a system at this terminal would likely require one tube, with one end in the change booth and the other in an upstairs office. The installed cost would be about $2,600 (26).

Barriers should be provided to sufficiently prevent or discourage illegal entry into the paid area. Within the terminal the only access to the paid area is via the turnstile. SEPTA has specific standards on turnstiles and entry provisions (see Appendix D).

Passengers will not use the bicycle as an access mode until some security measures, such as lockers or racks, are provided for bicycle parking. These provisions should be made on an experimental basis.

Personal Care Facilities

No benches or lounges have been provided in the terminal, perhaps for the prevention of vagrancy. It is recommended that individual seats, which would be uncomfortable for vagrants to sleep on, be provided for users.

Restrooms provide for personal comfort and are readily accepted by users, though conditions of present facilities could be greatly improved upon.

Parking Facilities

New and substantial parking facilities can be added by replacing the present 340-space lot with a two-level garage. A 650-space garage would cost about $2.4 million (26). By maintaining the current parking rate of 35 cents per day, it would take 41 years to collect enough to pay the construction costs alone. A new garage will require increased rates to be economical. At the rate of 70 cents per day, the same as that charged by the commercial lot nearby, 20 years would be required to pay construction costs. However, it is unknown if the lot could be filled at this higher rate.

Provisions For Special User Accessibility and Comfort

Elevators are generally only justified in transit stations to provide access for special users. They are a poor competitor for escalators with regard to capacity per unit cost. The decision to include elevators at this particular subway-elevated station platform should not be made independently of decisions to include elevators in other subway-elevated line stations. It would serve little purpose to provide wheelchair access at this terminal if wheelchair access were not provided at other stations along the line. One installed elevator would cost about $38,000 (26).

If elevators are provided for wheelchair access to the subway-elevated, a ramp would be required at the main entrance to the terminal to enable wheelchair users to access the station from cars, taxis and sidewalks.

Installing self-opening turnstiles that facilitate use by the handicapped would be contrary to SEPTA practice. In this case, reevaluation of this SEPTA standard on a system-wide basis may be in order. Other devices which would aid the mobility of special users (benefitting other users as well) include self-opening doors, moving sidewalks and escalators. Automatic self-opening doors cost about $1,800 per door installed with an activating carpet (26).

The long walkways that would be appropriate for the installation of moving sidewalks are the inclined walkways. Unfortunately, these corridors have bends in them which would require a more complicated and costly installation than straight moving walkways, which cost about $300 per linear foot (26).

The primary issues involved in deciding between the use of stairs or escalators at the terminal are capacity, comfort and cost. In deep subway stations, the use of escalators or elevators is common practice for providing comfort, as in the London subway. However, at this terminal no single level change exceeds 15 feet. For comfort reasons it is obviously more important to provide up escalators than down escalators.

An 84-inch wide stairway would have a maximum capacity of about 120 persons per minute, which is greater than an escalator of comparable width when operated at 90 feet per minute (capacity: 100 persons/minute) but less than the escalator when operated at 120 feet per minute (capacity: 133 persons/minute).

The cost of an installed 32-inch escalator for a 15-foot story height is about $45,000 (26). For a 48-inch escalator the cost is about $50,000 (26). Escalators require two to three kilowatts to operate. A stairway costs an average of $5,000.

STATION ELEMENTS THAT CONFORM TO POLICY GUIDELINES

The areas where SEPTA policies are well met and have a general high level of service and convenience are concessions and services, public telephones and physical environment. Each of these elements is discussed in the following sections.

Concessions and Services

In the present terminal there are stores catering to shoppers, as well as concessions that cater to travelers. Renovation could reduce total rentable space. However, if shopper facilities were reduced sufficiently, more traveler facilities could be provided that would rent for higher per-square-foot rates.

Many lockers are provided at the terminal, but no data were available on their use.

Telephones

The number and distribution of public phones in this terminal appears to be satisfactory at present.

Physical Environment

As far as climate control is concerned, the only substantial improvement would involve adding air conditioning to the rest of the terminal. Cost of the required system is a complex problem beyond the scope of this study.

Fully enclosing many of the partly enclosed areas would require the accommodation of vehicles as well. Buses could not be enclosed without extensive ventilation provisions. In any case, heating these areas would be very costly, due to the openings for vehicles.

SEPTA has numerous recommendations and standards (see Appendix D) for lighting provisions. The costs for lighting were included as a portion of the electrical system costs. Lighting within the terminal should be brought up to SEPTA standards, particularly on the subway-elevated platforms.

SUMMARY

The foregoing suggestions and recommendations would greatly improve the terminal's compliance with SEPTA's policies. This chapter has included suggested improvements to the station that will result in meeting SEPTA policies. In the next chapter, an evaluation of plan changes to improve passenger processing is described. These changes, together with improvements in policy related items, comprise the recommended renovation program for the station.

CHAPTER 6

GENERATION OF ALTERNATIVE RENOVATION PLANS

The generation of alternative renovation plans is largely a creative process which can be systematized only to a limited extent. One of the best sources for ideas in generating alternative plans is to look at those used in other station renovation projects.

The process here involves the following basic steps:

1. Establishment of constraints

2. Consideration of design concepts

3. Strategy development and analysis

4. Specification of alternative renovation plans

ESTABLISHMENT OF CONSTRAINTS

There are three types of constraints on a renovation project: (1) structural, (2) operational, and (3) fiscal. The ways in which each of these apply to this terminal are discussed below.

Structural Constraints

Structural constraints deal with two areas: (1) site characteristics, such as size and shape of surrounding land; and (2) architectural characteristics, such as building and foundation soundness.

The entire site of about 35 acres contains the terminal, maintenance shops, storage yards, and an abandoned power plant. The site offers much potential for replacement of the terminal if some of the other facilities on the site are modified or moved. If the alignment of the subway-elevated were to be substantially changed, all other modes would also have to be changed, resulting in a replacement rather than a renovation exercise. Maintaining the present subway-elevated alignment constrains expansion of the platforms, limiting them to serve only six cars instead of eight.

The building and its foundation appear to be structurally sound, as indicated by the absence of cracks and sloping walls or floors, although the few areas of exposed reinforcing rods must be repaired (see Figure 6.1).

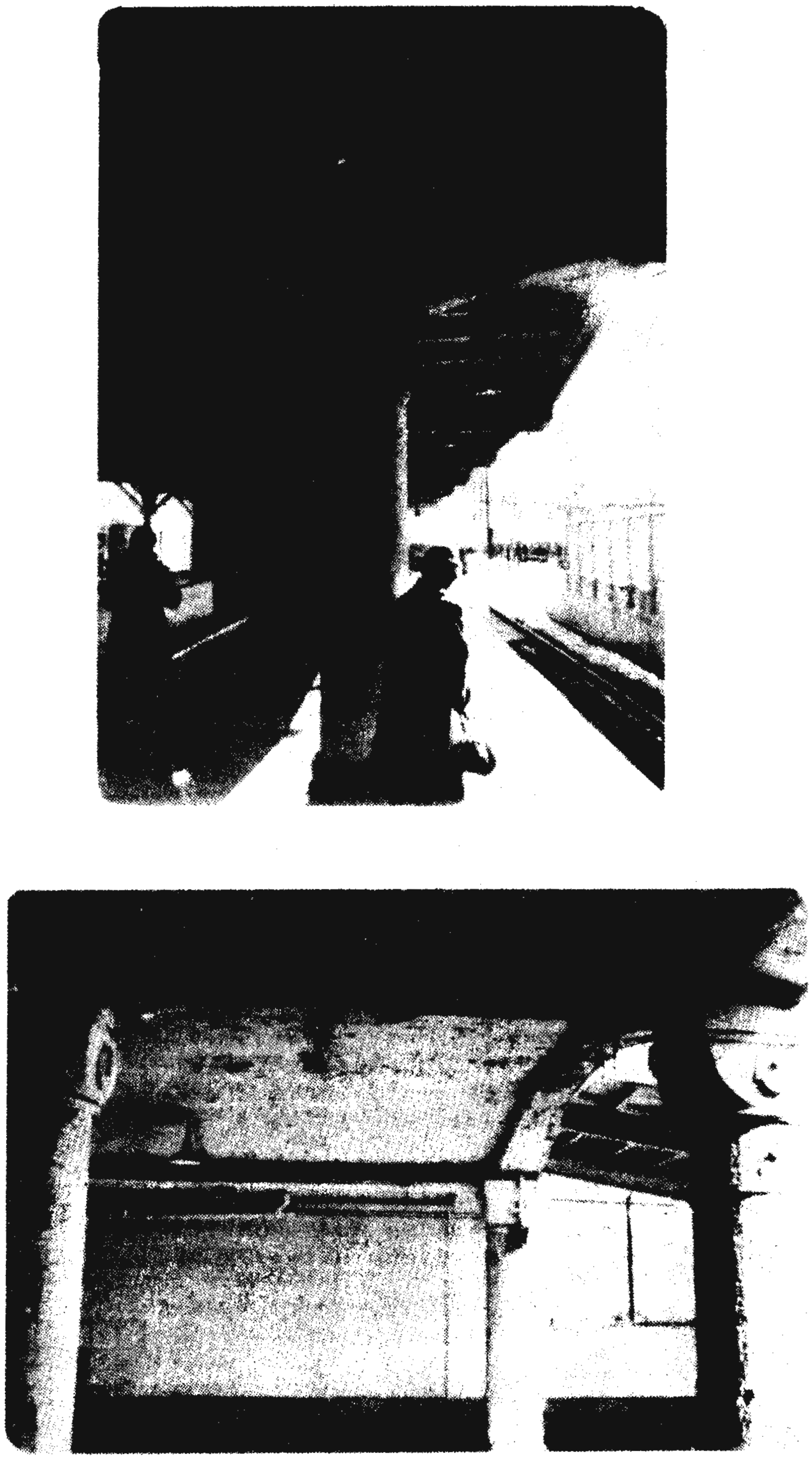


Figure 6.1. Exposed Reinforcing Rods

Operational Constraints

Since none of the three rail lines have compatible or interchangeable equipment, transfers between them cannot be eliminated by running one line's vehicle over another line's tracks. Each mode has only a limited number of workable platform arrangements, depending on the size and shape of the vehicle and the presence or absence of tracks.

In general, rail platform designs are inflexible. Usually the platforms are somewhat longer than one train length, are straight, and are at an even level with the train's doors. Bus platforms have much more flexibility in their design and arrangement, due to the maneuverability of buses.

Fiscal Constraints

If a transit authority imposes constraints on the cost of the renovation project before any evaluation or planning studies have been made, the project may be unnecessarily restricted. Preferably no firm dollar amount should be set until a comprehensive preliminary study is conducted for all stations under consideration and the relative benefits of alternative investments considered. In this manner, priorities can be established according to needs and considered as funds become available. It is useful, for example, for a car buyer to "shop around" before he or she sets a minimum or maximum cost constraint. The same principle applies on a larger scale; in this way, policy makers will be in a better position to make intelligent decisions on what and when to buy.

Since this is a demonstration of the applicability of the General Methodology to the renovation project, the fiscal constraints, i.e., upper limit of total project cost, shall be set at the equivalent of the total cost of the new facility that will provide a comparable level of service.

CONSIDERATION OF DESIGN CONCEPTS

Design concepts for this terminal's renovation project are considered under five categories:

1. Horizontal separation

2. Vertical separation

3. Area restriction

4. Modal priorities

5. Special user accommodations

Horizontal Separation

Horizontal separation refers to the lateral separation of the various modes and the resulting passenger transfer paths. At present many of the inter-terminal transfers are very inefficient. Due to the separate paid and unpaid zones of the subway-elevated platforms, cross-platform transfers between modes cannot be made. Some modes do allow cross-platform transfers, although these are few in number. A priority was set to consolidate, as much as possible, each mode to a given area to facilitate transfers from the subway-elevated. In generating alternative plans, attempts are made to improve, simplify and shorten these transfers.

Vertical Separation

Vertical separation refers to the manner in which modes are separated by level differences. The present terminal has two levels connected by stairs and ramps. The alternative plans consider two or three levels that can be connected by stairs, escalators or elevators.

Area Restriction

Area restriction refers to the areas of station access allowed before fare payment. Having paid and unpaid zones, as in the case of the subway-elevated, allows for lower boarding times and less queuing. This complicates transfers somewhat; but if the subway-elevated platform were changed to an all unpaid zone, the entire line would require changes. All other modes--the trolley and the high-speed line--have only unpaid zones, and the passengers pay when they disembark. Each concept has its advantages, and both are working quite well for their respective modes at this terminal.

Modal Priorities

Modal priority was established on the basis of passenger volume. Attempts were made to reduce transfer times between the most heavily used modes by locating high-volume access modes progressively closer to the line-haul mode's alignment. Modal priorities, in decreasing order, as indicated by the percentages of total passenger volume, are as follows:

1. Subway-elevated 39.7%

2. Buses 30.7%

3. Trolleys 10.3%

4. Norristown Rapid Transit 8.5%

5. Walk 6.0%

6. Park-n-ride 2.7%

7. Taxi & kiss-n-ride 2.1%

The above percentages are calculated on the basis of total daily arrivals and departures (15).

Special User Accommodations

The only special user accommodation considered during alternative plan development was level change aids for wheelchair users. This involves making a choice between the use of ramps and elevators. A ramp down to the subway-elevated, constructed according to recommended guidelines for wheelchair users, would be 355 feet long and would consume about 800 square feet of platform space. An elevator would require only about 10 percent of this ramp space and is therefore the preferred choice.

STRATEGY DEVELOPMENT AND ANALYSIS

This study employs general guidelines to generate alternative plans, which are: (1) to develop strategies addressing problems identified earlier in Chapter 4, and (2) to determine the relative importance and impacts of each strategy.

For this study twelve strategies were developed that deal with layout and enclosure changes. Each strategy is designed to alleviate a problem related to the station's structure and layout. These strategies and their expected impacts are presented in the Impact Analysis Matrix (see Table 6.1). The impacts are designated to have either negative, positive, or neutral effect on the following primary subsystems of a transit station:

1. Passenger processing

2. Passenger orientation

3. Physical environment

4. Security

5. Safety

TABLE 6.1

IMPACT ANALYSIS MATRIX

Passenger Processing	Passenger Orientation	Physical Environment	Security	Safety	SUBSYSTEMS
0/-	+/0/-	+/0/-	+	+/0/-	1. Expand services and concessions
+/0	+/0/-	+/0/-	-	+/0/-	2. Reduce services and concessions
+/0	+/0	+	0	+	3. Improve weather protection
0/-	0/-	-	0	-	4. Reduce weather protection
+	0	0	+	+	5. Reduce walking distances
+	+	0	+	+	6. Reduce conflicts of movement
0	+	0	0	0	7. Provide logical layout
+/0/-	+/0/-	0	+/0	+/0/-	8. Reduce level changes
+/0/-	+/0/-	0	0/-	+/0/-	9. Increase level changes
0	+/0	0	+	0	10. Provide long sight lines
0	0	+/0	+	0	11. Provide high ceilings to facilitate surveillance
+	+	0	0	0	12. Consolidate bus platforms

KEY

+ = positive
- = negative
0 = none
/ - and/or

As these strategies offer overall positive impacts and good potential for implementation, primary emphasis is placed on the following ones: (1) reduce walking distances, (2) reduce conflicts of movement, and (3) consolidate bus platforms.

Secondary emphasis was placed on the following strategies because they offer overall positive impacts, though less than those above, and they are not expected to be prohibitively costly. They are: (1) improve weather protection, (2) provide logical layout, (3) provide long sight lines, and (4) provide high ceilings to facilitate surveillance.

Alternative renovation plans can now be developed by using the above strategies and keeping within the established constraints.

SPECIFICATION OF ALTERNATIVE RENOVATION PLANS

Five alternative renovation plans were developed to provide long-term renovations. All involve gutting and rebuilding the terminal's interior, and they are expected to be serviceable for about 30 years. A brief description of each follows.

Alternative 1

Alternative 1 leaves the terminal layout much as it presently stands. Minor relocations and modifications are made on the city bus platforms, the taxi area, and the kiss-n-ride area. The plan would include the upgrading of the entire terminal to as close to new station quality as possible (see Figure 6.2).

Alternative 2

Alternative 2 involves tearing down the above-ground building portion of the bus circle area just east of the original 1907 subway-elevated structure. The taxi, city bus, and kiss-n-ride areas would remain where they are, although their platform arrangements would be modified. The ramp which goes from the West Chester Pike bus platform (node 23) to the main ramp (link 20-21-24) would be closed. A level corridor would be built from the bus platform to the southwest corner of the subway-elevated's main lobby, thereby eliminating two level changes and reducing congestion on the present main ramp (see Figure 6.3).

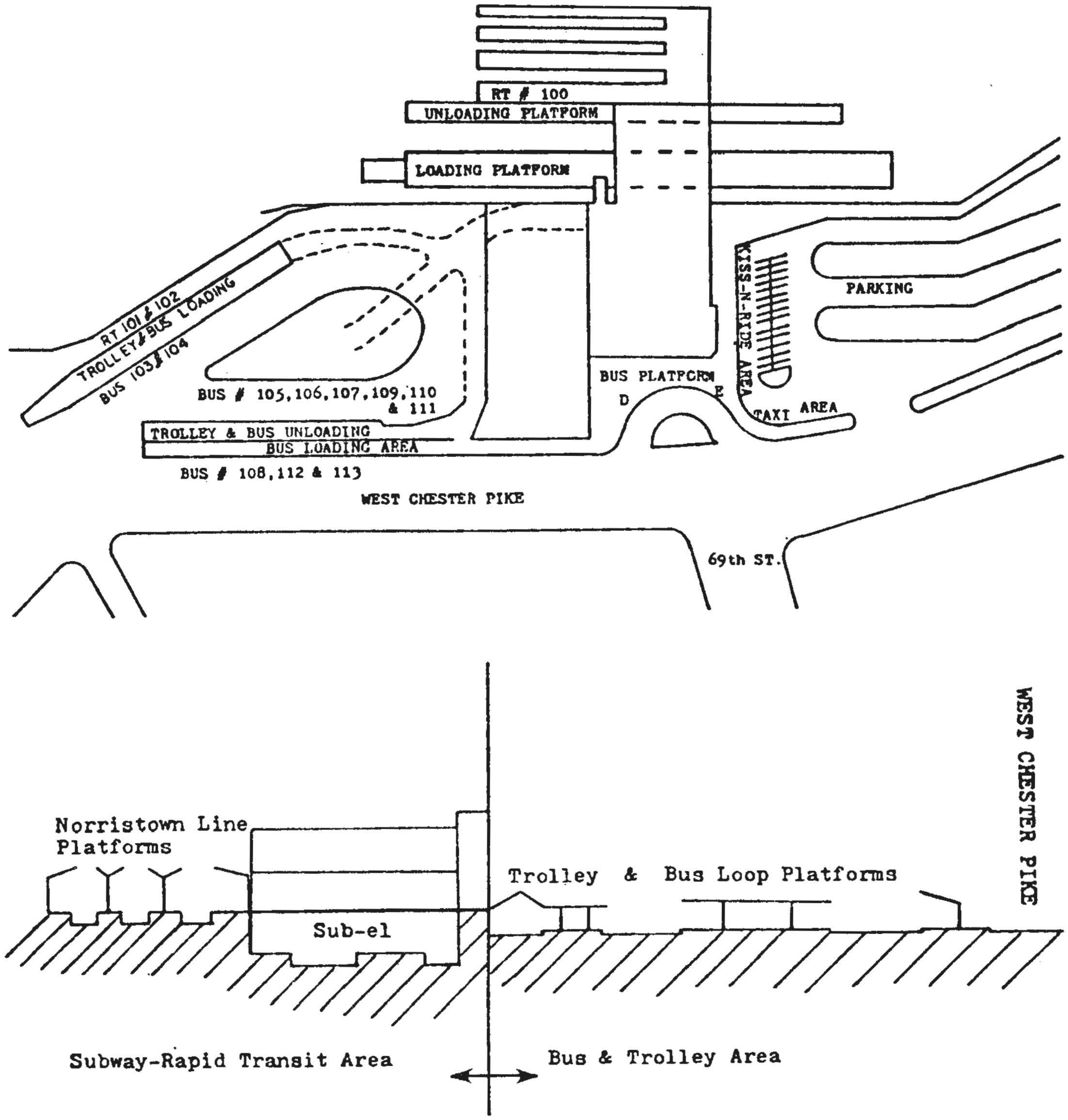
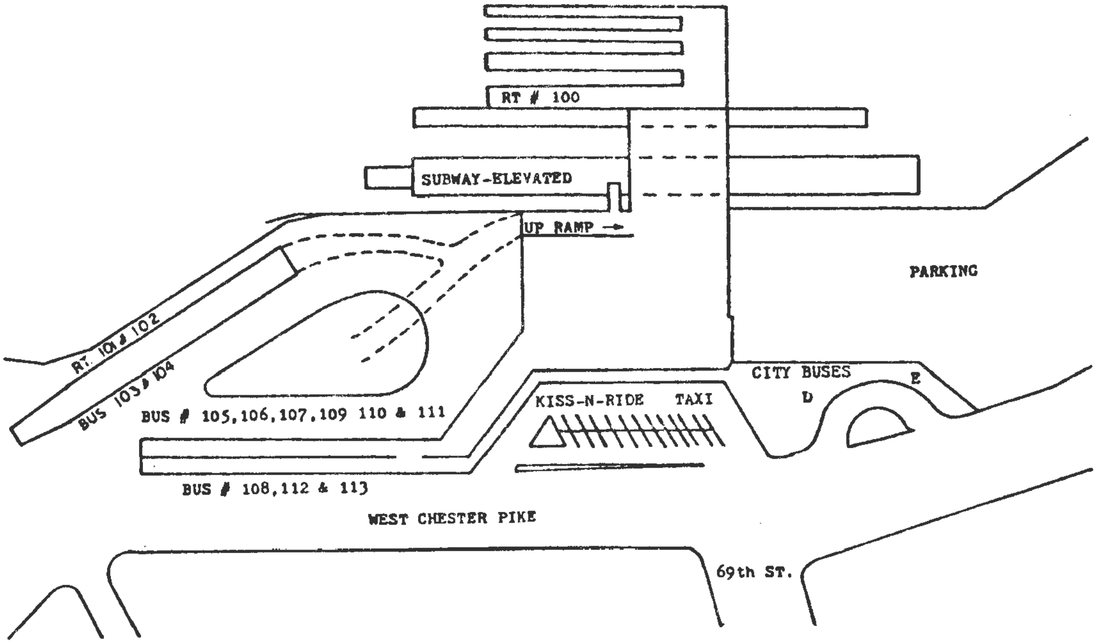


Figure 6.2. Alternative 1: Plan View and Evaluation



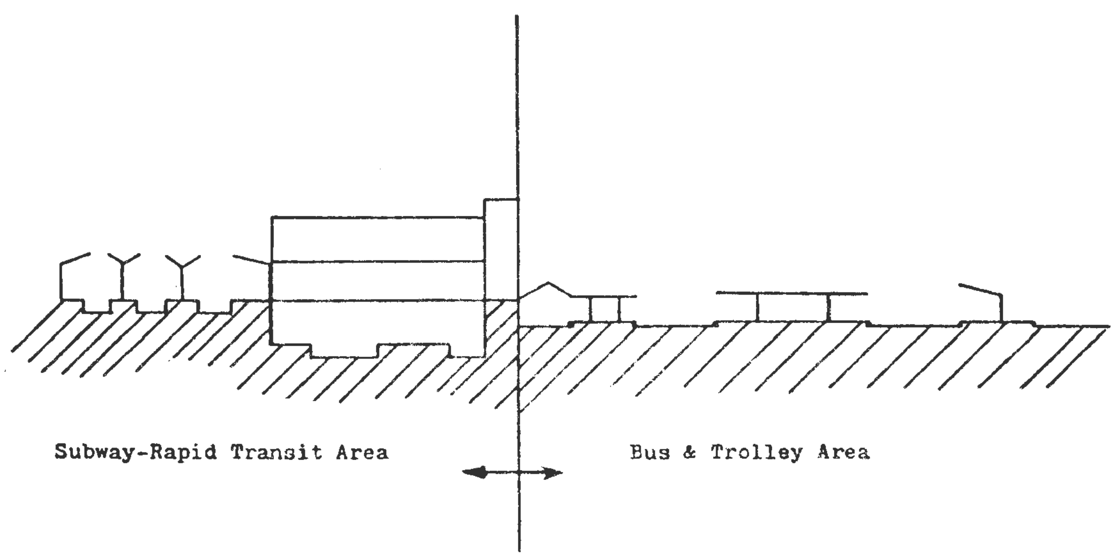


Figure 6.3. Alternative 2: Plan View and Evaluation

Alternative 3

Alternative 3 would eliminate the bus platforms in the center of the bus and trolley circle, thereby eliminating two-way traffic in this area. All but two bus routes will unload directly in front of the terminal. The west section of the subway-elevated building would be demolished. The kiss-n-ride and taxi areas would then be relocated between the subway-elevated building and the parking lot (see Figure 6.4.).

Alternative 4

Alternative 4 involves the removal of much of the present terminal building and construction of a new section over the subway-elevated tracks, west of the present track-spanning section. In addition to eliminating the sections of the terminal outlined in Alternative 3, the subway-elevated lobby would be demolished. Elevated corridors to all bus platforms would be provided. The taxi and kiss-n-ride areas would be relocated (see Figure 6.5).

Alternative 5

Alternative 5 involves removing all passenger terminal structures between West Chester Pike and the subway-elevated tracks in order to put the trolley loop below grade at an even level with the subway-elevated alignment. All bus platforms would be constructed at street level above the trolley loop. A new addition, spanning the subway-elevated alignment, would be made to each side of the present structure, similar to Alternative 4. The taxi area would be located in the bus area. The kiss-n-ride area would be located between the bus unloading area and the parking lot (see Figure 6.6).

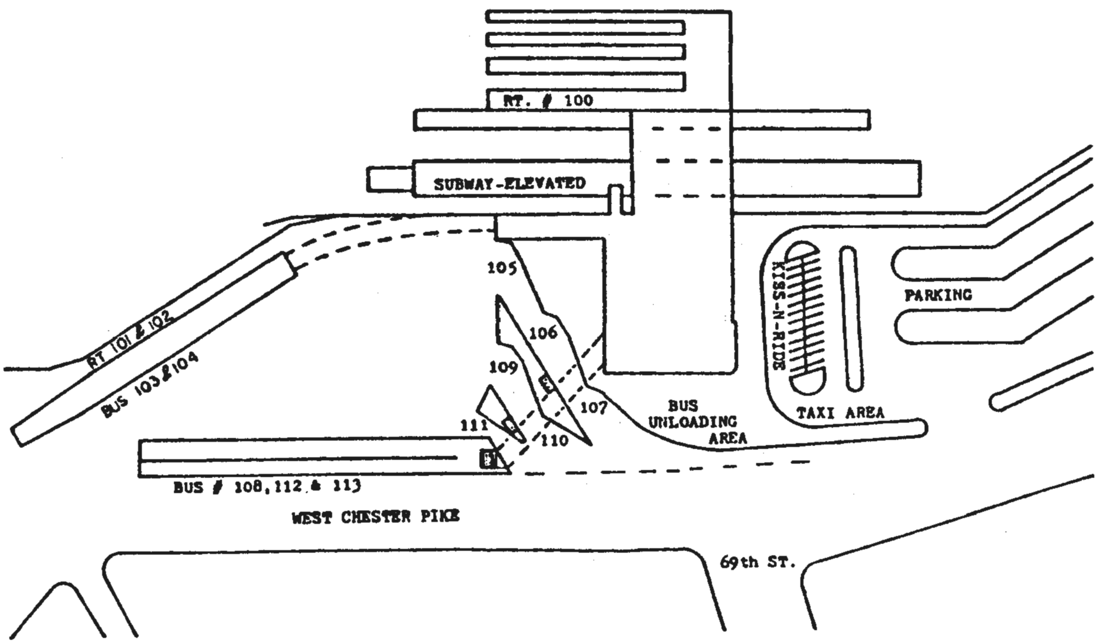
ESTIMATED CAPITAL COSTS

Estimated capital cost is calculated for each alternative based on current construction costs. Although these approximate figures are susceptible to inflation and the construction market, they are valuable for making comparisons in plan selection. Capital cost for each alternative is as follows:

Alternative 1: $3.1 million

Alternative 2: $2.4 million

Alternative 3: $1.9 million



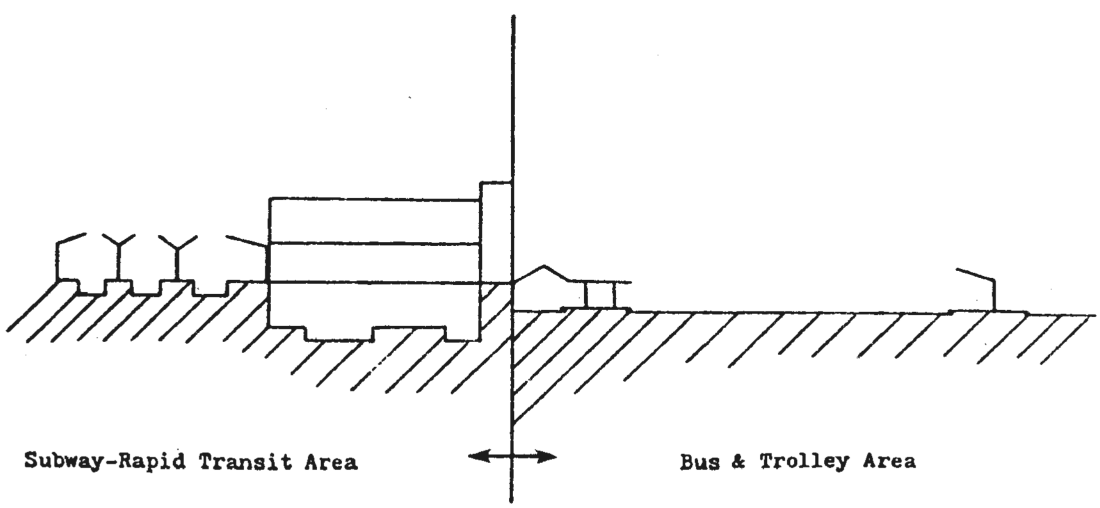


Figure 6.4. Alternative 3: Plan View and Evaluation

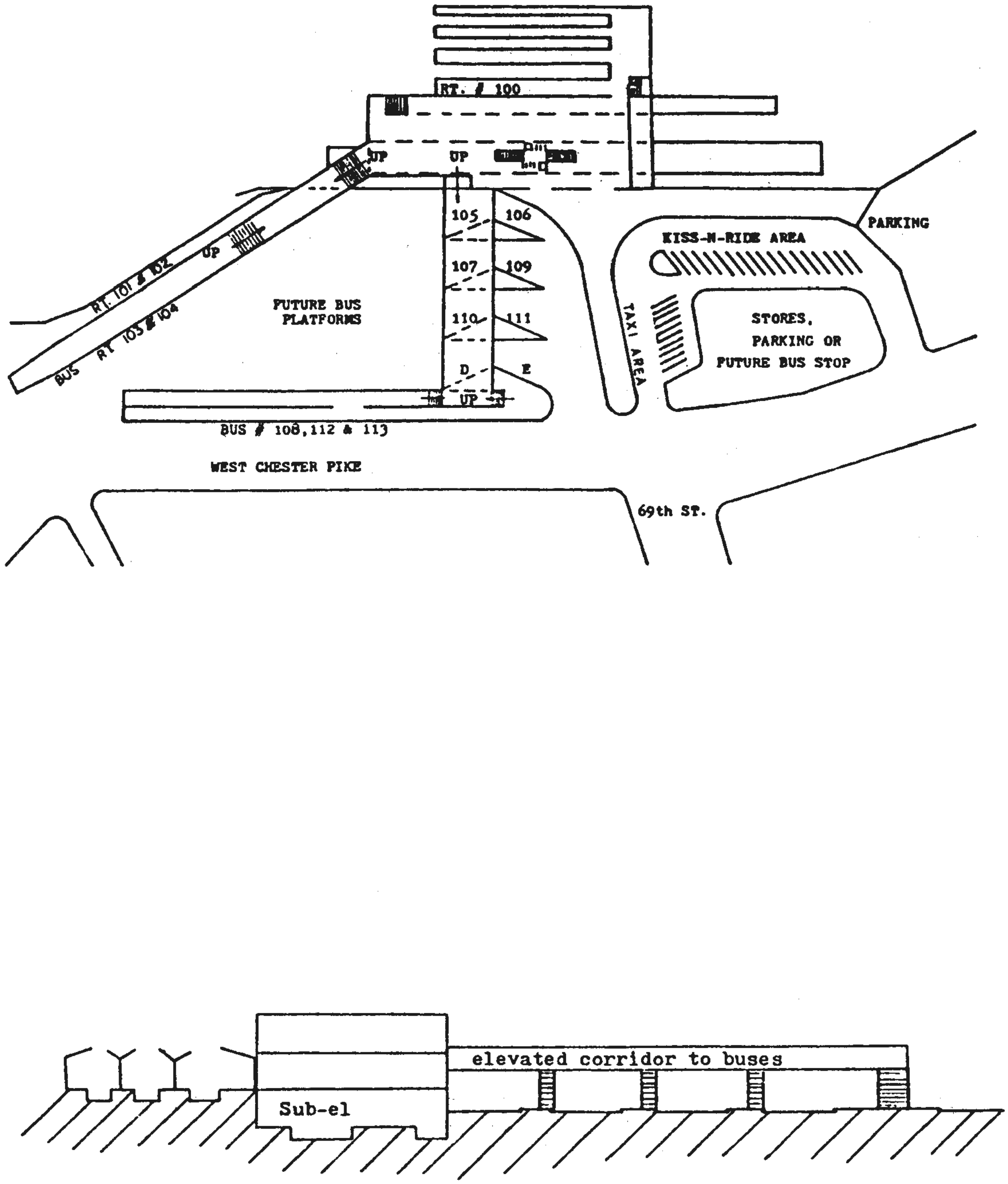


Figure 6.6. Alternative 4: Plan View and Elevation

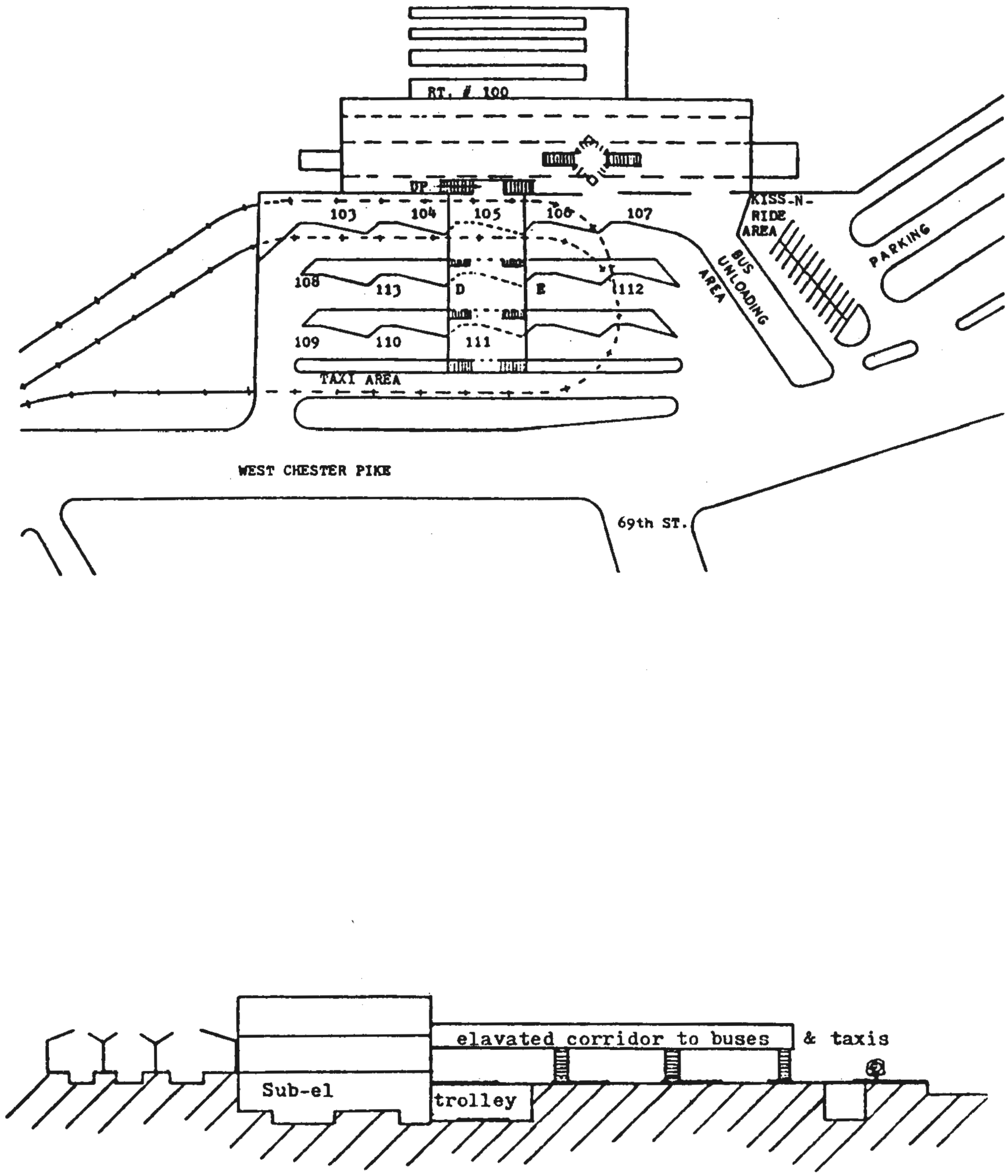


Figure 6.5. Alternative 5: Plan View and Elevation

Alternative 4: $2.9 million

Alternative 5: $4.4 million

A SHORT-RANGE ALTERNATIVE

The preceding alternatives were developed to satisfy a long-range development plan calling for a renovation that would last 20 to 30 years. However, if the long-range development plan called instead for the replacement of the terminal within less than 10 years, implementing the above plans would probably be too extensive and costly. In this case, an acceptable renovation plan would be one similar to Alternative 1, except that the buildings would not be gutted; they would instead be repaired and modified, where necessary, and repainted.

CHAPTER 7

EVALUATION OF ALTERNATIVE RENOVATION PLANS

OBJECTIVE SELECTION

The purpose of this chapter is to illustrate the use of evaluation procedures for the five alternatives outlined in Chapter 6. As discussed earlier, these plans will be evaluated according to appropriate objectives drawn from the Objectives-Criteria-Measures Chart (Table 4.1). Since the purpose of this task is to compare the alternatives, only those criteria significantly differing in performance are included. An evaluation of the relevant criteria for each user group is presented in the following sections.

PASSENGER PROCESSING OBJECTIVES

Crowding

The extent of crowding on links, platforms, and in queues was assumed to be nearly identical in all the conceptual designs. This assumption is valid because, except in the case of bulk arrivals, each design was specified to provide at least a Level of Service C on all links. Platforms were specified to provide acceptable service for all alternatives, and queues would be nearly the same.

Travel Impedances

Queuing delays (path and aggregate wait times) were assumed to be equal among the alternatives, because each alternative would have the same number of queuing points and devices.

Nodes and links were defined as in the previous evaluation (see Appendix E). Morning and afternoon peak walk times were calculated for every link in each conceptual design for both the present and the 1985 planning horizon (see Appendix E). Total aggregate walk times for the existing station and for each alternative plan are shown in Table 7.1.

TABLE 7.1

AGGREGATE WALK TIMES

Design Alternatives	Aggregate 10-min. Peak Walk Times (person-min.)	% Improvement over Present Station
Present	8333	0.0
Alternative 1	8078	3.1
Alternative 2	8013	3.8
Alternative 3	7340	11.9
Alternative 4	8768	-5.2
Alternative 5	5102	38.8

Conflicts

The only area that has severe conflict of movements was located at the junction of the path leading from the subway-elevated and that leading from the bus and trolley platforms (Node 24). This is caused by the bulk arrival flow from the subway-elevated. The probability of conflict for users crossing this flow for all alternative plans was estimated to be 80 percent.

The controlling point in this corridor is at the doors. Increasing the corridor's capacity would only result in the same or higher probability of conflict. Solutions to this problem will be discussed in the refinement of the chosen alternative stage.

Alternative 2 reduces the number of users who are exposed to this conflict, as does Alternative 3. Alternatives 4 and 5 eliminate the junction altogether, thereby eliminating any severe conflicts.

Disorientation

Signing would be standard for all alternatives.

Decision complexity measure (D_{ij}), for all paths through the terminal was calculated for each conceptual design. The maximum number of separate decisions for each alternative are as follows:

Present terminal:	7
Alternative 1:	7
Alternative 2:	5
Alternative 3:	6
Alternative 4:	7
Alternative 5:	7

The above measure (D_{ij}) describes the decision complexity only partly, because the alternative plans differ in the extent to which bus platforms have been consolidated. The high values for Alternatives 3, 4 and 5 are the result of separate platforms for different bus routes.

Safety

A major safety hazard found in the designs was the presence of stairs. Alternatives 1 and 2 have stairs only at the entrance, exit and lobby of the subway-elevated. Alternative 3 has additional stairs to some buses. Alternative 5 has additional stairs to some buses and the trolleys. Alternative 4 has stairs to all buses and the trolleys.

Reliability

Reliability is primarily determined by equipment down-time and equipment back-up provisions. The alternative plans do not address the subject of internal equipment. The performance of equipment shall be addressed later in the refinement stage.

Fare Collection and Entry

Alternatives 1, 2 and 3 provide the attendants with about the same degree of sight surveillance of the fare collection area as the present design. Alternatives 4 and 5 provide substantially better observation with concessions arranged around the edges of the concourse.

Level Changes

The maximum number of level changes are made in the present design and in Alternatives 1 and 2. All are equal to three, two of which are made on ramps. Alternatives 3 and 4 have a maximum of four level changes, although less than one percent of all users would have to make this many level changes. Most users would have to make a maximum of only three level changes. Alternative 5 has a maximum number of three level changes.

Physical Barriers

Most provisions for special users are detailed design considerations, except for elevator installation potential. Alternatives 4 and 5 offer more potential for including elevators to the subway-elevated, where they will not interfere with other users.

Emergencies

Alternatives 1, 2 and 3 would require the same evacuation times as the present design, which exceeds SEPTA's four-minute standard. Evacuation times for Alternatives 4 and 5, though lower than others, also do not meet SEPTA's standard. Plan specification additions could correct this problem by adding a new exit corridor or an emergency exit on the terminal's north side.

In the event of a morning service interruption on the subway-elevated for less than 48 minutes, all plans would provide Level of Service F (or better). All other loading platforms can remain above Level of Service F for periods of service interruption exceeding 60 minutes, even during the peak hour.

ENVIRONMENTAL OBJECTIVES

All alternatives provide a comfortable ambient environment, adequate lighting and personal comfort.

Aesthetic Quality

Alternatives 4 and 5, which provide one main concourse area, would establish a unified theme throughout the terminal. Alternatives 2 and 3 present a slightly less unified theme. Alternative 1 and the present design have three separate structures which present no unified theme.

Supplementary Services

The only difference between the alternatives regarding supplementary services is the amount of space available for concessions and advertising. Alternative 1 provides as much space as does the present station, while Alternative 5 provides less than half that amount. This reduction in concession space will not necessarily result in less income from rental fees, as smaller concessions might have higher per-square-foot rental fees.

Weather Protection

Weather protection by floor area for each alternative is shown in Table 7.2.

TABLE 7.2

WEATHER PROTECTION

Design	Totally Enclosed and Heated	Partly Enclosed	Totally Exposed
Present	43%	49%	8%
Alternative 1	43%	49%	8%
Alternative 2	38%	62%	0%
Alternative 3	42%	58%	0%
Alternative 4	44%	56%	0%
Alternative 5	59%	41%	0%

The above figures do not include the parking lot itself, nor the walkways to it; both of these are totally exposed in all alternatives.

Security

A procedure for determining the relative security provided is to calculate the percentage of area under attendant's observation measured against the total available area of paths, corridors, platforms, etc. (excluding the parking lot areas). The percentage of observable area for each alternative that can be viewed by attendants is as follows:

Alternative 1: 55%

Alternative 2: 55%

Alternative 3: 65%

Alternative 4: 45%

Alternative 5: 45%

FISCAL OBJECTIVES

Capital Costs

Capital costs for each alternative were estimated using Means' Building Construction Cost Data 1977 (26) as a source for unit costs for various types of construction and labor. These estimates are somewhat speculative, as they are based on square footage costs, including overhead, profit, and contingencies for municipal buildings. Either median or 75th percentile values were used, depending on the situation. Capital cost calculations are summarized in Appendix F.

Labor Costs

Each alternative would probably require the same number of employees, thus the labor costs would be the same.

Maintenance Costs

Although the alternative plans have different floor space, it is expected that net maintenance costs would be about the same. The extra space provided in some alternatives would be used for concessions, whose rental fees could pay for the additional maintenance.

User Costs

As in the previous evaluation, no user costs were calculated, due to the difficulties involved in establishing a reliable value for travel time during transfers in this specific location.

Finance Costs

The cost of financing a renovation project is determined by the type of financing, the cost of the project, current economic conditions, and other factors. Financial aspects could determine plan selection, depending on the choices available.

Scheduling Costs

Scheduling refers to the sequence of the various stages and the time required for the renovation construction project. Disruption of the terminal caused by renovation construction results in such costs as passenger delay, orientation, noise, longer walk paths, etc. All inconveniences caused by renovation are included as scheduling costs here. In general, the longer the project takes, the higher the scheduling costs. Possible schedules for the various alternatives can therefore affect plan selection.

Income

Non-transportation income (concessionaires, advertising, etc.) is roughly the same for each alternative.

DESIGN FLEXIBILITY OBJECTIVES

Expansion

There is very little potential for expansion in any of the designs, except for Alternatives 4 and 5, which could be expended to handle additional bus routes.

Reduction

All the alternatives are about equal in their potential for closing off seldom used areas. Alternatives 4 and 5 have the added advantage of easily closing off the bus platforms.

Joint Development

The only plan providing for joint development that interfaces the terminal, but is not congruent with it, is Alternative 4. An office building with 100,000 square feet of office space might be a possible joint development project (14).

COMMUNITY OBJECTIVES

Local Traffic Impacts

Alternative 5 is the only design that can substantially improve traffic flow on West Chester Pike. Bringing all street bus stops into the terminal would result in smoother flow of automobile traffic.

Growth

The area around the terminal has been declining slowly for the past several years, due to new developments farther out in the suburbs. Economic growth would probably be desirable in the area. The more extensive the renovation, the more likely that economic growth in the area will result. The alternatives become more extensive in the order of 1 to 5.

Local Disruption

The more extensive the renovation, the greater local disruption will be. However, because of the large size of the site, disruption of non-user activities would probably be minimal.

FACTOR PROFILE PREPARATION

A factor profile was prepared for each interest group by combining the information from the previous section with estimates of the limits of objective attainment. These estimates were based on one or more of the following: SEPTA standards and guidelines, present conditions, and/or speculation. The limits are included on the factor profiles so that the decision makers can judge their reasonableness (see Tables 7.4 through 7.7).

USER EVALUATION

Dominance Analysis

From the users' point of view, Alternative 5 dominates Alternative 4, because with Alternative 5, the resulting level of system goals attainment is always greater than or equal to that provided by Alternative 4. Therefore, Alternative 4 may be dropped from the user evaluation. All the other alternatives have at least one intersection with each other alternative in the profiles, indicating tradeoffs between them.

Tradeoff Analysis

The following tradeoff analysis was conducted by making paired comparisons between the non-dominated alternatives. For this analysis the incremental differences between the two alternatives were examined.

Alternative 1 vs. 2. The following list presents the advantages of each alternative.

Alternative 1	Alternative 2
1. provides slightly better supplementary services	1. provides a 0.7% greater improvement over present station aggregate walk time
	2. slightly reduces conflicts at Node 24
	3. lessens path choice complexity by about 30%
	4. provides a more unified visual theme

It is reasonable to assume that users would prefer Alternative 2 to Alternative 1.

Alternative 2 vs. 3. The preferred alternative from the first comparison is now compared to the next alternative.

Alternative 2	Alternative 3
1. lessens path choice complexity slightly	1. provides an 8.1% greater improvement in present station aggregate walk time
2. slightly safer due to fewer stairways	2. slightly reduces conflicts at Node 24
3. requires slightly fewer level changes	3. eliminates areas totally exposed to weather
4. provides slightly more concession space	4. makes 10% more of floor space observable

The advantages of Alternative 2 are all slight, whereas three of the advantages of Alternative 3 are substantial and are in areas which may be more important to most users. It is reasonable to assume that users would prefer Alternative 3.

Alternative 3 vs. 5. The preferred alternative from the second comparison is now compared to the last alternative.

Alternative 3	Alternative 5
1. lessens path choice complexity slightly	1. provides a 26.9% greater improvement in aggregate walk time
2. slightly safer due to few stairs	2. eliminate conflicts at Node 24
3. provides slightly more concession space	3. provides better entry control
4. makes 20% more of all floor space observable	4. slightly fewer level changes
	5. provides a more unified architectural theme
	6. an additional 17% of the terminal floor area enclosed from the weather

It is reasonable to assume that users would prefer Alternative 5 to Alternative 3.

User Preference

It is concluded from the above comparisons that the user's order of preference would be: Alternative 5, followed by Alternatives 3, 2, and then 1.

SPECIAL USER EVALUATION

Dominance Analysis

The only additional objective of interest to special users that was not of concern to users is Objective 9: Minimize Physical Barriers. Since there is no significant difference between Alternatives 4 and 5 for this objective, Alternative 4 is again dominated by Alternative 5.

Tradeoff Analysis

Since the attainment of Objective 9 is equal for Alternatives 1, 2 and 3 and greater for Alternative 5, the order of preference for special users is the same as that for users.

Special User Preference

It can be concluded that special users would prefer Alternative 5, followed by Alternatives 3, 2 and then 1.

OPERATOR EVALUATION

Dominance Analysis

It is clearly shown in the Operator Factor Profile (Table 7.4) that Alternatives 1 and 5 are dominated by Alternative 4; while Alternative 1 is dominated by Alternative 3.

Tradeoff Analysis

Alternative 3 vs. 4.

Alternative 3	Alternative 4
1. $1.0 million savings in capital costs	1. capacity for expanding or reducing bus platform areas
	2. provides space for joint development

The pressing needs for funds in other parts of SEPTA's operations and the uncertainty of return from a joint development venture will probably override the more remote community's objective of station development. The operator would probably prefer Alternative 3 to Alternative 4.

Operator Preference

It can be concluded that the operator would prefer Alternative 3, followed by Alternative 4. The other alternatives come next, although they are all dominated by either Alternative 3 or 4.

NON-USER EVALUATION

Dominance Analysis

It can be clearly seen in the Non-User Factor Profile (Table 7.5) that Alternative 1 is dominated by both Alternatives 3 and 4.

Tradeoff Analysis

Alternative 2 vs. 3.

Alternative 2	Alternative 3
1. provide a degree of historic restoration	1. $500,000 savings in capital costs
	2. more likely to promote economic growth in local community

Since the station has not received much attention related to its historical value, it is reasonable to assume non-users would prefer Alternative 3.

Alternative 3 vs. 4

Alternative 3	Alternative 4
1. a saving of $1.0 million in capital costs	1. provides space for joint development
	2. more likely to promote economic growth in local community
	3. provides for flexibility to expand or reduce bus platform areas

In determining whether a capital cost savings of $33,000 per year over a 30-year life might be more important than the improved economic growth and income that might result from joint development, the non-users, most of whom do not live in the local community, would probably prefer the former and therefore would choose Alternative 3 over Alternative 4.

Alternative 3 vs. 5

Alternative 3

1. saves $2.5 million in capital costs

Alternative 5

1. provides a more unified theme
2. provides flexibility to expand or reduce bus platform areas
3. improve traffic flow on West Chester Pike
4. more likely to promote growth in local community

As before, it is assumed that Alternative 3 has a slight edge, because most non-users, who would share in the cost, do not live in the local community and would prefer a less costly project.

Alternative 4 vs. 5. In order to determine which alternative has second preference, Alternatives 4 and 5 must be compared.

Alternative 4

1. saves $1.5 million in capital costs
2. provides space for joint development

Alternative 5

1. provides a more unified theme
2. improve traffic flow on West Chester Pike
3. more likely to promote economic growth in local community

To be consistent with the previous decisions, a slight edge must be given to Alternative 4.

Non-user Preference

Non-users would prefer Alternative 3, followed closely by Alternatives 4 and 5, then more distantly by Alternatives 1 and 2.

PLAN SELECTION

In order for the decision makers to select an alternative plan, the preferences of all four interest groups must be considered (see Table 7.3)

TABLE 7.3

GROUP PREFERENCES FOR NON-DOMINATED ALTERNATIVES

	User	Special User	Operator	Non-User
Most preferred alternative	5	5	3	3
	3	3	4	4
	2	2		5
Least preferred alternative	1	1		2

Since all the interest groups do not agree on one best alternative, a compromise must be pursued.

<u>Alternative 3 Selected on Compromise</u>

Since Alternative 3 is either the first or second choice of every group, it is the most acceptable compromise and is adopted as the chosen plan for this study.

If Alternative 3 had not been a possible choice, the dominated alternatives would have to be ranked in order to investigate other compromises.

If no compromise can be reached, the alternative generation and evaluation steps would have to be reiterated in order to find an alternative acceptable to all interest groups.

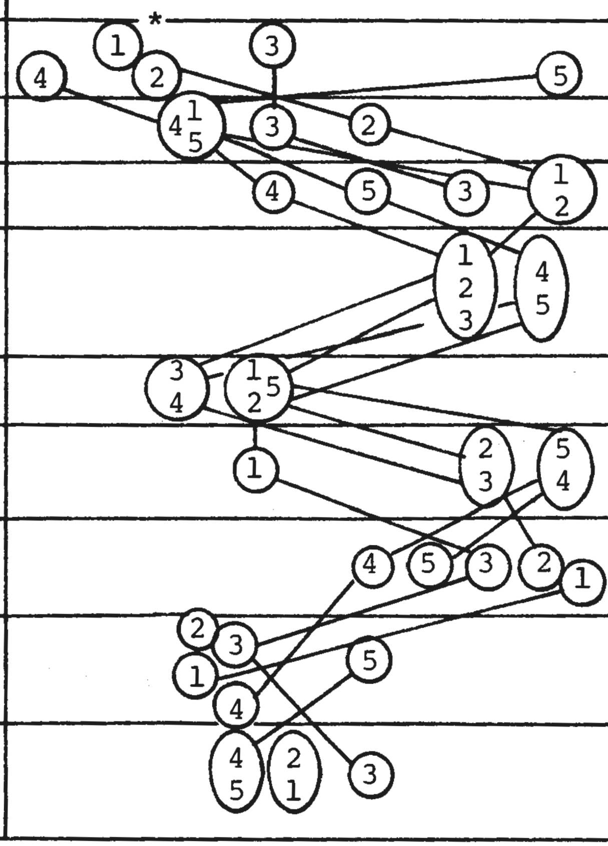
REFINEMENT OF THE SELECTED RENOVATION PLAN

After Alternative 3 is selected, modifications which might improve this renovation plan should now be considered. In addition, design features or plan specifications previously overlooked can now be evaluated. Modifications are explored to: (1) reduce delay and movement conflict at one problem location; (2) lower evacuation time to meet SEPTA standard; (3) explore different bus platform arrangements to accommodate additional bus stops; (4) improve equipment reliability; (5) reduce transit noise; and (6) improve orientation.

TABLE 7.4

USER FACTOR PROFILE: FIVE ALTERNATIVES

Objective	Worst Expected or Unacceptable Value	← Non-Attainment / Attainment →	Best Expected or Acceptable Value	Unit of Measure
2. Minimize Travel Impedances	9,000		4,000	aggregate walk time min.
4. Minimize Disorientation	10		1	Maximum D_{ij}
5. Maximize Safety	--		--	Descriptive
7. Provide for Efficient Fare Collection and Entry Control	--		--	Descriptive
8. Minimize Level Changes	5		0	Changes per path
14. Provide Aesthetic Quality	--		--	Descriptive
15. Provide Supplementary Services	--		--	Descriptive
16. Provide Protection from Weather	100% Open		100% Fully Enclosed	% fully % part % open
17. Provide Adequate Security	0%		100%	% area in view of attendants



*Number in circle represents the degree of attainment of that alternative.

TABLE 7.5

SPECIAL USER FACTOR PROFILE: FIVE ALTERNATIVES

Objective	Worst Expected or Unacceptable Value	← Non-Attainment / Attainment →	Best Expected or Acceptable Value	Unit of Measure
9. Minimize Physical Barriers	--	(1 2 3) (4 5)	--	Descriptive

NOTE: Alternative attainment value relationships for special users are the same as those for users for the following objectives:

14. Provide Aesthetic Quality
15. Provide Supplementary Services
16. Provide Protection from Weather
17. Provide Adequate Security

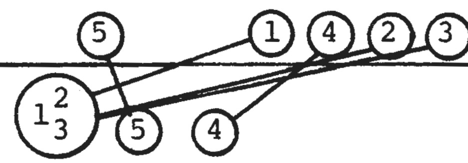
Alternative attainment value relationships for special users are similar to those of users but somewhat lower for the following objectives:

2. Minimize Travel Impedances
4. Minimize Disorientation
5. Maximize Safety
7. Provide for Efficient Fare Collection and Entry Control
8. Minimize Level Changes

TABLE 7.6

OPERATOR FACTOR PROFILE: FIVE ALTERNATIVES

Objective	Worst Expected or Unacceptable Value	← Non-Attainment / Attainment →	Best Expected or Acceptable Value	Unit of Measure
18. Minimize Costs	$6 million		$1 million	Dollars
21. Provide Design Flexibility	--		--	Descriptive

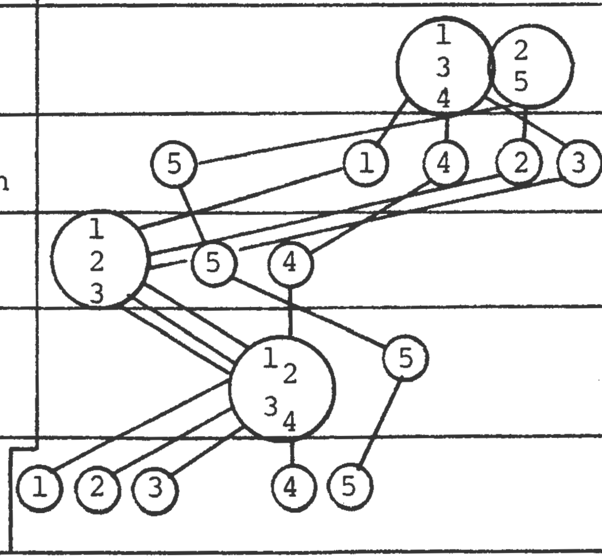


NOTE: Security of fares is the same for all alternatives. Separate spaces are the same as those for users.

TABLE 7.7

NON-USER FACTOR PROFILE: FIVE ALTERNATIVES

Objective	Worst Expected or Unacceptable Value	← Non-Attainment / Attainment →	Best Expected or Acceptable Value	Unit of Measure
14. Provide Aesthetic Quality	--		--	Descriptive
18. Minimize Costs -capital	$6 million		$1 million	Dollars
21. Provide Design Flexibility	--		--	Descriptive
22. Minimize Impacts on Local Traffic			--	Descriptive
23. Promote Desired Growth	--		--	Descriptive



Reduce Delay and Movement Conflict

Delays incurred by users disembarking from the subway-elevated could be reduced. The doors in this corridor (Link 32-24) are the primary features controlling the capacity. The stairs (Links 18-32 and 17-32) are the secondary capacity controling features.

Increasing the capacity of the corridor by increasing the width of the doors and stair would have the drawback of increasing the probability of conflicts. Therefore, in order to reduce exit times as well as conflicts, width of the doors, stairs and corridor must be increased. An alternative to increasing the existing corridor width is to provide an additional corridor.

Increasing the existing corridor width would require the demolition of a load bearing exterior wall. This would be costly and structurally difficult. The other more viable alternative of providing an additional corridor would require building an elevated corridor to the west of the existing corridor (Link 32-24). The cost of building this would be about $133,000 with an escalator access or $88,000 with a stairway access. With stairs, the capacity of the subway-elevated's main exit would be doubled, and an 18 percent reduction reallized in aggregate transfer time. However, conflicts would not be reduced during capacity flows, but the time duration in which severe conflicts occur would be reduced by about 50 percent.

Lower Evacuation Times

With the addition of the proposed corridor, evacuation times would be reduced to 3.7 minutes for a full train. However, if any of the three exits were blocked, SEPTA's 4.0 minute standard would still be exceeded.

The provision of an emergency exit from the subway-elevated unloading patform to the outside, east of the Norristown Highspeed Line waiting room, would assure the attainment of SEPTA's 4.0 minute evacuation standard. Four emergency exit doors, along with any other single exit, would meet the SEPTA standard.

Accommodate Additional Bus Stops

Four additional bus stops could be added to the bus area if the six sawtooth platforms were replaced by ten straight ones. The disadvantage of the straight platforms is that buses cannot pass each other, which increases delays. Also, in order to provide for buses arriving with short headways, the first buses would have to pull all the way forward, resulting in the elimination of assigned platforms. This might cause user disorientation and crowding at the forward end of the bus platforms.

Improve Equipment Reliability

In order to install reliable equipment, it is necessary to determine down time rates for various components. These determinations could be based on past experiences and information given by equipment manufacturers. Poor record keeping and lack of information regarding manufacturer testing methods can make this determination difficult and unreliable.

One way to greatly increase reliability is to install redundant mechanical devices. The primary mechanical devices that patrons must use at the terminal are doors and turnstiles. These devices are reliable and easily repaired. If one were to break down in the present terminal, it would not create a major problem or delay, except where only two doors are provided. In most cases, there is adequate space to install four doors.

Reduce Transit Noise

Although methods have been suggested to reduce transit noise (35), noise control within stations appears to be a difficult problem, due to platform requirements. Wheel and air brake noise exceeds SEPTA standards, and ways of reducing this noise should be investigated. Bus noise is also a problem. It is probably more appropriate to solve these problems on a system-wide basis, such as looking to newer vehicles.

Improve Orientation

A wall map of the surrounding area could be provided in the main lobby for better orientation, as well as a gesture of the station's good will.

SUMMARY

This concludes the demonstration of a general transit station design methodology by tracing the selection and refinement of a renovation plan for SEPTA's 69th Street Terminal. The next phase would require detailed architectural and structural design plans and specifications, in addition to detailed cost and finance estimates. This would be undertaken by SEPTA if the station were actually to be renovated.

CHAPTER 8

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSION

This study has selected an existing station--the 69th Street Terminal--to demonstrate the General Methodology's applicability in a renovation exercise. Information on the physical characteristics of the station, type of transit lines the station serves and passenger volumes of the station is obtained. Applying the steps prescribed by the General Methodology, a complete evaluation, based on relevant objectives, is made on the existing station. Problem areas are identified in this process. The structural, operational, and fiscal constraints applicable to a renovation plan is then defined. Using these problem areas and constraints as guidelines, five alternative plans are generated, and a complete evaluation of the performance of each is executed. The five plans are then compared and ranked in order of preference for each interest group. The "best" plan--Alternative 3--is selected, based on a compromise of these ranked preferences. Refinements and modifications are explored to improve and complete the chosen plan.

METHODOLOGY APPLICATION

It is concluded that this case study has demonstrated that the General Methodology can be applied to the renovation of a transit station. That application culminated in the selection of a renovation plan for SEPTA's 69th Street Terminal. Since decision makers were not actually involved in this process, the selected renovation plan is not necessarily the plan that would have been selected by the terminal's operator.

METHODOLOGY REFINEMENT

It is recommended that non-users be considered as an additional interest group in the evaluation process proposed by the General Methodology. This recommendation is made because some of SEPTA's basic goals lead to objectives which are of particular interest to non-users.

Because of the complex and varied elements of transit station planning and design, the General Methodology was developed with much built-in flexibility. In keeping with this idea, it is recommended that the use of factor profiles should be considered as an optional alternative to the use of numerical evaluation matrices. This recommendation is made because the use of factor profiles (1) facilitates dominance analysis, (2) facilitates interpretation of magnitude differences through visual means, (3) facilitates comparisons between criteria with regard to objective attainment, and (4) presents the expected limits of attainment.

It is also recommended that the use of paired comparisons be considered as an optional alternative to the use of utility indices for comparison and selection among alternatives.

NEEDED RESEARCH

In order to improve the presented methodology, it is recommended that additional research be conducted in the following areas of the evaluation process: (1) impact assessment, (2) project life, and (3) uncertainty.

Impact Assessment

The assessment of renovation impacts is in its infancy and tends to be descriptive. Careful studies of stations before and after renovation could lead to extensive knowledge of impacts and impact relationships. When more of these impacts can be measured quantitatively and described by mathematical models, better evaluations will be possible.

Project Life

Evaluations can be greatly improved by considering cost and effectiveness over the continuous life of the renovation. This consideration will require continuous and fairly accurate demand forecasts. Looking at costs over time rather than costs for a single point in time will improve the analysis. Also, the possibility of changing values, and therefore changing goals and objectives, over time should be investigated.

Uncertainty

Because station renovations last for 30 or more years, considerable uncertainty exists as to the life of each alternative. Research is needed to determine how this uncertainty can be incorporated into the cost-effectiveness evaluation, so that the decision makers can understand its implications for alternative selection.

With additional research in the above areas, better renovation investment decisions should be possible.

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APPENDICES

Appendix A

EVALUATION OF EXISTING TERMINAL

Appendix B

FRUIN'S LEVEL OF SERVICE STANDARDS

Appendix C

LOCAL TRAFFIC CONDITIONS

Appendix D

SEPTA POLICY GUIDELINES THAT PERTAIN TO THIS TERMINAL

Appendix E

ALTERNATIVE PLANS NETWORKS AND ANALYSIS

Appendix F

CAPITAL COST SUMMARY FOR EACH ALTERNATIVE

APPENDIX A

EVALUATION OF EXISTING TERMINAL

APPENDIX A.1

PASSENGER PROCESSING EVALUATION

METHODS

There are two basic ways of calculating performance measures for a passenger processing system, that is, by manual technique or by computer simulation.

The manual technique utilizes steady-state formulas. The computer simulation utilizes the UMTA Station Simulation Program (USS). Because the USS model was still in the refinement and documentation stage at the start of the demonstration, the manual technique was used.

MANUAL METHOD

The manual method for passenger processing evaluation presented by the General Methodology (3) includes the following steps:

1. Define the system as a Link-Node Network
2. Determine pedestrian volumes for each path
3. Determine path choice
4. Load inbound passengers onto the network
5. Load outbound passengers onto the network
6. Determine walk times and crowding on links
7. Determine queuing times and crowding at nodes
8. Determine wait times for transit vehicles
9. Summarize performance measures for criteria

How each step is carried out will be explained in the following sections.

1. Define the System as a Link-Node Network

Paths passengers take through the terminal (origin-destination pairs) are systemized into a network of links and nodes (see Figure A.1.1 and Table A.1.1).

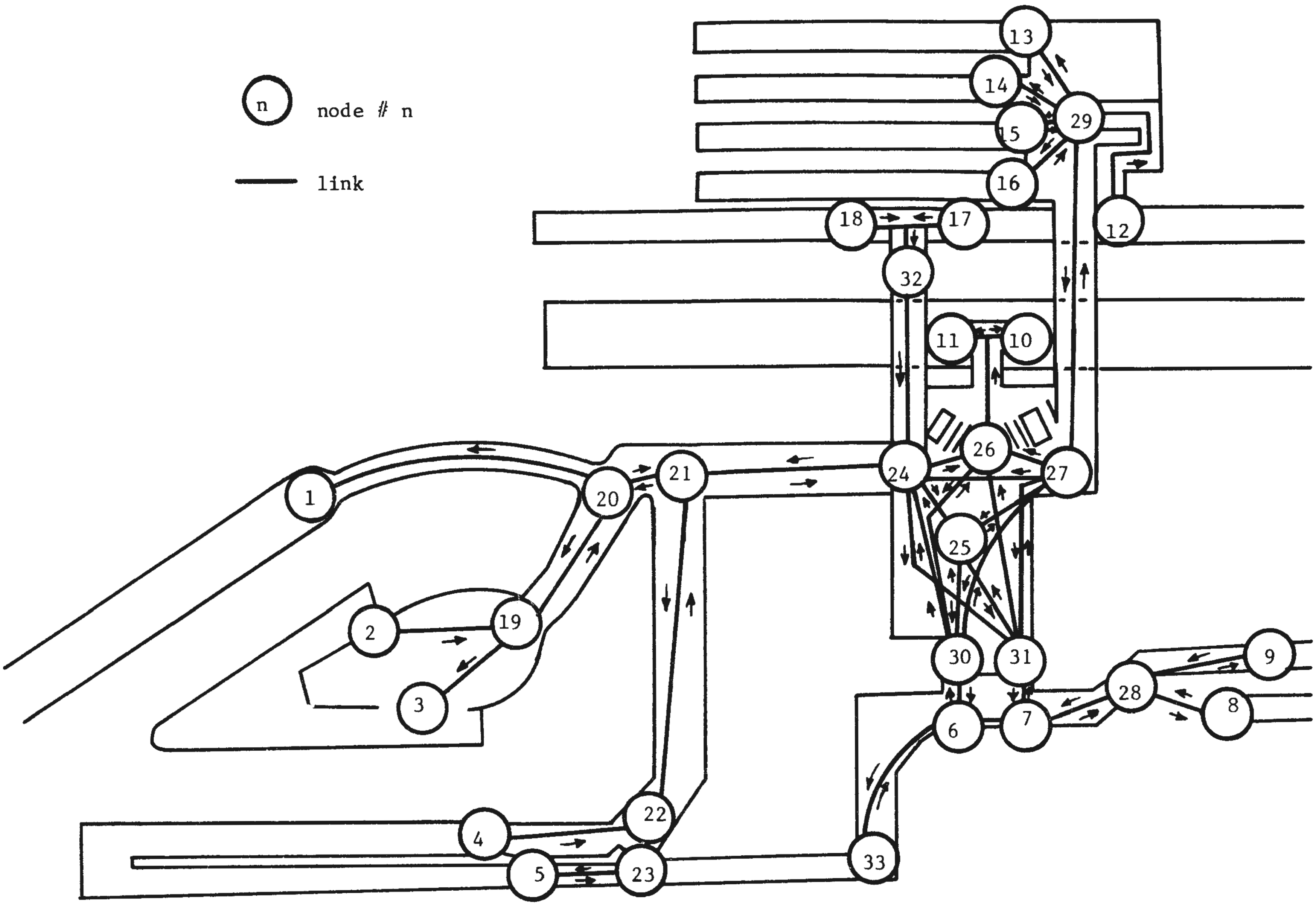


Figure A.1.1. Link Node Network for 69th Street Terminal

TABLE A.1.1

PRESENT STATION NETWORK - NODES

Node	Description
1	Door to loading platform
2	Door from unloading platform
3	Door to loading platform
4	Platform - ramp interface
5	Beginning of bus waiting
6	Sidewalk decision point
7	Sidewalk decision point
8	Bus platform
9	Bus platform
10	Sub-el platform, east end (inbound)
11	Sub-el platform, west end (inbound)
12	Sub-el outbound platform exit
13	Door to Norristown Line platform
14	Door to Norristown Line platform
15	Door to Norristown Line platform
16	Door to Norristown Line platform
17	Sub-el platform, east and exit (outbound)
18	Sub-el platform, west and exit (outbound)
19	Corridor entrance/exit
20	Decision point
21	Decision point
22	Decision point
23	Decision point
24	Decision point
25	Change/ticket booth
26	Fare collection gates for sub-el
27	Decision point
28	Decision point
29	Norristown waiting area, decision point
30	Left main door into lobby of PTC building
31	Right main door into lobby of PTC building
32	Top of stairs, sub-el exit
33	Sidewalk - crosswalk interface

Each link, being a passageway, can be described by four elements: (1) type--whether it's a level walkway, ramp or flight of stairs, (2) movements allowed--whether it's one-way or two-way, shared or not shared, (3) length, and (4) minimum width (see Table A.1.2).

Nodes are queuing points and/or decision points. They are typically fare collection devices, doors, platform entrances or exits and junctions of paths (see Table A.1.1).

Any likely path passengers might take through the terminal can therefore be described by a series of links and nodes.

2. <u>Determine Pedestrian Volumes for Each Plan</u>

In 1971 a study of the terminal was conducted for the Delaware Valley Regional Planning Commission (DVRPC), which calculated peak 60 and peak 10 minute volumes for all terminal origin-destination pairs. Each origin-destination pair, represented by a series of links and nodes and its corresponding volumes, is presented in Table A.1.3.

According to the 1971 consultant study (14), Philadelphia-bound (inbound) passengers using the subway-elevated train from the terminal averaged 22,900 per day in 1960 and 18,000 per day in 1970. The study also estimated 1985 inbound passengers at about 22,500 per day. To establish some relationship between these figures and those of the 1971 counts (15), the 1971 daily volume was assumed to be the same as that for 1970. The expected increase in inbound ridership from 1971 to 1995, then, is about 25 percent. If the terminal remains unchagned and the relative volumes on all modes remains unchanged, then the 1985 link volumes will be 125 percent of the 1971 link volumes. The above assumptions are reasonable in view of the unlikelihood of substantially more development in one specific area than the terminal's access mode now serves.

The 1985 planning horizon was used because the estimates were available. If this was an actual redesign of the terminal rather than a methodology demonstration, a planning horizon of 20 to 30 years would have been selected. In any case, this will illustrate changes of the terminal's performance if no action is taken before 1985.

3. <u>Determine Path Choice</u>

Because origin-destination (O-D) pairs were calculated in the 1971 study, path choice criteria did not need to be selected at this time. Passenger volume on each link and node can be determined directly from the O-D data.

TABLE A.1.2

PRESENT STATION NETWORK - LINKS

Link	Type	Movement	Length (feet)	Width (min.) (feet)
1-20	1-8% to 1	1-way	150	7.8 at doors
2-19	D-6% to 19	1-way shared	50	9.6 at doors
3-19	1-6% to 3	1-way shared	50	9.2 at doors
4-22	D-6% to 22	1-way	175	6.0 at doors
5-23	level	1-way	150	11.6
6-7	level	2-way	25	13.3
6-30	stairs	2-way	15	4.8 at doors
6-33	level	2-way	80	13.3
7-28	level	2-way	100	7.5
7-31	stairs	2-way	15	4.8 at doors
8-28	level	2-way	25	7.5
9-28	level	2-way	30	7.5
10-26	stairs	1-way shared	25	10.3
11-26	stairs	1-way shared	25	10.3
12-29	stairs	1-way	45	5.8 at doors
13-29	level	2-way shared	25	8.7 at doors
14-29	level	2-way shared	20	8.7 at doors
15-29	level	2-way shared	15	8.7 at doors
16-29	level	2-way shared	10	11.2 at doors
17-32	stairs	1-way shared	25	6.5
18-32	stairs	1-way shared	25	6.5
19-20	I-6% to 19	2-way	25	6.5
20-21	level	2-way	40	17.0 - 2.0*
21-22	I-6% to 22	2-way	175	12.5 - 2.6*
21-24	I-6% to 24	2-way	90	20.0
22-23	level	2-way	20	9.2 at doors
23-33	level	2-way	120	11.6
24-25	level	2-way shared	30	***
24-26	level	1-way shared	35	***
24-27	level	2-way shared	70	***
24-30	level	2-way shared	105	12.9
24-31	level	2-way shared	115	12.9
24-32	level	1-way	70	9.6 at doors
25-26	level	1-way shared	30	***
25-27	level	2-way shared	40	***
25-30	level	2-way shared	50	12.9
25-31	level	2-way shared	60	12.9
26-27	level	1-way shared	35	***
26-30	level	1-way shared	90	12.9
26-31	level	1-way shared	90	12.9
27-30	level	2-way shared	110	12.9
27-31	level	2-way shared	105	12.9
27-29	level	2-way	125	8.1 at doors

NOTES: ***These shared areas have no well-defined physical minimum limits.
**Lockers take up 2.6 feet on side of corridor.
*Trash cans take up 2.0 feet on side of corridor.

TABLE A.1.3

ORIGIN-DESTINATION PAIR VOLUMES

Origin-Destination	A.M. Peak		P.M. Peak	
Link Path	Hour	10-min.	Hour	10-min.
29-27-26	611	126	67	8
8/9-28-7-6-30-26	69	16	7	1
9-28-7-6-30-26	23	6	1	0
6-30-26	34	8	1	0
33-6-30-26	127	30	30	3
8/9-28-7-31-26	181	39	17	2
9-28-7-31-26	62	13	2	0
7-31-26	89	19	3	0
33-6-7-31-26	334	72	75	15
23-22-21-24-26	357	76	23	23
2-19-20-21-24-26	959	203	89	89
4-22-21-24-26	1581	334	138	138
5-23-22-21-24-26	547	116	81	81
12-29	161	27	648	223
8/9-28-7-6-30-27-29	4	1	1	0
9-28-7-6-30-27-29	1	0	0	0
6-30-27-29	2	1	0	0
33-6-30-27-29	8	2	5	1
33-6-7-31-27-29	20	4	11	2
8/9-28-7-31-27-29	11	2	3	1
9-28-7-31-27-29	4	1	0	0
7-31-27-29	5	1	1	0
23-22-21-24-27-29	21	4	4	4
2-19-20-21-24-27-29	57	12	16	16
4-22-21-24-27-29	94	19	25	25
5-23-22-21-24-27-29	32	7	15	5
9-28-7-6-30-24-21-22-23-5	1	0	0	0
8/9-28-7-6-30-24-21-22-23-5	2	0	3	0
6-30-24-21-22-23-5	1	0	1	0
33-6-30-24-21-22-23-5	3	1	13	2
9-28-7-31-24-21-22-23-5	2	0	1	0
8/9-28-7-31-24-21-22-23-5	5	1	8	2
7-31-24-21-22-23-5	2	0	1	0
33-6-7-31-24-21-22-23-5	8	2	32	6
32-24-21-22-23-5	56	10	468	110
12-29-27-24-21-22-23-5	1	0	28	7
29-27-24-21-22-23-5	16	3	35	4
9-28-7-6-30-24-21-20-19-3	2	0	1	0
8/9-28-7-6-30-24-21-20-19-3	7	2	8	1
6-30-24-21-20-19-3	2	1	1	0

Table A.1.3 (Cont'd)

Origin-Destination Link Path	A.M. Peak Hour	A.M. Peak 10-min.	P.M. Peak Hour	P.M. Peak 10-min.
33-6-30-24-21-20-19-3	12	3	32	3
9-28-7-31-24-21-20-19-3	6	1	2	0
8/9-28-7-31-24-21-20-19-3	17	4	19	3
7-31-24-21-20-19-3	8	2	4	1
33-6-7-31-24-21-20-19-3	31	7	82	16
32-24-21-20-19-3	207	36	1192	281
12-29-27-24-21-20-19-3	3	0	72	17
29-27-24-21-20-19-3	61	13	90	11
9-28-7-6-30-24-21-20-1	3	0	1	0
8/9-28-7-6-30-24-21-20-1	9	8	11	2
6-30-24-21-20-1	5	2	2	0
33-6-30-24-21-20-1	18	4	28	5
9-28-7-31-24-21-20-1	9	2	4	0
8/9-28-7-31-24-21-20-1	25	5	31	2
7-31-24-21-20-1	12	2	6	2
33-6-7-31-24-21-20-1	47	11	134	29
32-24-21-20-1	310	54	1874	441
12-29-27-24-21-20-1	5	0	114	27
29-27-24-21-20-1	86	18	145	18
9-28-7-6-30-24-21-22-23-5	1	0	0	0
8/9-28-7-6-30-24-21-22-23-5	2	1	4	0
6-30-24-21-22-23-5	1	0	1	0
33-6-30-24-21-22-23-5	5	1	13	2
9-28-7-31-24-21-22-23-5	2	0	1	0
8/9-28-7-31-24-21-22-23-5	6	1	8	1
7-31-24-21-22-23-5	3	1	1	0
33-6-7-31-24-21-22-23-5	12	3	32	7
32-24-21-22-23-5	78	13	474	112
12-28-27-24-21-22-23-5	22	4	65	11
23-22-21-24-30-6-7-28-9	1	0	3	0
2-19-20-21-24-30-6-7-28-9	4	1	11	1
4-22-21-24-30-6-7-28-9	3	1	8	1
5-23-22-21-24-30-6-7-28-9	2	1	10	1
4-22-21-24-30-6-7-28-9	3	0	9	1
32-24-30-6-7-28-9	9	2	120	29
29-27-31-7-28-9	3	1	9	1
23-22-21-24-30-6-7-28-8/9	19	4	11	1
2-19-30-21-24-30-6-7-28-8/9	50	11	43	5
4-22-21-24-30-6-7-28-8/9	40	8	33	4
5-23-22-21-24-30-6-7-28-8/9	29	9	39	5
4-22-21-24-30-6-7-28-8/9	43	6	34	4
32-24-30-6-7-28-8/9	116	20	438	103

Table A.1.3 (Cont'd)

Origin-Destination Link Path	A.M. Peak Hour	A.M. Peak 10-min.	P.M. Peak Hour	P.M. Peak 10-min.
12-29-27-31-7-28-8.9	2	0	26	6
29-27-31-7-28-8.9	32	7	33	4
23-22-21-24-30-6	5	1	2	0
2-19-20-21-24-30-6	13	3	8	1
4-22-21-24-30-6	10	2	6	1
5-23-22-21-24-30-6	7	2	8	1
4-22-21-24-30-6	11	2	7	1
32-24-30-6	29	5	91	21
29-27-31-7	8	8	6	1
23-22-21-24-30-6-33	20	4	22	3
2-19-20-21-24-30-6-33	54	11	88	12
4-22-21-24-30-6-33	43	9	67	9
5-23-22-21-24-30-6-33	31	10	80	9
4-22-21-24-30-6-33	47	7	69	11
32-24-30-6-33	126	22	907	213
12-29-27-30-6-33	2	0	55	13
29-27-30-6-33	35	7	68	9

4. Load Inbound Passengers Onto the Network

5. Load Outbound Passengers Onto the Network

Ten-minute peak hour volumes from each O-D pair were assigned to the appropriate links. The loaded morning peak 10-minute network volumes and the loaded afternoon peak 10-minute network volumes are presented in Figures A.1.2 and A.1.3 respectively.

6. Determine Walk Times and Crowding On Links

In order to calculate the walk times and crowding measures on a link, the flow on that link must be adjusted to reflect the micro-peak. This adjustment is made by using a surge factor of 1.3 for the peak 10-minute volumes.

Effective widths of links and nodes are the actual minimum widths or doorway widths. When a wall existed on one side of the corridor, 1.5 feet were subtracted. Two feet were subtracted for obstructions placed in corridors, such as trash cans and lockers. One foot was subtracted for walls in stairwells because users on the outside often use the handrail. Three additional feet were subtracted to compensate for two-way movements on stairs.

The adjusted flow was then divided by the effective width to determine the number of pedestrians per foot width per minute (PFM). The level of service was then found graphically from Figure A.1.4. The average space mean speed for each level of service was then read off from graph in Figure A.1.5. The average walk times were obtained by dividing corridor length by pedestrian speed.

Levels of service for stairways were found in the same way as for corridors using Figure A.1.6. Speeds on stairways vary, depending on directions, as shown in Figures A.1.7 and A.1.8. These speeds are for the horizontal distance covered by the stairs. On two-way stairs, the major flow was used to determine direction.

Aggregate walk times were calculated for the 10-minute morning and 10-minute afternoon peak periods and presented in Tables A.1.4 and A.1.5 respectively. The average morning walk time for all passengers was 1.5 minutes in 1971 and predicted to be 1.8 minutes in 1985. The average afternoon walk time was 1.8 minutes in 1971 and predicted to be about the same in 1985. The five most often used paths account for 56 percent of total morning peak volume and 58 percent of the total afternoon peak volume.

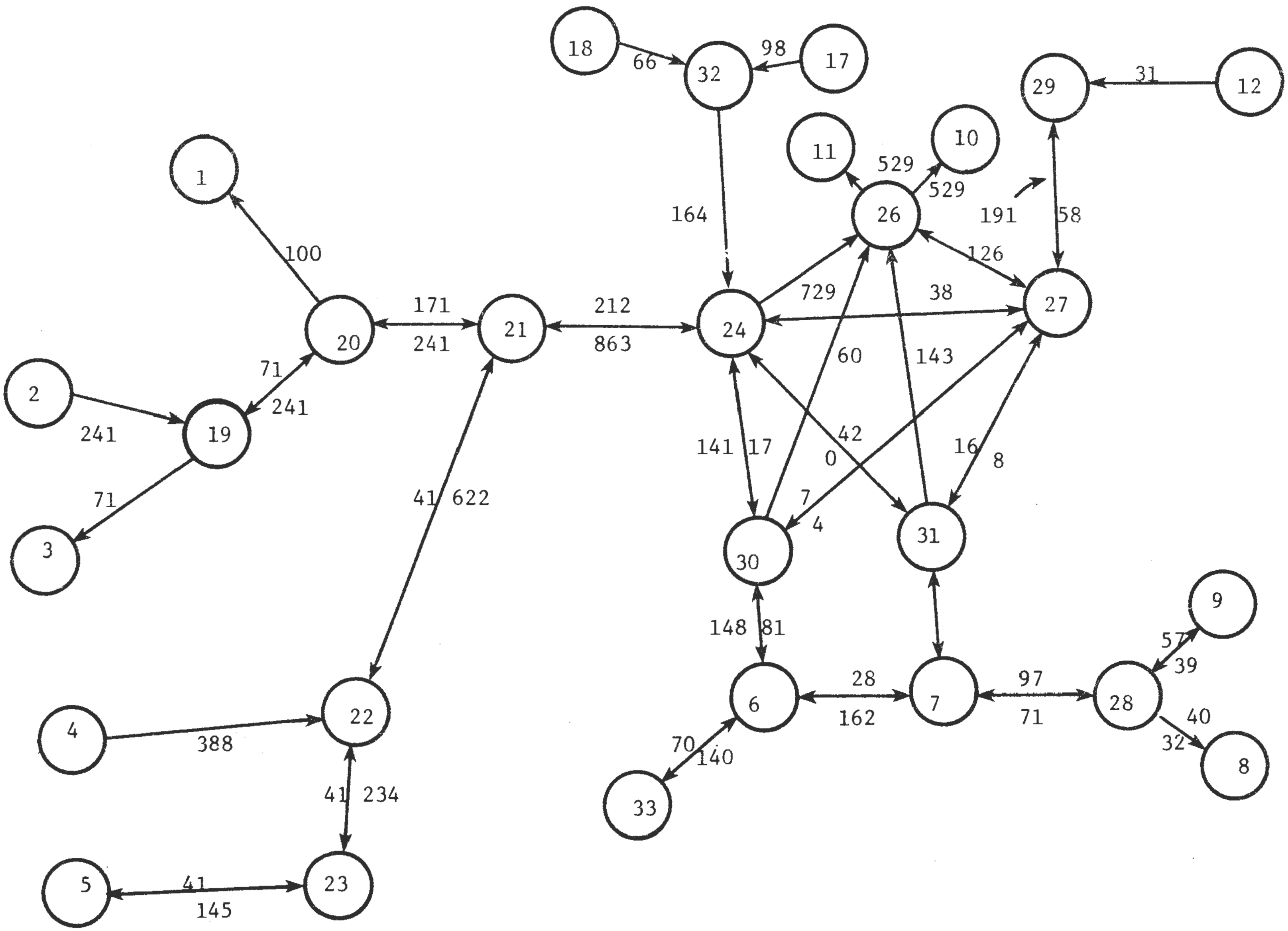


Figure A.1.2. Loaded Network - Morning Peak 10-Minutes

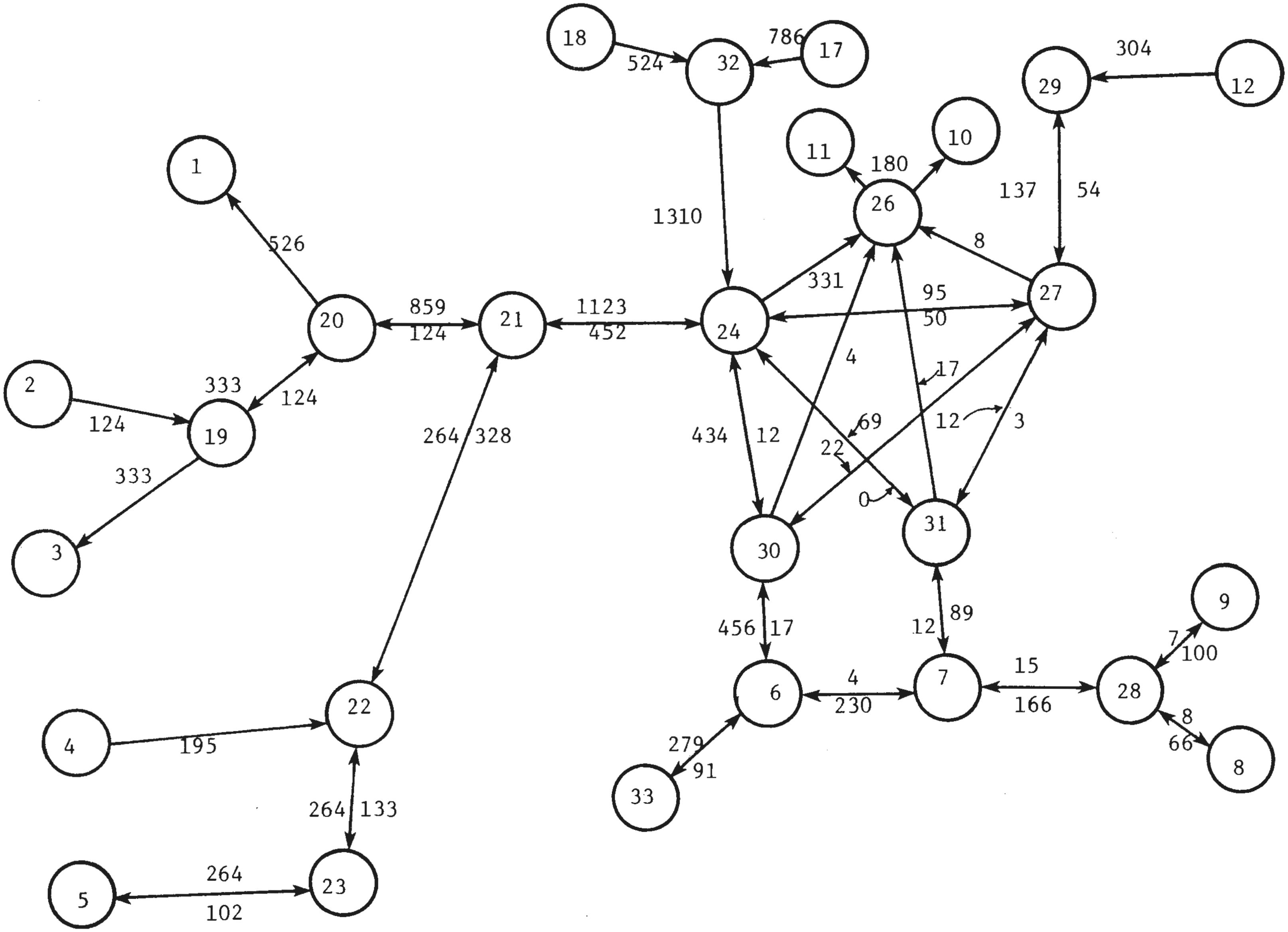
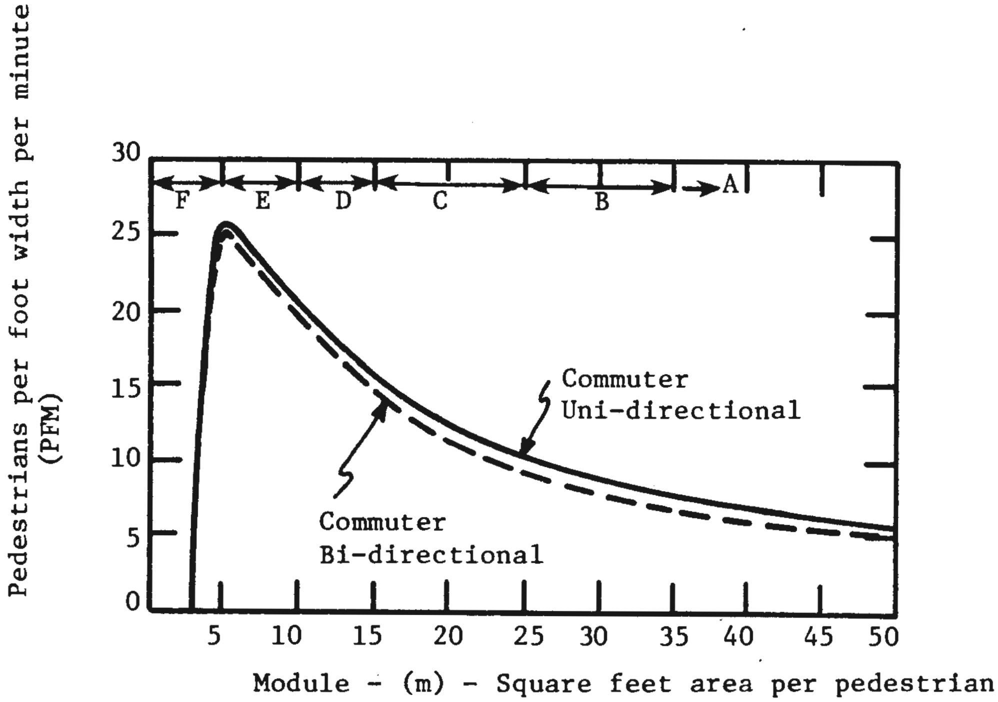
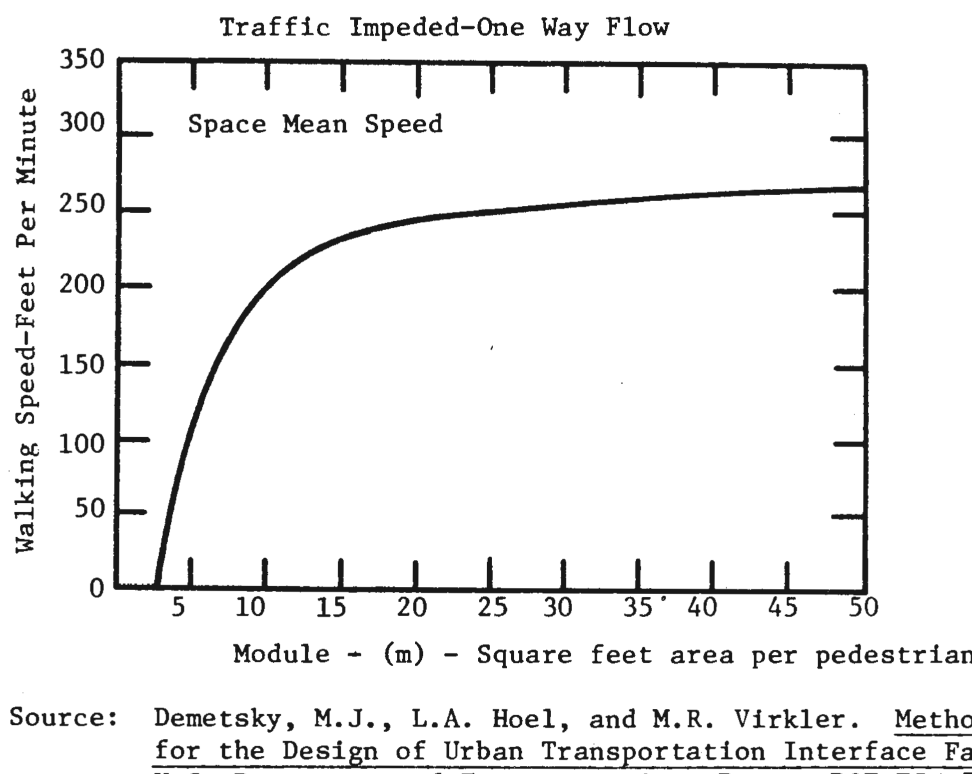


Figure A.1.3. Loaded Network - Afternoon Peak 10-Minutes



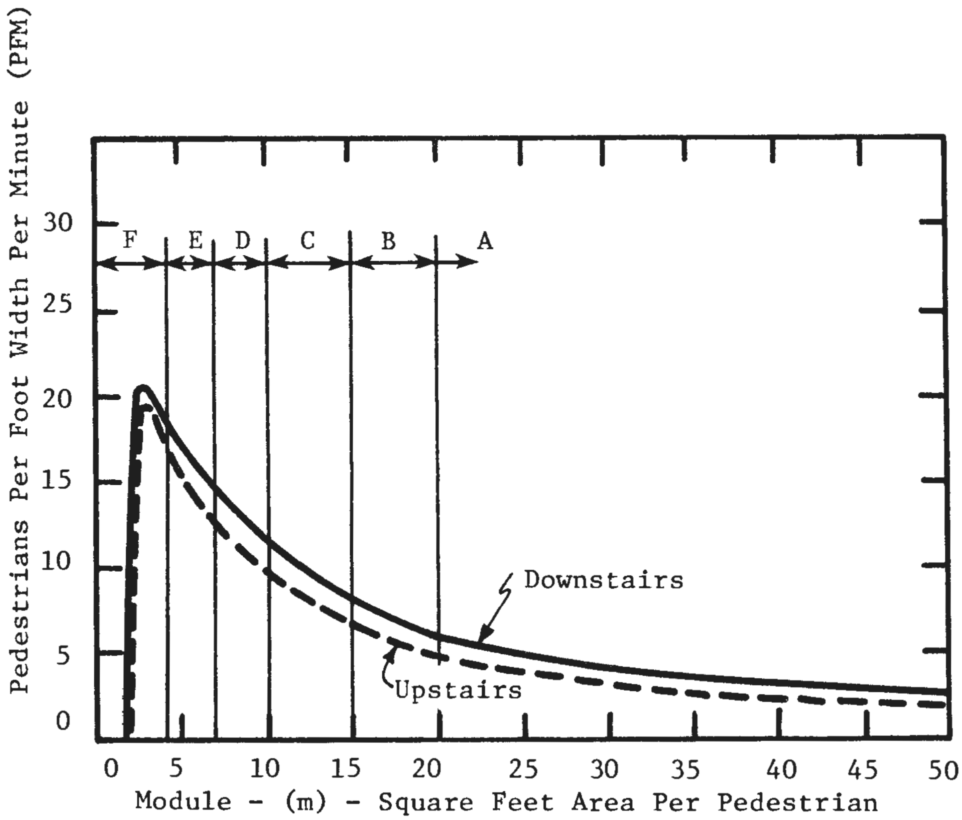
Source: Demetsky, M.J., L.A. Hoel, and M.R. Virkler. Methodology for the Design of Urban Transportation Interface Facilities. U.S. Department of Transportation, Report DOT-TST-77-46, December 1976.

Figure A.1.4. Level of Service Standards for Walkways.



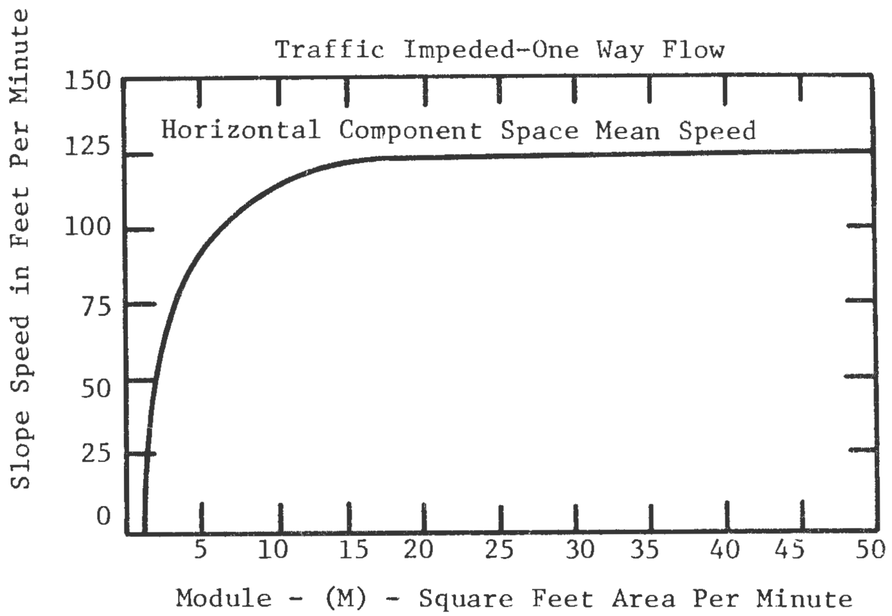
Source: Demetsky, M.J., L.A. Hoel, and M.R. Virkler. Methodology for the Design of Urban Transportation Interface Facilities. U.S. Department of Transportation, Report DOT-TST-77-46,

Figure A.1.5. Pedestrian Speed on Walkways.



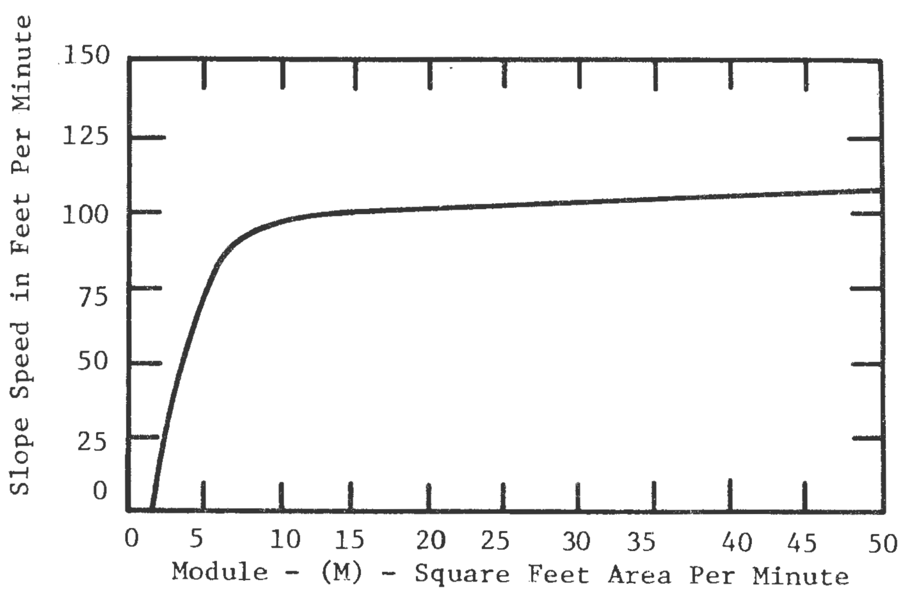
Source: Demetsky, M.J., L.A. Hoel, and M.R. Virkler. Methodology for the Design of Urban Transportation Interface Facilities. U.S. Department of Transportation, Report No. DOT-TST-77-46, December, 1976.

Figure A.1.6. Level of Service Standards for Stairways.



Source: Demetsky, M.J., L.A. Hoel, and M.R. Virkler. Methodology for the Design of Urban Transportation Interface Facilities. U.S. Department of Transportation, Report No. DOT-TST-77-46, December, 1976.

Figure A.1.7. Pedestrian Speed Downstairs.



Source: Demetsky, M.J., L.A. Hoel, and M.R. Virkler. Methodology for the Design of Urban Transportation Interface Facilities. U.S. Department of Transportation, Report No. DOT-TST-77-46, December, 1976.

Figure A.1.8. Pedestrian Speed Upstairs.

TABLE A.1.4

PRESENT MORNING WALK TIMES

Link (x,y)	10-minute Peak Volume (persons) 1971	1985	Adjusted Flow (P/M) 1971	1985	Effective Width (feet)	Level of Service 1971 (PFM) Letter	1985 (PFM) Letter	Speed on Link (ft/min) 1971	1985	Length (feet)	Walk Time On Link (min.) 1971	1985	Aggregate 10-minute Walk Time (F-minutes) 1971	1985
1-way level or ramp														
20-1	100	125	13	16	7.8*	1.6 A	2.1 A	270	270	150	.55	.55	55	69
2-19	241	301	31	39	9.6*	3.3 A	4.1 A	270	270	50	.19	.19	46	54
19-3	71	89	9	11	9.2*	1.0 A	1.2 A	270	270	50	.19	.19	14	17
4-22	388	485	50	63	6.0*	8.3 B	10.4 C	260	240	175	.67	.73	260	354
24-32	164	205	21	27	9.0**	2.3 A	3.0 A	270	270	70	.26	.26	43	53
2-way level or ramp														
19-20	312	390	40	50	11.2**	3.6 A	4.5 A	270	270	155	.57	.57	178	222
20-21	412	515	53	66	12.0***	4.4 A	5.5 A	270	270	40	.15	.15	62	77
21-24	1075	1344	140	175	17.0**	8.2 B	10.3 C	260	240	90	.35	.38	376	511
21-22	663	829	86	108	6.9****	12.5 C	16.0 D	240	220	175	.73	.80	484	663
22-23	275	344	35	44	9.2*	3.8 A	4.8 A	270	270	20	.07	.07	19	24
23-5	186	233	24	30	10.1*-*	2.4 A	3.0 A	270	270	150	.55	.55	102	128
33-6	210	263	27	34	11.8*-*	2.3 A	2.9 A	270	270	80	.30	.30	63	79
6-7	190	238	25	31	11.8*-*	2.1 A	2.6 A	270	270	25	.09	.09	17	21
7-28	168	210	22	28	7.5	2.9 A	317 A	270	270	100	.37	.37	62	78
27-29	249	311	33	41	10.2**	3.2 A	4.0 A	270	270	125	.46	.46	115	143
28-9	96	120	12	15	7.5	1.6 A	2.0 A	270	270	30	.11	.11	11	13
28-8	72	90	9	11	7.5	1.2 A	1.5 A	270	270	25	.09	.09	6	8

* width of doors
** two walls
*** two walls plus trash can
**** two walls plus lockers

- one wall
**- narrowest point in lobby
**-- two walls plus pillar

(Cont'd)

Table A.1.4 (Cont'd)

Link (x,y)	10-minute Peak Volume (persons) 1971	1985	Adjusted Flow (P/M) 1971	1985	Effective Width (feet)	Level of Service 1971 (PFM) Letter	1985 (PFM) Letter	Speed on Link (ft/min) 1971	1985	Length (feet)	Walk Time On Link (min.) 1971	1985	Aggregate 10-minute Walk Time (F-minutes) 1971	1985
Shared, level														
31-24	42	53								115	.43	.43	18	23
31-26	143	179								90	.33	.33	47	59
31-27	24	30	29	36	12.9**-	2.2 A	2.8 A	270	270	105	.38	.38	9	11
30-27	11	14								110	.41	.41	5	6
30-26	60	75								90	.33	.33	20	25
24-30	158	198	28	35	12.9**-	2.2 A	2.7 A	270	270	105	.38	.38	60	75
24-26	729	911								35	.13	.13	95	118
24-27	80	100	105	131	20.0**-	5.3 A	6.6 A	270	270	70	.26	.26	21	26
27-26	126	158								35	.13	.13	16	20
24-27	80	100	27	34	20.00**-	1.3 A	1.7 A	270	270	--	--	--	--	--
Stairs, 1-way														
26-10,11	1058	1323	138	173	14.0**	9.9 C	12.3 D	117	108	25	.21	.23	222	304
12-29	31	39	4	5	7.0**	0.6 A	0.7 A	105	105	45	.43	.43	13	17
17-32	98	123	13	16	5.5**	2.4 A	2.9 A	105	105	25	.24	.24	24	29
18-32	66	83	9	11	5.5**	1.6 A	2.0 A	105	105	25	.24	.24	16	20
Stairs, 2-way														
6-30	229	286	30	38	13.0**--	2.3 A	2.9 A	122	15	15	.12	.12	27	34
7-31	209	261	27	34	13.0**--	2.1 A	2.6 A	105	105	15	.14	.14	29	37
										TOTAL			2335	3318

Table A.1.5

Present Afternoon Walk Times

Link (x,y)	10-minute Peak Volume (persons) 1971	1985	Adjusted Flow (P/M) 1971	1985	Effective Width (feet)	Level of Service 1971 (PFM)	Letter	Level of Service 1985 (PFM)	Letter	Speed on Link (ft/min) 1971	1985	Length (feet)	Walk Time On Link (min.) 1971	1985	Aggregate 10-minute Walk Time (F-minutes) 1971	1985
1-way, level or ramp																
20-21	526	658	68	85	7.8*	8.7	B	10.9	C	260	240	150	.57	.63	300	414
2-19	124	155	16	20	9.6*	1.6	A	2.1	A	270	270	50	.19	.19	24	29
19-3	333	416	43	54	9.2*	4.7	A	5.8	A	270	270	50	.19	.19	63	79
4-22	195	244	25	31	6.0*	4.2	A	5.2	A	270	270	175	.65	.65	127	158
2-way, level or ramp																
19-20	457	571	59	74	11.2**	5.3	A	6.6	A	270	270	155	.57	.57	260	326
20-21	983	1229	128	160	12.0***	10.6	C	13.3	C	240	240	40	.17	.17	167	209
21-24	1575	1969	205	256	17.0**	12.1	C	15.1	D	240	220	90	.38	.41	599	807
21-22	592	740	77	96	6.9***	11.1	C	13.9	C	240	240	175	.73	.73	432	540
22-23	397	496	51	64	9.2*	515	A	6.9	A	270	270	20	.07	.07	28	35
23-5	366	458	47	59	10.1*-*	4.7	A	5.8	A	270	270	150	.55	.55	201	252
33-6	370	463	48	60	11.8*-*	4.1	A	5.1	A	270	270	80	.30	.30	111	139
6-7	234	293	31	39	11.8*-*	2.6	A	5.3	A	270	270	25	.09	.09	21	26
7-28	181	226	24	30	7.5	3.2	A	4.0	A	270	270	100	.37	.37	67	84
27-29	191	239	25	31	10.2**	2.5	A	3.0	A	270	270	125	.46	.46	88	110
9-28	107	134	14	17	7.5	1.9	A	2.3	A	270	270	30	.11	.11	12	15
8-28	74	93	10	12	7.5	1.3	A	1.6	A	270	270	25	.09	.09	7	8

* width of doors
** two walls
*** two walls plus trash can
**** two walls plus lockers
- one wall
**- narrowest point in lobby
**-- two walls plus pillar

(Cont'd)

Table A.1.5 (Cont'd)

Link (x,y)	10-minute Peak Volume (persons) 1971	1985	Adjusted Flow (P/M) 1971	1985	Effective Width (feet)	Level of Service 1971 (PFM) Letter	1985 (PFM) Letter	Speed on Link (ft/min) 1971	1985	Length (feet)	Walk Time On Link (min.) 1971	1985	Aggregate 10-minute Walk Time (F-minutes) 1971	1985
Shared, level														
24-31	69	86								115	.43	.43	30	37
26-31	17	21								90	.33	.33	6	7
27-31	15	19	16	20	12.9**-	1.2 A	1.6 A	270	270	105	.38	.38	6	7
27-30	23	29								110	.41	.41	9	12
26-30	4	5								90	.33	.33	1	2
24-30	446	558	59	73	12.9**-	4.6 A	5.7 A	270	270	105	.38	.38	169	212
24-26	331	414								35	.13	.13	43	54
24-27	145	181	62	77	20.0**-	3.1 A	3.9 A	270	270	70	.26	.26	38	47
26-27	8	10								35	.13	.13	1	1
24-27	145	181	20	25	20.0**-	1.0 A	1.3 A	270	270	--	--	--	--	--
Stairs, 1-way														
26-10,11	360	450	47	59	14.0**	3.6 A	4.5 A	122	122	25	.20	.20	72	90
12-29	304	380	40	50	7.0**	5.0 A	6.3 A	105	105	45	.43	.43	131	163
Stairs, 2-way														
6-30	473	591	61	77	13.0**	4.7 A	5.9 B	122	120	15	.12	.12	57	71
7-31	101	126	13	16	13.0**--	1.0 A	1.5 A	105	105	15	.14	.14	14	18
Bulk Arrivals	# per train													
17-32	786	983	262	328	5.5**	17.0 E	17.0 E	80	80	25	.31	.31	244	305
18-32	524	655	175	218	5.5**	17.0 E	17.0 E	80	80	25	.31	.31	162	203
32-24	1310	1637	437	546	9.0**	17.0 E	17.0 E	175	175	70	.40	.40	524	655
										TOTAL			4014	5015

7. <u>Determine Queuing Times and Crowding at Nodes</u>

Within the terminal, queues can form and cause delays at doors, entry turnstiles, vehicles or wherever there is a restriction in flow. Delays at the stairs because of queuing is minimal. Since vehicle delays are functions of vehicle operation rather than station design, they were not calculated. However, crowding on platforms was evaluated.

At the entry turnstiles and doors, the following equations are considered to be appropriate for calculating the expected time in the queuing system, w, and the expected number in the queue, L_q (22):

$$w = \frac{\mu(\lambda/\mu)^k P_O}{(k-1)!\,(k\mu-\lambda)^2} + \frac{1}{\mu}$$

$$L_q = \frac{\lambda\mu(\lambda/\mu)^k P_O}{(k-1)!\,(k\mu-\lambda)^2}$$

where: λ = arrival rate (persons per minute)

μ = service rate of single channel (persons/min.)

k = number of service channels

$$P_O = \frac{1}{\left[\sum_{n=0}^{k-1} \frac{1}{n!}\left(\frac{\lambda}{\mu}\right)^n\right] + \frac{1}{k!}\left(\frac{\lambda}{\mu}\right)^k \frac{k\mu}{k\mu-\lambda}}$$

These equations, suggested in the General Methodology, are dependent on the assumption that arrival and service rates are randomly distributed according to the Poisson distribution. This assumption may be questionable and can only be verified by field investigation. However, for the few cases in which these equations were used, waiting times were often insignificant in relation to service times. (See Tables A.1.6 and A.1.7 for morning and afternoon average queue size, average time in queuing system and aggregate delay times. Table A.1.8 gives transfer times on the five most often used paths.)

There is only one non-platform queue that is large enough to require analysis. The turnstile entry to the subway-elevated is expected to have an average sizable queue of 13.2 users. At Level of Service C for queuing areas (21), this requires 112 square feet of floorspace and is not a problem here.

Table A.1.6

Morning Queuing Delays

Queue Link or Node	Arrival Rate (P/M 1971	Arrival Rate 1985	Service Rate (P/M)	No. of Channels	Expected Time in Queuing System (min.) '71	Expected Time in Queuing System (min.) '85	Expected Number in Queue '71	Expected Number in Queue '85	Aggregate 10-min. Delay 1971 (per.-min.)	Aggregate 10-min. Delay 1985 (per.-min.)
Turnstiles										
26-10,11	106	133	30	8	.03	.03	3.3	13.2	32	40
Doors										
1	10	13	45	2	.02	.02	0.0	0.0	2	2
6-30	23	29	45	2	.02	.02	0.1	0.1	5	6
7-31	10	13	45	2	.02	.02	0.0	0.0	2	3
26-10,11	106	133	45	4	.03	.03	0.4	0.4	32	49
12-29	3	4	45	2	.02	.02	a	a	1	1
22-23	27	34	45	4	.02	.02	a	a	5	7
13,14,15, 16-29	26	33	45	10	.02	.02	a	a	5	7
4-22	39	49	45	2	.02	.02	a	a	8	10
2	24	30	45	4	.02	.02	a	a	5	6
3	7	9	45	4	.02	.02	a	a	1	2
32-24	16	21	45	4	.02	.02	a	a	3	4
Total Aggregate 10-min. Delay									101	129
Average Delay min./person									0.07	0.07

a. queuing delays occurred at vehicle doors instead of at platform doors (see text)

Table A.1.7

Afternoon Queuing Delays

Queue Link or Node	Arrival Rate (P/M) 1971	Arrival Rate (P/M) 1985	Service Rate (P/M)	No. of Channels	Expected Time in Queuing System (min.) '71	Expected Time in Queuing System (min.) '85	Expected Number in Queue '71	Expected Number in Queue '85	Aggregate 10-min. Delay 1971 (per.-min.)	Aggregate 10-min. Delay 1985 (per.-min.)
Turnstiles										
26-10,11	36	45	30	8	.02	.03	b	b	11	14
1	53	66	45	2	.03	.06	0.6	2.0	16	33
6-30	47	59	45	2	.03	.04	0.4	1.2	14	24
7-31	21	26	45	2	.02	.02	0.1	1.1	4	5
26-10,11	36	45	45	4	.02	.02	0.0	0.0	7	9
12-29	30	38	45	2	.02	.02	a	a	6	8
22-23	40	50	45	4	.02	.02	a	a	8	10
13,14,15 16-29	33	41	45	10	.02	.02	a	a	7	9
4-22	20	25	45	2	.02	.02	a	a	4	5
2	12	15	45	4	.02	.02	a	a	2	3
3	33	42	45	4	.02	.02	a	a	7	8
Bulk Arrivals	volume / train									
32-24	437	546	45	4	1.22	1.52	c	c	1598	2488
Total Aggregate 10-min. Delay									1684	2616
Average Delay min./person									0.07	0.07

a. queuing delays occurred at vehicle doors instead of at platform doors (see text)

b. these queue lengths are shorter than the A.M. queues

c. delays were calculated according to the time required to pass the point of minimum capacity, size of queue is less than 546

TABLE A.1.8

TRANSFER TIMES ON MOST OFTEN USED PATHS

Paths	Walk Times (minutes) 1971	Walk Times (minutes) 1985	Delay Times (minutes) 1971	Delay Times (minutes) 1985	Transfer Times (minutes) 1971	Transfer Times (minutes) 1985
Morning						
4-22-21-24-26	1.9	2.0	.08	.08	2.0	2.1
2-19-20-21-24-26	1.4	1.4	.08	.08	1.5	1.5
29-27-26	0.6	0.6	.08	.08	0.7	0.7
5-23-22-21-24-26	1.8	1.9	.08	.08	1.9	2.0
23-22-21-24-26	1.3	1.4	.08	.08	1.4	1.5
Afternoon						
32-24-21-20-1	1.5	1.6	1.29	1.59	2.8	3.2
32-24-21-20-19-3	1.7	1.7	1.29	1.59	3.0	3.3
12-29	0.4	0.4	.07	.07	0.5	0.5
32-24-30-6-33	1.2	1.2	1.29	1.59	2.5	2.8
4-22-21-24-26	1.9	1.9	.07	.07	2.0	2.0

Platforms should provide enough space to hold all passengers when all vehicles are unloading at capacity. On the subway-elevated one train can hold approximately 900 persons in its six 55-foot cars. A 900-person train is unlikely, however, as passengers disembark before 69th Street. Actual volumes are expected to be about 550 in 1985. This results in 9.6 square feet per person or a Level of Service C, which is acceptable for extended periods of time.

The GM buses have an easy capacity of 77 persons, are 40.0 feet long, and require a platform at least 12 feet wide to provide a Level of Service of C. Because people can move into the terminal, the 11.6-foot bus platform is probably acceptable; however, the 7.5-foot bus platform should be lengthened.

The Media-Sharon Hill trolleys have a capacity of about 110 persons and are 50.5 feet long. They require a platform about 14 feet wide for Level of Service C. The existing platform is 11.6 feet wide, but again this is probably acceptable, because users can leave this platform at a rate of 90 persons per minute.

The Norristown High Speed Line cars have a capacity of about 110 persons and are 55.2 feet long. Assuming two car trains on each track, the present platforms provide a Level of Service of C.

Loading platform level of service is a function of waiting time and therefore of vehicle headway. If platforms become too crowded, shorter headways can be used to alleviate this problem.

Ordinarily, path volumes have to be adjusted at this point, going back to Step 4. However, it is not necessary for this study, as path choice did not have to be selected.

8. <u>Determine Wait Times for Transit Vehicles</u>

Wait times for transit vehicles are used to determine queuing area requirements on loading platforms. They are normally equal to one-half the headway for short headways. Since it was assumed that headways would be reduced if extreme crowding occurred on the present platforms, wait times were not determined.

9. <u>Summarize Criteria Measures</u>

Terminal passenger processing was good in 1971. In 1985, level of service will generally go down. A detailed summary is available in the text (Chapter 4).

APPENDIX A.2

PROBABILITY OF CONFLICT OF PASSENGER MOVEMENT

Observation at the terminal indicated that only one severe conflict situation exists. At junction of paths leading from the subway-elevated platform and the trolley/bus platform (Node 24), there are substantial cross flows (see Figure A.2.1).

Crossing flows were analyzed according to the flow rates per foot width (PFW) of corridor width. These flow rates per foot width were then converted graphically, using Figure A.2.2 to square feet per pedestrian, which Fruin (21) defines as pedestrian Module. Figure A.2.3 was then used to determine the probability of a conflict for individuals crossing either flow. Fruin (21) defines a conflict as any stopping or interruption of the normal walking pace due to too close a confrontation with another pedestrian.

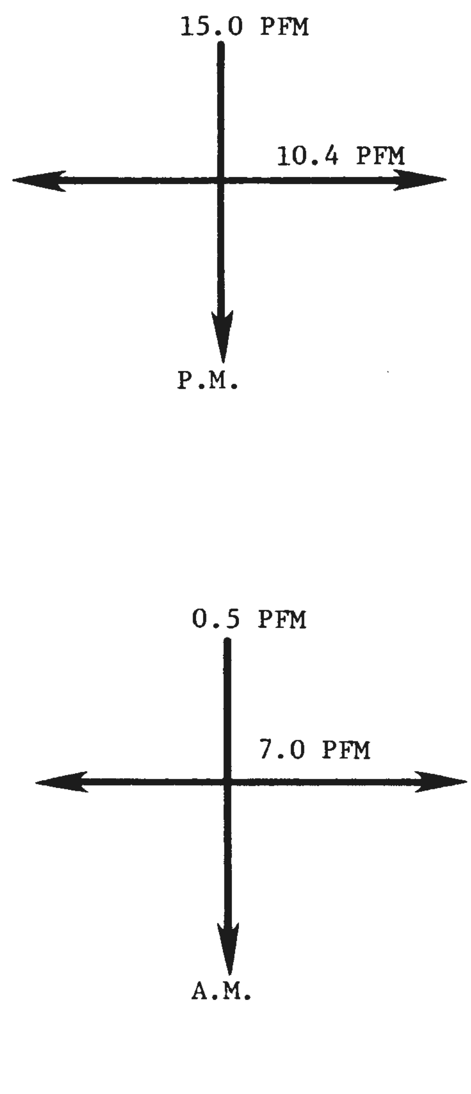


Figure A.2.1. Conflicts at Node 24 in 1971

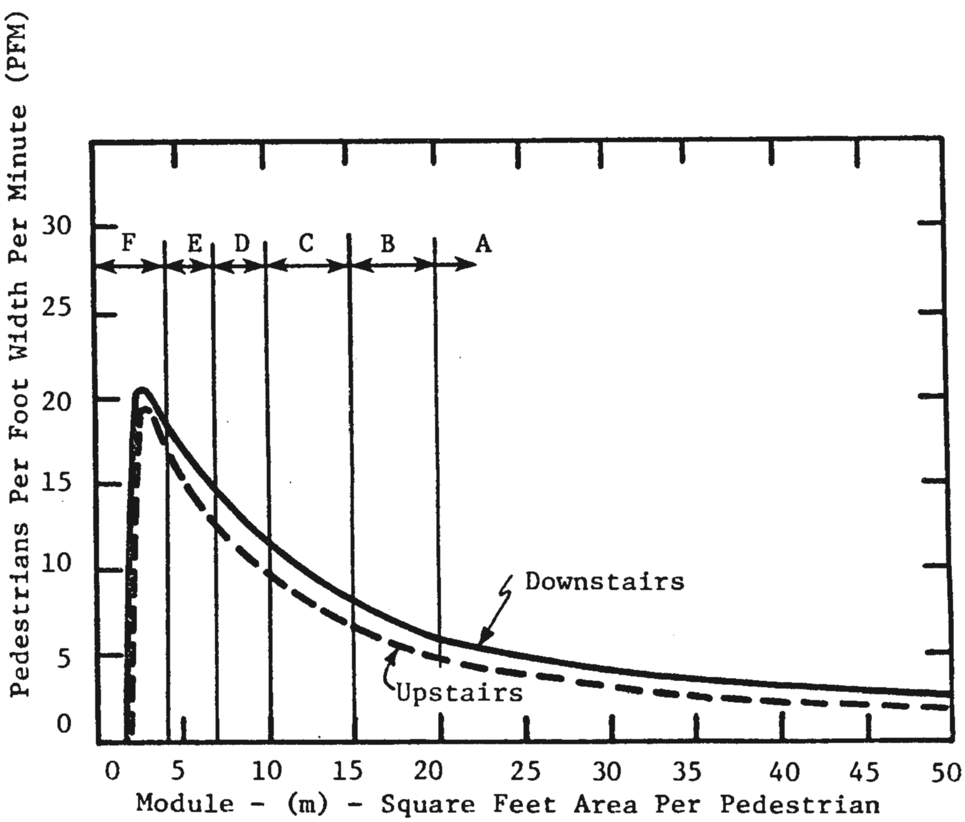


Figure A.2.2. Level of Service Standards for Stairways

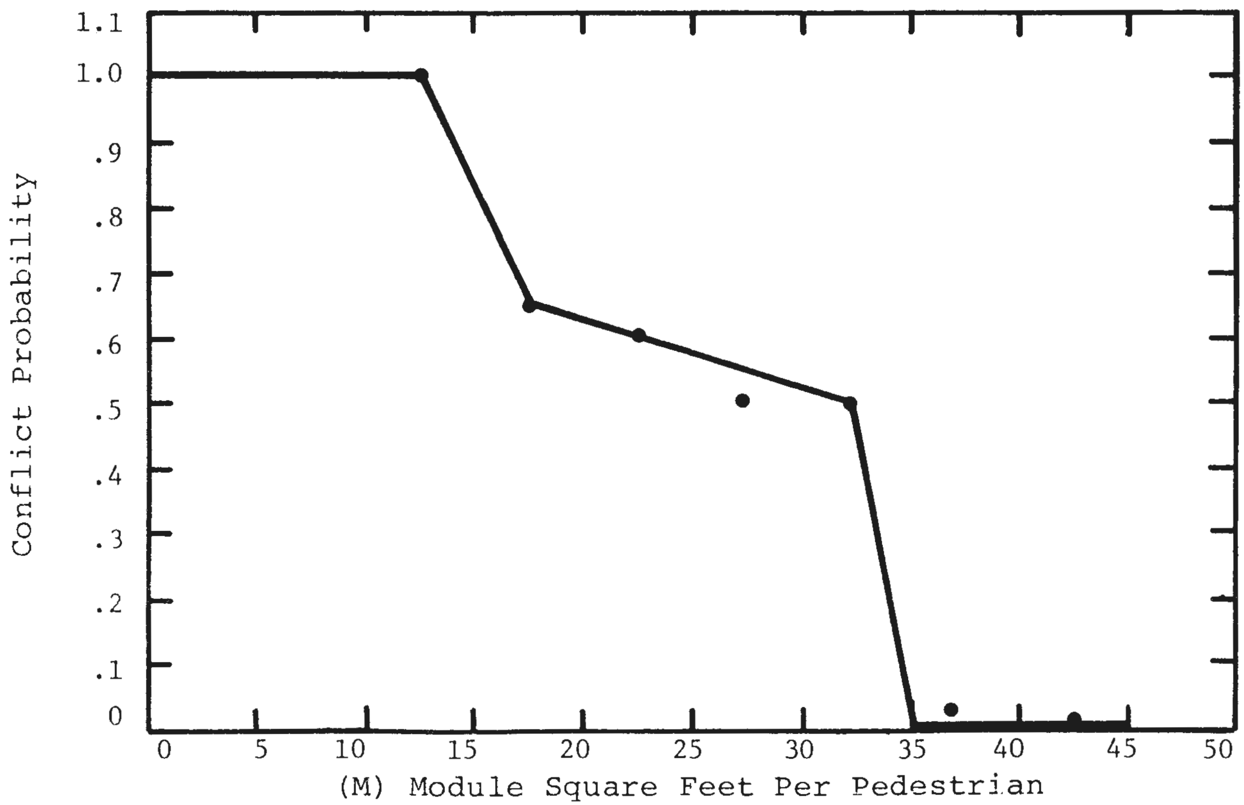


Figure A.2.3. Cross Flow Traffic-Probability of Conflicts

APPENDIX A.3

NOISE LEVEL DATA AT 69TH STREET TERMINAL*

Maximum Sound Level (dbA)	Background Sound Level (dbA)	Location* (number)	Duration (seconds)	Source
96	65	1	0-10	air brakes
94	64	2	10-30	wheels
92	70	3	10-30	wheels
90	60	4	0-10	wheels
90	70	8	0-10	air brakes
88	65	1	0-10	wheels
86	70	3	0-10	air brakes
86	65	5	0-10	wheels
86	62	6	10-30	bus
84	65	7	10-30	bus
81	64	9	10-30	wheels
79	65	1	60+	pedestrians
79	62	10	60+	pedestrians
77	68	11	30-60	pedestrians
76	69	12	30-60	pedestrians
76	64	13	60+	pedestrians
75	65	14	60+	pedestrians
74	68	15	60+	pedestrians
74	66	16	60+	pedestrians
73	64	2	10-30	trolley
72	64	9	10-30	trolley
	50	20	60+	closed corridor
	63	17,18,19	60+	empty corridor or waiting room
79		In vehicle	60+	car & track
89		In vehicle	10-30	wheels

*Data collected Friday, October 21, 1977 from 4 p.m. to 6 p.m.
**Actual location in terminal identified in Figure A.3.1.

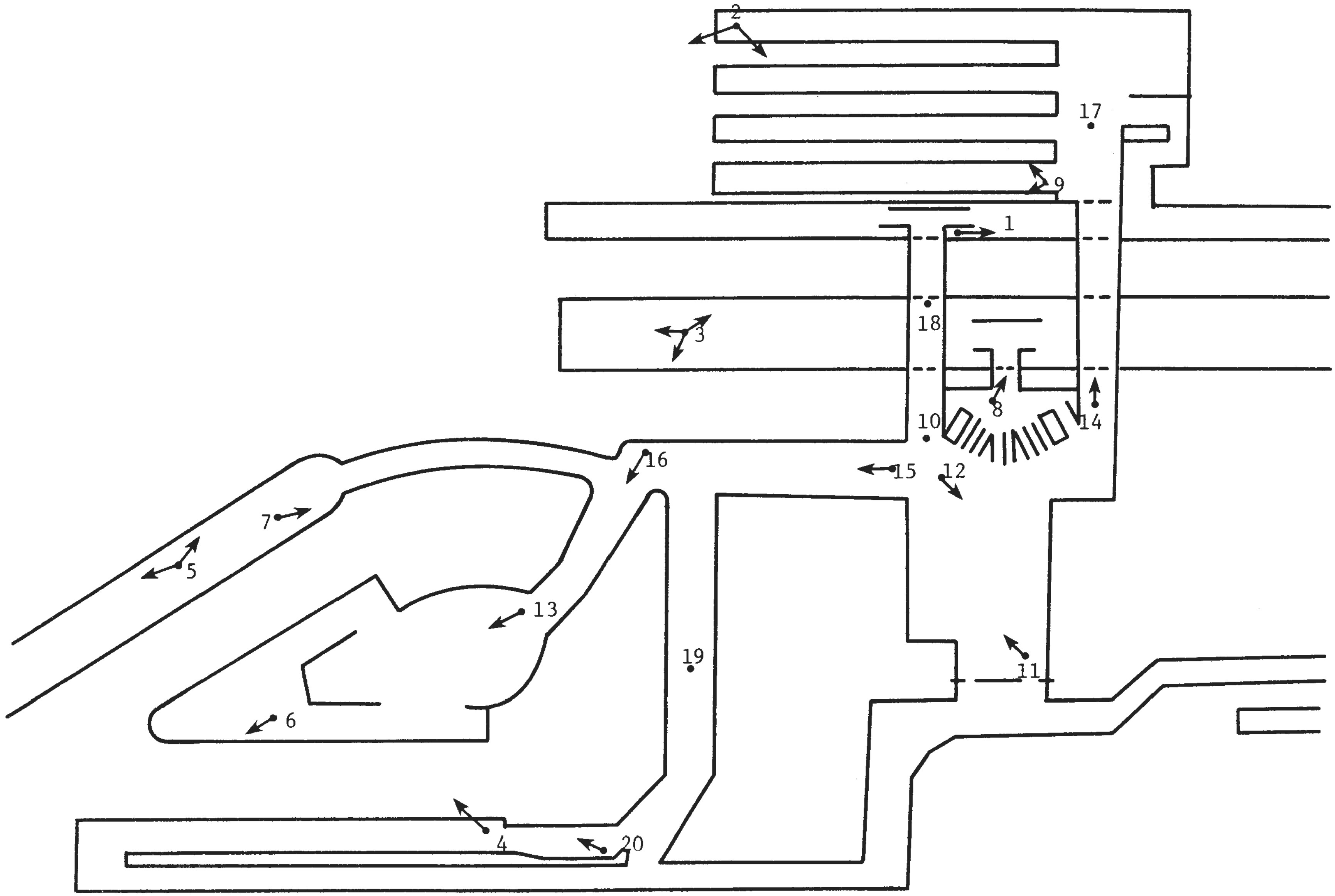


Figure A.3.1. Noise Level Locations - Friday, October 21, 1977, 4 P.M. - 6 P.M.

APPENDIX A.4

LABOR OPERATING COSTS, 1978

Position	No. of Employees	Daily Cost
Cashier	10	$293.25
Stationperson	2	105.44
Towerperson	3	168.96
Supervisors	2	124.40
Yard book person	1	54.40

Source: Scott, C. F., Manager-Liaison and Agency Interface of SEPTA, letter to author, April 13, 1978.

APPENDIX B

FRUIN'S LEVEL OF SERVICE STANDARDS*

CRITERIA MEASUREMENTS AND DESIGN SPECIFICATIONS

A number of criteria suggested in this report have been investigated in depth elsewhere. This Appendix provides a summary description of a number of selected measures in the passenger processing and environmental categories whose quantification is not readily apparent. The criteria appear under their corresponding objective from Figure 4.1. Those criteria with which most planners are familiar are included for clarity in cross referencing Figure 4.1.

Objective 1: Minimize Travel Impedances

Criteria: Total walk time
Total time in system
Individual path analysis (origin-destination times)

Objective 2: Minimize Crowding on Links

The following Level of Service definitions have been recommended for pedestrian systems (1):

Descriptions for Walkways

Level of Service	Occupancy and Flow	Qualitative Description
A	Occupancy = 35 ft^2/person or more Flow = 7 PFM** or less	Sufficient area is provided for pedestrians to freely select their own walking speed, bypass slower pedestrians, and avoid crossing conflicts with others.
B	Occupancy = 25-35 ft^2/person Flow = 7-10 PFM	Sufficient space is provided to select normal walking speed and to bypass other pedestrians in primarily one-directional flows. If reverse-direction or

*Source: Criteria for Evaluating Alternative Transit Station Designs, by L. A. Hoel, M. J. Demetsky, and M. R. Virkler, December 1976

**PFM = Pedestrians per foot width of walkway, per minute

Level of Service	Occupancy and Flow	Qualitative Description
		crossing movements exist, minor conflicts will occur, slightly lowering mean speeds and potential volumes.
C	Occupancy = 15-25 ft^2/person	Freedom to select individual walking speed and to freely pass others is restricted. If cross movements and reverse flows exist, there will be a high probability of conflict and frequent adjustment of speed and direction would be required to avoid contact. There is reasonably fluid flow.
D	Occupancy = 10-15 ft^2/person Flow = 15-20 PFM	The majority of persons would have their normal walking speeds restricted and reduced. There would be difficulty in bypassing slower moving pedestrians and avoiding conflicts. Pedestrians involved in reverse-flow and crossing movements would be severely restricted and multiple conflicts would occur. There is some probability of intermittently reaching critical density, causing momentary stoppage of flow.
E	Occupancy = 5-10 ft^2/person Flow = 20-25 PFM	Virtually all have their normal walking speeds restricted. At the lower end of this range, forward progress would only be made by shuffling. Insufficient area would be available to bypass slower-moving pedestrians. Extreme difficulty would develop for those attempting reverse-flow and cross-flow movements. The design volume approaches the capacity of the walkway and frequent stoppages and interruptions of flow would result.

Level of Service	Occupancy and Flow	Qualitative Description
F	Occupancy = 5 ft	All individual walking speeds are restricted and forward progress is only made by shuffling. There is frequent, unavoidable contact with others. Reverse of crossing movements are impossible. Flow is sporadic.

Descriptions for Queuing

Level of Service	Occupancy (ft^2/person)	Qualitative Description
A	13 or more (average inter-person spacing is 4 ft. or more)	Free Circulation Zone-space is provided for standing and free circulation through queuing area without disturbing others.
B	10-13 (average inter-person spacing is 3 1/2 - 4 ft.)	Restricted Circulation Zone-space is provided for standing and restricted circulation through the queuing area without disturbing others.
C*	7-10 (average inter-person spacing is 3 - 3 1/2 ft.)	Personal Comfort Zone-space is provided for standing and restricted circulation through the queuing area by disturbing others.
D**	3-7 (avg. inter-person spacing is 2-3 ft.)	No Touch Zone-space is provided for standing without personal contact with others, but circulation through the queuing area is severely restricted, and forward movement is only possible as a group.

*Level of Service C is within the range of personal comfort body buffer zone established by psychological experiments.

**Fruin states that based on psychological experiments, this Level of Service D should not be recommended for long-term periods of waiting.

Level of Service	Occupancy (ft^2/person)	Qualitative Description
E***	2-3 (avg. inter-person spacing is 2 ft. or less)	Touch Zone-space is provided for standing, but personal contact with others is unavoidable. Circulation within the queuing area is not possible.
F****	2 or less (close contact with surrounding persons)	The Body Ellipse-space if approximately equivalent to the area of the human body. Standing is possible, but close unavoidable contact with surrounding standees causes physical and psychological discomfort. No movement is possible.

***Fruin states that Level of Service E can only be sustained for short periods of time without physical and psychological discomfort and that the only recommended application would be for elevator occupancy.

****Fruin states that in large crowds, at Level of Service F panic is possible.

Descriptions for Stairways

Level of Service	Occupancy and Flow	Qualitative Description
A	Occupancy = 20 ft^2/ person or more Flow = 5 PFM	Sufficient area is provided to freely select walk speed and bypass other slower moving pedestrians. No serious difficulties will be experienced with reverse flows.
B	Occupancy = 15-20 ft^2/person Flow = 5-7 PFM	At stairway level-of-service B, representing a space approximately 5 treads long and 3 to 4 feet wide, virtually all persons may freely select locomotion

Level of Service	Occupancy and Flow	Qualitative Description
C	Occupancy = 10-15 ft^2/person Flow = 7-10 PFM	At stairway Level of Service C, representing a space approximately 4 to 5 treads long and about 3 feet wide, locomotion speeds would be restricted slightly, due to an inability to pass slower moving pedestrians. Minor reverse-traffic flows would encounter some difficulties.
D	Occupancy = 7-10 ft^2/person Flow = 10-13 PFM	At stairway Level of Service D, representing a space approximately 3 to 4 treads long and 2 to 3 feet wide, locomotion speeds are restricted for the majority of persons, due to the limited open tread space and an inability to bypass slower moving pedestrians. Reverse flows would encounter significant difficulties and traffic conflicts.
E	Occupancy = 4-7 ft^2/person Flow = 13-17 PFM	At stairway Level of Service E, representing a space approximately 2 to 4 tread lengths long and 2 feet wide, the minimum possible area for locomotion on stairs, virtually all persons would have their normal locomotion speeds reduced, because of the minimum tread length space and inability to bypass others. Intermittent stoppages are likely to occur, as the critical pedestrian density is exceeded. Reverse-traffic flows would experience serious conflicts. This level of service would only occur naturally with a bulk arrival traffic pattern that immediately exceeds available capacity.

Level of Service	Occupancy and Flow	Qualitative Description
F	Occupancy = 4 ft^2/person Flow = Variable, up to 17 PFM	At stairway Level of Service F, representing a space approximately 1 to 2 tread lengths long and 2 feet wide, there is a complete breakdown in traffic flow, with many stoppages. Forward progress would depend on movement of those in front.

Objective 3: Minimize Queues

Criteria: Total delay time in queue
Number in queue at node
Time in queue while traveling from Node (a) through Node (b)

Objective 4: Minimize Conflicts

Criteria: Measures of crossing flows

Objective 5: Minimize Disorientation

Criteria: Connectivity from Node-Link network (directness of path). This can be derived from network connectivity analysis. Availability of directional information.

Objective 6: Maximize Safety

Criteria: Safety features on mechanical facilities.
Elimination of design hazards.

Objective 7: Maximize Reliability of System Components

Criteria: Back-up facilities in case of breakdown.
Inspection and maintenance procedures.
Alternatives available.

APPENDIX C

LOCAL TRAFFIC CONDITIONS*

ROAD NETWORK

West Chester Pike and its continuation as Market Street is an important route into Philadelphia, since it is one of the few roads crossing Cobbs Creek. Garrett Road and Victory Avenue carry high traffic volumes in a north-south direction.

Existing Traffic Volumes

Traffic volumes are heavy in the vicinity of the terminal. Peak hour traffic volumes on West Chester Pike are heavier inbound in the morning and outbound in the afternoon, reflecting its role as a major urban arterial serving city-oriented travel. In the morning peak hour, eastbound traffic is about three times as heavy as westbound traffic. The afternoon volumes are the reverse of the morning but with heavier movements in the minor direction.

Access

Access modal split is summarized in Table 3.1. Of the major access routes to the terminal, over 70 percent of automobile traffic approaches from West Chester Pike and Garret Road, which are also important bus arrival routes. Approximately 16 percent of the automobile traffic arrives from the south, while the north and east are approach directions for the remaining 14 percent.

Conflicting points exist at the bus and tram entrance and at the main entrance to the terminal. Both areas require movements against heavy traffic flows which are dangerous and increase travel time for both motorists and transit passengers.

PARKING SPACES

Within a five-minute walking distance from the terminal are almost 2,000 parking spaces with about 1,400 spaces in off-street lots and garages and 570 spaces at curbside.

A 340-space lot, owned and operated by SEPTA, is east of the terminal with a rate of $0.35 for 24 hours. A commercial lot across Victory Avenue contains 88 spaces with a charge of $0.70 per day. Three municipal lots south of West Chester

*Source: Delaware Valley Regional Planning Commission Urban Corridor Demonstration Program by Wilbur Smith and Associates and Louis T. Klauder and Associates, September 1971.

Pike permit the 24-hour parking with charges of $0.06 for one-half hour to $0.25 for five hours. Of the 660 spaces in private lots, almost 550 are free to shoppers and are closed until 9:30 a.m. to prevent usage by commuters.

While only a small percentage of passengers drive to the terminal, they utilize about 1,200 vehicles, over 950 of which are parked at lots. At the same time, another 560 drive to stops along tram or bus routes and "park and ride."

ACCIDENTS

During the three-year period (January 1966 through December 1968), the average annual accident and property damage along West Chester Pike was greatest at its intersection with Garrett Road. The intersection with 69th Street had the second highest number of accidents, and the Chatham Road intersection had the least. These rates reflect the relative traffic conflicts and volumes at the three intersections.

At all three intersections, rear-end collisions accounted for the greatest number of accidents. The second highest type was the angle or turning accident, with "hitting a fixed object" next in frequency.

The annual personal injury cost was estimated at $14,400. Combined with the annual property damages, this amounts to $34,700 per year.

CURB PARKING AND TURNING REGULATIONS

Along West Chester Pike, parking is prohibited at all times on the north side. On the south side, it is allowed during off-peak hours, affording three moving lanes of traffic on West Chester Pike eastbound during the peak hours. Parking is prohibited at all times along Victory Avenue and allowed on both sides of Garrett Road any time.

There are no turning restrictions at the intersections of West Chester Pike with 69th Street Boulevard at Chatham Road. At the complex intersection of West Chester Pike with Garrett Road and Victory Avenue, however, left turns are prohibited from Victory Avenue, southbound, onto West Chester Pike. This limits bus access to the terminal from Victory Avenue, forcing a circuitous approach via Bywood Avenue, Fairfield Avenue, and Garrett Road to the bus entrance.

VOLUME-CAPACITY RELATIONSHIPS

The volume-capacity ratios reflect the variation in traffic volumes by direction on West Chester Pike and Victory Avenue-Garrett Road between the morning and afternoon peak hours. For West Chester Pike, eastbound in the morning peak hour and westbound in the afternoon peak hour, the ratios significantly exceed 1.0, indicating a low level of service. Garrett Road northbound in the morning and Victory Avenue southbound in the afternoon exhibit similar low levels of service. In most cases, the minor direction ratios during the peak hours are below 1.0 but still high enough to support overall traffic congestion.

SPEED AND DELAY CHARACTERISTICS

A marked difference in travel time and delay exists between peak and off-peak periods. Lengthy travel times correspond to the heaviest movements eastbound in the morning and westbound in the evening. During these periods, it can take over five minutes to travel from Chatham Road to Brief Avenue, a distance of less than half a mile. Principal delays are caused by traffic signals.

TRAFFIC SIGNAL CONTROL SYSTEM

While a cable connects signals at Garrett Road and 69th Street along West Chester Pike, timing of these signals is not progressively coordinated. At West Chester Pike and Garrett Road, a manual control prevails which can advance the phase but not alter cycle length. Trams and buses are accommodated by separate phases in the overall cycle at Garrett Road, and separate pedestrian phases are provided at both intersections.

Signal Display

Both "far left" and "far right" mounted signals are provided along West Chester Pike. Most are pedestal mounted, which, combined with the extensive commercial activities in the area, the overhead tram lines and the normal sun conditions of an east-west street, results in poor signal visibility. Driver reaction times are also adversely affected, resulting in travel time delay.

Most signals have 8-inch diameter red/yellow/green lenses; others have single and double arrows in 8-inch or 12-inch lenses (vertical arrow with a left or right arrow superimposed upon it in the same lens). Railroad signals are used at the Media-Sharon Hill tram tracks, including a cross buck with two flashing red signals.

PAVEMENT MARKINGS

Pavement markings, because of age and amount of traffic, are very difficult to discern. Streets were originally marked for three traffic lanes with stop lines and pedestrian crosswalks delineated at each signalized intersection. Lack of pedestrian crosswalks is particularly dangerous because of the large numbers of people oriented to the terminal across West Chester Pike. This is worsened by the unprotected tram tracks and the confusing five-approach intersection of West Chester Pike, Victory Avenue, and Garrett Road.

APPENDIX D

SEPTA POLICY GUIDELINES PERTAINING TO THIS TERMINAL

Following are selected SEPTA Policy Guidelines that pertain to the 69th Street Terminal. There are two types of guidelines. One is the planning aspect, where the desired objectives for each subsystem is defined. The other is the component aspect, where the type of physical equipment to fulfill the stated objectives is described.

The outline below summarizes topics covered.

SEPTA POLICY GUIDELINES ON PLANNING

Site Planning

- Automobile access
- Pedestrian
- Transit access
- Paving and sidewalks

Circulation

- Emergency exiting
- Horizontal circulation
- Vertical circulation

Control Point

- Paid/Unpaid Area

Structures and Sheltered Areas

- Acoustics

*Source: Design Standards Manual by M. L. Wurman, SEPTA, March 1975.

Platform

General Recommendations

Platform length

Platform edges

Service Systems

Heating

Lighting

Illumination levels

Emergency lighting

Visual comfort criteria

SEPTA POLICY GUIDELINES ON STATION COMPONENTS

Materials

Criteria

Circulation

Escalators

Elevators

Control Point

Coinpassers

Platform

Edge warning strip

Service System

Station washdown system

Lighting

Lamp type and recommendations

1. AUTOMOBILE ACCESS

a. Access

1. Automobile access points should minimize conflicts of station destined traffic with other highway traffic by providing adequate space for cars to queue while trying to enter the station site without stopping through traffic.
2. Automobile access points should be limited to the fewest number possible, preferably two (two lanes each), to permit a simple, one-way traffic flow.
3. Access points into site should be a minimum of 35' from any intersection.
4. A minimum of 100' should be provided for the queuing of automobile drop-off. This queuing should in no way inhibit access into parking lots or access to boarding/discharging area for buses.

b. Parking

1. Entry into parking lots should not deter entrance to site for any mode.
2. Entrance into parking lots should never be directly off highways.
3. In the planning of parking lots, it is desirable that the maximum walking distance be kept under 800'.
4. Large parking lots should be broken down into small distinct "cells" of no larger than 1.5 acres. This permits an identity to be established in searching for vehicles and allows the control of random traffic flow.
5. The walkway strip between "cells" should be a minimum of 10' wide to permit snow piling in winter and provide a walkway for pedestrian movement to station.
6. Parking stalls within "cells" should be aligned perpendicular to entry facade of station. This arrangement facilitates easy search for parking spaces and encourages the use of pedestrian walkways between "cells."
7. A minimum of 2 parking spaces should be provided at each station for the handicapped or one space for every 150 parking spaces. These spaces should be properly signed and striped. The location of handicapped parking spaces shall be as close to station entry as possible.

c. Dimensional Standards

The following standards should be used for sizing parking stalls.

1. Parallel parking stalls should be 8.5' wide and 22' long.
2. Typical perpendicular stall size would be 10' wide and 20' long.
3. Mature trees should be preserved in parking areas if possible. In such cases a 3' irrigation grate should be placed around tree trunk. Parking stalls should start 5' on either side of tree.

4. Perpendicular or diagonal parking stalls for the handicapped shall be 12' wide and 20' long.

d. Parking Fare Collection

The Authority currently has in operation three types of fare collection methods:
1. Central coin-slot type
2. Automatic collection gate type
3. Parking meters

The central coin-slot type is used most frequently throughout the current system. This collection method does not demand entry and exit controls. Fare is paid in a central box according to stall number. This fare box should be centrally located to all parking areas (if parking on both sides of track, provide one fare box for each side) and should be along a path all passengers follow, thus one may not unwillingly forget parking fare. This fare system reduces queuing at entrances and equipment servicing requirements.

Automatic collection gate type demands a controlled entrance with coin machine and gate, and an exit treadle at all exits from the parking lot. This collection method is least favorable because of queuing problems at entrances and coin machine breakdowns prohibit automobile access completely.

Parking meters are of the standard parking meter type and require one meter in front of each stall. This fare system minimizes queuing at entrances, however, does have service disadvantages over the central coin-slot type.

2. PEDESTRIAN

a. Access

1. Pedestrian access from the surrounding community should be encouraged by providing direct route, paved walkways--separated from parking areas--to station control area.
2. Grade separated pedestrian crossings of vehicular or bus transit ways should not be used where the topography requires an up and down movement except in crossing vehicular right-of-ways with over 5,000 vehicles per peak hour.
3. Pedestrian crossings of vehicular or bus transit way should be defined by a 12'wide change in paving texture or painted yellow warning stripes.

b. Pedestrian Over/Under Passes

1. Pedestrian over/under pass should be provided over trackage at every station on a rapid or commuter rail line.
2. All over/under passes should occur in the paid or controlled area except where the over/under pass is to be used for general community use. In this special situation, the control point (or station entry point) should be positioned to provide access to all platforms via the same over/under pass.
3. The entire over/under pass route should be surveyed before entering. One should feel that the "trip" through the over/under pass could be completed without confronting anyone not observed before starting.
4. Where, because of no other alternative, pedestrians must use the same over/under pass with vehicular traffic, adequate sidewalk width and lighting should be provided. For this situation to be operative, the grade separated crossing must be central to all components--parking, station, platforms.

3. TRANSIT ACCESS

a. Transfer

1. When bus or rail feeders are integrated with rapid rail or commuter rail stations, transit loading and discharging facilities should occur off-street and not disrupt normal traffic flow.
2. Since this transfer is a potential impedance to travel, every effort should be made to make the connection direct and uncomplicated with excess circulation.
3. Transit loading and discharging facilities should provide weather protection and shelter between the feeder mode and rail line.
4. The optimum solution is discharging feeder bus and boarding rapid vehicle from the same platform (cross platform transfer).

b. Bus Platforms or Berths

1. All bus stops must be designed for right-hand boarding and discharging.
2. Buses should not use the same stopping point for both loading and discharging passengers except where bus volume is light.
3. The optimum sequence at bus interchange points is:
   queuing for bus;
   unloading platform;
   holding area for bus;
   loading platform.
4. Where possible, each major line should have its own berth. This has the advantage of making the holding area synonymous with boarding allowing passengers to wait on the bus.

c. Vehicle Dimensions

The following are clearances for various SEPTA vehicles. Rail vehicles are included for possible cross platform transfer clearances.

1. Overhead clearances:

bus	10'3"
streetcar	13'6"
trackless trolley	11'3"
Market/Frankford car	13'6"
Broad Street car	13'6"
Commuter Rail Car	16'1" (including catenary and insulators)

2. Turning radius:

bus, critical dimension	40.75'

5. PAVING AND SIDEWALKS

a. All walkways, paths, and sidewalks should be paved with fixed, firm materials, with a slip-resistant surface texture with any joints filled flush. Vast areas of concrete or asphalt paving should be relieved by strips or area patterns of contrasting pavers. Loose gravel surfaces, unsealed cobble stones are not acceptable for sidewalk surfaces.

b. Bar or screen gratings are prohibited from sidewalk areas.

c. 5'0" is the minimum clear dimension for all sidewalks.

d. A 5 percent gradient is the maximum slope for all walkways or sidewalks; above this slope, use stairs.

e. Sidewalk curb cuts should be ramped at pedestrian crossings to accommodate the handicapped.

f. Walls along sidewalks should flare away at their terminations a minimum of 10' to reduce secretive hiding spaces.

2. EMERGENCY EXITING

a. Capacity

The circulation system should permit the total capacity of a loaded train to exit from the station in four minutes.

In order to calculate the crowd capacity of any station the following set of guidelines should be used. These guidelines refer to obstruction-free space. Obstructions are structural columns, walls, projections, light standards, kiosks or free-standing signs.

Rules Defining Obstruction Free Space

1. Where an obstruction occurs within the path of circulation, the distance between the obstruction and any edge of the circulation path must be greater than 4 feet in width to be included as free circulation areas for capacity calculations.
2. Where obstructions occur in a row (e.g., a colonnade) forming aisles of circulation, these aisles must be greater than 6 feet in width to be included as free circulation areas for capacity calculations.

Capacity Guidelines

1. Horizontal passageways: 25 PFM
2. Stairways and ramps: 15 PFM
3. Escalators (at a speed of 90 ft. per min.): 100 P/M for 40" tread width and 60 P/M for 24" tread width
4. Moving walk (at a speed of 90 ft. per min.): 100 P/M for 36" width and 60 P/M for 24" width
5. Exit gate: Free swinging, 15 PFM (3'0" wide door will give 45 P/M)
6. Exit doors: 30 P/M
7. Rotogates: 25 P/M
8. Turnstiles (free movement): 50 P/M
9. Cashiers' booth passimeter: 30 P/M

PFM = pedestrians per foot width of walkway per minute
P/M = pedestrians per minute

NOTE: It is desirable to add 1.5 feet of width to each side of any constrained or enclosed path of circulation above its calculated capacity.

b. Number of Exits

There should not be less than two exits from any station area or platform.

c. Location of Exits

The maximum distance from a platform end to an exit should not exceed 200'.

d. Auxiliary Exits

Where the above recommendations for exit width, location, and number cannot be met within the normal circulation system, auxilliary emergency exits must be provided.

1. Emergency exit stairways or corridors of a minimum width of 44" and a minimum ceiling height of 7'0" can be provided. Openings into the exit stair or corridor should have a smoke barrier with a 20 minute rating.
2. Emergency line exits along the tunnel r.o.w. can be provided where the distance between stations is not too great. Such walkways should have a minimum width of 2'0". Cross-over should also be provided every 1000'.

3. HORIZONTAL CIRCULATION

a. Minimum Width of Horizontal Passageways

In addition to capacity, the required width of any route is also dependent upon the nature of the space through which the route passes (tunnel, bridge, open sidewalk). Constrained paths of circulation, as in tunnels, require greater width than above-grade walkways for psychological comfort. Therefore, no matter how low the anticipated capacity, paths of circulation should not be planned below the following recommended standards for width.

Minimum Width Requirements	Min. Width
Unconstrained/open: sidewalks, walkways, pathways	5'0"
Constrained/open: bridges, overpasses, elevated walkways	8'0"
Constrained/enclosed: tunnels, underpasses, concourses, subway passageways and corridors	12'0"

b. Gradient

The maximum grade allowable for horizontal circulation shall be 5 percent. Beyond this gradient, requirements for vertical circulation apply.

c. Doors

Entrance doors and other doors in the path of circulation, including all emergency doors and gates shall have a width of 36". Where a two leaf door is used, the clear opening, free of any protruding hardware, through each leaf, shall not be less than 30". Doors shall not impede access by the handicapped and should have a common floor level on either side for a distance of 5 linear feet.

d. Height

The minimum height for enclosed or roofed paths of circulation shall be 9'0" for areas with suspended ceilings and 8'0" for areas with solid ceilings.

e. Configuration

Paths of circulation should encourage right hand movement wherever possible. They should provide visual contact with points of destination at the earliest moment and avoid blind corners, hidden alcoves and circuitous routes.

4. VERTICAL CIRCULATION

a. Design Goals

1. Vertical components of the circulation system should be located as a natural extension of the flow of movements, an integral part of the path of circulation.
2. Stairs, ramps, escalators and elevators should be architecturally articulated so they are visible from a distance to aid in decision making and should provide views, wherever possible, of patron destinations. Avoid "cheek walls" around stairways and passages leading to vertical circulation which "hide" and give no clarification between vertical and horizontal circulation.
3. Where possible stairs, escalators and ramps should be located within and moving through an open space rather than within a contained shaft or space.
4. Stairs, ramps, escalators and elevators should be located so as to maximize employee surveillance. This is particularly crucial in the case of escalators and elevators where control for safety is required.
5. Escalators should be paired with stairs when possible to eliminate confusion due to reversing directions, shutdowns for repairs, etc. All changes in level must have stair access. Nonoperating escalators cannot be considered stairs.
6. Escalators are required to be used where vertical dimensions up are over 12' and where vertical dimensions down exceed 24'.
7. The layout for vertical movement should encourage the use of escalators over stairs.

b. Width

1. Stairways and Ramps

   Where circulation paths end in a stair or ramp, the vertical circulation should equal the width of the horizontal path.

   The minimum width for any stair or ramp should be 6'0" (existing stairs or ramps where necessary may retain a minimum width of 4'0").

   The required width for any stair or ramp should be calculated in accordance with the section on capacity for emergency exiting.

2. Escalators

   The minimum width of an escalator should be 32" between the handrails with a 24" tread (4' 0 1/4" clear opening) and a 48" maximum width between the handrails with a 40" tread

(5' 4 1/4" clear opening). If the escalator must be in a constrained shaft or enclosure, the width of the shaft should be a minimum of 6'0".

c. Landings

1. Stairways and Ramps

   Landings are required at 8'0" of vertical rise for a stairway and at intervals not exceeding 30'0" linear for a ramp.

   The minimum depth for landings in all stairs or ramps shall be equal to the width of the stair or ramp. However, all landings must have a minimum depth of 4'6".

   The minimum width of a landing must equal the width of the stairway or ramp.

2. Escalators

   An intermediate landing between two escalator runs should comply with the requirements for run-off.

d. Run-Off

The distance between a stair, escalator or ramp and any obstruction or conflicting movement or waiting area in a line is called the run-off.

1. The run-off from a stair or ramp to a solid obstruction such as a wall, kiosk, or pier, shall be equal to 1.7 times the width of the stairway or ramp.
2. The run-off from a stair or ramp to the edge of a queuing space shall be at least 10'0".
3. The run-off between two stairs where the landing must accommodate crossing circulation should be a minimum of 20'0" and preferably 25'0".
4. The run-off from an escalator to a solid obstruction should be a minimum of 15'0".
5. The run-off from an escalator to the edge of a queuing space should be a minimum of 15'0".
6. The run-off to another escalator in the same direction should be a minimum of 15'0".
7. The run-off between two escalators where the landing must accommodate crossing circulation should be a minimum of 20'0" and preferably 25'0".
8. Where a stair and escalator are in the same well, the run-off to the stair/escalator in the same direction should be a minimum of 15'0".
9. Where a stair and escalator are in the same well, the run-off to a solid obstruction should equal 1.7 times their combined width.

Passimeter at cashier booth	25 P/M
Turnstiles coin-operated/single slot	25 P/M
Gates (3 ft. clear opening)	60 P/M

NOTE: P/M = People per Minute

Example: If peak hour traffic is 3,000 persons, then the control system must be capable of admitting 3000/60 x 2 or a design traffic of 100 persons per minute. Given a turnstile design capacity of 25 persons per minute, the platform requires a minimum of (100/25) or 4 turnstiles (1 agent operated and 3 automatic turnstiles).

Regardless of the calculations, a minimum required number of devices for a fare collection at any station on the rapid rail lines should be:
- 1 agent operated turnstile
- 2 automatic turnstiles

Egress Capacity

NOTE: The design of egress equipment and location will affect emergency exit standards (see Section C - emergency exiting).

Egress equipment should provide for the comfortable egress of riders at maximum anticipated user volumes and the safe egress for emergency exiting under full vehicle and station evacuation conditions. Therefore exiting equipment should permit:

1. The highest anticipated peak load at a station to exit from the paid area within the projected peak period headway time or three (3) minutes, whichever is less.
2. The total capacity of a theoretically fully loaded train to exit from the station in a time span of four minutes in emergencies. At terminals and stations serving major crowd attractions (i.e., stadiums, etc.) this volume should be increased by the platform capacity calculated at 15 sq. ft. per person.

For purposes of determining the number of egress devices required, the following pedestrian volumes should be used:
- Rotogates: 25 P/M
- Free Turnstiles: 50 P/M
- Pass Gate (emergency use only): 60 P/M

Regardless of calculations, a minimum of 2 exits are required from any unpaid area.

7. ACOUSTICS

a. Introduction

Numerous reports on the subject of noise control have been produced. Many of these are in the Authority's file. The overwhelming conclusion of these reports is that although the most expeditious and effective means toward the solution of excessive noise lies in the reduction of noise generated by the vehicle itself through technical design improvements in traction equipment, wheel design and track design, noise levels along rights-of-way and in station areas can be controlled or alleviated by barriers baffling and absorption techniques where technically feasible.

b. Current Programs Under Evaluation*

Numerous acoustical design treatments have been incorporated into or are proposed for use in transit facilities in several cities over the next few years. The evaluation of these solutions is not yet sufficient to allow their inclusion as recommendations in this manual. Some have received much publicity and may offer effective and feasible solutions to SEPTA's specific problems. As such useful alternatives evolve, they will be incorporated into this section of the design manual.

Until then some of these design techniques are identified for monitoring:

- flared tunnel portals
- resonant chambers and panels
- suspended ceilings of sound absorptive material (in several CBD stations)
- track level sound absorption (on platform face)

c. Recommended Noise Level Limits

1.	Train entering and leaving station	80dba
2.	Passby noise level at 40 m.p.h.	87dba
3.	Wayside noise level 50' from the track centerline	75dba

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* A more comprehensive description of projects, materials and methods for noise abatement are contained in the UMTA publication "Prediction and Control of Rail Transit Noise and Vibration--A State of the Art Assessment", UMTA DOT available from NTIS-PB#233 363/AS.

d. Minimum Noise Level

Train station noises should not be reduced below 45dba in order that the warning noise of entering trains be maintained as a necessary safety factor.

e. Acoustical Design Recommendations

1. Non-durable absorptive surface materials should not be applied or employed to reduce noise in accessible public areas or surfaces.
2. Configuration of walls and non-repetitive distribution of elements should be employed to eliminate where possible the tendency to concentrate noise in station areas.

1. GENERAL RECOMMENDATIONS

Platforms must be designed to meet both the requirements for movement as well as assembly. In the planning of the platform area one must consider entrance paths, boarding and alighting from vehicles, queuing at exit points, and waiting. In addition to this section for proper planning and design refer to sections:
C. Circulation
D. Control Point

a. Obstructions

The minimum clearance between the edge of a platform and intermittent obstructions such as columns on the platform should be 3'0".

No path should be created along the edge of a platform by such an obstruction which encourages one person to pass another where less than adequate space is available. Thus no clearance between 3'0" and 5'0" in width is allowed.

b. Maximum Density

Platform areas should be adequate to hold the peak hour loading projections at a maximum density of 8 square feet per person, 10 to 15 sq. ft./person preferred. This allows adequate comfort levels in waiting, while permitting cross movement during boarding and disembarking.

c. Minimum Width

Side platforms should be at least 12'0" wide excluding stairways, queuing at fare collection space, etc. Existing side platforms which are less than 12'0" but more than 10'0" may be extended at this existing width as long as there are no columns on the platform.

Island platforms which contain stairways within the platform or end the platform with a stairway should allow at least 8'0" clear on either side of the stairway and should have an overall width equal to or greater than 23'0". However, island platform ends may taper to a minimum of 16'0" in width when not ending with a stairway.

d. Platform Drainage

The recommended and minimum platform slope, toward the track bed, is 1/8" per linear foot at all stations.

2. PLATFORM LENGTH

The following are the desirable platform lengths for the various rail lines in the SEPTA system.

a. Market/Frankford Line: (8 car train @ 55'/car + 20') = 460'
b. Broad Street Subway: (8 car train @ 67.5'/car + 10') = 550'
c. Broad-Ridge Spur: (4 car train @ 67.5'/car + 10') = 280'
d. Subway/Surface Underground Stations: (2 car lengths @ 46'8"/car + 15') = 108'4"
e. Commuter Rail: (7 car train @ 85') = 595'

NOTE: The required platform length varies from line to line within the SEPTA commuter rail system. The size of the platform proper will be determined by the Authority for each station. However, "sidewalks" should be provided to equal this length when the platform proper is reduced in length. Platforms should be designed in 85' modules.

f. Norristown High Speed Line: (2 car train) = 80'

4. PLATFORM EDGES

All high platform edges of rapid rail stations, and commuter rail stations should for their entire length, be of 5/16" heavy duty hypalon, ribbed and metal backed, with integral yellow warning stripes.

The minimum depth shall be 24" and a maximum depth of 40". This shall be divided into a nosing piece of 15" in depth (standard tread size) consisting of an 8" safety yellow stripe and a 7" internal stripe in black or the coded color of that station. The final and separate piece of the same material shall be in safety yellow for the required width.

Low platform edges at subway surface stations (light rail), and commuter rail stations should provide a rubber safety strip 12" to 18" wide in safety yellow for the entire length of the platform.

2. HEATING

a. Heat shall be provided:

1. In all fully enclosed above ground rooms where water supply lines are present. Wall mounted electric heaters are recommended for this purpose which should be individually thermostatically controlled to provide a minimum of 50°F at 0°F outside temperature.

2. In all cashier booths, toilet rooms, ticket rooms, operator rest rooms, starter rooms, and other operating personnel rooms which are fully enclosed. Where central mechanical systems are not present, wall mounted electric thermostatically controlled heaters are recommended which will provide a maintained 70°F at 0°F ambient outside temperature. Where air conditioning facilities are recommended as in cashier booths, the heating may be provided as an integral function of the air conditioning unit.

3. In all above ground, fully enclosed, public waiting rooms with a 65°F maintained temperature at 0°F outside temperature.

b. Heating shall not otherwise be required in public areas of underground stations, in open and partially open above-grade shelter and platform areas, nor in nonpublic equipment rooms of above ground and underground stations except where plumbing, electrical, or mechanical equipment requirements demand temperature control.

c. Because of the significant number of unit electric heaters which may be employed throughout the system, it is recommended that these units be standardized to the greatest degree practicable.

d. Outdoor space heaters such as infra-red radiant heaters, gas heaters, air curtains, etc., are not recommended for use in any station environment because of vulnerability to maintenance and vandalism problems and in recognition of their inefficiency in energy conservation. It is recommended that wind screens and other planning devices be employed with the greatest resourcefulness in order to eliminate the need for supplementary heat.

3. RECOMMENDED MINIMUM MAINTAINED ILLUMINATION LEVELS

Area	Minimum Level in Footcandles
Platform, underground	20
Platform, under canopy, grade and above grade	15
Platform, uncovered, grade and above grade	5
Trackway with station areas, underground	5
Trackway between stations, underground	3
Ticketing area, transfer machines, automatic turnstiles	40
Cashier booth and approaches at coin passer	80
Cashier booth:	
interior	30
at work surface at window	100
Waiting room, full enclosure	20
Waiting and sitting areas under canopy or in shelter, grade and above grade	10
Concessions and vending machine areas	30
Public space in commercial area at terminals, major interchange and concourses, underground or in full building enclosure	40
Concourses and underground passages, corridors	20
Decision points in passages, concourse intersections, at foot or head of stair with multiple directional choice, underground or in full enclosure	35
Mezzanines, track coossovers, underground or in full enclosures	20
Rotogates, exit gates, exit turnstiles, threshold of major or centrally located exit stairways, underground or in full enclosure	40
Stair and escalator	30
Storage areas	5
Toilets	30
Service and utility rooms	30
Electrical, mechanical, train control equipment rooms operator rest rooms	30
Approaches and threshold to enclosed stair and escalator, at grade	10
Headhouses to stair, full enclosure, at grade:	
at top of stair	30
public and waiting areas (when applicable)	20
Bus and streetcar shelter, off street	10
Bus and streetcar shelter, on street (a)	2
Bus and streetcar loading platforms, off street, and at loops and turn arounds	5
Bus and streetcar loading platforms, on street:	
at interconnection points, heavy use areas and hazardous traffic areas	5
at secondary locations (a)	1

Area	Minimum Level in Footcandles
Threshold areas to platform and shelter areas at off street, grade, and above grade stations (b).......	5
Pedestrian walkways (c)............................	3
Open stairways to above grade, off-street stations (d)..	5
Yard and grounds area at off-street, grade, and above grade stations..................................	1
Vehicular drop off points, kiss and ride areas.......	5
Parking areas.......................................	2
Entrance and exit roadways..........................	2

a. Full use should be made of available street and commercial lighting and it is recommended that when the existing ambient lighting level at on-street bus and trolley loading platforms and shelters is a minimum of 1/2 footcandle, and the lit environment provides a sense of safety, ease of surveillance at perimeter, and gradual fall-off of level between adequately spaced street lights or commercial lighting, then no additional lighting shall be required at these locations.

b. Threshold areas are defined as those transition areas in the vicinity (5-10 ft.) of a platform, accessway or shelter wherein the passenger encounters changes in vertical elevation (stair, ramps), in paving materials, in lighting levels, and other potential minor hazards.

c. The illumination on all pedestrian approaches to off street stations shall be smoothly gradated between the access point and the station platform; and level of lighting shall in no case fall below 2 footcandles at the access point on the public street.

d. When there is a distance of over 30' from the top of open stairs to the platform areas to above grade, off street stations, the minimum lighting level on the pedestrian walkway shall be the same as that established for the open stair (5 fc.).

Notes:
1. All lighting levels given are <u>minimums</u>.
2. The minimum level in all public areas in enclosed spaces is 20 footcandles.
3. These levels should be increased where economically feasible and practical in accord with appropriate design standards.
4. Lighting levels should never be increased to a point causing unacceptable brightness ratios and other forms of optical discomfort and neither should they be increased to provide static uniformity of levels in all areas.

5. Where lighting levels are increased beyond these minimums, careful consideration must be given to proper transition, either in time or distance, from brightly lighted station areas to the relatively low ambient level of normally lighted public areas, streets and sidewalks.

4. EMERGENCY LIGHTING

a. Recommended Average Minimum Maintained Illumination Levels

Area	Minimum Level in Footcandles
Platforms, mezzanines, concourses, passageways, waiting rooms	1
Rotogates, exit turnstiles, gates, exit stairway thresholds	3
Stair	2
Electrical service rooms	1
Service and utility rooms	0.5
Underground track areas	0.5

b. Emergency Lighting Where Required

Emergency lighting shall be provided in all station facilities as follows:

1. In all rooms and public spaces in full enclosure;
2. In all tunnels and emergency exits;
3. In all structure-elevated station platforms;
4. In all enclosed or partially enclosed stairways, ramps, escalators, passageways and concourses, even if not enclosed at access points;
5. Where applicable life-safety codes apply.

c. Emergency Lighting System

1. Emergency lighting shall be accomplished by the type of system which employs selected luminaires of the basic lighting system to provide the reduced level of emergency light. Secondary lamps in high intensity discharge type fixtures shall be acceptable.

   Spot type reflector lamps shall not be used where mounting height is limited to ten feet or less and should not be used at all if other means of emergency lighting are practicable.

2. At stations where an emergency DC circuit is available which is separate and distinct from traction power circuits, it may be employed as a source of emergency power for emergency lighting directly, or with appropriate devices to convert to AC power.

3. Designers may investigate the feasiblity of using traction power as a power source for emergency lighting. Where DC power is used as the main source of emergency power at stations requiring emergency lighting of over one thousand square foot area (1000 sq. ft.), whether open or enclosed, the DC current shall be converted to AC by means of an inverter or motor-alternator in order that standardized lighting fixtures may be employed in the design.

4. At stations where it is possible to bring in two separate and distinct primary electrical service lines, the second line may be used as one, but not the only, source of emergency power for emergency lighting.

5. At individual stations having less than one thousand square feet (1000 sq. ft.) of floor area wherein emergency lighting is required, the requirement of (3) above is relaxed to permit individual battery pack type rechargeable units. These units should be employed with reluctance and are permitted only where the remote bettery type unit is economically infeasible, regardless of the square footage involved. Individual battery pack units, where used, should be mounted at a height of ten feet or greater, and located so as to provide general illumination over the entire area as well as focusing on exitways. The units should be located and aimed so that the beam does not shine directly in the eye of exiting passengers.

6. It is desirable that DC emergency generating equipment and circuit be enlarged and expanded throughout the entire system.

5. VISUAL COMFORT CRITERIA

a. Surface Luminance

The luminance of any source or surface in the transit environment relative to adjacent or surrounding surfaces shall not exceed the following Luminance Ratios (Brightness or Contrast Ratios):

1. Station interior, underground or fully enclosed:

Wall to floor	3:1
Wall to ceiling	3:1
Signs, information panels: panel to adjacent and background surfaces	5:1
Top of wall to ceiling at cove lighting or wall washers	10:1

2. Shelters, canopies platforms, at or above grade:

Wall to floor	3:1
Wall to ceiling	5:1

3. In the public area of any transit environment where foot-candle levels exceed 30, all luminance ratios shall be less than 10:1 except for luminances produced at the luminaires in the area.

4. Ideally, the luminance ratio between luminaires and adjacent surfaces should be limited to 20:1. However, it is recognized that this maximum is unpractical in the transit environment. Designers are encouraged to evaluate luminaire selection and placement in order to limit excessively high ratios.

   In no case should the luminaire to adjacent surface ratio exceed 80:1.

b. Glare

Direct glare and disability glare as defined by IES shall be avoided or minimized to the greatest extent possible. The discomfort glare rating of any public area in the transit environment shall not exceed 125 and the visual comfort probability (VCP) shall not be less than 50%.

c. Reflectance Values

The recommended reflectance values for major surface components of the transit environment are as follows:

1. Ceilings	80 to 95 percent
2. Walls	50 to 85 percent
3. Floor	15 to 55 percent

These values may of course vary beyond the ranges given for small portions of any surface. Should major wall surfaces be increased above or below the range recommended, designers shall exercise special care in evaluation of luminance ratios and general illumination design.

II

Components

INTRODUCTION

None of the following components have been formally adopted by SEPTA as standard. They represent either components designed with SEPTA approval for a specific facility or components recommended by the consultants as a part of an overall design program.

There are numerous other materials, components and subsystems currently under study and development by SEPTA as part of the Authority's interest in standardization and these should be incorporated into this section as soon as they are approved.

Where desirable, more detailed specifications and construction documents available at SEPTA as part of recent facility improvement programs are referenced for the designers' use.

2. CRITERIA

a. Safety

In general all materials and finishes used in the system shall be incombustible, although certain minor elements may be of wood, rubber or plastic. However, where such materials are used over any significant area, they shall be of such a composition that does not support its own combustion (self-extinguishing).

All materials, especially surface finishes (paint, film coatings) shall provide a flame spread rating of not more than 25 and shall be of the type that does not contribute noxious fumes when burning.

Materials and finishes used shall provide adequate slip-resistance, glare-resistance, prevent abrasion, splinters, or the possibility of similar personal injury, recognizing the frequent presence of crowds and of the handicapped and infirm.

Materials, their attachments and supporting structures shall be designed and selected to adequately withstand the extreme demands placed upon Authority property by crowds, vandalism and normal operational vibration.

b. Maintainability

The selection of materials and finishes must take into account the fact that frequent, high quality maintenance is not likely. Therefore, every effort should be made to choose materials with impervious surfaces that will resist soiling. Design and details which complicate maintenance and cleaning operations such as dirt catching corners, points or surfaces must be avoided wherever possible.

The type of conditions which will confront transit facilities include:

- Water and dirt tracked in or brought in by wet vehicles;
- Salt (in winter);
- Airborn dirt and dust;
- Greasy brakeshoe dust;
- Graffiti and other types of vandalism;
- Trash discarded by users.

c. Durability

In selecting materials, finishes and assemblies, those which provide the longest useful life, without rusting, decay, corrosion, general weakening, or other failure under normal use, should be favored. Materials which maintain a fresh sharp appearance over time are desired.

d. Replaceability

Recognizing that wear and damage will take place, materials should be repairable and replaceable with a minimum of disruption of normal facility functions and should blend into the existing material.

e. Economy

Economy is an underlying consideration in all of the above criteria in terms of long and short term costs. All aspects, including initial material costs, installation costs, replaceability and durability as well as realistic maintenance costs should be taken into account in determining a material or component's suitability for use in transit facilities.

1. ESCALATORS

a. Codes

All work shall be done in strict accordance with the current requirements of the National Board of Fire Underwriters, the National Electrical Code, the American Standard Safety Code for Elevators, Dumb-waiters and Escalators A17.1, and Commonwealth of Pennsylvania Department of Labor and Industry Regulations and applicable local codes such as the Philadelphia Building Code.

b. Interchangeability

All parts of the installation shall be built to standard dimensions, tolerances and clearances in order to insure complete interchangeability of similar parts of similar machines and devices, and all mechanical fastenings subject to wear and replacement shall be S.A.E. standard removable and replaceable types.

c. General Design

1. Escalators shall be of the cleat step, reversible type, capable of operating under full load conditions in either direction, arranged to operate on an incline of 30 degrees from the horizontal and shall operate quietly and smoothly at a rated speed of 90 feet per minute. The escalator shall be capable of providing a 10' per minute speed for maintenance purposes and controls shall be provided and identified for their operation.

2. Escalators shall be of self contained units consisting of structural steel truss, tracks, step drive units, steps, step chains, comb plates, handrails, driving machine, controller, safety devices, balustrades and all other parts required to provide the complete moving stairway installations.

3. Openings shall be provided at important points to give access for making inspections and repairs of escalator parts. Provisions shall also be made at the top and bottom of the moving stairways for removing worn-out or damaged carriages.

4. Stainless steel anti-slide knobs, cleats or other deterrent construction shall be provided at the escalator deck panels to prevent sliding. Arrangement of the anti-slide devices shall be approved by SEPTA.

5. As a standard of quality, escalators as made by Otis Elevator Company or Westinghouse Electric Company are considered acceptable.

3. ELEVATORS

The interior wall finish of all elevators should be stainless steel number 4 finish.

Where, for some special design purpose, decorative panels are used on the interior surfaces, the panels should be replaceable and should be made of easily maintainable, wear and vandal resistant material such as porcelain enamel, melanine plastic, etc.

Hung ceilings and loose lighting diffusers should not be employed in cab design.

Handrails shall be required around perimeter of cab interior. Rails shall be mounted at 3' above cab floor and constructed of stainless steel with number 4 finish.

Operating controls at elevator doors and within cabs shall be mounted no higher than 40 inches and shall conform in all respects to ANSl regulations for elderly and handicapped usage.

Door closing speeds shall not exceed 1 ft/sec.

1. COINPASSERS

Alt #1 Tiltman Langley

Modular Slimstile SC turnstile with heavy duty turnstile head and freewheeling exit. Brushed satin stainless steel finish with high security self-locking vault partitioned to segregate tokens from standard coinage. Equipped with single drop coin chute with Tiltman Langley electronic logic to accept quarters, dimes, nickels and SEPTA tokens, the fare being 35¢ made up of any combination of 25¢, 10¢ and 5¢ coins; escalation rotary switch to adjust fares by 5¢ levels up to 80¢; with escrow dumped on operation of the turnstile head or by abort button returning coinage to reject cup; with segregator to separate tokens from coins and a Tiltman Langley self-locking coin vault.

Coinpassers shall have nonresettable visual counter, top mounted, digital display of fare increments, illuminated panel indicating "PROCEED", illuminated panel indicating "CLOSED", and at reverse end "EXIT/NO EXIT."

The power consumption for each of the units is approximately 40 W fed from a 110V/60Hz source. Input power should be provided through a #16/3 conductor SJ 300V rubber covered cable in conduit with a floor mounted base receptacle within the cabinet envelope.

1. EDGE WARNING STRIP--CONCRETE PLATFORMS

a. Acceptable manufacturers shall be R.C.A. Rubber Company, Ace Rubber Company and R.C. Musson Rubber Company.

b. Nosed Edge Warning Strip

"Transit-flor" 5/16" heavy duty ribbed step treads, metal backed, 15" width, 62" length, with double ribbed tread design as manufactured by R.C.A. Rubber Products, Inc., or equal approved by SEPTA. The underside of the steel backing plate shall be rubber coated. Provide color banding. The rear strip shall be 5/16" heavy duty ribbed sheet material by same manufacturer but without metal backing. Cut to 9" width and provide longest possible lengths. Adhesive should be selected by contractor from the following products, or equal approved by engineer:

1. R.C.A. #56 Latex Adhesive by R.C.A. Rubber Company
2. "Rub-Bub" 3ZA Cement by Ace Rubber Products, Inc.
3. Armstrong S-237 Adhesive by Armstrong Company
4. "EC-2141 General Purpose Adhesive" by 3M Company

c. Warning strip shall be applied over troweled underlayment using appropriate adhesives. Metal backed portion shall in addition be bolted through to substrate.

1. STATION WASHDOWN SYSTEM

The station washdown system shall be a high pressure hot water, automatic detergent mix system with valve cabinets for hose connections spaced throughout the station permitting 50' hose reach to all parts of the public area of the station. The equipment room for the system shall be no less than 200 square feet and shall be located in a service room in the platform area which is within the limits of the system piping loop and not remote from it. The feeder lines to the valve cabinets are high pressure and shall be located wherever possible in exposed accessible locations in service room ceilings or in suspended ceilings in platform areas. High pressure piping system will require appropriate anchorage and pressure chambers to absorb heavy line surges. Detailed information on a model washdown system has been recently developed for Second Street Station of the Market-Frankford Line.

1. LAMP TYPES AND RECOMMENDATIONS

a. Incandescent

The use of incandescent lamps should be phased out in favor of more efficient sources and their use permitted only where required because of mounting height or beam control limitations such as at displays, focal points or within lamp bank type signs and signal devices. Whenever used, diodes or higher voltage lamps with lower voltage power shall be employed to prolong life.

b. Fluorescent

This lamp type should remain the most prominent in use within the SEPTA system because of its many favorable characteristics including low source brightness, high life cycle costing efficiency, relatively long life and suitability in linear configuration for most transit environments and its use is recommended for most station lighting application with the exception of high bay areas. It is recommended that the four and eight foot T-12 800 MA Warm White lamp become the standard lamp in the system, although it is recognized that 430 MA lamps will be required to remain in the inventory for existing and special uses.

c. Mercury Vapor

This lamp type should be used in all large area high bay (over 13 feet mounting height) applications and in conventional mounting heights (8-12 feet) as more efficient smaller wattage lamps and luminaires are developed for this application. It is recommended that the deluxe white mercury lamp in voltages of 400 W and above become the standard high intensity lamp in the system.

d. High Pressure Sodium

While not recommended for wide employment at this time, progress in the development of this lamp type should be carefully followed by all designers since it offers potentially great benefits in cost efficiency. It should be introduced into the system with great care and selectivity and particularly evaluated for use in yard and parking areas.

APPENDIX E

ALTERNATIVE PLANS NETWORKS AND ANALYSIS

TABLE E.1

1985 MORNING WALK TIMES FOR ALTERNATIVE 1

Link (x,y)	10-Minute Peak Volume (persons)	Adjusted Flow (P/M)	Level of Service Letter (PFM)	Effective Width Required or Present (feet)	Speed on Link (ft/min)	Length (feet)	Walk Time on Link (minutes)	Aggregate Walk Time (P-M)
1-way, level or ramp								
20-1	125	16	A 2.1	7.8*	270	150	.55	69
2-19	301	39	A 4.1	9.6*	270	50	.19	54
19-3	89	11	A 1.2	9.2*	270	50	.19	17
4-22	485	63	C 10.4	6.0*	240	175	.73	354
32-24	205	27	A 3.0	9.0**	270	70	.26	53
2-way, level or ramp								
19-20	390	50	A 4.5	11.2**	270	155	.57	222
20-21	515	66	A 5.5	12.0***	270	40	.15	77
21-24	1344	175	C 10.3	17.0**	240	90	.38	511
21-22	829	108	C 12.5	8.7	240	175	.73	604
22-23	344	44	A 4.8	9.2*	270	20	.07	24
5-23	233	30	A 3.0	10.1*-*	270	150	.55	128
6-33	263	34	A 2.9	11.8*-*	270	80	.30	79
6-7	238	31	A 2.6	11.8*-*	270	25	.09	21
27-29	311	41	A 4.0	10.2**	270	125	.46	143

NOTES:
- * width at doors
- ** two walls
- *** two walls plus trash can
- *-* one wall
- **- narrowest point in lobby
- **-- two walls plus pillar

(Cont'd)

Table E.1 (Cont'd)

Link (x,y)	10-Minute Peak Volume (persons)	Adjusted Flow (P/M)	Level of Service Letter (PFM)	Effective Width Required or Present (feet)	Speed on Link (ft/min)	Length (feet)	Walk Time on Link (minutes)	Aggregate Walk Time (P-M)
Shared, level								
31-24	53	36	A 2.8	12.9**-	270	115	.43	23
31-26	179					90	.33	59
31-27	30					105	.38	11
30-27	14					110	.41	6
30-26	75					90	.33	25
24-30	198	35	A 2.7	12.9**-	270	105	.38	75
24-26	911					35	.13	118
24-27	100	131	A 6.6	20.0**-	270	70	.26	26
26-27	158					35	.13	20
24-27	100	34	A 1.7	20.0**-	270	--	--	--
Stairs, 1-way								
26-10,11	1323	173	C 8.5	20.4	117	25	.21	283
12-29	39	5	A 0.7	7.0**	105	45	.43	17
17-32	123	16	A 2.9	5.5**	105	25	.24	29
18-32	83	11	A 2.0	5.5**	105	25	.24	20
Stairs, 2-way								
6-20	286	38	A 2.9	13.0**	122	15	.12	34
7-31	261	24	A 2.6	13.0**	105	15	.14	37
						TOTAL		3139

TABLE E.2

1985 AFTERNOON WALK TIMES FOR ALTERNATIVE 1

Link (x,y)	10-Minute Peak Volume (persons)	Adjusted Flow (P/M)	Level of Service Letter (PFM)	Effective Width Required or Present (feet)	Speed on Link (ft/min)	Length (feet)	Walk Time on Link (minutes)	Aggregate Walk Time (P-M)
1-way, level or ramp								
20-1	685	85	C 10.9	7.8*	240	150	.63	414
2-19	155	20	A 2.1	9.6*	270	50	.19	29
19-3	333	54	A 5.8	9.2*	270	50	.19	79
4-22	244	31	A 5.2	6.0*	270	175	.65	158
2-way, level or ramp								
19-20	571	74	A 6.6	11.2**	270	155	.57	326
20-21	1229	160	C 13.3	12.0***	240	40	.17	209
21-24	1969	256	C 12.5	20.5	240	90	.38	738
21-22	740	96	C 13.9	6.9****	240	175	.73	540
22-23	496	64	A 6.9	9.2*	270	20	.07	35
5-23	458	59	A 5.8	10.1*-*	270	150	.55	252
6-33	463	60	A 5.1	11.8*-*	270	80	.30	139
6-7	293	39	A 3.3	11.8*-*	270	25	.09	26
27-29	239	31	A 3.0	10.2**	270	125	.46	110

NOTES:
* width at doors
** two walls
*** two walls plus trash can
**** two walls plus lockers
- one wall
**- narrowest point in lobby
**-- two walls plus pillar

(Cont'd)

Table E.2 (Cont'd)

Link (x,y)	10-Minute Peak Volume (persons)	Adjusted Flow (P/M)	Level of Service Letter (PFM)	Effective Width Required or Present (feet)	Speed on Link (ft/min)	Length (feet)	Walk Time on Link (minutes)	Aggregate Walk Time (P-M)
Shared, level								
31-24	86	20	A 1.6	12.9**-	270	115	.43	37
31-26	21					90	.33	7
31-27	19					105	.38	7
30-27	29					110	.41	12
30-26	5	73	A 5.7	12.9**-	270	90	.33	2
24-30	558					105	.38	212
24-26	414	77	A 3.9	20.0**-	270	35	.13	54
24-27	181					70	.26	47
26-27	10	25	A 1.3	20.0**-	270	35	.13	1
24-27	181					-	-	-
Stairs, 1-way								
26-10,11	450	59	A 4.5	14.0**	122	25	.20	90
12-29	380	50	A 6.3	7.0**	105	45	.43	163
Stairs, 2-way								
6-30	591	77	B 5.9	13.0**--	120	15	.12	71
7-31	126	16	A 1.3	13.0**--	105	15	.14	18
Bulk Arrivals, persons/train								
17-32	983	328	E 17.0	5.5**	80	25	.31	305
18-32	655	218	E 17.0	5.5**	80	25	.31	203
32-24	1637	546	E 17.0	9.0**	175	70	.40	655
						TOTAL		4939

TABLE E.3

1985 MORNING WALK TIMES FOR ALTERNATIVE 2

Link (x,y)	10-Minute Peak Volume (persons)	Adjusted Flow (P/M)	Level of Service Letter (PFM)	Effective Width Required or Present (feet)	Speed on Link (ft/min)	Length (feet)	Walk Time on Link (minutes)	Aggregate Walk Time (P-M)
1-way, level or ramp								
20-1	125	16	A 2.1	7.7*	270	150	.55	69
2-19	301	39	A 4.1	9.6*	270	50	.19	54
19-3	89	11	A 1.2	9.2*	270	50	.19	17
4-43	485	63	C 10.4	6.0*	240	175	.73	354
24-32	205	27	A 3.0	9.9**	270		.26	53
2-way, level or ramp								
19-20	390	50	A 4.5	11.2**	270	155	.57	222
20-21	515	66	A 5.5	12.0***	270	40	.15	77
21-24	515	66	A 3.9	17.0**	270	90	.15	172
5-43	233	30	A 3.0	10.1*-*	270	150	.55	128
6-7	238	31	A 2.6	11.8*-*	270	25	.09	21
7-41	210	27	A 2.3	11.8*-*	270	125	.46	97
30-42	96	13	A 3.7	3.5*-*	270	80	.30	28
24-42	733	95	C 12.5	7.6*-*	240	130	.54	397
42-43	829	108	C 12.5	8.7**	240	120	.50	415
6-44	263	34	A 2.9	11.8*-*	240	175	.65	170

NOTES:
* width at doors
** two walls
*** two walls plus trash can
- one wall
**- narrowest point in lobby
**--two walls plus pillar

(Cont'd)

Table E.3 (Cont'd)

Link (x,y)	10-Minute Peak Volume (persons)	Adjusted Flow (P/M)	Level of Service Letter (PFM)	Effective Width Required or Present (feet)	Speed on Link (ft/min)	Length (feet)	Walk Time on Link (minutes)	Aggregate Walk Time (P-M)
Shared, level								
31-24	53	71	A 1.4	50.0**	270	115	.43	23
31-40	179					115	.43	77
31-29	30					220	.81	24
30-29	14					225	.83	12
24-30	198					105	.39	77
30-40	75					110	.41	31
24-40	911	131	A 6.6	20.0	270	40	.15	137
24-29	100					125	.46	46
29-40	158	34	A 1.7	20.0	270	75	.28	44
24-29	100					-	-	-
Stairs, 1-way								
40-10,11	1323	173	C 8.5	20.4	117	20	.17	226
12-29	39	5	A 0.7	7.0**	105	45	.43	17
17-32	123	16	A 2.9	5.5**	105	25	.24	29
18-32	83	11	A 2.0	5.5**	105	25	.24	20
Stairs, 2-way								
6-30	286	38	A 2.9	13.0**--	122	15	.12	34
7-31	261	34	A 2.6	13.0**--	105	15	.14	37

TOTAL 3108

TABLE E.4

1985 AFTERNOON WALK TIMES FOR ALTERNATIVE 2

Link (x,y)	10-Minute Peak Volume (persons)	Adjusted Flow (P/M)	Level of Service Letter (PFM)	Effective Width Required or Present (feet)	Speed on Link (ft/min)	Length (feet)	Walk Time on Link (minutes)	Aggregate Walk Time (P-M)
1-way, level or ramp								
20-1	658	85	C 10.9	7.8*	240	150	.63	414
2-19	155	20	A 2.1	9.6*	270	50	.19	29
19-3	333	54	A 5.8	9.2*	270	50	.19	79
4-43	244	31	A 5.2	6.0*	270	175	.65	158
2-way, level or ramp								
19-20	571	74	A 6.6	11.2**	270	155	.57	326
20-21	1229	160	C 13.3	12.0***	240	40	.17	209
21-24	1229	160	B 9.4	17.0**	260	90	.35	425
5-43	458	59	A 5.8	10.0*-*	270	150	.55	252
6-7	268	35	A 3.0	11.8*-*	270	25	.09	25
7-41	226	29	A 2.5	11.8*-*	270	125	.46	105
30-42	198	26	B 7.3	3.5*-*	260	80	.31	61
24-42	543	71	B 9.2	7.6*-*	260	130	.50	272
42-43	740	96	C 11.0	8.7*-*	240	120	.50	370
6-44	463	60	A 5.1	11.8*-*	270	175	.65	301

NOTES: * width at doors
** two walls
*** two walls plus trash can
- one wall
**-- two walls plus pillar

(Cont'd)

Table E.4 (Cont'd)

Link (x,y)	10-Minute Peak Volume (persons)	Adjusted Flow (P/M)	Level of Service Letter (PFM)	Effective Width Required or Present (feet)	Speed on Link (ft/min)	Length (feet)	Walk Time on Link (minutes)	Aggregate Walk Time (P-M)
Shared, level								
31-24	86	71	A 1.4	50.0**	270	115	.43	37
31-40	21					115	.43	9
31-29	19					220	.81	15
30-29	29					225	.83	24
24-30	385					105	.39	150
30-40	5					110	.41	2
24-40	414	77	A 3.9	20.0	270	40	.15	61
24-29	181					125	.46	84
29-40	10	25	A 1.3	20.0	270		.28	3
24-29	181						-	-
Stairs, 1-way								
40-10,11	450	59	A 4.5	14.0**	122	20	.16	74
12-29	380	50	A 6.3	7.0**	101	45	.46	169
Stairs, 2-way								
6-30	616	80	A 6.2	13.0**--	122	15	.12	74
7-31	101	13	A 1.0	13.0**--	105	15	.14	14

(Cont'd)

Table E.4 (Cont'd)

Link (x,y)	10-Minute Peak Volume (persons)	Adjusted Flow (P/M)	Level of Service Letter (PFM)	Effective Width Required or Present (feet)	Speed on Link (ft/min)	Length (feet)	Walk Time on Link (minutes)	Aggregate Walk Time (P-M)
Bulk Arrivals, per./train								
17-32	983	328	E 17.0	5.5**	80	25	.31	305
18-32	655	218	E 17.0	5.5**	80	25	.31	203
24-32	1637	546	E 17.0	9.0**	175	70	.30	655
							TOTAL	4905

TABLE E.5

1985 MORNING WALK TIMES FOR ALTERNATIVE 3

Link (x,y)	10-Minute Peak Volume (persons)	Adjusted Flow (P/M)	Level of Service Letter (PFM)	Effective Width Required or Present (feet)	Speed on Link (ft/min)	Length (feet)	Walk Time on Link (minutes)	Aggregate Walk Time (P-M)
1-way, level or ramp								
20-1	125	16	A 2.1	7.8*	270	150	.55	69
20-21	125	16	A 1.3	12.0***	270	40	.15	19
24-21	125	16	A 0.9	17.0**	270	90	.33	41
4-43	485	63	C 10.4	6.0*	240	175	.73	354
32-24	205	27	A 3.0	9.0**	270	70	.26	53
56-57	33	4	A 0.4	10.0	270	50	.19	6
56-7	269	35	A 3.5	10.0	270	50	.19	51
24-55	44	6	A 1.0	6.0	270	75	.28	12
2-way, level or ramp								
5-43	233	30	A 3.0	10.1*-*	270	150	.55	128
51-43	829	108	C 12.5	8.7**	240	20	.08	69
52-53	844	110	C 12.5	8.8**	240	35	.15	123
53-54	874	114	C 12.5	9.1**	240	45	.19	164
24-90	770	100	B 10.0	10.0*-*	260	90	.35	267
30-90	104	14	A 1.4	10.0	270	35	.13	13
6-57	254	33	A 3.3	10.0	270	75	.28	71
7-57	261	34	A 3.4	10.0	270	40	.15	39

NOTES:
* width at doors
** two walls
*** two walls plus trash can
- one
**-- two walls plus pillar

(Cont'd)

Table E.5 (Cont'd)

Link (x,y)	10-Minute Peak Volume (persons)	Adjusted Flow (P/M)	Level of Service Letter (PFM)	Effective Width Required or Present (feet)	Speed on Link (ft/min)	Length (feet)	Walk Time on Link (minutes)	Aggregate Walk Time (P-M)
Shared, level								
31-24	53					115	.43	23
31-40	433					115	.43	186
31-29	45	90	A 1.8	50.0**	270	220	.81	36
30-29	14					225	.83	12
24-30	76					105	.39	30
30-40	75					110	.41	31
24-40	658	97	A 4.8	20.0	270	40	.15	99
24-29	85					125	.46	39
29-40	158	32	A 1.6	20.0	270	75	.28	44
24-29	85					-	-	-
1-way, stairs								
40-10,11	1323	173	C 8.5	20.4	117	20	.17	226
12-29	39	5	A 0.7	7.0**	105	45	.43	17
17-32	123	16	A 2.9	5.5**	105	25	.24	29
18-32	83	11	A 2.0	5.5**	105	25	.24	20
52-58	15	2	A 0.4	5.0	105	25	.24	4
53-59	30	4	A 0.8	5.0	105	25	.24	8
2-way stairs								
6-30	254	14	A 1.1	13.0**--	122	15	.12	30
7-31	530	69	B 5.3	13.0**--	101	15	.15	79
51-52	829	108	C 8.5	12.7	117	25	.21	117
54-90	874	114	C 8.5	13.4	98	25	.26	223

TABLE E.6

1985 AFTERNOON WALK TIMES FOR ALTERNATIVE 3

Link (x,y)	10-Minute Peak Volume (persons)	Adjusted Flow (P/M)	Level of Service Letter (PFM)	Effective Width Required or Present (feet)	Speed on Link (ft/min)	Length (feet)	Walk Time on Link (minutes)	Aggregate Walk Time (P-M)
1-way, level or ramp								
20-1	658	85	C 10.9	7.8*	240	150	.63	414
20-21	658	85	B 7.1	12.0***	260	40	.15	101
24-21	658	85	A 5.0	17.0**	270	90	.33	219
4-43	244	31	A 5.2	6.0*	270	175	.65	158
56-57	24	3	A 0.3	10.0	270	50	.19	4
56-7	131	131	A 1.7	10.0	270	50	.19	25
24-55	208	208	A 4.5	6.0	270	75	.28	58
2-way, level or ramp								
5-43	458	59	A 5.8	10.1*-*	270	150	.55	252
51-43	740	96	C 11.0	8.7**	240	20	.08	62
52-53	809	105	C 11.9	8.8**	240	35	.15	118
53-54	949	123	C 13.5	9.1**	240	45	.19	178
24-90	736	96	B 9.6	10.0*-*	260	90	.35	255
30-90	213	28	A 2.8	10.0	270	35	.13	28
6-57	506	66	A 6.6	10.0	270	75	.28	142
7-57	65	8	A 0.8	10.0	270	40	.15	10

NOTES:
* width at doors
** two walls
*** two walls plus trash can
- one wall
**-- two walls plus pillar

(Cont'd)

Table E.6 (Cont'd)

Link (x,y)	10-Minute Peak Volume (persons)	Adjusted Flow (P/M)	Level of Service Letter (PFM)	Effective Width Required or Present (feet)	Speed on Link (ft/min)	Length (feet)	Walk Time on Link (minutes)	Aggregate Walk Time (P-M)
Shared, level								
31-24	50	114	A 2.3	50.0**	270	115	.43	21
31-40	133					115	.43	57
31-29	24					220	.81	20
30-29	29					225	.83	24
24-30	635					105	.38	247
30-40	5					110	.41	2
24-40	303	62	A 3.1	20.0	270	40	.15	45
24-29	176					125	.46	81
29-40	10	24	A 1.2	20.0	270	75	.28	49
24-29	176					-	-	-
1-way, stairs								
40-10,11	450	59	A 2.9	20.4	122	20	.16	74
12-29	380	50	A 6.3	7.0**	101	45	.46	169
52-58	69	9	A 1.8	5.0	122	25	.20	14
53-59	140	18	A 3.6	5.0	122	25	.20	28
2-way, stairs								
6-30	506	66	B 5.1	13.0**--	120	15	.13	63
7-31	196	26	A 2.0	13.0**--	105	15	.14	28
51-52	740	96	C 7.6	12.7	98	25	.26	192
54-90	949	123	C 9.1	13.4	98	25	.26	247

(Cont'd)

Table E.6 (Cont'd)

Link (x,y)	10-Minute Peak Volume (persons)	Adjusted Flow (P/M)	Level of Service Letter (PFM)	Effective Width Required or Present (feet)	Speed on Link (ft/min)	Length (feet)	Walk Time on Link (minutes)	Aggregate Walk Time (P-M)
Bulk Arrivals, per./train								
17-32	983	328	E 17.0	5.5**	80	25	.31	305
18-32	655	218	E 17.0	5.5**	80	25	.31	203
32-24	1637	546	E 17.0	9.0**	175	70	.40	655
						TOTALS		4548

TABLE E.7

1985 MORNING WALK TIMES FOR ALTERNATIVE 4

Link (x,y)	10-Minute Peak Volume (persons)	Adjusted Flow (P/M)	Level of Service Letter (PFM)	Effective Width Required or Present (feet)	Speed on Link (ft/min)	Length (feet)	Walk Time on Link (minutes)	Aggregate Walk Time (P-M)
1-way, level								
93-94	125	16	A 3.2	6.8	270	85	.31	39
61-62	68	9	A 1.8	5.0	270	40	.15	10
61-63	138	18	A 3.6	5.0	270	80	.30	41
63-62	58	7	A 1.4	5.0	270	75	.28	16
68-69	21	3	A 0.6	5.0	270	35	.13	3
4-68	859	112	C 12.5	9.0	240	175	.73	626
2-way, level								
5-68	233	30	A 3.0	10.1*-*	270	150	.55	128
64-65	1351	176	C 12.5	14.1	240	40	.17	230
65-66	1320	172	C 12.1	14.1	240	40	.17	224
66-67	1291	168	C 11.0	14.1	130	40	.17	219
64-91	1380	179	C 12.7	14.1	240	40	.17	235
29-70	31	4	A 0.4	10.0	270	120	.44	14
72-95	85	11	A 0.4	25.0	270	175	.65	55
71-95	301	39	A 1.6	25.0	270	175	.65	196

NOTES: ** two walls
- one wall

(Cont'd)

Table E.7 (Cont'd)

Link (x,y)	10-Minute Peak Volume (persons)	Adjusted Flow (P/M)	Level of Service Letter (PFM)	Effective Width Required or Present (feet)	Speed on Link (ft/min)	Length (feet)	Walk Time on Link (minutes)	Aggregate Walk Time (P-M)
Shared, level								
63-70	170	46	A 3.1	15.0	270	110	.41	69
69-70	185					35	.13	24
63-69	980	142	B 9.4	15.0	260	60	.23	226
63-29	113					190	.73	83
29-69	158	35	A 3.5	10.0	270	125	.46	73
63-29	113					-	-	-
1-way, stairs								
1-93	125	16	A 2.3	10.0	122	25	.20	26
62-94	125	16	A 2.3	10.0	105	25	.24	30
92-61	205	27	A 2.2	12.0**	105	25	.24	49
12-29	39	5	A 0.7	7.0**	105	45	.43	17
64-99	29	4	A 0.8	5.0**	122	25	.20	6
65-98	31	4	A 0.8	5.0**	122	25	.20	6
66-97	29	4	C 8.5	5.0**	122	25	.20	6
69-10,11	1323	173		20.4	117	20	.17	226
2-way, stairs								
67-68	1291	168	C 8.5	19.7	98	25	.26	329
63-91	1380	179	C 8.5	21.1	117	25	.21	295
70-95	386	50	A 4.1	12.2	105	10	.10	39

TOTAL 3540

TABLE E.8

1985 AFTERNOON WALK TIMES FOR ALTERNATIVE 4

Link (x,y)	10-Minute Peak Volume (persons)	Adjusted Flow (P/M)	Level of Service Letter (PFM)	Effective Width Required or Present (feet)	Speed on Link (ft/min)	Length (feet)	Walk Time on Link (minutes)	Aggregate Walk Time (P-M)
1-way, level								
93-94	658	85	C 12.5	6.8	240	85	.35	233
63-62	106	14	A 2.8	5.0	270	75	.28	29
68-96	165	21	A 4.3	5.0	270	35	.13	21
4-68	418	54	A 6.0	9.0	270	175	.65	271
2-way, level								
5-68	458	59	A 5.8	10.1*-*	270	150	.55	252
64-65	1356	176	C 12.5	14.1	240	40	.17	226
65-66	1217	158	C 11.2	14.1	240	40	.17	207
66-67	1079	140	B 9.9	14.1	260	40	.15	166
64-91	1495	194	C 13.7	14.1	240	40	.17	254
29-70	34	4	A 0.4	10.0	270	120	.44	15
72-95	308	40	A 1.6	25.0	270	175	.64	200
71-95	481	63	A 2.5	25.0	270	175	.64	308
Shared, level								
63-70	731	98	A 6.5	15.0	270	110	.41	298
69-70	24					35	.13	3
63-69	416	79	A 5.2	15.0	270	60	.22	92
63-29	195					190	.70	137
29-69	10	27	A 2.7	10.0	270	125	.46	5
63-29	195					-	-	-

NOTES: ** two walls, *-* one wall

(Cont'd)

Table E.8 (Cont'd)

Link (x,y)	10-Minute Peak Volume (persons)	Adjusted Flow (P/M)	Level of Service Letter (PFM)	Effective Width Required or Present (feet)	Speed on Link (ft/min)	Length (feet)	Walk Time on Link (minutes)	Aggregate Walk Time (P-M)
1-way, stairs								
1-93	658	85	C 8.5	10.0	117	25	.21	141
62-94	658	85	C 8.5	10.0	98	25	.26	168
12-29	380	50	B 6.3	7.0**	101	45	.46	169
64-99	139	18	A 3.6	5.0**	122	25	.20	28
65-98	139	18	A 3.6	5.0**	122	25	.20	28
66-97	139	18	A 3.6	5.0**	122	25	.20	28
69-10,11	450	59	A 2.9	20.4	122	20	.16	74
2-way, stairs								
67-68	1079	140	C 7.1	19.7	98	25	.26	281
63-91	1495	194	C 9.2	21.1	98	25	.26	389
70-95	789	103	C 8.5	12.2	117	10	.09	67
Bulk Arrivals, per./train								
92-61	1637	546	E 17.0	12.0**	80	25	.31	512
61-62	551	184	E 17.0	10.0	175	40	.23	126
61-63	1086	362	E 17.0	10.0	175	80	.46	500

TOTAL 5228

TABLE E.9

1985 MORNING WALK TIMES FOR ALTERNATIVE 5

Link (x,y)	10-Minute Peak Volume (persons)	Adjusted Flow (P/M)	Level of Service Letter (PFM)	Effective Width Required or Present (feet)	Speed on Link (ft/min)	Length (feet)	Walk Time on Link (minutes)	Aggregate Walk Time (P-M)
1-way, level								
61-89	38	5	A 0.5	10.0	270	70	.22	8
61-83	168	22	A 2.2	10.0	270	115	.43	72
83-89	31	4	A 0.4	10.0	270	100	.37	11
29-40	158	21	A 1.0	20.0	270	75	.28	44
2-way, level								
84-86	215	28	A 3.7	7.6**	270	70	.26	56
86-87	83	11	A 2.1	5.0**	270	40	.15	12
87-88	39	5	A 1.1	5.0**	270	40	.15	6
83-29	53	7	A 0.7	10.0	270	165	.61	32
29-82	91	12	A 0.8	15.0	270	130	.48	44
81-82	1278	166	A 6.6	25.0	270	165	.61	780
Shared, level								
83-40	234	56	A 5.6	10.0	270	75	.28	65
83-82	199					160	.59	118
82-40	931					50	.21	194
83-82	199	174	C 12.5	13.9	240	-	-	-

NOTE: ** two walls

Table E.9 (Cont'd)

Link (x,y)	10-Minute Peak Volume (persons)	Adjusted Flow (P/M)	Level of Service Letter (PFM)	Effective Width Required or Present (feet)	Speed on Link (ft/min)	Length (feet)	Walk Time on Link (minutes)	Aggregate Walk Time (P-M)
1-way stairs								
92-61	205	27	A 2.2	12.0**	105	25	.24	49
12-29	39	5	A 0.7	7.0**	105	45	.43	17
86-101	133	17	A 2.2	7.6	122	25	.20	27
87-102	44	6	A 0.9	5.0	122	25	.20	9
40-10,11	1323	173	C 8.5	20.4	117	20	.17	226
2-way stairs								
83-85	296	39	B 5.8	6.7	101	25	.25	73
88-103	39	5	A 1.0	5.0	105	25	.24	9
83-84	215	28	A 2.5	11.1	105	25	.24	51

TOTAL. 1903

TABLE E.10

1985 AFTERNOON WALK TIMES FOR ALTERNATIVE 5

Link (x,y)	10-Minute Peak Volume (persons)	Adjusted Flow (P/M)	Level of Service Letter (PFM)	Effective Width Required or Present (feet)	Speed on Link (ft/min)	Length (feet)	Walk Time on Link (minutes)	Aggregate Walk Time (P-M)
1-way, level								
83-89	55	7	A 0.7	10.0	270	100	.37	20
29-40	10	1	A 0.1	20.0	270	75	.28	3
2-way, level								
84-86	721	94	C 12.5	7.6**	240	70	.29	210
86-87	226	29	A 5.9	5.0**	270	40	.15	33
87-88	19	2	A 0.5	5.0**	270	40	.15	3
83-29	118	15	A 1.5	10.0	270	165	.61	72
29-82	111	15	A 1.0	15.0	270	130	.48	53
81-82	269	35	A 1.4	25.0	270	165	.61	164
Shared, level								
83-40	88	87	B 8.7	10.0	260	75	.29	169
83-82	579					160	.62	356
82-40	353	121	B 8.7	13.9	260	50	.19	68
83-82	579					-	-	-
1-way, stairs								
12-29	380	50	B 6.3	7.0**	101	45	.46	169
86-101	495	64	C 8.5	7.6	117	25	.21	106
87-102	208	27	B 5.4	5.0	120	25	.21	43
40-10,11	450	59	A 2.9	20.4	122	20	.16	74

NOTE: ** two walls

(Cont'd)

Table E.10 (Cont'd)

Link (x,y)	10-Minute Peak Volume (persons)	Adjusted Flow (P/M)	Level of Service Letter (PFM)	Effective Width Required or Present (feet)	Speed on Link (ft/min)	Length (feet)	Walk Time on Link (minutes)	Aggregate Walk Time (P-M)
2-way, stairs								
83-85	438	57	C 8.5	6.7	98	25	.26	112
88-103	19	2	A 0.5	5.0	122	25	.20	4
83-84	721	94	C 8.5	11.1	98	25	.26	187
Bulk Arrivals, per./train								
92-61	1637	546	E 17.0	12.0**	80	25	.31	512
61-89	290	97	E 17.0	10.0	175	60	.34	99
61-83	1348	449	E 17.0	10.0	175	115	.66	886

TOTAL 3199

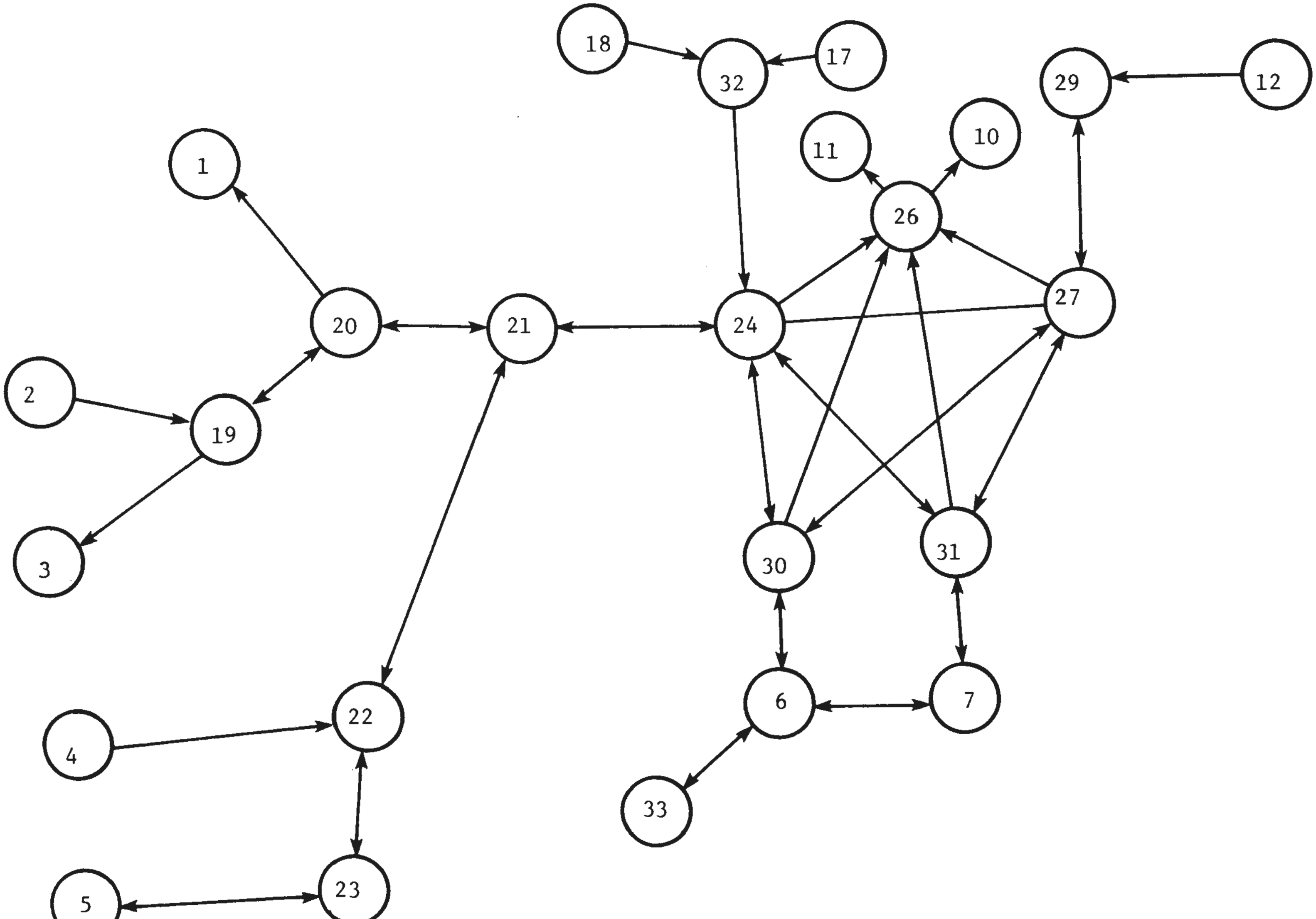

Figure E.1. Network - Alternative 1

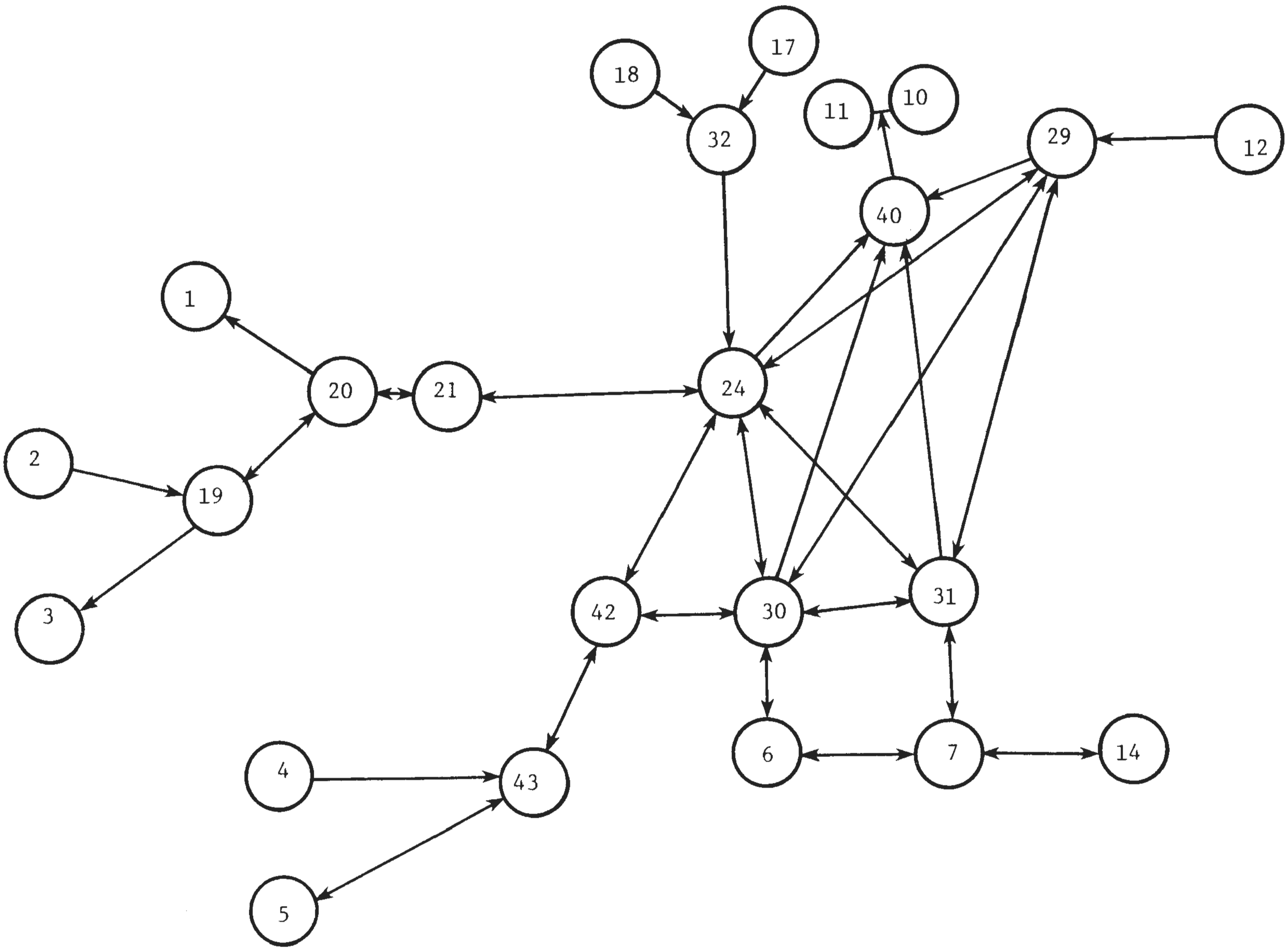

Figure E.2. Network - Alternative 2

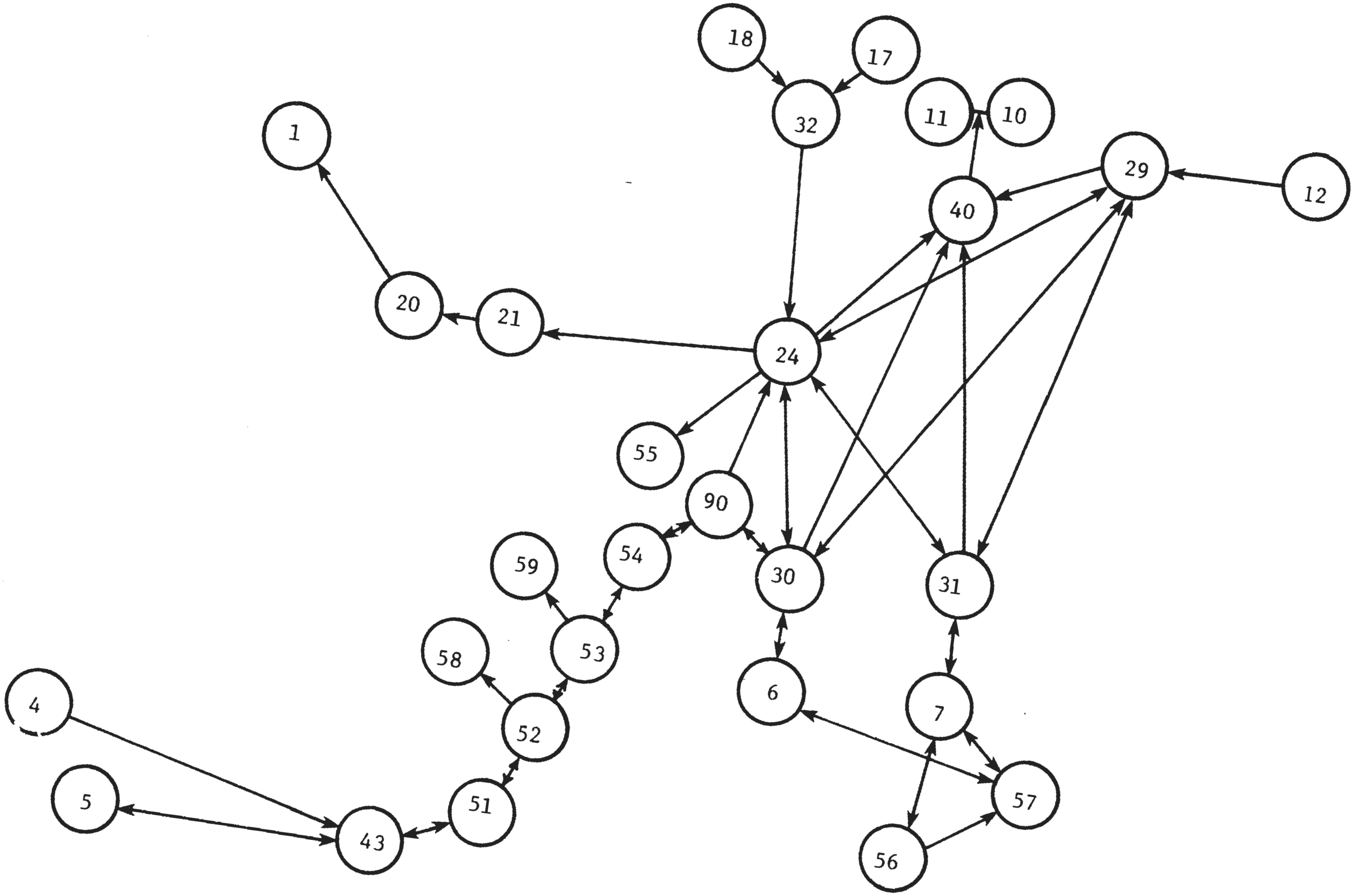

Figure E.3. Network - Alternative 3

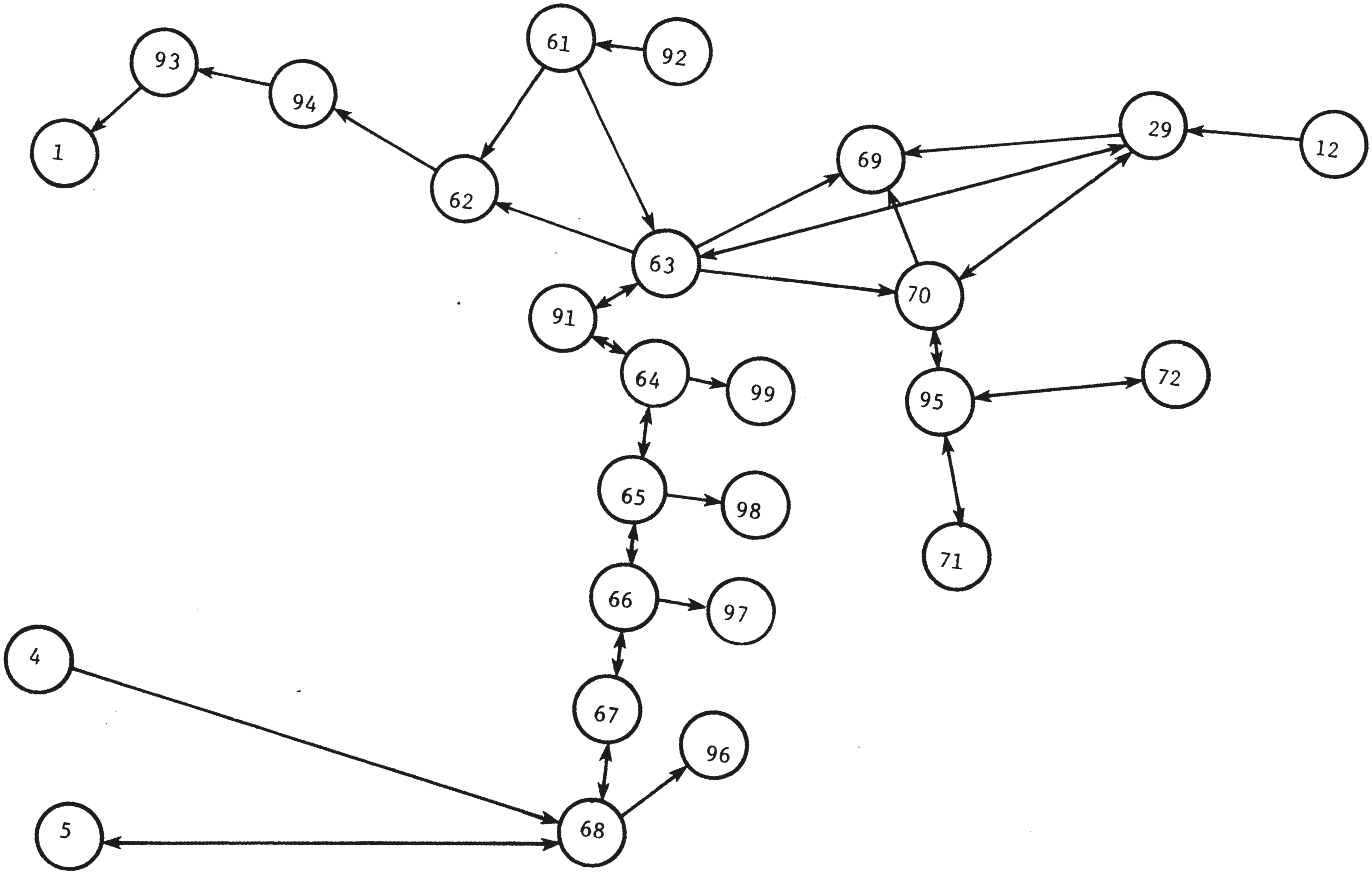

Figure E.4. Network - Alternative 4

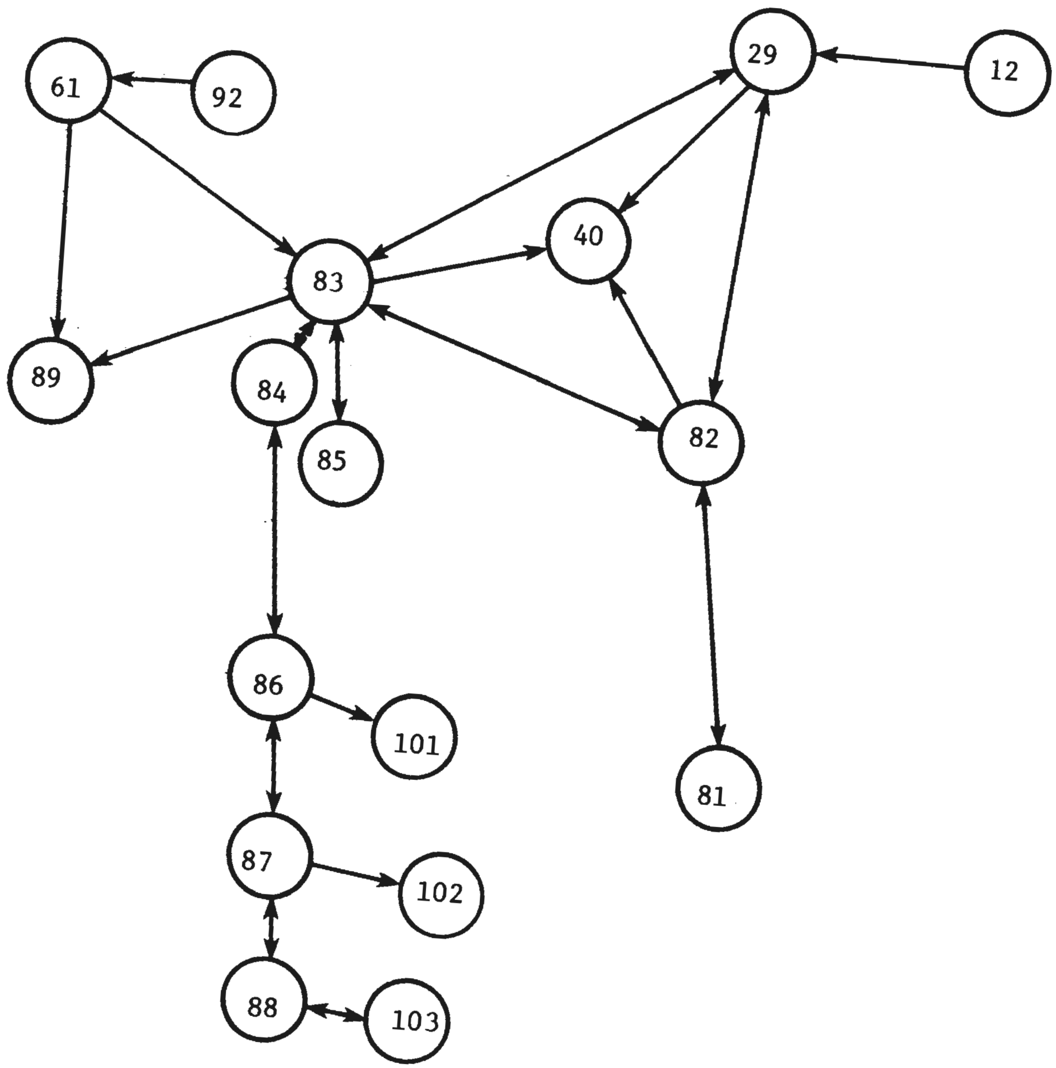

Figure E.5. Network - Alternative 5

APPENDIX F

CAPITAL COST SUMMARY FOR EACH ALTERNATIVE

TABLE F.1

CAPITAL COST - ALTERNATIVE 1

Estimated total capital cost:		$ 3.1 million
Main terminal area	75,400 sq. ft. all existing	
Enclosed wings	6,600 sq. ft. all existing	
Covered platforms	41,000 sq. ft., 31,000 existing	
Demolish volume	0 cu. yds.	

1. Main terminal	
- gut ($7.15/sq. ft.)	$ 539,000
- rebuild ($ 30.68/sq. ft.)[1]	2,314,000
2. Enclosed wings	
- paint, flooring, electrical ($4.90/ sq. ft.)[2]	32,000
3. Covered platforms ($20.00/sq. ft.)[3]	200,000
4. New pavement ($4.00/sq. ft.)[4]	4,100
TOTAL	$ 3,089,100

NOTES:
1. \$49.75 - 22.8% (\$49.75) = \$30.68
   Masonary cost 18.5%; Roofing cost 4.3%
2. 12.3% of $39.75 median cost
3. includes sidewalk, supports and translucent panel covering
4. 1.5" wearing course, 1.0" base course, and .75" finish course

TABLE F.2

CAPITAL COST - ALTERNATIVE 2

Estimated total capital cost: $ 2.4 million

Main terminal area	54,500 sq. ft. all existing
Enclosed wings	14,700 sq. ft., 9,700 existing
Covered platforms	37,000 sq. ft. 31,000 existing
Demolish volume	15,200 cu. yds.

1. Total demolition cost	
- demolition ($2,70/cu.yd.)	$ 41,000
- disposal ($3.45/cu.yd.)[1]	10,500
- dump ($2.50/cu. yd.)	7,600
2. Old terminal renovation	
- gut ($7.15/sq. ft.)	389,000
- rebuilt ($30.68/sq. ft)	1,672,400
3. New wing ($39.75/sq. ft.)	199,000
4. Covered platforms ($20.00/sq. ft.)	120,000
5. New pavement ($4.00/sq. ft.)	4,000
TOTAL	$ 2,443,500

NOTE: 1. Disposal volume was assumed to be 20% of demolition volume.

TABLE F.3

CAPITAL COST - ALTERNATIVE 3

Estimated total capital cost: $ 1.9 million

Main terminal area	37,000 sq. ft.	all existing
Enclosed wings	8,800 sq. ft.	6,300 existing
Covered platforms	43,000 sq. ft.	31,000 existing
Demolish volume	28,100 cu. yds.	

1.	Total demolition cost	
	- demolition ($2.70/cu. yd.)	$ 76,000
	- disposal ($3. 45/cu. yd.)	19,400
	- dump ($2.50/cu. yd.)	14,000
2.	terminal renovation	
	- gut ($7.15/sq. ft.)	264,600
	- rebuild ($30.68/sq. ft.)	1,135,400
3.	New wing ($39.75/sq. ft.)	99,000
4.	Covered platforms ($20.00 sq. ft.)	240,000
5.	New pavement ($4.00/sq. ft.)	8,000
	TOTAL	$ 1,856,000

TABLE F.4

CAPITAL COST - ALTERNATIVE 4

Estimated total capital cost		$ 2.9 million
Main terminal area	40,000 sq. ft. 12,000 existing	
Enclosed wings	13,300 sq. ft., all new	
Covered platforms	43,400 sq. ft. 31,000 existing	
Demolish volume	46,700 cu. yds.	

1.	Total demolition cost	
	- demolition ($2.70/cu. yd.)	$ 126,000
	- disposal ($3.45/cu. yd.)	32,000
	- dump ($2.50/cu. yd.)	23,000
2.	Main terminal (new) ($49.75/sq. ft.)[1]	1,393,000
	Main terminal (old)	
	- gut ($7.15/sq. ft.)	86,000
	- rebuild ($30.68/sq. ft.)	460,000
3.	New wings ($39.75/sq. ft.)	529,000
4.	Covered platforms ($20.00/sq. ft.)	248,000
5.	New pavement ($4.00/sq. ft.)	9,000
	TOTAL	$ 2,906,000

NOTE: 1. The 75th percentile cost was used because the new structure spans the subway-elevated platforms.

TABLE F.5

CAPITAL COST - ALTERNATIVE 5

Estimated total capital cost	$ 4.4 million

Main terminal area	63,500 sq. ft., 12,000 existing
Enclosed wings	10,400 sq. ft., 2,600 existing
Covered platforms	28,000 sq. ft., 6,000 existing
Demolish volume	46,700 cu. yds.
Track removal	400 linear feet (LF)
New track	1100 LF
Excavation	2,200 cu. yds.

1. Total demolition cost	
- demolition ($2.70/cu. yd.)	$ 126,000
- disposal ($3.45/cu.yd.)	32,000
- dump ($2.50/cu. yd.)	23,000
2. Main terminal (new) ($49.75/sq. ft.)	2,562,100
Main terminal (old)	
- gut ($7.15/sq. ft.)	86,000
- rebuild ($30.68/sq. ft.)	460,000
3. New wings ($39.75/sq. ft.)	310,000
4. Covered platforms ($20.00/sq. ft.)	440,000
5. New pavement ($4.00/sq. ft.)	9,000
6. Track realignment	
- track removal ($6.55/LF)	2,600
- new track ($63.85/LF)	70,200
- excavation ($1.45/cu. yd.)[1]	3,200
TOTAL	$ 4,395,900

NOTE: 1. This does not include disposal.

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