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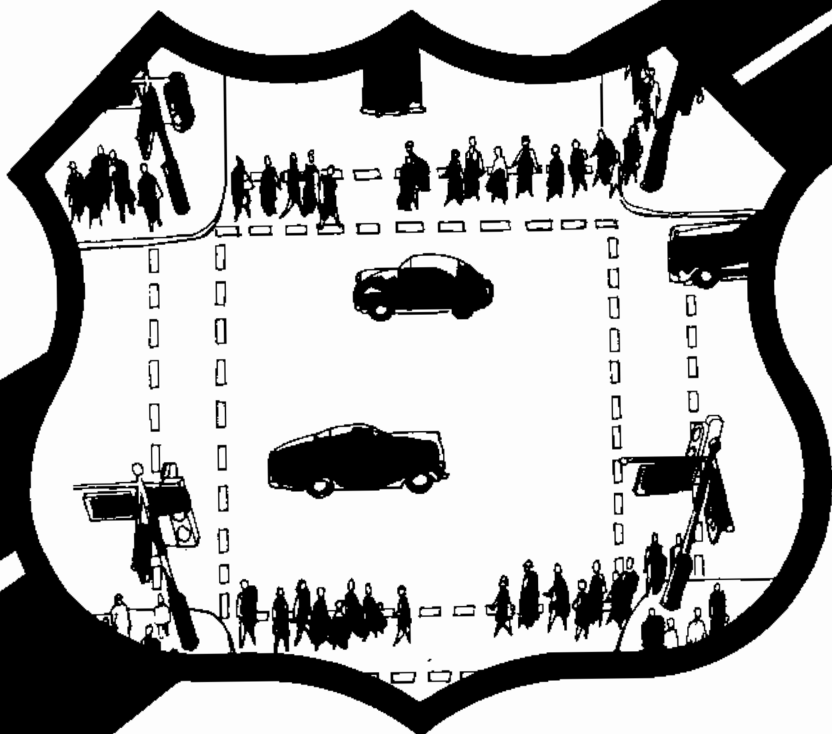
A PEDESTRIAN PLANNING PROCEDURES MANUAL

Vol. II. Procedures
November 1978
Final Report



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Prepared for
FEDERAL HIGHWAY ADMINISTRATION
Offices of Research & Development
Environmental Design & Control Division
Washington, D.C. 20590

FOREWORD

This manual identifies the significant data, procedures and criteria that should be considered in the planning, selection and evaluation of both comprehensive pedestrian systems and individual facilities.

Research in pedestrian safety is included in the Federally Coordinated Program of Highway Research and Development as Task 1 of Project 1E, "Safety of Pedestrians and Abutting Property Occupants." Mr. John C. Fegan is the Project Manager from the Office of Research and Mr. Richard Richter is the Implementation Manager from the Office of Development.

Sufficient copies of Volume I are being distributed to provide a minimum of three copies to each regional office, five copies to each division office and ten copies for each State highway agency. Two copies each of Volume II and Volume III are being sent to the regional and division offices and five copies of each to the State highway agency. Direct distribution is being made to the division offices.

Charles F. Scheffey
Director, Office of Research
Federal Highway Administration

NOTICE

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16. Abstract

The Manual identifies the significant data, procedures and criteria that should be considered in the planning and evaluation of both comprehensive pedestrian systems and individual facilities.

This volume is operational and sequential in nature. The procedures are grouped into two major phases:

A demand modelling phase, in which the existing (and projected) movement of pedestrians is examined using a gravity model approach to produce a network plan showing the assignment of pedestrian volumes; and

A network evaluation phase, in which first phase output is utilized to develop a plan addressing the specific planning of the pedestrian system elements and modal interface requirements. In addition, methods have been incorporated for examining and evaluating both system's effectiveness and potential impacts.

Other volumes in this series are:

Vol. No.	Report No.	Short Title
I	79-45	Overview
III	79-47	Technical Supplement

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PREFACE

The Pedestrian Planning Process is presented in three separate volumes.

VOLUME ONE

Volume One, the Overview, provides a general background and introduction to pedestrian planning and to the technical procedures of Volume Two. The major topic areas covered in this volume include:

The pedestrian planning context

- background
- the need for pedestrianization
- objectives of pedestrian planning
- relationship to land use/transportation planning

The need for a pedestrian planning process

- state of the art
- rationale for the process (utilization, benefits and impacts, pathway choice)

Overview of the Pedestrian Planning Process (PPP)

- major PPP phases (the demand modelling phase, the design and evaluation phase)
- description of the PPP tasks (brief overview of each task)

Application of the Pedestrian Planning Process

- objectives of the process
- using the procedures
- determining procedure(s) applicability

VOLUME TWO

Volume Two, the Procedures, is operational and sequential in nature. Each procedure within the Manual sets forth all the fundamental requirements for successfully conducting that specific aspect of pedestrian facilities planning, design and evaluation in terms of:

- Approach
- Data provided or required
- Specific methods of analysis or evaluation to be used
- Use and interpretation of output to aid in the decision-making process
- Relationship of specific procedures to the overall PPP

VOLUME THREE

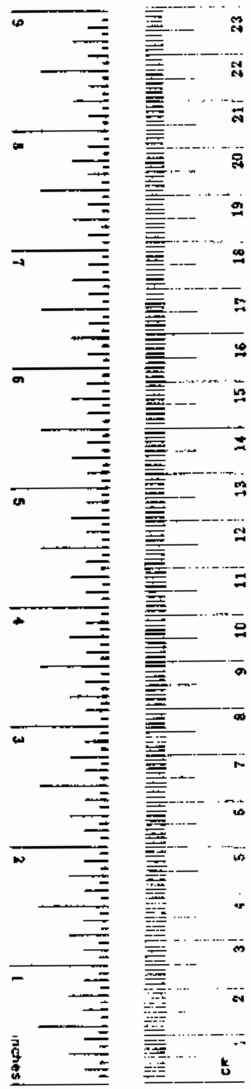
Volume Three, the Technical Supplements, explains the derivation of the data provided in Volume Two and presents considerably more detailed data and methodologies for various tasks as well as worked examples. This material is supplemental to the Procedures Volume and is to be used in conjunction with it. This volume also provides the user with a fundamental understanding of the research underlying the development of the Process, allows him to examine its assumptions, and modify data to suit his specific conditions.

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

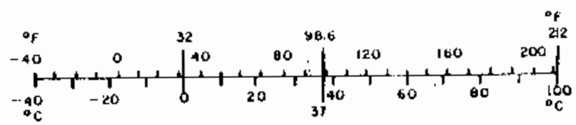
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2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

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



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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OVERVIEW OF THE PEDESTRIAN PLANNING PROCESS (PPP)

A. INTRODUCTION

The purpose of this overview is to provide a brief synopsis of the pedestrian planning process, and to familiarize potential users with the PPP components and their interrelationships. Guidelines for applying the process are provided in Section IV of the Overview.

Pedestrian planning heretofore has most often been based on subjective judgement rather than on technical, analytical, objective procedure. This has resulted, in many cases, in the apparent failure of pedestrian facilities that may have been well designed, but ill conceived or misplaced. Pedestrian facilities do not necessarily attract pedestrian users. In order to be utilized, they must be designed to accommodate desired movement more adequately than alternative paths. The PPP is designed to accomplish this end.

In brief, the PPP identifies the significant procedures and criteria that should be considered in the planning, design, evaluation and implementation of pedestrian systems. Applicable system components include street closings; street conversions (to full or partial malls); street improvements such as widened sidewalks; skyways, overcrossings and second-level walkways; subways; vertical change elements such as stairs and ramps; mechanical systems; and various other facilities dedicated to the accommodation of pedestrian movement. The process also integrates a broad range of environmental, economic, social-behavioral, and operational factors that should be considered by urban designer and traffic engineers using the Process. In addition to the technical procedures and operational criteria, methods have been incorporated for examining and evaluating both system effectiveness (in terms of feasibility) and potential impacts (social, economic, physical and behavioral).

Additionally, the process has the following characteristics:

- Can be applied to both large-scale (extended pedestrian systems) or small-scale (single facility or component) projects;
- Deals with short trip-making (usually less than 15 minutes) -- walking only trips as well as the walking trip component of other more extended trips;
- Is sensitive to pedestrian behavior in terms of real and perceived factors that influence movement;
- Allows the user flexibility in data collection, procedure application, and level of analytical detail; and
- Operates primarily as a responsive rather than generative tool.

The last point requires explanation. The PPP is most appropriate when applied to those situations where major land use and urban transportation policies have been determined. The process then responds to these policies to determine the appropriate location, linkage, access, extent and nature of pedestrian accommodations. Conversely, the model is not appropriate as a predictor of land use growth and distribution, for example; that is, it does not generate a basis for major urban policy. However, in some cases, the PPP may impact on policy. For example, the process may provide a basis for the strategic location of major generators such as a subway station or a convention center.

B. Major Pedestrian Planning Process Phases

In section III C, the PPP overview will be discussed in terms of individual process tasks. In this section the PPP is presented in terms of its two major phases. The phases are as follows:

- A demand modelling phase, including Tasks 1 through 13, during which the present and/or future movement of pedestrians is examined to produce a network plan showing the distribution and assignment of pedestrian volumes; and

- A network design and evaluation phase, including Tasks 13 through 27, during which the first phase output is utilized, together with additional analyses, to develop a network plan addressing the specific planning and design of network segments including pathway links, nodes and modal interface requirements.

Each of these major phases is discussed in more detail below.

1. The Demand Modelling Phase

This section deals with the Task 1 through 13 leading to the development of a network plan showing the distribution and assignment of pedestrian trip making within the study area. Primary components of this phase include examination of: (1) the present and future pedestrian trip generation characteristics of various land use activities; (2) the trip making propensity between land use activities as a function of connecting pathway attributes; (3) the trip exchange patterns resulting from (1) and (2); and (4) the assignment of these trips to alternative network pathways. This collection of tasks, together with numerous supporting functions, comprises the demand modelling phase.

The importance of the modelling tasks, relative to the remainder of the process, should not be exaggerated since they are simply a means to an end rather than an end in themselves. However, the model embodies several concepts that may be unfamiliar to urban designers and traffic engineers; therefore, a special discussion of its characteristics is in order.

The objective of the modelling effort is to forecast future movement of pedestrians given that extensive modification to the existing urban environment will be accomplished. Indeed, in the absence of extensive change (addition of new land uses, modification of the traffic network, etc.), it may be more efficient to simploy conduct surveys or counts to define movement. However, where the impact of urban change on pedestrian movement is not clear, it may be advantageous to conduct the modelling.

The primary output of the modelling phase is a network plan which shows the distribution and assignment of future pedestrian volumes. Distribution refers to the way in which trips produced at a point are allocated to one or more points which attract these trips. Assignment refers to the way in which trips produced and attracted are allocated to alternative connecting routes. This output is obtained through the following steps:

(1) A specific trip purpose is chosen for analysis;

(2) For each existing pedestrian centroid (activity/center) that produces and/or attracts trips related to the trip purpose being examined, a trip generation rate is determined;

(3) The existing centroids are then described in terms of a network showing interconnecting routes, and each route is assigned a measure of separation between centroids in terms of real or perceived time;

(4) The trip generation measures and inter-centroid separation measures, converted to measures of trip-making propensity (friction factors) are then manipulated mathematically (using a gravity model approach) to distribute and assign the trips;

(5) The trip volumes are then arrayed on the network plan and compared to the extent possible with similar statistics obtained through surveys, counts or other means;

(6) As appropriate, trip generation rates and the friction factor propensity curves are adjusted until the user is confident that the gravity model is adequately simulating reality;

(7) Finally, future land uses and pathway links are introduced into the network and operated upon by the calibrated model to obtain the primary model output -- the distribution and assignment of forecasted pedestrian volumes.

The output of (7) above forms the basis for the remainder of the process. At this point, however, it is important to caution that the process cited above is performed only to the extent that it is necessary to obtain a basis for the remaining effort. The modelling output is not an end in itself; it is simply a means to an end -- the pedestrian design plan. In some cases, simple counts or gross estimates may suffice, provided the user is comfortable that an appropriate degree of accuracy exists. Furthermore, the user should belabor the modelling effort only as necessary to obtain the basis for proceeding with the process.

Trip generation rates express the rate at which trips are generated (produced and attracted) for a given trip purpose. These rates usually indicate the peak hour, directional trips per unit of centroid site. For example, an office building may produce 10 trips out per 1000 gross square feet for employee lunch trips leaving during the peak hour of 11:45 AM to 12:45 PM. Similarly, a peak 15-minute rate might be 5 trips out per 1000 gross square feet between noon and 12:15 PM, with the other 5 trips (on the average) spread over the other 3/4 of the peak hour.

Intercentroid separation is a measure of the trip time (or distance) between two centroids. Briefly, a nominal measure based on distance, time and energy is developed, with all units converted to time. This nominal measure will include the actual walking time, delays due to waiting, crowding and similar impedances, and time-equivalent penalties associated with stairs, etc. An effective measure of separation is then obtained by adjusting the nominal separation to account for pedestrian behavior and perception of the pathway. For example, a 10-minute trip might seem like (be perceived as) an 8-minute trip if the pathway is attractive and comfortable; but might seem like a 12-minute trip if the pathway is dreary. The resulting measure of effective separation is then converted to a measure of trip propensity (the relative probability that the pedestrian will make the trip on foot). This measure is called the friction factor and is developed based on known characteristics of pedestrian behavior as a function of trip purpose.

The trip distribution and assignment is accomplished in two interrelated steps. First, a gravity model approach is made to distribute trips produced by each centroid among all attraction centroids as a function of intercentroid separation and strength of attraction. This determines how many trips produced at each production centroid go to each attrac tion centroid. Trips can then be assigned to specific routes (series of pathway links) using an appropriate ration ale. A simple rule is to assign all trips to the route characterized by the minimum separation and none to competing routes (all-or-nothing assignment); trips can also be split based on their relative friction factors or other scheme (generically known as stochastic assignment). Following this step, the user has a "loaded" network showing pedestrian volumes for each network link.

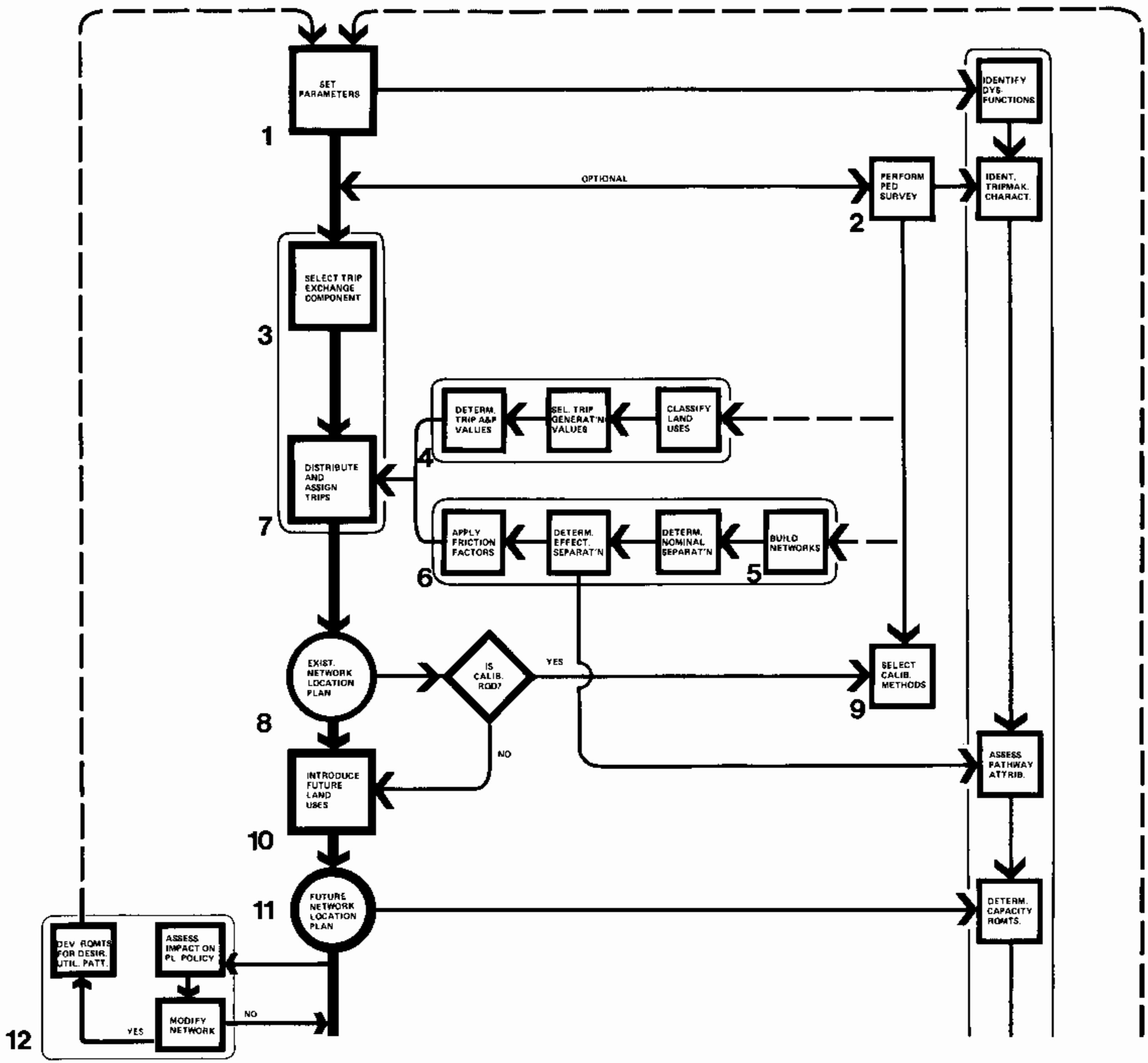
2. The Design And Evaluation Phase

The second major phase consists of Task 13 through 27, and leads to the development of a network design plan and its supporting documentation. The network plan provides specific planning and design detail for network segments including pathway links, land use acitivites and network nodes, and transportation modal interfaces.

Primary components of the PPP included in this Phase are: (1) interface with the traffic and transit network; (2) resolution of multimodal conflicts; (3) development of specific pedestrian network planning and design requirements; (4) network design treatments; and (5) systems evaluation.

In the first PPP Phase, the locations of major network corridors based upon their utilization potential, were identified. Since the implementation of a pedestrian system may have a substantial impact upon the existing vehicle access network in terms of capacity, accessibility, etc., an important aspect of this phase will be to apply a set of procedures for evaluating the impact of pedestrian decisions upon the vehicle network. The design process will thus identify the specific potential for pedestrianization through a consideration of multi-modal requirements and alternative movement strategies. This component will address the definitive nature and extent of each network segment and each pathway element.

The resolution of multimodal conflicts, through the use of pedestrian-vehicular separation, modification to the


SET PARAMETERS
1
OPTIONAL
PERFORM PED SURVEY
2
IDENTIFY DYS-FUNCTIONS
IDENT. TRIPMAK. CHARACT.
SELECT TRIP EXCHANGE COMPONENT
3
DETERM. TRIP A&P VALUES
SEL. TRIP GENERAT'N VALUES
CLASSIFY LAND USES
4
DISTRIBUTE AND ASSIGN TRIPS
7
APPLY FRICTION FACTORS
DETERM. EFFECT. SEPARAT'N
DETERM. NOMINAL SEPARAT'N
BUILD NETWORKS
5
6
EXIST. NETWORK LOCATION PLAN
8
IS CALIB. RQD?
YES
NO
SELECT CALIB. METHODS
9
ASSESS PATHWAY ATTRIB.
INTRODUCE FUTURE LAND USES
10
FUTURE NETWORK LOCATION PLAN
11
DETERM. CAPACITY RQMTS.
DEV RQMTS FOR DESIR. UTIL. PATT.
ASSESS IMPACT ON PL POLICY
MODIFY NETWORK
YES
NO
12

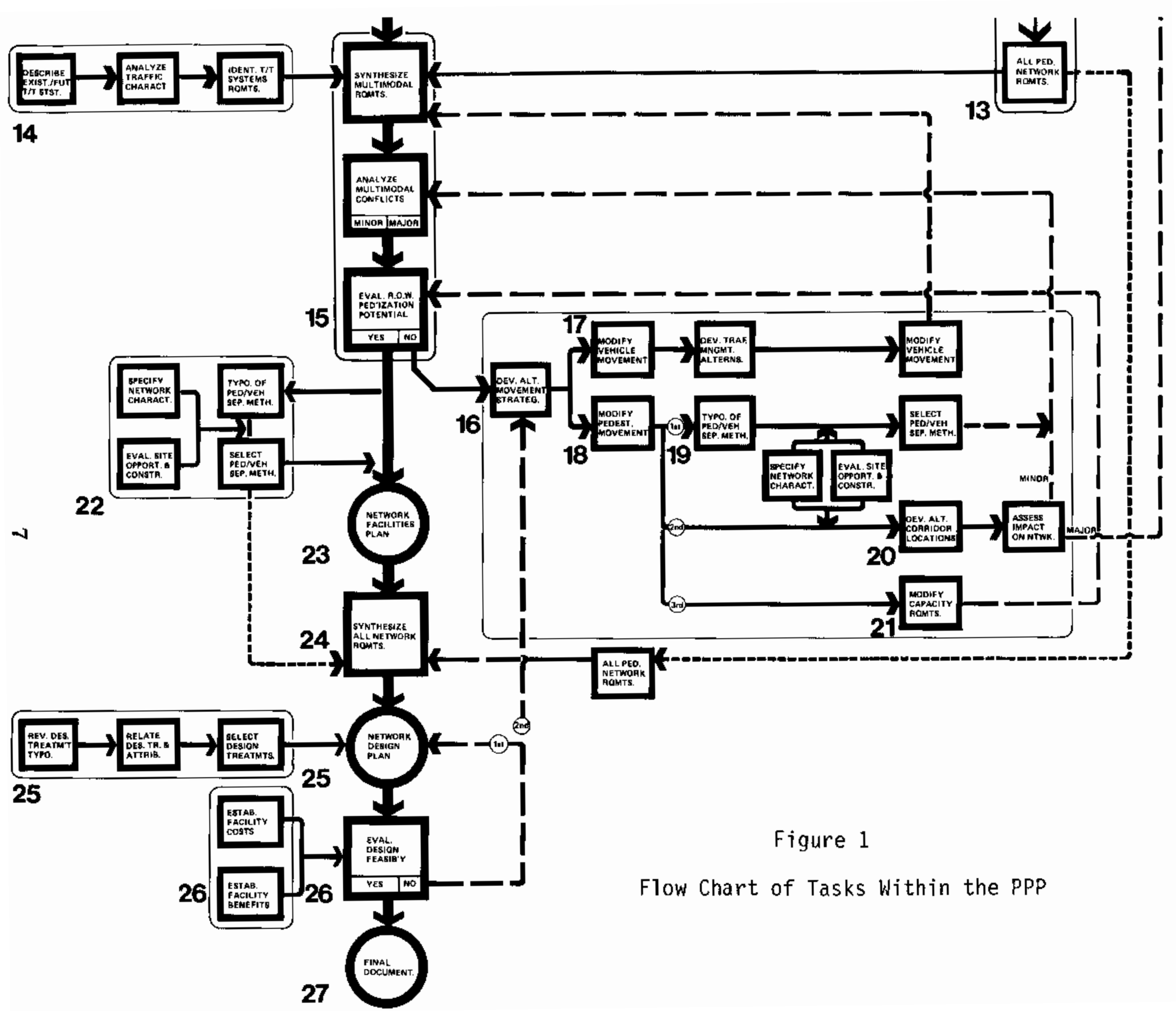


Figure 1

Flow Chart of Tasks Within the PPP

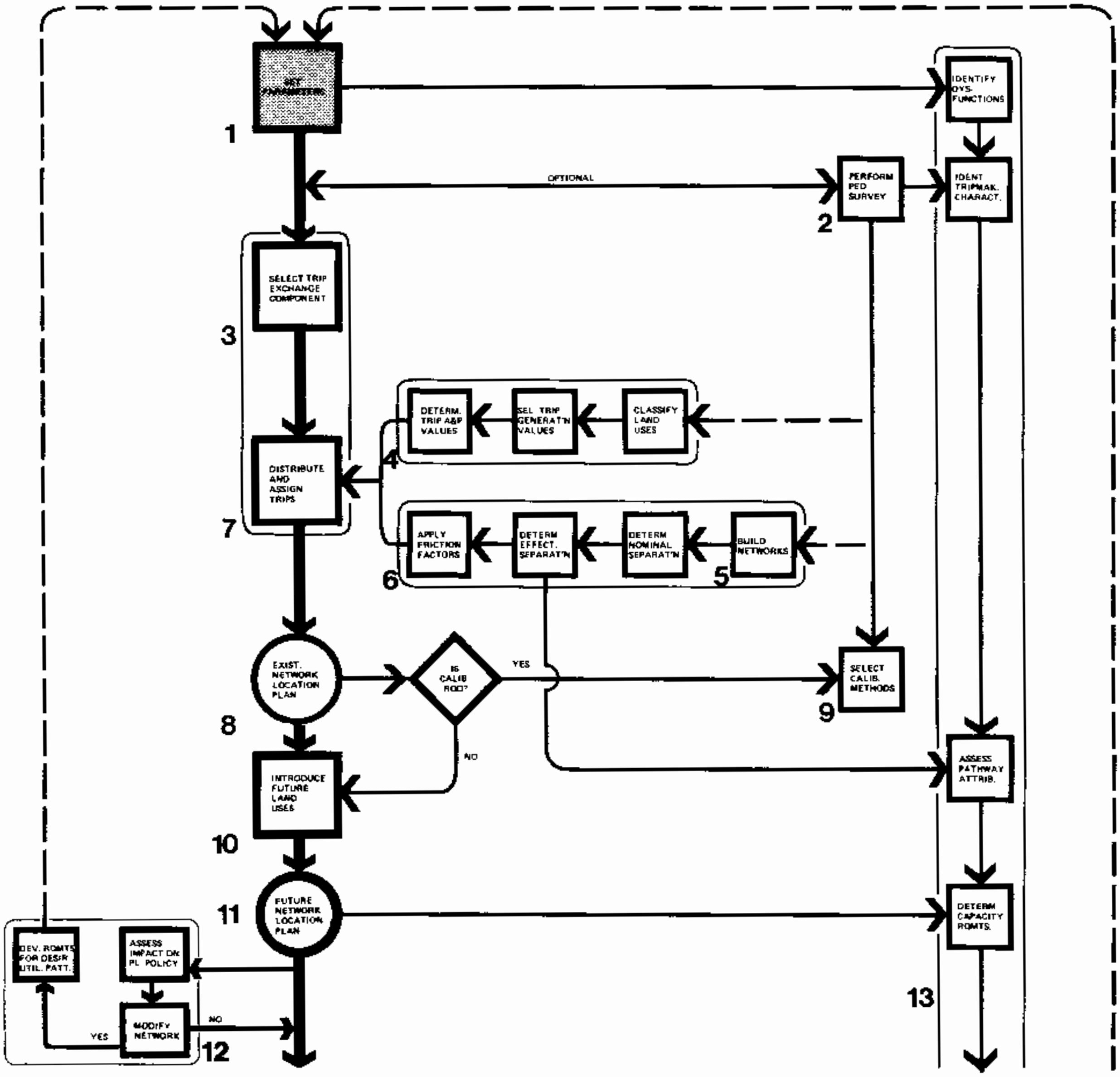
traffic network through improved traffic management techniques, and/or development of alternative pedestrian movement corridors, will result in a more refined set of requirements for the pedestrian network and its various components. These requirements are then synthesized using input from the entire process to form the basis for the network design.

Evaluation procedures have been included within each of the respective methodologies and technical procedures at several critical steps within the Pedestrian Planning Process, since the performance as well as the outcome of these procedures required that a specific assessment be made within that procedure. However, comprehensive evaluation procedures addressing the cost and benefit of the completed network design have also been included to provide a final assessment of the PPP output.

The interrelationship between the Tasks in the Procedures is shown in Figure 1. It should be noted that a comprehensive flow through the process would be conducted sequentially from Task 1 to Task 27, with the exception of Task 13 which is initiated together with Task 1. However, the actual application of the process will depend on site-specific needs and emphasis, and upon the need for conducting reassessment of preceeding tasks as indicated by the feedback loops shown on Figure 1.

The Task flowchart, divided for each of the two major PPP phases, introduces each Task in this Volume with the Task about to be discussed shown as shaded.

SET STUDY PARAMETERS 1



TASK 1

SET STUDY PARAMETERS

1.1 Task Overview

Before initiating subsequent tasks, the user must examine the problems and issues that produce the need to apply the Pedestrian Planning Process, and based upon this examination, set objectives and specific parameters to guide the remainder of the study. The purpose of this task is to define the extent to which each procedure will be invoked.

The assessment will involve the following:

- Explicit definition of the problems and issues to be addressed, and establishment of clearly defined study objectives (which initiates Task 13 as well)
- Analysis, in sketch terms, of the study area and issues associated with its size and configuration;
- Review of data avilability and requirements based on the above; and
- Resolution of the approach and relative allocation of effort to individual study phases and procedures (work plan).

In situations where the study will be performed as a team effort, the above assessment is of particular importance so that all participants -- representing in most cases, different points of view -- have a clear understanding of the process application and its objectives. A work plan reflecting these discussions should be developed and reviewed periodically throughout the course of the study.

At a lower level of detail, the following questions are typical of those that influence the extent and allocation of study effort:

- The size and configuration of the cordon area of the study;
- The length of the planning horizon (long range vs. short range, for example);
- The location, extent and probability of realization for future land uses;
- The need for conducting a pedestrian survey, and other data-related issues; and
- The manner in which the study will be responsive, both in terms of its initial objectives and related to modification, if necessary, during its course, to the inputs, participation and review by participants from the public and/or private sectors.

A prerequisite for this task is a familiarity with the concepts and process outline contained in the Overview, in particular Sections III and IV, and with Supplement 1, "Definitions of Concepts and Terms used in Pedestrian Planning."

1.2 Procedures

Task 1 consists of the following procedures which are discussed in subsequent sections:

- Definition of problems, issues and objective
- Analysis of the study area
- Review of data requirements and availability
- Development of a work plan.

1.2.1 Definition of problems, issues and objectives

Generally, the PPP will be invoked - in whole or in part - in response to a given problem, or set of problems, of which pedestrian planning is a component of the solution. Typical objectives of this response include:

- Improvement of vehicular traffic flow
- Economic revitalization of commercial activity
- Improvement of appearance and environmental image
- Reduction of adverse traffic impacts
- Provision of open space and amenities
- Evaluation of people movement facilities, plans or proposals

The above list is not exhaustive and several objectives may coexist.

The user must clearly define the problems and issues to be addressed, and the objectives to be met by the process application. It may be necessary to adjust this definition of problems, issues and objectives several times, during this task and during subsequent tasks, as more insight becomes available. These definition of issues or dysfunctions also constitute input to Task 13 which the Planner should review at this point in the process. If the study is being conducted as a team effort and/or if review is to be conducted by several organizations, these early discussions will be of extreme importance to ensure that all participants understand the study requirements and its subsequent outputs.

1.2.2 Analysis Of Study Area

Associated with the user's definition of issues, will be a review and sketch analysis of the related study area. Such an analysis should be directed towards understanding the following:

a. The clustering or delineation of the major land use zones.

b. The significant peak movement time periods (Fig. 2 illustrates a graphic analysis of (a) and (b) above. Task 3 further defines and elaborates this subject).

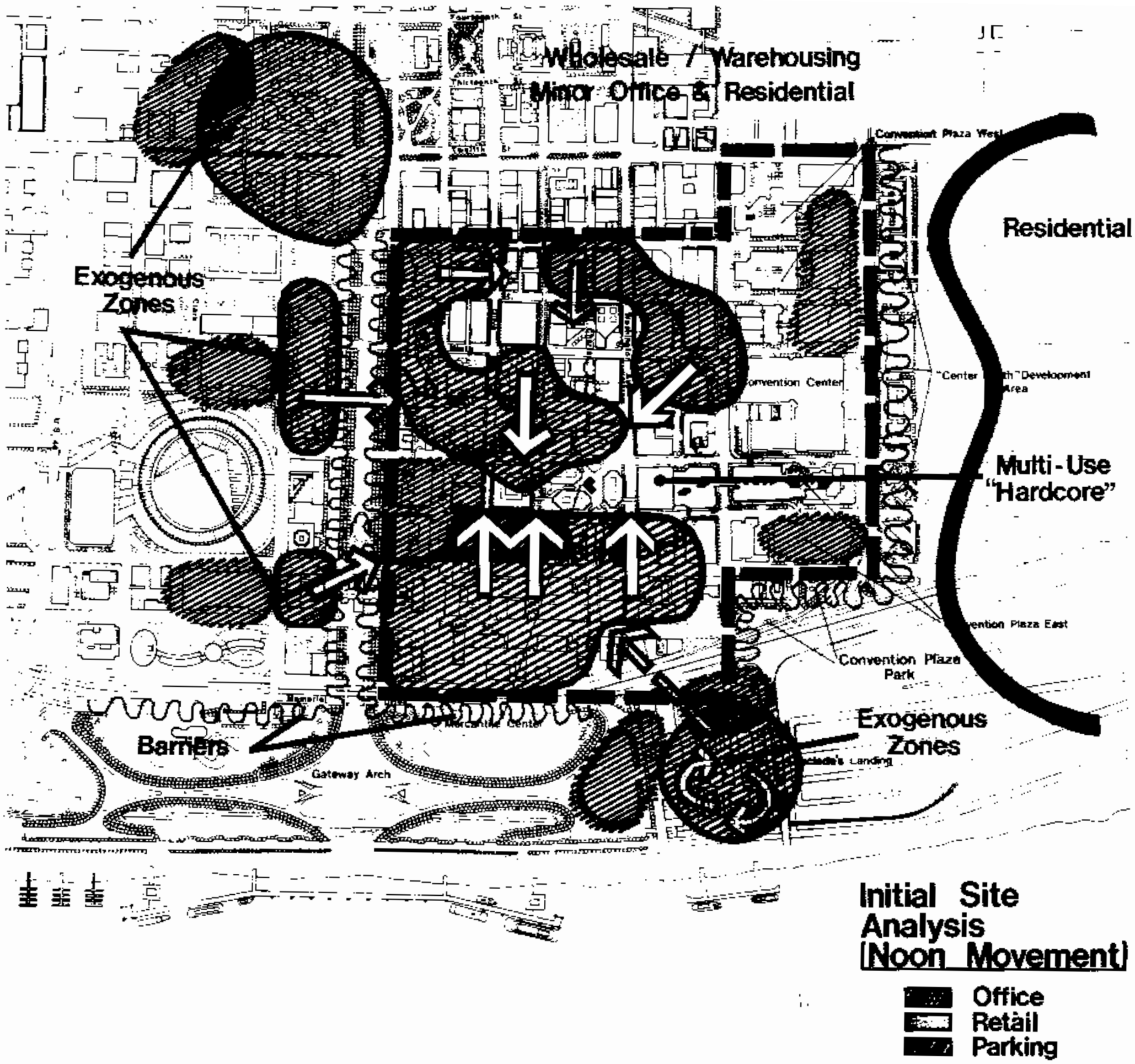


Figure 2

Initial Site Analysis

c. The major peak-hour pedestrian trip routes and their component trip purposes. (Ped counts, if available, will indicate major routes from which some notions of land use exchange may be developed. Also, data, if available, on total square footage by land use type in the study area can be very useful in interpreting the nature, magnitude and temporal exchange pattern of ped movement. The tables on generation data in Task 4 will provide a further understanding of the generation implications of land use size.

d. Major topographic features and natural or man-made physical boundaries or visual "edges."

e. Any significant variations in climatic conditions.

f. Future land use changes.

At this point in the task, the following elements should have been produced:

1. An approximate definition of the study cordon area and its required level of analytic detail.

2. A fix on the appropriate time horizon for the planning study and the related land use or other environmental changes to be considered within that time period.

3. A decision on whether to use the modelling technique for establishing the location of high potential utilization corridors.

Related to (1) above, the user should be aware of the relationship between size of area, level of detail, and the consequent analytic effort required. These issues are discussed under Task 5, sections 5.1 and 5.3.1.

Related to (2) above, a short range plan would be defined as one which could be implementated within three years and takes into consideration all existing land uses as well as those projects under construction or about to be built. A long range plan is one which could be implemented within five years and takes into account all existing uses and committed projects that will be constructed by then. In developing the short range plan, the planner should look to the five year development forecast and similarly, for the long range plan to a ten year development forecast so that appropriate phasing can be established.

Related to (3) above, in general, if the following conditions occur, either separately or in combination, then a modelling approach will be appropriate:

- The planning issues involved are strategic, comprehensive (systems oriented) and long range
- Reliable forecasting of future ped movement is required
- An understanding of how land uses are related in terms of their functional trip exchanges is required.

An alternative approach which determines the high potential utilization corridors from ped counts and surveys rather than from modelling, as the basis for the subsequent planning and design phases of the PPP, may be warranted under the following conditions: The planning issues

- Are very specific or local (not systems oriented) and short range in nature (limited forecasting)
- Do not involve major future land use changes
- Do not require a knowledge of functional land use relationships

1.2.3. Review Of Data Requirements

Before finalizing an approach to the study, the planner must review the data required for those tasks that will be executed. Data collection and analysis are invariably major line and budget items.

Figs. 3 and 4 summarize the kinds of data required at various points in the PPP. Survey-related data inputs have been separated out from the diagram and are presented in Figure 6 so as to facilitate an early decision on its execution.

Certain data, if readily available, can profitably be used in the process prior to the task for which it is essential. One such example is that of using pedestrian counts to aid in the study area analysis in this Task, even though they are only essential to the calibration excercise conducted in Task 9.

Data provided for the modelling tasks in the Manual reflect average fair weather conditions. Since pedestrian behavior varies considerably with the weather, if local data is to be used, it should be compatible seasonally with manual data or be so adjusted.

For further detail on the data required for each task, the planner should refer to the "Data Required" section within that task.

The manual does not deal directly with the integration into the planning process of participation by the various interest groups that will be impacted, directly or indirectly, by implementation of the plan or facility. These parties may be in both the public or private sector and their interrelationships will vary from place to place and project to project. While their interaction with the PPP cannot thus be specified, the importance of recognizing and establishing participatory mechanisms for such potentially impacted groups has been shown repeatedly to be a critical ingredient in the successful planning, design and implementation of pedestrian networks or facilities. The creation of supportive coalitions, openness to critical public evaluation, resolution of "political" issues are all part of this planning process, as it is of any other. Planning and design compromises that derive from such input may often override the more technically based decisions suggested by the Manual's methodology. The list of typical impacts associated with the implementation of ped facilities in the Overview, pages 10-12, can be used as a guide to identifying interest groups thus ensuring that the process is adapted and so structured to account for such "external" inputs and the associated time and effort that may be involved in potential iterations of tasks resulting from these inputs.

1.2.4 Development of a work plan

The results of this task should be summarized in a work plan for the entire study that delineates the study procedures to be invoked, a time schedule for their completion, and the estimated level of resources to be allocated to each. A narrative statement of study objectives should also be developed and reviewed periodically during the study.

TASK No.	DATA REQUIRED (NOT IN MANUAL)
1	- Policy objectives
1	- Land Use and Transport. Proposals/ Plans
1	- Base map(s)
13	- Field observation-based data on requirements
2	- Ped survey results (optional)
	- Base map(s)
4	- Land use by type & size (incl. future)
4	- Vacancies data
4	- Transit usage data
4	- Parking by type & size
4	- Land use generation checks (optional)
5	- Portal Locations
6	- Signal timing (optional)
6	- Attribute scoring (incl. future)
7	- Computer programs (UTPS) & related instructions
9	- Peak hour pedestrian counts
9	- Site specific values developed for gen., attraction & production, friction factors (optional)

PROCESS

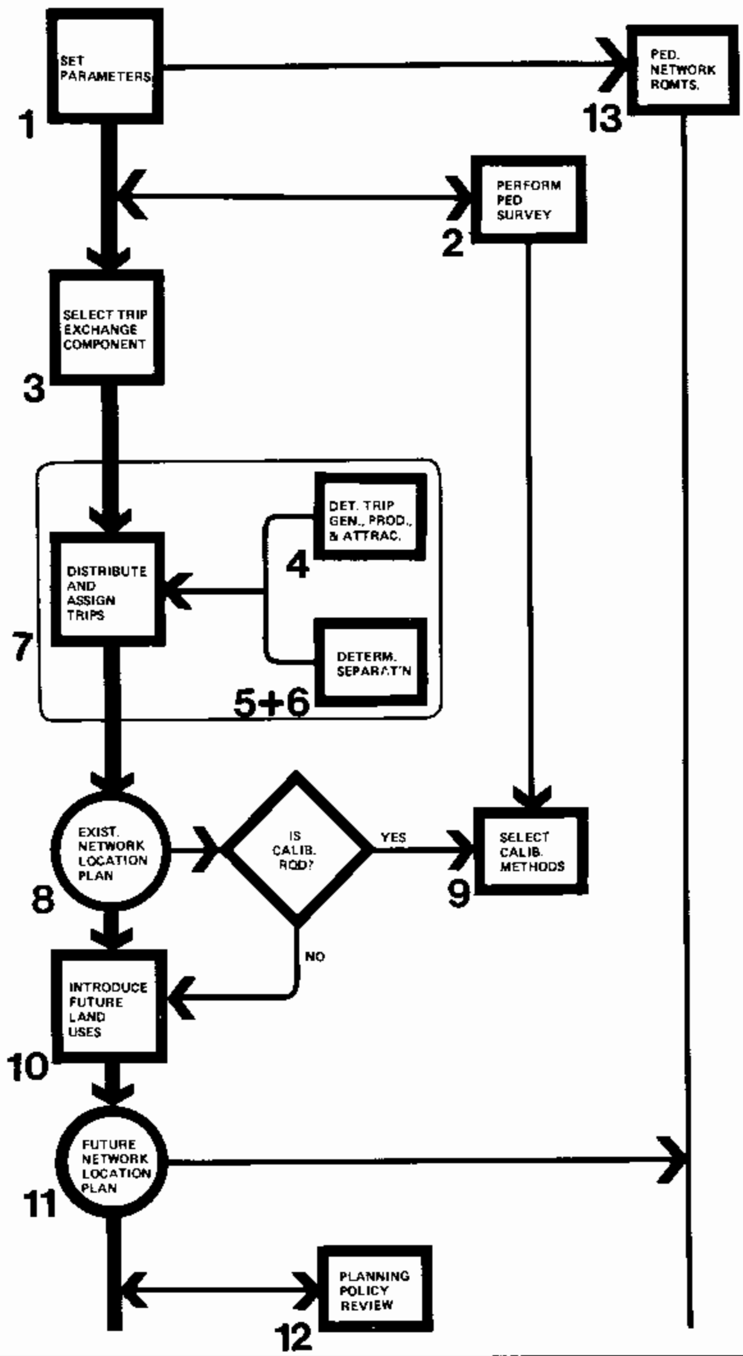


Figure 3

Data Inputs To The PPP; Tasks 1-13

TASK No.	DATA REQUIRED (NOT IN MANUAL)	PROCESS
13	- Site observation & analysis of ped. network rqmts. & dysfunct. - Counts at initial sidewalk intersections (optional)	
14	- Pre-existing traffic, transit & parking studies or management plans - Field observation - Traffic volumes & operating characteristics	
16-21	- Field observation (conditions of applicability)	

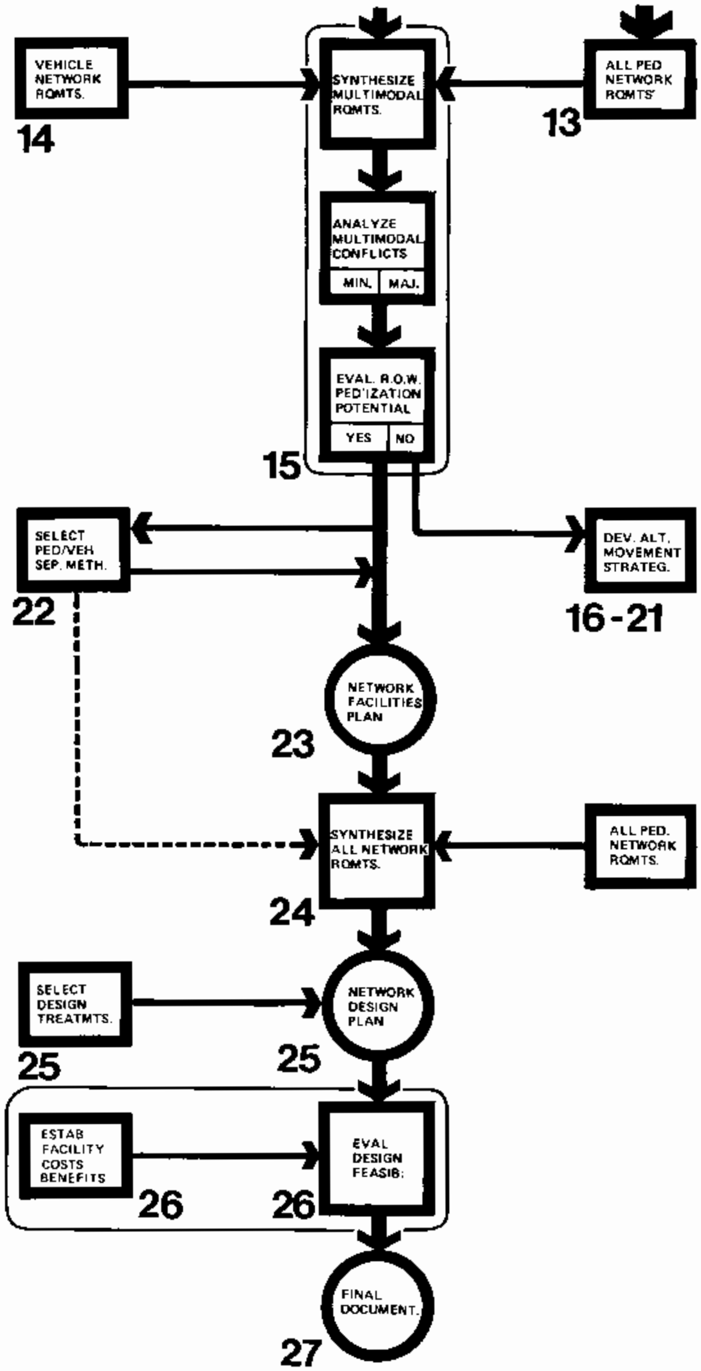
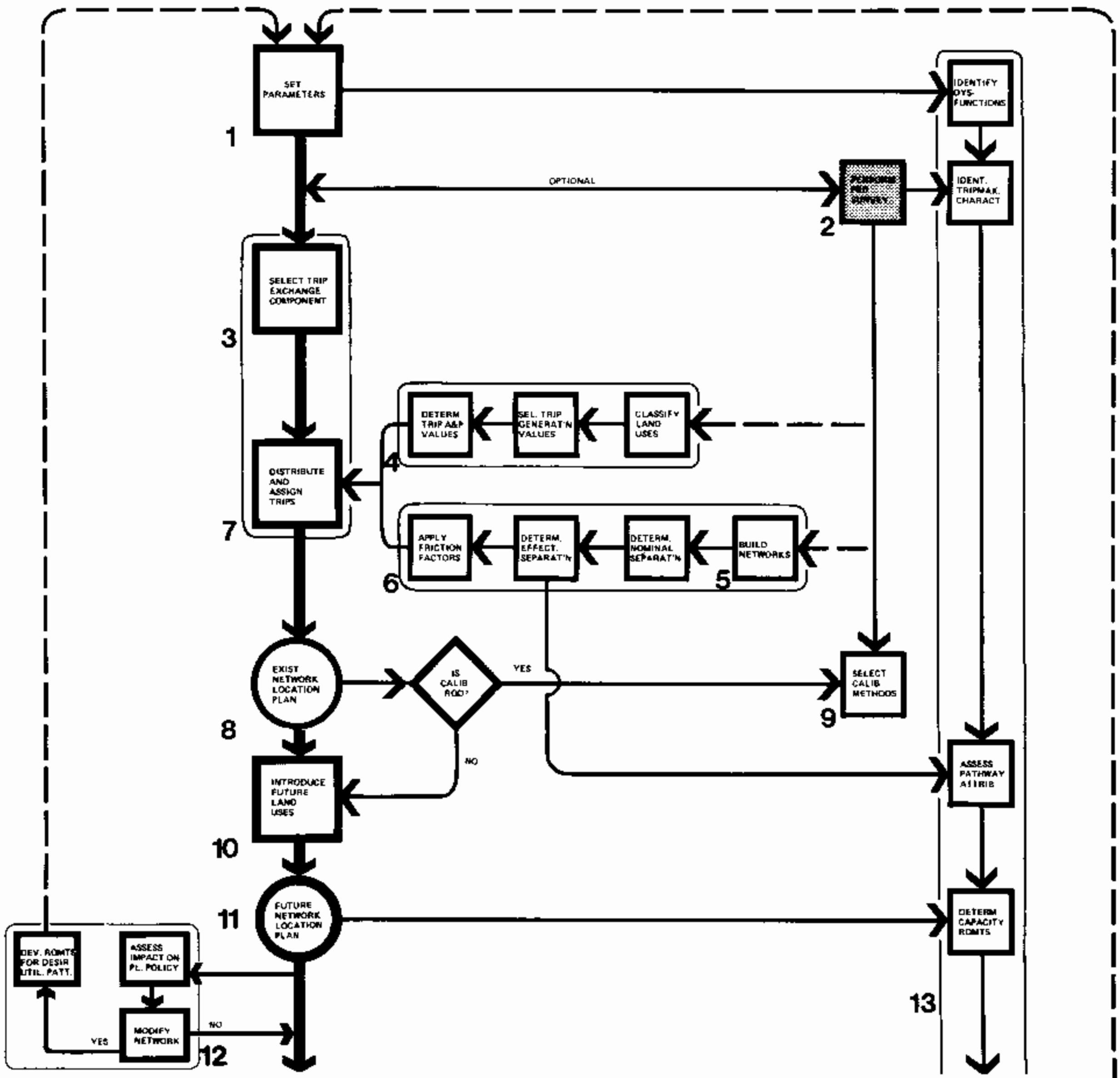


Figure 4

Data Inputs To The PPP; Tasks 13-27

PERFORM PEDESTRIAN SURVEY (OPTIONAL) 2



TASK 2

PERFORM A PEDESTRIAN SURVEY (OPTIONAL)

2.1 Task Overview

The Pedestrian Planning Process has been designed to minimize the need to collect and analyze site specific data. However, the user must recognize that if the input to them are general, as the aggregated data presented within the process are, the results will be less site specific than if locally unique information had been used. Therefore, where greater accuracy is desired, throughout the process, site specific data should be collected and used. Secondary benefit of this effort is that it provides better, and sometimes unexpected, insights into local pedestrian behavior, and greater confidence in the process outputs. It also provides the planner greater flexibility to modify and tailor individual procedures to suit the given situation. Although many data elements concerning pedestrian movement can be obtained by unobtrusive methods such as counting, photography, and tracking, other data can only be obtained using more direct methods. The method that provides the most reliable and useful data, within reasonable bounds on cost is a pedestrian survey. Accordingly then, the planner has the option to conduct a pedestrian survey. However, manpower, time schedule and budget issues must be considered so that any surveying efforts can be tailored to these or other constraints.

An illustrative sample of a survey instrument compatible with the modelling and other procedures in the Manual is shown in Fig 5. This sample survey has been designed to provide a large amount of relevant input to many tasks in the PPP (see Fig. 6). Major probe areas identified by the survey are illustrated in Fig. 7. However, the survey instrument is offered as a guideline only. Certain probe areas may require modification in order that they be responsive to site specific conditions and issues under study or a different survey approach (eg. street interviews) might be elected. Prior to undertaking any surveying, the sample survey prototype should be evaluated in a cost/benefit sense.

To assist the planner in approaching and executing the survey task, the sample survey has been broken down, as shown in Fig. 6, into those question clusters and the related analysis that constitute various inputs to the modelling tasks.

In general the survey provides for the collection of two kinds of data:

1. Data that is perceptual and attitudinal and provides the planner with insights and interpretive abilities
2. Data that is factual and provides site specific technical inputs to the modelling tasks.

While these two categories often overlap and the same data can either be analyzed rapidly to provide a sense of pedestrian behavior, or more rigorously, to yield numerical parameters for the same behavior, the

STREETS FOR PEOPLE

THE CITY OF NEEDS YOUR OPINION ON HOW TO MAKE DOWNTOWN A BETTER PLACE

is continually striving to meet the needs of all people who use the Downtown Area. One of the ways the City is working to meet these needs is by creating a better walking environment. The City would like your participation in the creation of this environment. This survey is intended to take into account your walking experience and your needs as a pedestrian.

GENERAL INFORMATION:

1. Please Print.
2. Read and answer all questions carefully.
3. Please mail within 5 days - No postage necessary.

PART A

The following set of general questions are to be completed by all downtown users.

1 During a normal week how many days do you come to the downtown?

- [ ] 5 or more days
- [ ] 2 - 4 days
- [ ] Once
- [ ] Less Than Once

2 In general where is your point of arrival and departure located? (such as bus stop or parking space)

Arrival: ____________________

Departure: ____________________

3 What is the main purpose for your trips?

- [ ] Downtown Employee (if checked, please complete Part B)
- [ ] Shopping (if checked, please complete Part C)
- [ ] Personal Business
- [ ] Other ____________________ (please specify)

4 By what means do you arrive in the downtown?

- [ ] Bus
- [ ] Taxi
- [ ] Walk
- [ ] Car - As Driver
- [ ] Car - As Passenger
- [ ] Other ____________________ (Please Specify)

5 If you travel by auto, do you have difficulty finding a parking space?

- [ ] Never
- [ ] Occasionally
- [ ] Always

THANK YOU FOR PARTICIPATING

Figure 5

Prototypical Pedestrian Survey

PART B

The following set of questions are <u>to be completed only by employees who work downtown</u>. The questions refer to your trips to and from your place of work.

6 Where is your place of work? (building name or location)

____

7 Within 15 minutes, when do you normally:

Arrive in the Downtown ______________ AM / PM

Depart the Downtown ______________ AM / PM

8 After arrival in the downtown, how many blocks do you have to walk to get to work and how many minutes does it generally take?

________ Blocks To Work ________ Minutes Required

8a Please mark the path(s) that you take during this walking trip on the attached street map by drawing and arrow from start to end. (An example is shown on the attached map.)

The following questions refer to your lunchtime trips.

9 On average, how many days a week do you leave your place of work at lunch time?

________ Days A Week

10 How many of these trips are for: (write the number of trips in the appropriate box/s)

- ☐ Eating Only
- ☐ Shopping Only (other than eating)
- ☐ Recreation and Exercise Only
- ☐ Eating and Shopping
- ☐ Eating and Other(______________ Please Specify)
- ☐ Shopping and Other (______________ Please Specify)
- ☐ Other Only (______________ Please Specify)

11 Within 15 minutes when do you generally go out and return from your lunch time trips?

Go Out: __________ Return: __________

12 Please identify (by name or location) three places that you are most likely to visit during lunchtime. (In sequence)

Place	Visits Per Week
1. ______________	________
2. ______________	________
3. ______________	________

12a Please mark the path(s) that you take during this walking trip on the attached street map by drawing and arrow from start to end. (An example is shown on the attached map.)

Figure 5 (continued)

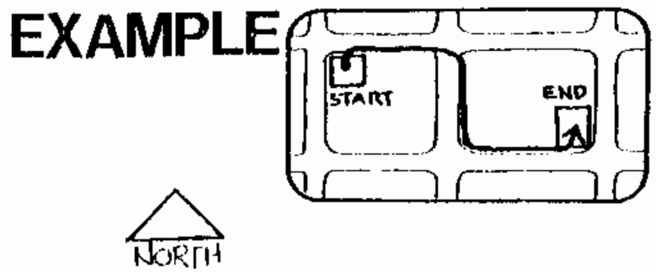
Please mark the path that you take during your walking trip in the downtown area by drawing an arrow from start to end on the street map below. An example is shown at the right of the page. Be as accurate as possible and show short cuts, where you cross streets, etc.

Please use the following line types to indicate the nature of your walking trip(s).

Work Trip ————————

Lunch Trip 〰〰〰〰〰

Shopping Trip — — — —



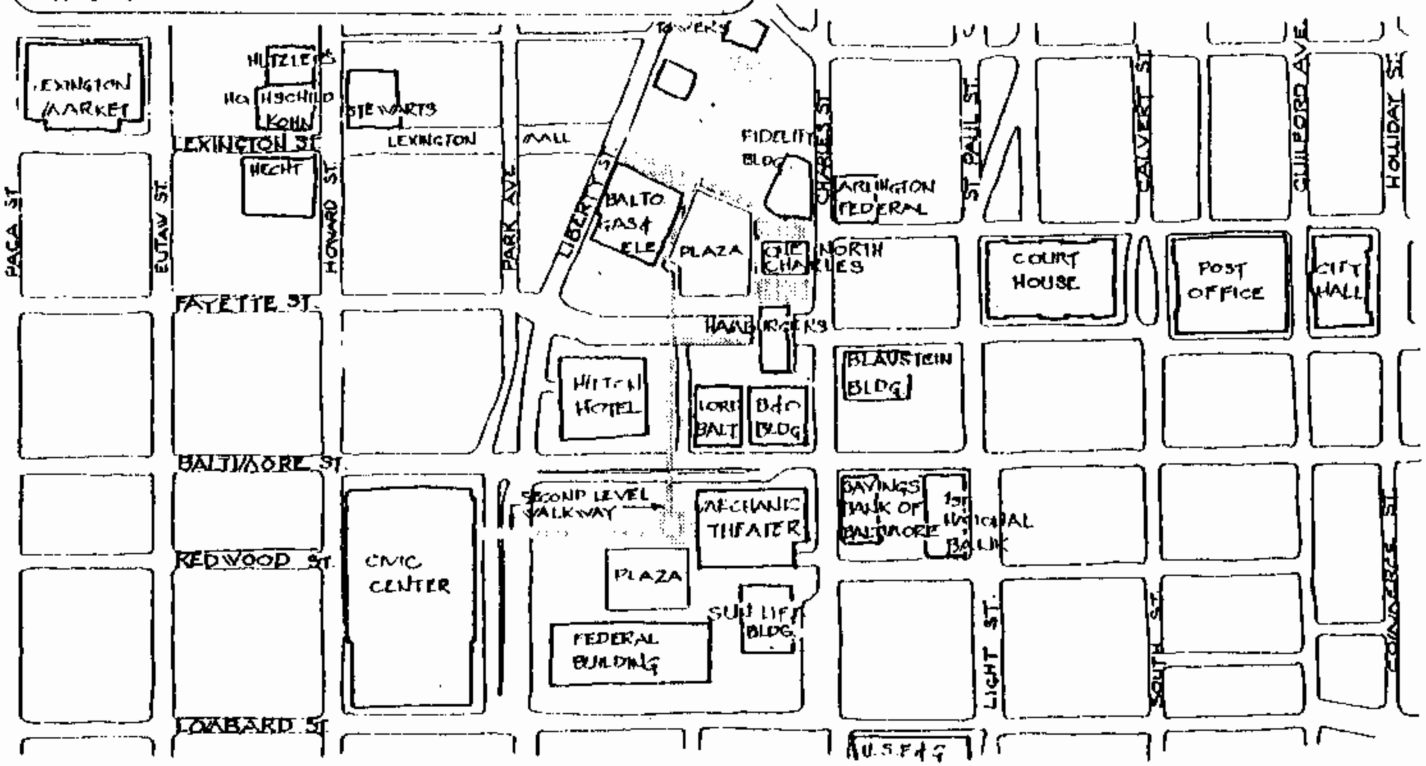


Figure 5 (continued)

PART C

The following set of questions are to be completed only by shoppers (other than employees).

13 When do you generally arrive and depart from the downtown?

Arrive		Depart
☐	Before 11:30 AM	☐
☐	11:30 - 1:30 PM	☐
☐	1:30 - 4:00 PM	☐
☐	4:00 - 6:00 PM	☐
☐	After 6:00 PM	☐

14 If you arrive by auto, how far must you park from your primary destination?

☐ Less Than 1 Block
☐ 2 - 4 Blocks
☐ More Than 5 Blocks

15 How many stops do you generally make during your shopping trip?

______ Stops

16 Please list the three places that you are most likely to visit during your shopping trips. (In sequence)

1. ______
2. ______
3. ______

17 Do you generally have lunch downtown during your shopping trip?

☐ No
☐ Yes (Please specify name and location)
______

17a Please mark the path(s) that you take during this walking trip on the attached street map by drawing and arrow from start to end. (An example is shown on the attached map.)

PART D

The following set of questions are to be completed by all respondents. The questions refer to leisure time trips(entertainment/recreation).

18 Do you spend any of your leisure time in the downtown area?

☐ None
☐ About Once A Week
☐ More Than Twice A Week
☐ Weekends Only

19 If you come downtown for leisure activities, how do you spend your time?

☐ Strolling, Sightseeing,
☐ Window Shopping
☐ Theater
☐ Restaurants
☐ Special Events
☐ Culture
☐ Other

20 Where in the downtown do you spend the majority of your leisure time? (Please specify name and location.)

Name ______ Location ______

Figure 5 (continued)

PART E

The following set of questions are to be completed by all respondents. The intent of the questions is to find out what your attitudes and opinions are regarding the nature of the downtown walking environment.

21 Why do you choose the particular path(s) that you do for your walking trip(s)? (Please indicate which of the reasons listed below are the 3 most significant by using a "1" for your first choice, "2" for your second choice, and "3" for your third choice.)

- ☐ Less Problem With Traffic
- ☐ Shortest in Time
- ☐ Shortest in Distance
- ☐ Most Interesting and Attractive
- ☐ Most Familiar
- ☐ Comfortable to Walk
- ☐
- ☐ Has More People and Activity
- ☐ Safe from Crime
- ☐ Less Exposed to Weather
- ☐ Has Stores and Shops
- ☐ Less Air Pollution and Noise
- ☐ No Special Reason
- ☐ Other

22 Do you generally need directions to make walking trips in the downtown?

- ☐ No
- ☐ Yes (if yes, please indicate below how you find your way)

- ☐ Used Map
- ☐ Asked Someone
- ☐ Used Street Names and/or Numbers
- ☐ Landmarks/Familiar Buildings
- ☐ Guessed My Way
- ☐ Other (Please Specify)

23 In general, which areas and streets within the downtown would you avoid walking due to your feelings of safety from criminal acts? Indicate locations:

____________ Street between ____________ and ____________
____________ Street between ____________ and ____________
____________ Street between ____________ and ____________
____________ Street between ____________ and ____________

24 What problems and inconveniences do you associate with walking in the downtown? (Please indicate which of the problems listed below are the 3 most significant by using a "1" for your first choice, "2" for your second choice, and "3" for your third choice.)

- ☐ Too Many Steps
- ☐ Danger from Traffic
- ☐ Long Waits for Traffic or Signals
- ☐ No Place to Rest
- ☐ Unsafe from Crime
- ☐ Air Pollution, Exhaust
- ☐ Requires More Time
- ☐ Longer in Walking Distance
- ☐ Too Steep
- ☐ No Protection from Bad Weather
- ☐ Easy to Get Lost, Confusing
- ☐ No Sun, Too Shady
- ☐ Dirty, Bad Appearance
- ☐ Too Many Obstacles/
- ☐ Barriers
- ☐ Too Crowded
- ☐ Unfamiliar
- ☐ Too Noisy
- ☐ No Shops or Stores
- ☐ Uninteresting
- ☐ No Shade, Too Sunny
- ☐ Other ____________

25 Are there places or areas within the downtown that are located inconveniently for walking trips?

Name ____________ Location ____________

Figure 5 (continued)

26 What can be done to improve the walking environment if to encourage greater use? (Please indicate which of the improvements listed below are the 3 most significant by using a "1" for your first choice, "2" for your second choice, and "3" for your third choice.)

- ☐ Provide shelter from weather
- ☐ Provide more places to sit and rest
- ☐ Provide more stores, shops and restaurants
- ☐ Provide better directional signs
- ☐ Provide more escalators
- ☐ Provide better access to activities
- ☐ Provide better lighting
- ☐ Provide more landscaping
- ☐ Provide more activities and events
- ☐ Provide more interest (fountains/sculpture)
- ☐ Provide better police protection
- ☐ Provide Greater Safety from Vehicles
- ☐ Provide street malls
- ☐ Other (please fill in below)

THANK YOU FOR YOUR COOPERATION

PLEASE

FOLD - SEAL & MAIL

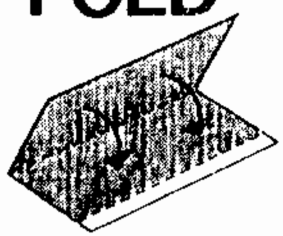


Figure 5 (continued)

POSTAGE WILL
BE PAID BY
ADDRESSEE

BUSINESS REPLY MAIL
FIRST CLASS PERMIT NO.

NO POSTAGE
STAMP NECESSARY
IF MAILED IN THE
UNITED STATES

STREETS FOR PEOPLE
THE CITY OF
P.O. BOX

Figure 5 (concluded)

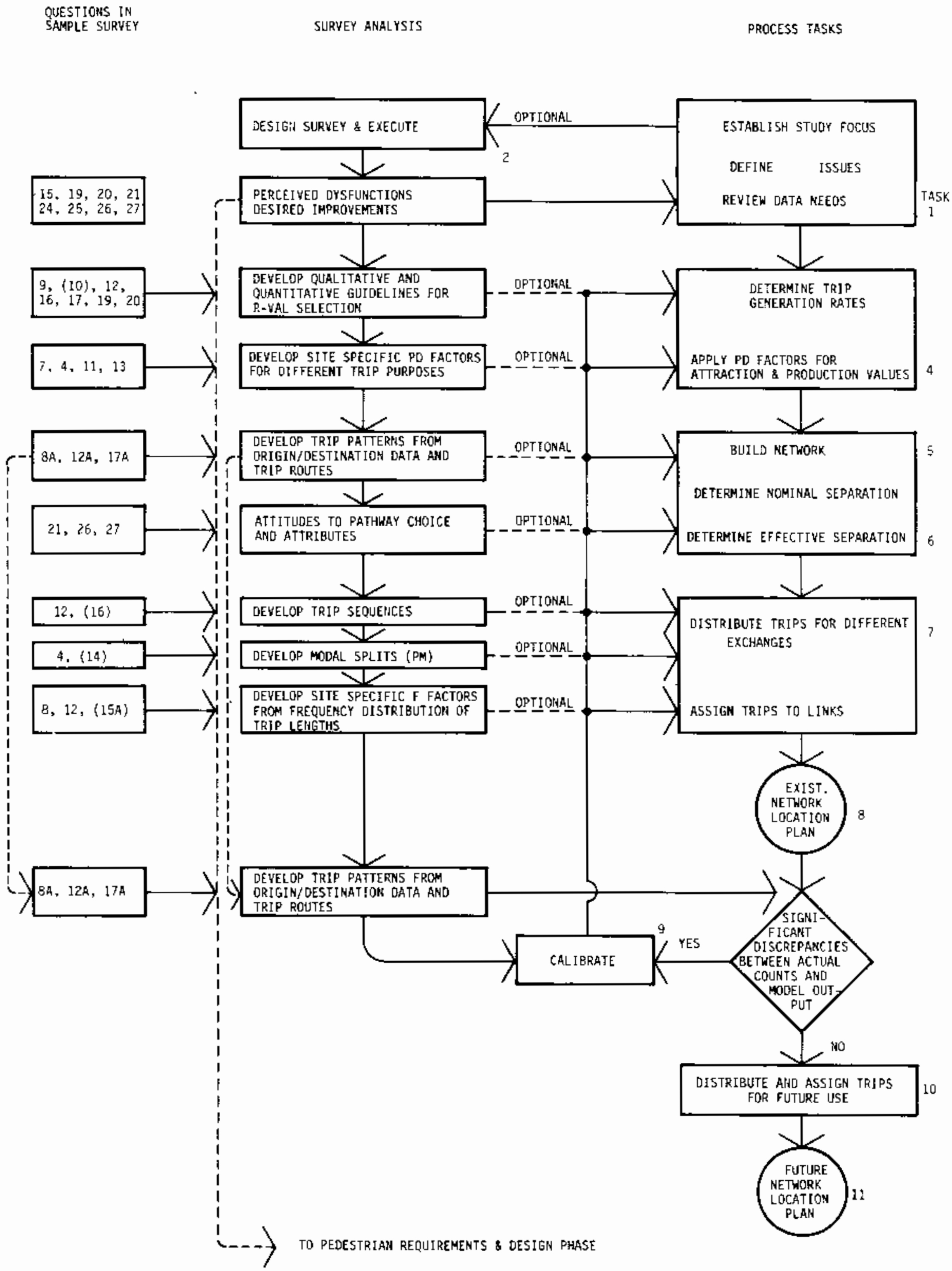


Figure 6

Pedestrian Survey Inputs To The PPP

TARGET DATA AREAS FOR PEDESTRIAN SURVEY

* EMPLOYEE WORK TRIPS
  - Time of arrival/departure
  - Mode of Arrival
  - Trip routes
* EMPLOYEE LUNCH TRIPS
  - Trip purposes
  - Trip routes
  - Origin/destination data
  - Temporal data
  - Trip lengths
* SHOPPING TRIPS
  - Origin/destination data
  - Trip lengths
  - Temporal data
* ENTERTAINMENT/RECREATIONAL TRIPS
  - Frequency
  - Trip purpose
  - Destination data
* ATTITUDES AND PERCEPTIONS
  - Pathway choice criteria
  - Perceptions of the pedestrian environment
  - Perceived dysfunctions
  - Desired improvements

Figure 7

Major Survey Probe Areas

two kinds of data have their specific and timely contributions. From this point of view, it is clear from Fig. 6 that if a survey is to be performed, the earlier it is implemented and analyzed, the more useful will it be for reviewing the decisions made during Task 1.

After the first analytical input is completed, the planner has the choice, as the diagram indicates, of developing his own site-specific technical data through further survey analysis for use in the modelling tasks or using the Manual's generic technical data and deferring until the calibration task to see if any further selective analysis of survey data is required for calibration purposes. The latter option will probably be less time-consuming while the former will likely produce more accurate output.

2.2 Procedures

2.2.1. Modify survey for site specific issues.

The sample survey provided herein includes only general questions that are likely to be applicable to most cities. It is intended that the user modify the survey to elicit responses and data relevant to his particular context.

Although is is not the intention of the PPP, if exact numerical simulation of existing pedestrian movement is desired, then the survey will require appropriate expansion to develop more exact and fine-tuned origin-destination data and related movement, as well as a careful distribution and sampling design to allow of statistically valid deductions. Similar amplification of the survey would be required if it is serve as the basis for a non-model-based determination of the network location plan.

2.2.2. Distribute survey

The planner should consider a limit on the absolute number of survey responses to be analyzed based on an assumed return rate of between 15% and 30% for a hand-distributed, mail-back type of survey. If responses are to be manually analyzed, this number should be less than 500, if computer analyzed, less than 2000.

- The proposed method of distribution is as follows:

  (1) The respondent population will consist of pedestrians leaving selected trip generation centroids within the defined area for which the system is planned. In general, sampling will be confined to only those peak periods of pedestrian movement apt to have an impact on planning and design.

  (2) The surv / will be hand-distributed with mail-back response. A survey distribution design will be developed to suit the particular study area to be covered. The key elements of the distribution method are:

a. Identification of the major pedestrian trip generation centroids to be surveyed
b. Estimates of the generated trip volumes of each centroid
c. Allocation of the sample size to each centroid
d. Determination of the sample frequency (that is, hand one survey to every "nth" pedestrian, when "n" is the estimated generation volume divided by the number of surveys to be distributed)
e. Specific instructions for distribution of the surveys and briefing of surveyors.

It should be noted that the distribution procedure recommends that the surveys be distributed at major pedestrian activity centroids, rather than at random points. This approach allows for the development of more reliable origin-destination data and generation profiles. The surveys can be coded for each point of trip production or attraction, and the response stratified; when combined with appropriate count data, statistically valid conclusions can be developed concerning the generation at a given point. By comparing results obtained from numerous centroids, similarities and contrasts between centroids can yield meaningful information regarding the trip purpose, temporal nature, origin-destinations, and other characteristics of the generation. Due to a proliferation of origins and destinations, and the inability to relate survey response to any other known characteristics of the population surveyed, random distribution of surveys within the study area does not produce this higher level of effective results.

An important objective of the design should be to obtain a knowledge of the ratio and/or absolute volumes of employees and non-employee shoppers in the study area. Previous surveys have indicated that there is probably a higher response rate for employees than for shoppers, and it may be necessary to account for this in the survey design. One approach might be to combine a hand-distributed, mail-back survey with random on-street interviews to obtain a basis for cross-checking mail responses and adjusting for non-responses. Furthermore, a knowledge of the employee/shopper split can be useful in the selection of movement components that will be subjected to more detailed analysis, and for obtaining information on the utilization of public transit, and long versus short-term parking.

2.2.3. Analyze survey.

Fig. 6 associates the survey-based inputs to the modelling process with the relevant question numbers in the sample survey. If the user desires to analyze the survey for technical inputs that will substitute the Manual's, he is referred to the calibration task (Task 9) where relevant appendix references are cited.

One analytical check the user may wish to perform (which could also be deferred until the Calibration Task) is a comparison of the Manual's attribute rankings and weights (see Table 20) with that derived

ATTRIBUTES		SURVEY-BASED ATTRIBUTES — SURVEY QUESTION #21											
		1 LESS PROBLEM WITH TRAFFIC	2 SHORTEST IN TIME	3 SHORTEST IN DISTANCE	4 MOST INTERESTING AND ATTRACTIVE	5 MOST FAMILIAR	6 COMFORTABLE TO WALK	7 MOST DIRECT	8 HAS MORE PEOPLE AND ACTIVITY	9 SAFE FROM CRIME	10 LESS EXPOSED TO WEATHER	11 HAS STORES AND SHOPS	12 LESS AIR POLLUTION AND NOISE
1	ACCESSIBILITY		◆	◆									
2	AMENITIES						◆						
3	ATTRACTIVENESS				◆				◆			◆	
4	PHYSICAL COMFORT						◆				◆		◆
5	PSYCHOLOGICAL COMFORT									◆			
6	INFORMATION					◆		◆					
7	SAFETY	◆											

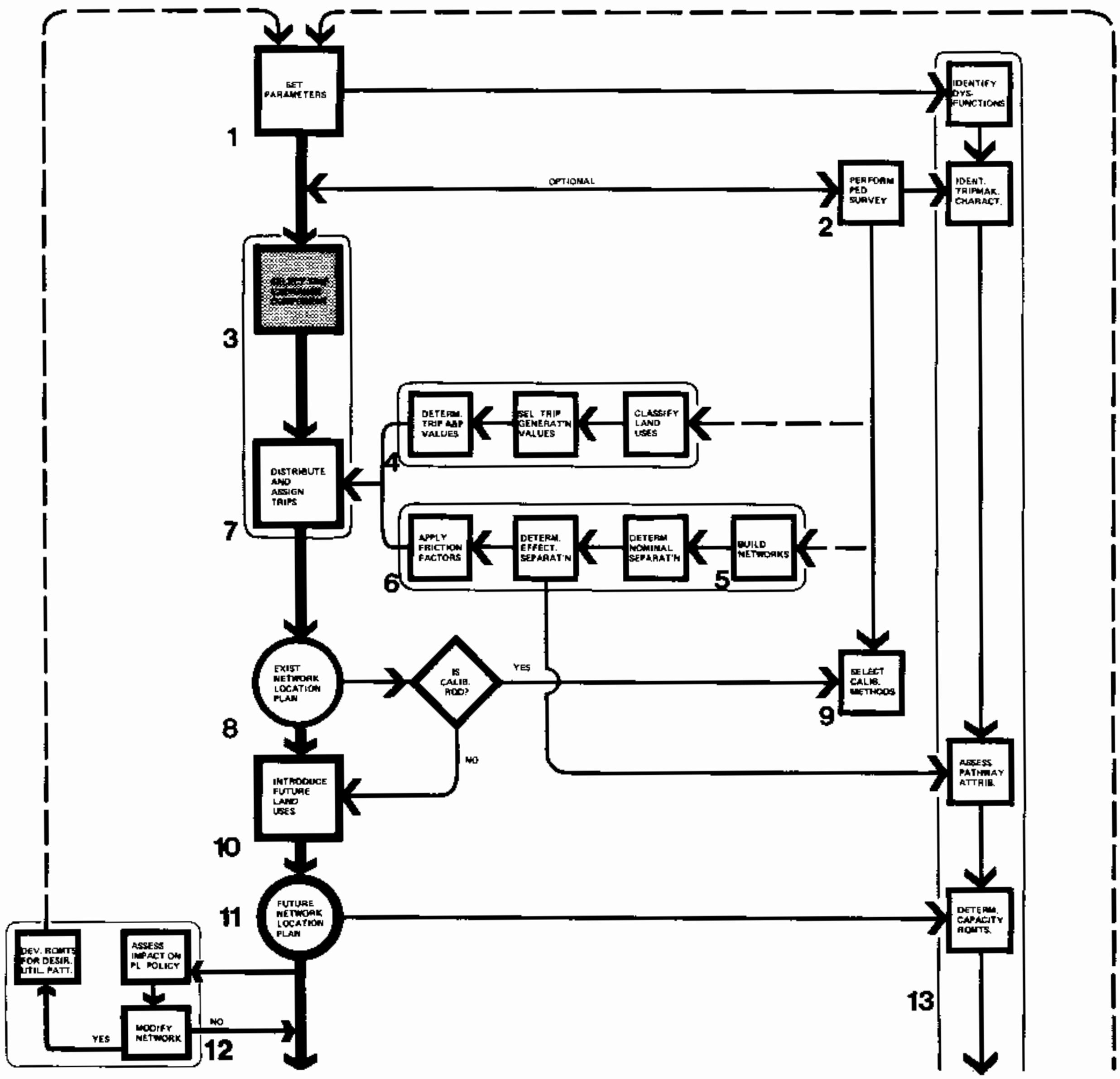
Figure 8

Relationship Between Survey Question And Pathway Attribute from questions 21, 26 and 27. Fig. 8 provides a cross-matching of categories to aid in this optional procedure.

Care should be taken in the interpretation of responses to perceptual questions. For example, while safety and pollution hazards might exist, these are generally not perceived as such; similarly traffic signal delays might be taken for granted by peds circulating in a downtown and not perceived as an impediment to walking.

SELECT TRIP EXCHANGE COMPONENTS FOR EXAMINATION

3



TASK 3

SELECT MOVEMENT (TRIP EXCHANGE) COMPONENT(S) FOR EXAMINATION

3.1 Task Overview

Task 3 is the first of a series of interrelated tasks leading to development of pedestrian network location plan which forms the basis for subsequent tasks. The task sequence beginning with this task is as follows:

- Task 3 - one or more major components of pedestrian movement within the urban core are selected for examination, and each component is then examined in Task 4 through 11;
- Task 4 - centroids of pedestrian trip production and attraction are identified, average hourly measures of two-way trip generation (R-values) are developed, and these values are converted to production and attraction volumes for each movement component;
- Task 5 - for each movement component, a graphic pedestrian network composed of centroids and interconnecting pathways is developed;
- Task 6 - for each movement component, measures of inter-centroid travel time (separation) are computed, and are converted to trip-making probabilities (friction factors);
- Task 7 - based on existing land uses only, each movement component is examined using a gravity demand model approach to distribute and assign pedestrian trips within each network;
- Task 8 - trip distribution and assignment volumes are collected, as appropriate, across all movement components to obtain a network location plan for existing land uses, which shows the relative utilization of network pathways;
- Task 9 - the network location plan, for existing land uses developed in Task 8 is compared for consistency with independent data, for example, pedestrian counts, and if deemed necessary, steps 4 through 8 are repeated until a satisfactory location plan is obtained,
- Task 10 - future land uses are introduced and step 7 repeated to obtain movement component distributions and assignments reflecting future, as well as existing uses; and
- Task 11 - a network location plan, including future uses, is developed in a manner similar to that employed in Task 9.

In Task 3, which initiates the above sequence of tasks, one or more major components of daily movement within the urban core are selected. The rationale for this approach is discussed below.

The trip distribution and assignment model utilized in Task 7 is only applicable to short, peak period analysis where trips are single-purpose and unidirectional (from the viewpoint of the individual pedestrian).

The model is not capable of simulating the dynamics of trip making involving multiple stops, direction reversals, meandering and similar complexities of pedestrian behavior. For this reason, the analysis of pedestrian trip exchange is treated as one or more "snapshots" made at appropriate peak periods. Typically, this would include the following movement components:

Noon office to retailing trip exchanges;
Noon retailing to retailing trip exchanges;
PM employee to terminal trip exchanges;
PM shopper to terminal trip exchanges; and
Other trip exchanges.

This list is not intended to be exhaustive and the user is encouraged to assess the site specific need for each type of analysis. The "other trip exchanges" category refers to any specific component of pedestrian movement deemed worthy of examination. Additional guidance is provided in the procedures.

3.2. Procedures

In Task 1, it was recommended that the user review pedestrian movement in terms of its temporal behavior so as to estimate the probable peaks to be analyzed in later tasks. In certain situations, the critical peaks will be obvious, while in others they may be less defined. The following discussion will aid the user in focusing on the peak appropriate to his situation and its trip purpose makeup.

Generally, the total daily volumes of pedestrian movement in an urban area can be subdivided into distinct categories on the basis of trip purpose and temporal considerations. Within this set of trip categories, a smaller subset can be identified that accounts for the majority of the pedestrian movement that impacts upon facilities planning. By concentrating on a small number of trip categories, the analysis is simplified, yet the relative distribution of trips throughout the network during peak periods is obtained. In this task, guidance is given for selecting those trip categories that will be considered in subsequent tasks.

In most urban areas, total pedestrian movement follows a temporal pattern consisting of six phases as illustrated in Figure 9.

(1) 7:00 to 9:00 A.M. - The morning period of increased activity, dominated by employees moving from their point of mode transfer to their place of employment, with the peak generally occurring between 8:00 and 9:00 A.M.;

(2) 9:00 to 11:00 A.M. - The morning period of reduced activity, consisting of diverse trip purposes including business trips, early shopping trips and some commuters;

(3) <u>11:00 A.M. to 2:00 P.M.</u> - The noon period of intense activity, consisting of lunch trips, primary and employee shopping trips and personal buisness trips, with the peak generally occurring between noon and 1:00 P.M.;

(4) <u>2:00 to 4:00 P.M.</u> - The afternoon period of reduced activity, characterized by a diversity of trip purposes augmented by an increasing level of shopping activity;

(5) <u>4:00 to 7:00 P.M.</u> - The early evening period of increased activity, dominated by employees and shoppers moving from offices and stores, respectively, to points of mode transfer, with the peak generally occurring between 5:00 and 6:00 P.M.;

(6) <u>7:00 P.M. to 7:00 A.M.</u> - The overnight period of reduced activity depending on store closing hours, entertainment activities and similar factors.

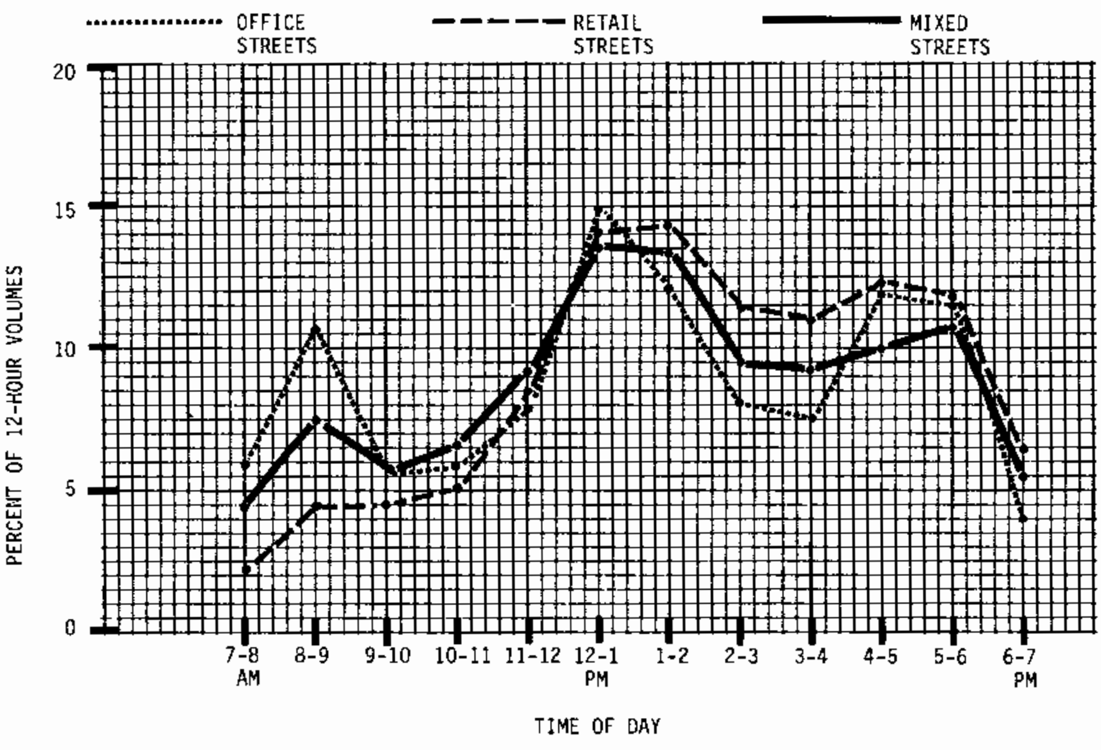


Figure 9

Typical Temporal Pattern Of Pedestrian Volumes

For pedestrian planning purposes, it will usually be sufficient to consider movement associated with only the peak periods in (1), (3) and (5), and within these periods, only the movement associated with the following trip components:

(1) The Morning or A.M. Peak - which consists of predominantly of the unidirectional movement by area employees making trips between points of mode transfer, such as bus stops and parking garages, and places of employment.

(2) The Noon Peak - which usually encompasses the period of the most intense pedestrian activity. Two components of this movement which account for a majority of the trip volumes are -

   (a) Office to Retailing Trips - Consisting of employee lunch and shopping trips. These trips are unidirectional, originating at places of employments with destination at restaurants, cafeterias, department stores, specialty shops, and similar activities.

   (b) Retailing to Retailing Trips - Bidirectional movement made up of trips by employees between stores or restaurants and stores, and by primary shoppers making similar trips.

   (c) Retailing to Office Trips - Return trips similar to (2)(a) above.

(3) The Afternoon or P.M. Peak - Which consists primarily of unidirectional movement originating at places of employment retailing centroids with destinations at points of mode transfer. This peak is usually the second most intense level of activity in central urban areas. Two components of this movement which account for a majority of the trip volumes are -

   (a) Employee Terminal Trips - Unidirectional trips by area employees between places of employment and points of mode transfer.

   (b) Shopper Terminal Trips - Unidirectional trips by primary shoppers between retail centroids - mostly department stores and specialty shops, and points of mode transfer.

In subsequent tasks, data are provided to estimate pedestrian volumes associated with categories 2(a), 2(b), 3(a), and 3(b). Employee terminal trips during the morning peak, Category (1), can be approximated by the P.M. employee terminal trip movement. The latter component is more defined, and therefore, is more suitable for the examination of peak conditions. Similarly, the retailing-to-office component of noon movement is best approximated by the more defined office-to-retailing component.

Therefore, it is recommended that four components of movement be considered for examination:

- Noon office to retailing trips;
- Noon retailing to retailing trips;
- P.M. employee terminal trips; and
- P.M. shopper terminal trips.

It should be noted that the terms Noon peak and P.M peak refer to the peak hours within the time periods 11 A.M. to 2 P.M. and 4 P.M. to 7 P.M., rather than to a predetermined hour. The peak hours for the two Noon and P.M. trip exchanges referred to above need not, therefore, coincide.

The user is encouraged to examine the above list, which is not intended to be exhaustive, and consider other movement components that should be analyzed.

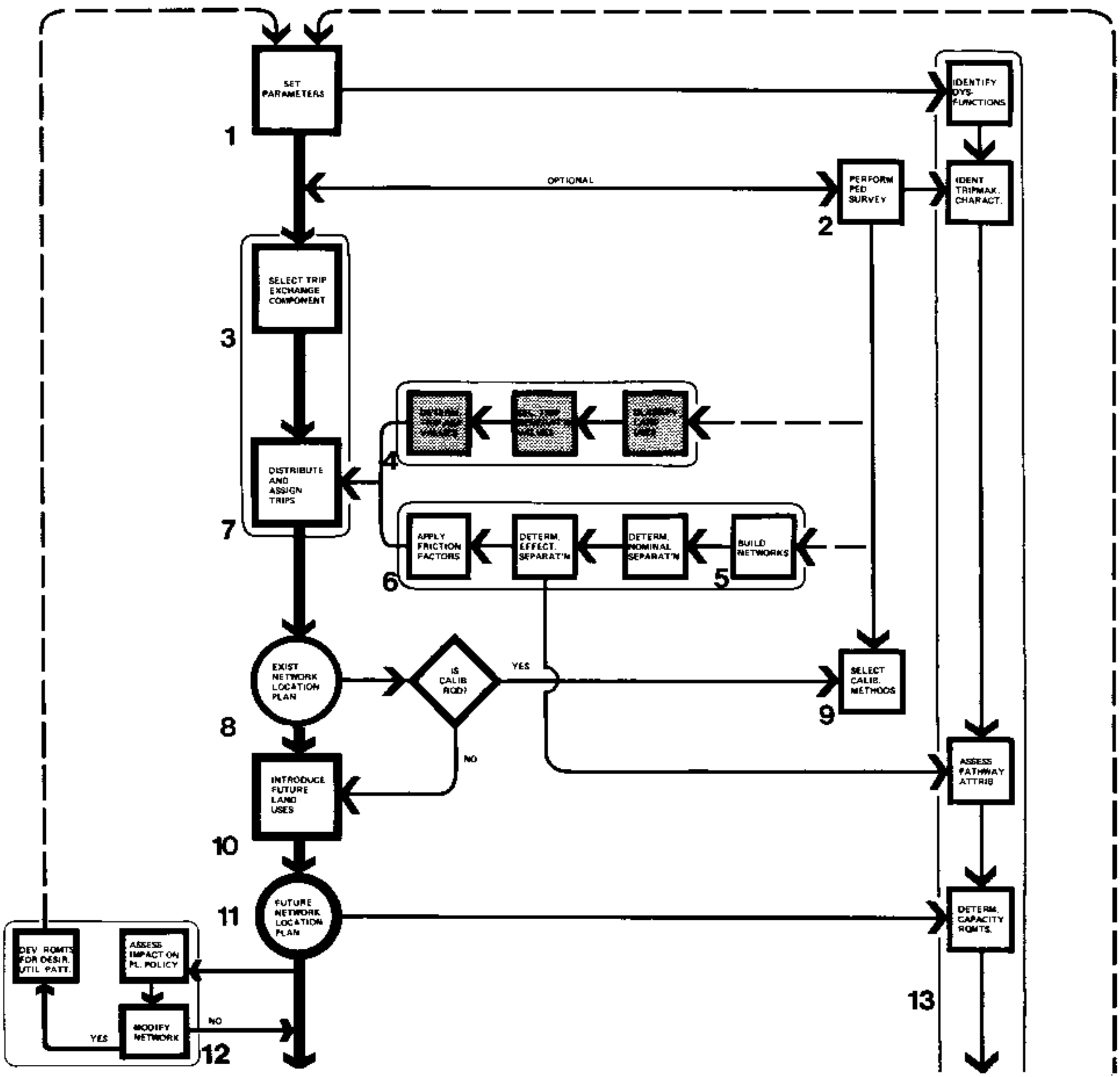
In general, this choice will be dependent on the objectives of the analysis, site-specific conditions, and size of the study area, and will, in addition, require some consideration of:

- Data availability;
- Expected trip volume in each category;
- Trip length characteristics; and
- Resource (including computer) availability.

Task 4 through 11 are repeated, as appropriate, for each movement component selected for examination.

DEVELOP CENTROID ATTRACTION AND PRODUCTION VALUES

4



TASK 4

DEVELOP CENTROID PRODUCTION AND ATTRACTION VALUES

4.1 Task Overview

Within the distribution model, land uses act either as producers or attractors of unidirectional peak-hour trips. To determine the number of such trips associated with a given land use or cluster of like land uses (centroids), an average hourly measure of two-way trip generation characteristic of the land use is initially selected and multiplied by a size parameter for the land use. This product, called the trip generation potential of the land use, is then modified by a factor to account for the one way peak period trip type to be modelled in subsequent tasks. These factors are called peak directional (PD) factors. Within Task 4, then, the following sequence of steps is conducted;

- Land uses are classified, and characterized by a measure of size;
- Using data provided in the procedures which reflects national, aggregated experience or similar data obtained by making use of site-specific sources, a set of generation factors (R-values) by land use type are selected and
- Multiplied by the land use size parameter to produce a generation value which is
- Modified through multiplication with a peak directional (PD) factor associated with a specified peak period and pedestrian trip purpose.

The production or attraction values needed by this last step are used as input to Task 7, at which time the trips are analytically distributed throughout the pedestrian system.

The classification of land uses for the purpose of estimating pedestrian generation has been designed to include those uses responsible for the majority of pedestrian trip making in the urban core. Analysis of downtown Baltimore has shown, for example, that 95% of all pedestrian trips made occur within 50% of the land area as indicated in Fig. 10.

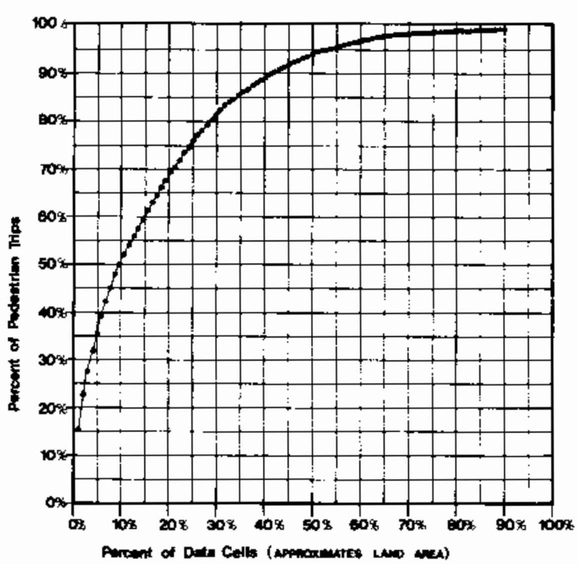


Figure 10

Density Of Tripmaking

Some land uses, such as wholesaling or warehousing have been purposely omitted since they generate minimal pedestrian traffic in most central areas. Special land uses such as tourist attractions and convention facilities defy generalization and can only be estimated using site-specific input. The classification used in the Procedures includes:

Office

- Local use buildings
- Headquarters buildings
- Mixed use buildings

Retail (excluding food related)

- Specialty retailing
- General merchandising stores

Retail (including food related)

- Fast food carry out
- Fast food with service
- Full service

Parking

- Parking lot
- Parking garage

Residential

- Single family dwelling
- Apartment dwellings
- Hotels and motels

Modal Transfer

- Bus stops
- Taxi stands
- Subway stations
- Bus terminals
- Railway stations

Other

- Tourist attractions
- Parks
- Stadia
- Convention halls, etc.

Following classification, the land uses are characterized by an appropriate measure of their size. Typical dimensions include net square feet for office and retailing, number of seats for restaurants, number of occupied rooms for hotels, and so on.

Data are provided in the Procedures for estimating average land use generation rates for offices, retailing, restaurants, parking and residential. These data were derived from extensive analysis of trip generation counts, and are based on national coverage over a representative range of cities. Figure 11 uses average generation rates to illustrate differences in the generation potential of various land use types. Figure 12, 13, 14 and 15 show daily temporal trip generation derived from typical data samples for individual buildings and streets. The data generally reflect average, moderate weather conditions with no precipitation. The user is encouraged to compare these data with site-specific information where possible in either this task, or, if appropriate, in Task 9, Calibration.

Generation (the R-factor) is estimated in trips produced and attracted (two-way trips) during an average hour measured from 7:00 AM to 7:00 PM on a weekday. Ranges are provided and the user will be required to use judgement to account for variation caused by site-specific factors such as the following:

- The different quality of like-type generators
- Availability of accessible and competing opportunities
- Special or unique land uses
- Vacancy rates

R-factors are determined for each centroid -- both existing and future -- and multiplied by the centroid's size parameter to produce its trip generation. Since this product represents average hourly generation, accounting for all trip purposes, it is independent of the movement component analysis; and therefore, is only computed once for each centroid.

Once a movement component has been chosen for analysis, the average trip generation for each centroid is converted by multiplication with factors provided in the Procedures to reflect three movement-specific conditions:

1. The increased two-way volumes associated with the peak period under consideration (as a multiple of average hourly volumes);

2. The percentage of trips out to reflect production, or trips in to reflect attraction, associated with the peak period under consideration; and

3. The fractions of an hour represented by the peak period under consideration.

The resultant production and attraction values (A & P values) are input to the model in Task 7.

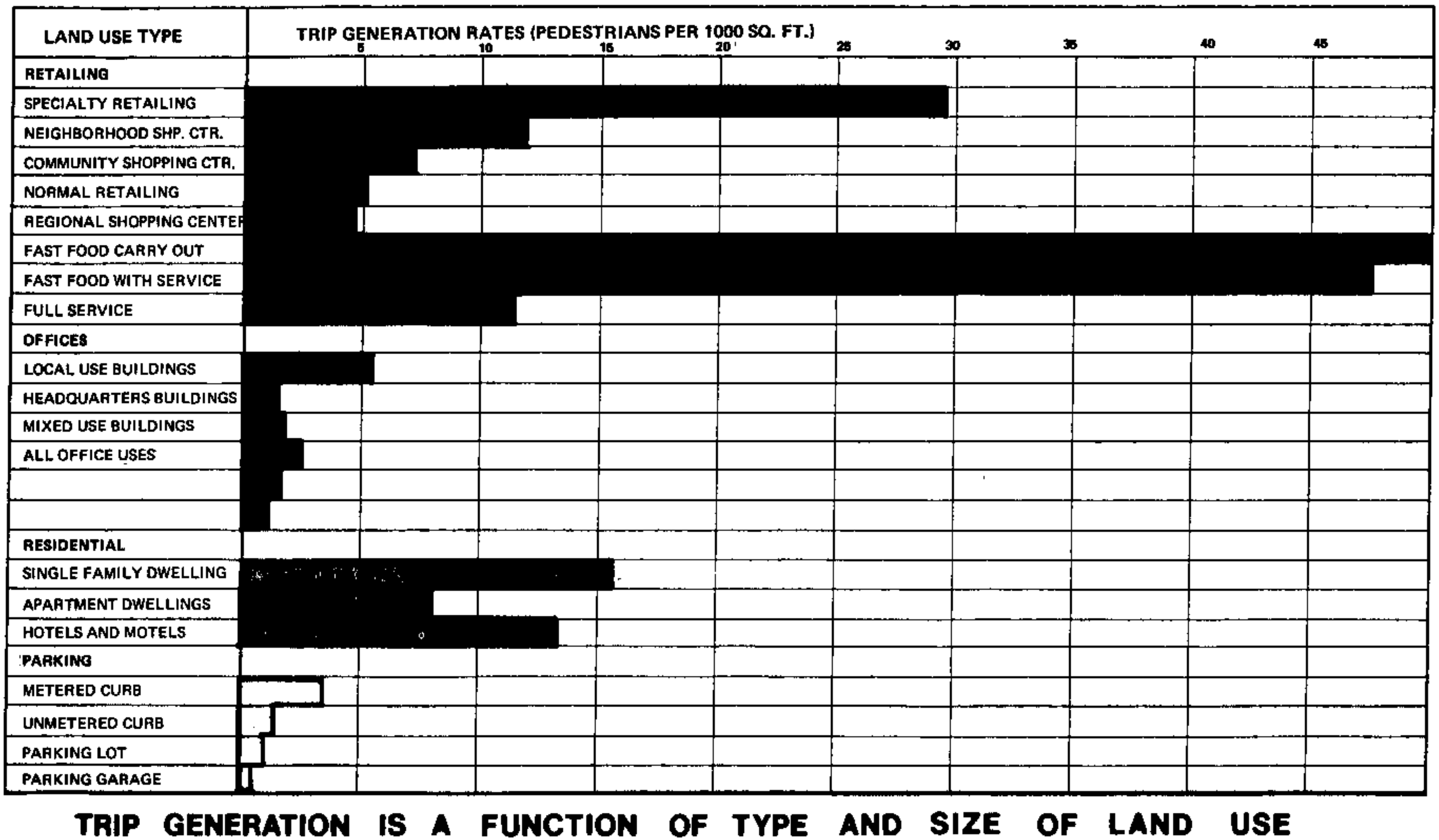


Figure 11

Average Land Use Generation Rates

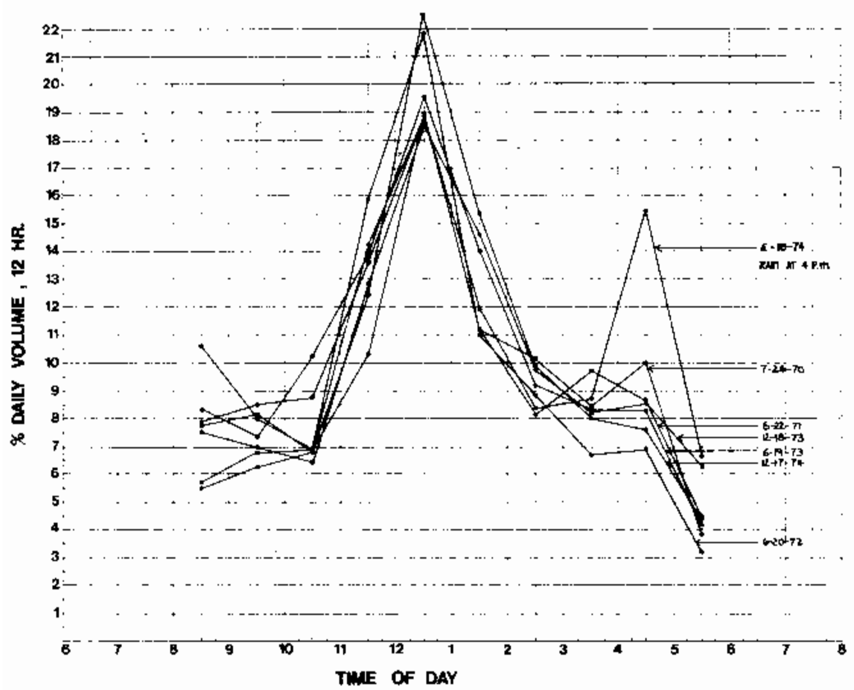


Figure 12

Pedestrian Volume Counts On A Retail Street - Summers And Winters

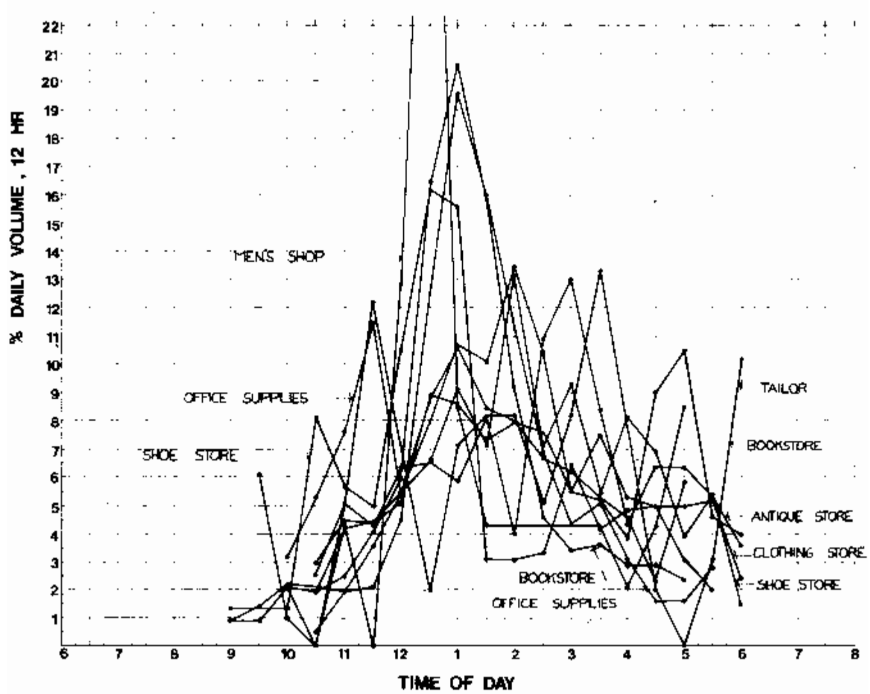


Figure 13

Pedestrian Generation - Specialty Shops

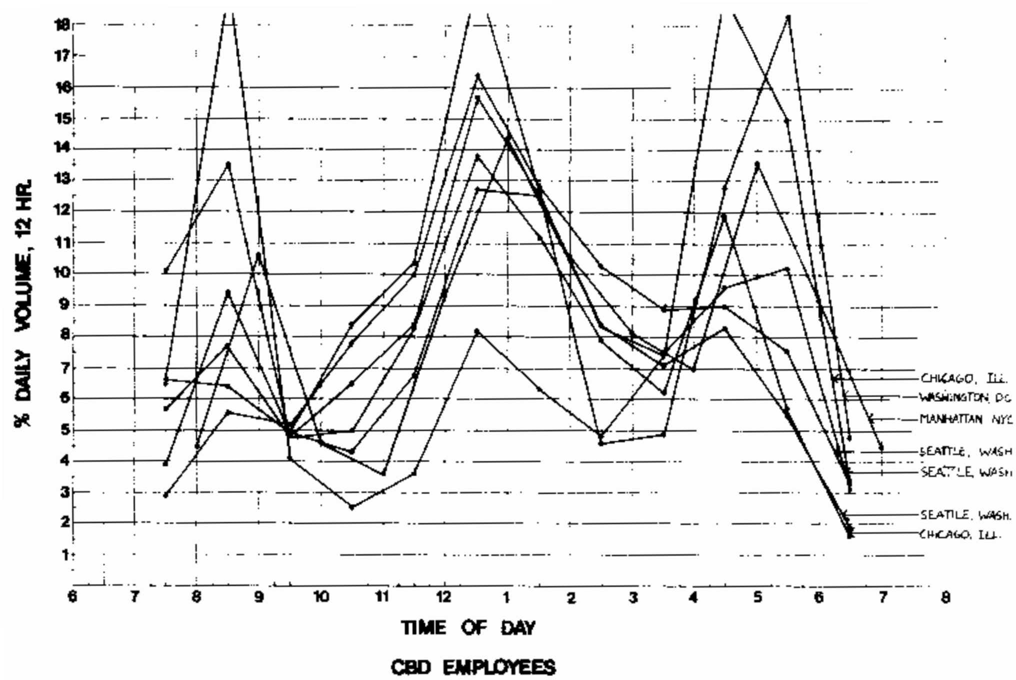


Figure 14

Pedestrian Volume Counts On Office Streets - 4 Cities

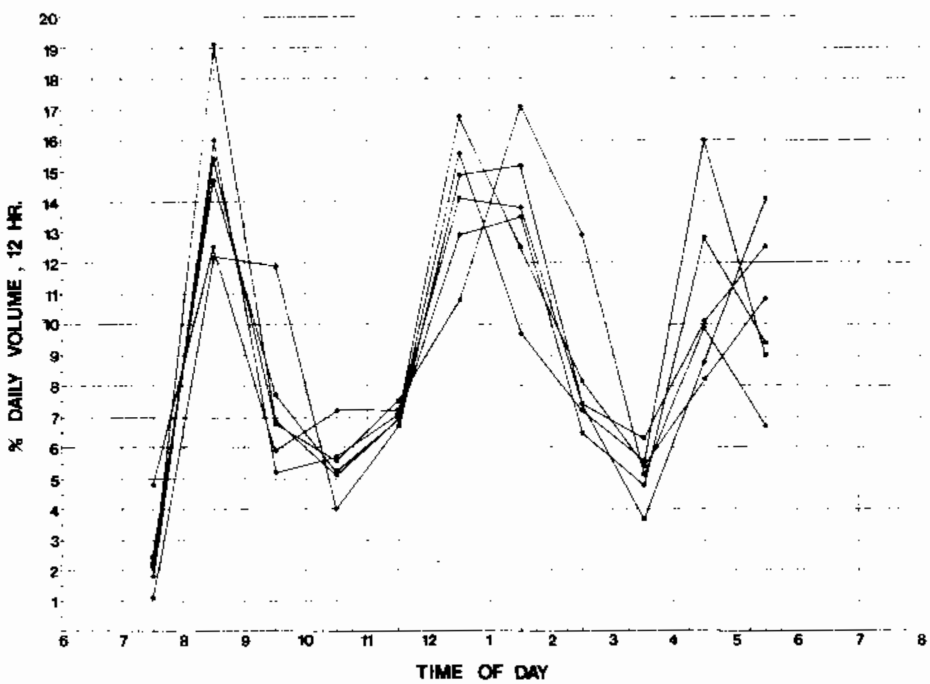


Figure 15

Pedestrian Generation - Office Buildings

4.2 Data

4.2.1. Data Required

1. Data classifying land uses by type
2. Data classifying land uses by size at the desired level of disaggregation
3. Data on special land uses from which trip generation can be derived
4. Base map(s) consistent with the study's level of detail. Typically, such base map(s) would include the following:

   - The outlines of major buildings and building masses delineated at the grade or sidewalk level

   - Street rights-of-way showing curb lines and median islands

   - Major geographic features including topographic changes, plazas and parks, parking lots, vacant parcels, waterfront boundaries, railroad lines, etc.

   - Future land uses

4.2.2. Data Provided

1. Supplement 2 Report on person trip generation for selected land uses relative to pedestrian planning
2. Supplement 3 Procedures for field measurement of pedestrian trip generation data
3. Supplement 4 The development of peak-directional factors

4.3 Procedures

4.3.1 Classify Land Uses

Where necessary, the existing study of land use classifications must be reconstituted to conform with the pedestrian trip generation categories defined below. If a standard classification system is to be adopted then as a guide, Table 1 presents Standard Industrial Classification (S.I.C.) and Standard Land Use Classification (S.L.U.C.) category numbers that correspond, where possible, with this Manual's categories.

Category A - Offices

A1 - Local Use Buildings: These buildings serve the public and tend to be occupied by doctors, lawyers, brokers and certain governmental agencies (e.g., post offices, departments of motor vehicles). These buildings are characteristically smaller than 200,000 square feet in size.

LAND USE PPP CATEGORY		TYPICAL LAND USE CLASSIFICATION SYSTEM	STANDARD INDUSTRIAL CLASSIFICATION S.I.C.	STANDARD LAND USE CLASSIFICATION SLUC (IN PART)
LOCAL OFFICES	A1	U.S. POSTAL SERVICE	43	67
		SECURITY AND COMMODITY BROKERS DEALERS, EXCHANGES, AND SERVICES	62	61
		REAL ESTATE	65	61
		COMBINATIONS OF REAL ESTATE, INSURANCE, LOANS, LAW OFFICES	66	61
		BUSINESS SERVICES	73	63
		HEALTH SERVICES	80	65
		LEGAL SERVICES	81	65
		SOCIAL SERVICES	83	86
		MISCELLANEOUS SERVICES	89	65
HEADQUARTERS BUILDINGS	A2	BANKING	60	61
		INSURANCE	63	61
		HOLDING & INVESTMENT OFFICES	67	61
		GOVERNMENT ADMINISTRATION OF HUMAN RESOURCES	94	67
		GOVERNMENT ADMINISTRATION OF ECONOMIC PROGRAMMING	96	67
MIXED USE BUILDINGS	A3	INCLUDES ANY A1 BUILDINGS OVER 200,000 SQ. FT. AND ANY BUILDINGS WITH A MIX OF		
		A1 & A2 USES (CHARACTERISTICALLY LESS THAN 400,000 SQ. FT. IN SIZE)		

TABLE 1

CORRELATIONS BETWEEN MANUAL'S LAND USE CATEGORIES AND STANDARD CLASSIFICATIONS

LAND USE PPP CATEGORY		TYPICAL LAND USE CLASSIFICATION SYSTEM	STANDARD INDUSTRIAL CLASSIFICATION S.I.C.	STANDARD LAND USE CLASSIFICATION SLUC (IN PART)
SPECIALTY RETAILING	B1	APPAREL & ACCESSORY STORES	56	56
		FURNITURE, HOME FURNISHINGS AND EQUIPMENT STORES	57	57
		PERSONAL SERVICES	72	62
		FOOD STORES	54	54
		AUTOMOBILE DEALERS & GASOLINE SERVICE STATIONS	55	55
GENERAL MERCHANDISE STORES	B2	GENERAL MERCHANDISING	53	53
		(INCLUDES ANY B1 BUILDING LARGER THAN 20,000 SQ. FT.)		
FOOD RELATED RETAILING	C1,C2 C3	EATING & DRINKING PLACES	58	58
PARKING	D1,D2 D3	AUTOMOTIVE REPAIR, SERVICES AND GARAGES	75	46
RESIDENTIAL	E1,E2	PRIVATE HOUSEHOLDS	88	11,12
	E3	HOTELS, ROOMING HOUSES, LAMPS AND OTHER LODGING	70	13,15
MODAL TRANSFER	F	LOCAL AND SUBURBAN TRANSIT AND INTERURBAN HIGHWAY PASSENGER TRANSPORTATION	41	41,42
OTHER	G	AMUSEMENT & RECREATION SERVICES, EXCEPT MOTION PICTURES	79	74,73
		MUSEUMS, ART GALLERIES, BOTANICAL GARDENS & ZOOLOGICAL GARDENS	84	71
		MOTION PICTURE	78	72
		EDUCATIONAL SERVICES	82	68

Table 1 (cont'd.)

Correlations Between Manual's Land Use Categories And Standard Classifications

A2 - Headquarters Buildings: Used as offices by insurance, banking and similar corporate occupants. Pedestrian trips generated by the buildings in this category are mostly limited to those made by employees working in the buildings. Hence, generation is lower than most other offices. Also included in this category, due to the internalization of trip making, are all office buildings over 400,000 square feet in size.

A3 - Mixed Use Buildings: These buildings have a mix of public and private offices, the nature of which may vary widely from building to building. They include headquarters buildings over 400,000 square feet and local use buildings serving the public over 200,000 square feet.

Category B - Retailing

B1 - Specialty Retailing: Generally smaller, specialized, individual stores and businesses with gross areas of 20,000 square feet or less. Such uses include boutiques, jewelry stores, gift shops, bookstores, shoe stores, clothing stores, jr. department stores, grocery stores, barber shops, branch banks.

B-2 - General Merchandise Stores: Large urban stores with diversified retailing having gross areas ranging from 200,000 - 1,000,000 square feet. These include department stores, variety stores and direct selling organizations.

Category C - Food Related Retailing

C1 - Fast Food Carry Out: Establishments characterized by substantial carry out business, although there may be some seating usually without table service. Counter seating is minimal. Examples include fast food carry outs, carry out delis, sandwich shops and similar facilities.

C2 - Fast Food with Service: Establishments specializing in fast food service, but with less emphasis on carry-out business. There is often counter-seating, as well as table-seating. Examples include cafeterias and luncheonettes.

C3 - Full Service: Full service restaurants with table seating and service, often with bars and lounges.

Category D - Parking

D1 - Offstreet, Outdoor Lot
D2 - Offstreet, Garage

Category E - Residential

E1 - Single Family Dwelling
E2 - Apartment Buildings
E3 - Hotels/Motels

Category F - Modal Transfer

- Bus Stops
- Taxi Stands
- Subway Stations
- Bus Terminal
- Railway Stations
- Similar Facilities

G - Other

This category covers any other land uses not included in the categories above such as:

- Cinemas
- Theatres
- Educational Facilities
- Tourist Attractions
- Convention Hall/Civic Centers
- Stadia
- Parks/Open Space

Where such uses have known seating capacity, turnover rates and temporal characteristics, generation rates may be reasonably estimated. Where they are variable, data on their generation behavior (if significant), must be developed.

4.3.2. Select Pedestrian Trip Generation Rates

Prior to the selection of R-values, it is important that the appropriate formats are prepared for organizing and recording data. Examples of such formats are provided as follows:

- Fig. 16 shows a typical block map marked up for use in the determination of generation, production and attraction values. This data is recorded on

- Fig. 17, a typical worksheet for this task. Data reflecting all the subsequent procedures in this task are recorded on the worksheet.

In selecting R-values, it is important to consider any factors that would vary estimates within the ranges provided. These factors were listed in Section 4.1 and are elaborated below.

BLOCK 128	STREET LINKS 42,56,94,106	EXISTING USES ☑ FUTURE USES ☐

MOVEMENT COMPONENT CODE (A&P VALS.)	GENERATION PER 1000 SQ. FT.	
1 OFFICE TO RETAIL (includ. rest.)	A - OFFICE	D - PARKING
2 RETAIL TO RETAIL (includ. rest.)	B - RETAIL	E - HOTEL
3 OFFICE TO TERMINAL	C - FOOD RELATED	F - MODAL TRANSFER
4 SHOPPER TO TERMINAL	RETAIL	G - OTHER

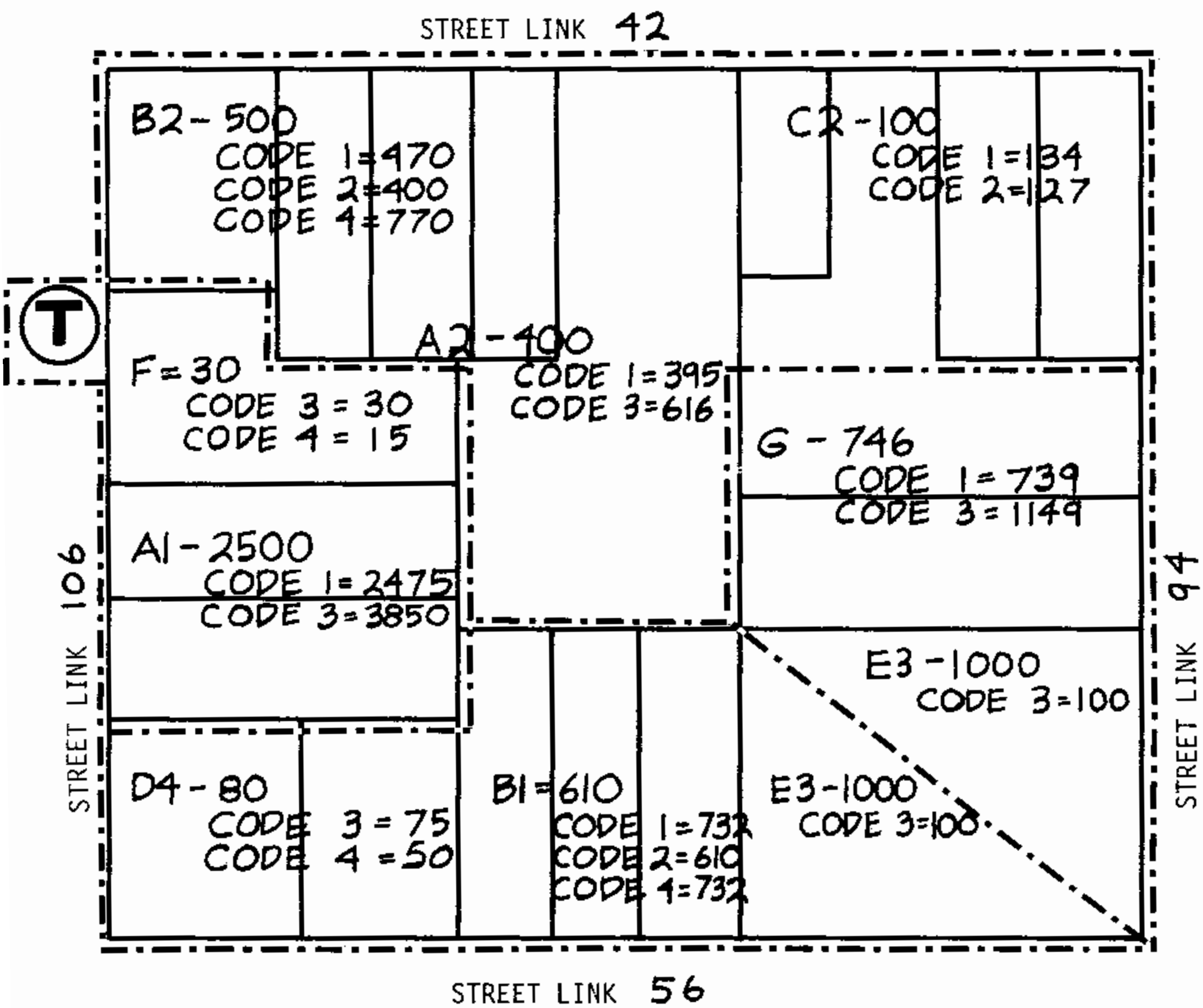


Figure 16

Sample Analysis Of City Block For Generation Rates

MOVEMENT COMPONENT CODE	
1 - OFFICE TO RETAIL (incl. rest)	4 - RETAIL TO TERMINAL
2 - RETAIL TO RETAIL (incl. rest)	5
3 - OFFICE TO TERMINAL	6

EXISTING USES	☐
FUTURE USES	☐

LOCATION

LAND USE			GENERATION			ATTRACTION & PRODUCTION			NETWORK CENTROID NUMBERS	REVISIONS
ADJACENT STREET/ LINK CODE #	LAND USE CATEGORY	SIZE (1000 sq. ft.)	R VALUE	GENERATION		(MOVEMENT) EXCHANGE COMPONENT	PD FACTOR VALUE	A OR P VALUE		
				COMPONENT	TOTAL					

Figure 17

Typical Worksheet For The Analysis Of Generation, Attraction And Production

1. Quality of Generator: Two stores side by side of a similar size and land use may generate pedestrian trips at different rates due to differences in their public appeal, quality of merchandise, amenities offered shoppers, management, etc. Such variables, as they apply to all land uses, can not be ascertained from the data but rather from observations and understandings of the local planner.

2. Availability of Accessible and Competing Opportunities: Two stores of similar size and land use may have differing degrees of accessibility. One might be located at the center of the central core area together with a variety of stores while the other is isolated on one of the outlying streets of the core area. The two will generate differently and require the use of different R-values in the range provided.

3. Special Land Uses: Special or unique land uses (i.e., plazas, tourist attractions, civic centers, etc.) may generate large amounts of pedestrian activity at particular times of the day, week or year. Their generation may also be sensitive to other conditions like weather, recreation periods, etc. These special land uses are classified under L.U. category "Other" and, if significant, will require the development of R-values by the user.

4. Vacancy Rates: Attention should be paid to vacancy rates per category and area within the city as these are site specific and can not be accounted for within the generation data.

The pedestrian survey, if performed, can provide useful insight into contextual issues and generation rates.

The user may choose to select different generation rates for future land uses compared with existing land uses if the extent or quality of proposed future projects or redevelopment argue for an increased intensity of foot traffic generation.

The data for estimating generation is divided into subsections based on land use as follows:

Section A	-	Office
Section B	-	Retailing
Section C	-	Food Related Retailing
Section D	-	Parking
Section E	-	Residential
Section F	-	Modal Transfer

In addition "Other" uses may require data development by the user.

A. <u>Offices</u>

Generation factors, R, for offices are expressed as the average number of trips generated per hour per 1,000 square feet on an average weekday between 7:00 AM and 7:00 PM.

Representative values of R are given in Table 2, together with measures of the standard deviation and range associated with the field measurements examined. These measures can be used as guidelines for adjusting R to suit local conditions. The size ranges shown in the figure are for guidance only.

Secondary Land Use Category	Size Range (1000's Square Feet-Gross)		
	Less Than 200	200 - 400	More Than 400
A1 Local Use Buildings	R = 5.4 Std. Dev. = 1.4 Range 3.4 to 7.2		
A2 Headquarters Buildings	R = 1.5 Std. Dev. = 0.7 Range 0.6 to 2.6		R = 1.2 Std. Dev. = 0.4 Range 0.4 to 2.1
A3 Mixed Use Buildings	R = 1.8 Std. Dev. = 0.6 Range 0.9 to 2.8		
All Office Uses	R = 2.5 Std. Dev. = 1.7 Range 0.6 to 7.2	R = 1.7 Std. Dev. = 0.6 Range 1.1 to 2.8	R = 1.2 Std. Dev. = 0.4 Range 0.4 to 2.1

Table 2

Trip Generation Factors
For Offices (Category A)

Table 3 is a sample list of land uses and accompanying size and generation data to be used as further guideline in the selection of R-values.

	Use	Hourly Trips/ 1000 sq. ft.	Size/ 1000 sq. ft
A1 Local Use Buildings	Motor Vehicles Dept.	14.6	15
	Post Office	14.6	36
	City Hall	7.2	18
	Medical Office	6.5	20
	Medical Office	6.2	39
	Medical Office	5.5	10
	Stockbrokers	4.0	100
	Municipal Bldg.	3.4	184
A2 Headquarters Buildings	Banking Headquarters	2.1	852
	Insurance Headquarters	1.5	1000
	Government Bldg.	1.4	863
	Headquarters (unspec.)	1.2	1634
	Headquarters (unspec.)	1.1	1048
	Insurance Headquarters	1.1	1060
	Banking Headquarters	1.0	1460
	Banking Headquarters	0.9	949
	Insurance Headquarters	0.8	500
	Government Building	0.4	1660
A3 Mixed Use Buildings	Corporate Headquarters	2.6	90
	Corporate Headquarters	1.7	109
	Insurance Headquarters	1.3	127
	Corporate Headquarters	1.3	266
	Insurance Headquarters	0.6	100

Table 3

Sample Office Land Uses And Their Generation

As a subset of office land use, local use buildings appear to exhibit several other trip generation characteristics. For the limited data examined, there was an inverse relationship between R and the building size, as shown in Figure 18. That is, the generation rate for local use buildings decreases as building size increases. This would appear to be a reasonable situation - as building size increases, less intensive uses may be attracted, in some cases, related uses, such as pharmacies in buildings of doctor's offices, would tend to reduce the trip rate per 1000 square feet, while not generating additional trips.

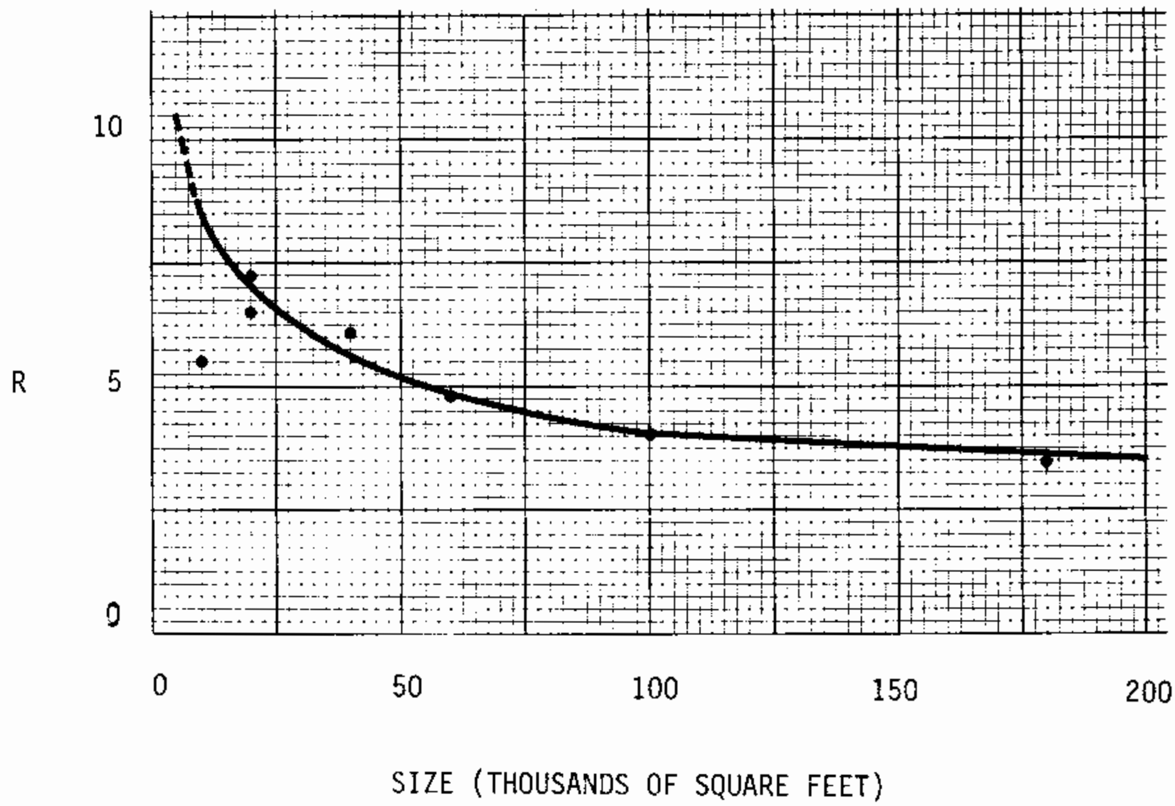


Figure 18

Relationship Between R and Building Size
For Local Use Office Buildings (Category A1)

Also, several data points, associated with a post office and a motor vehicles department, indicated an R of about 15 trips per hour per 1,000 square feet. The R for these points exceeded the group average by more than six standard deviations. Hence they clearly did not exhibit generation values characteristic of the group and were excluded; however, the potential existence of such high intensity generators should be recognized when applying the factors.

B. Retailing (Excluding Food-Related)

Except where otherwise specified, the generation factors, R, for this category of retailing are expressed as the average number of trips generated per weekday hour of operation per 1,000 square feet of gross area.

Representative values of R are given in Table 4, together with measures of the standard deviation and range associated with the field measurements examined. These measures can be used as guidelines for adjusting R-values to suit local conditions.

Secondary Land Use Category	Typical Size Range (1000's Sq. Ft.)	Average Hourly Generation Rates
B1 Specialty Retailing	20 or Less	R = 29.6 Std. Dev. = 14.2 Range 13.6 to 67.2
B2 Normal Retailing	200 to 1000	R = 5.1 Std. Dev. = 1.0 Range 3.0 to 6.2

Table 4

Trip Generation Factors
For Non-Food Retailing (Category B)

Using average within the retailing subgroups, an inverse relationship between R and building size (gross area) was obtained. The relationship is shown in Figure 19; note that R is approximately equal to 100 divided by the square root of the gross building size in 1,000's of square feet.

The data is based on gross building area. On the average, sales area represents about 76.1% of the gross area; or trip generation rates based on sales area should be adjusted to be about 31% higher than those associated with gross area.

The data base used for the derivation of R-values suggests that downtown urban stores are typically either small and specialized or very large and diversified. Where stores of intermediate size exist, then depending on their nature, Rvalues may be selected from:

- The low range of B1 retailing
- The high range of B2 retailing
- The graph in Fig. 18

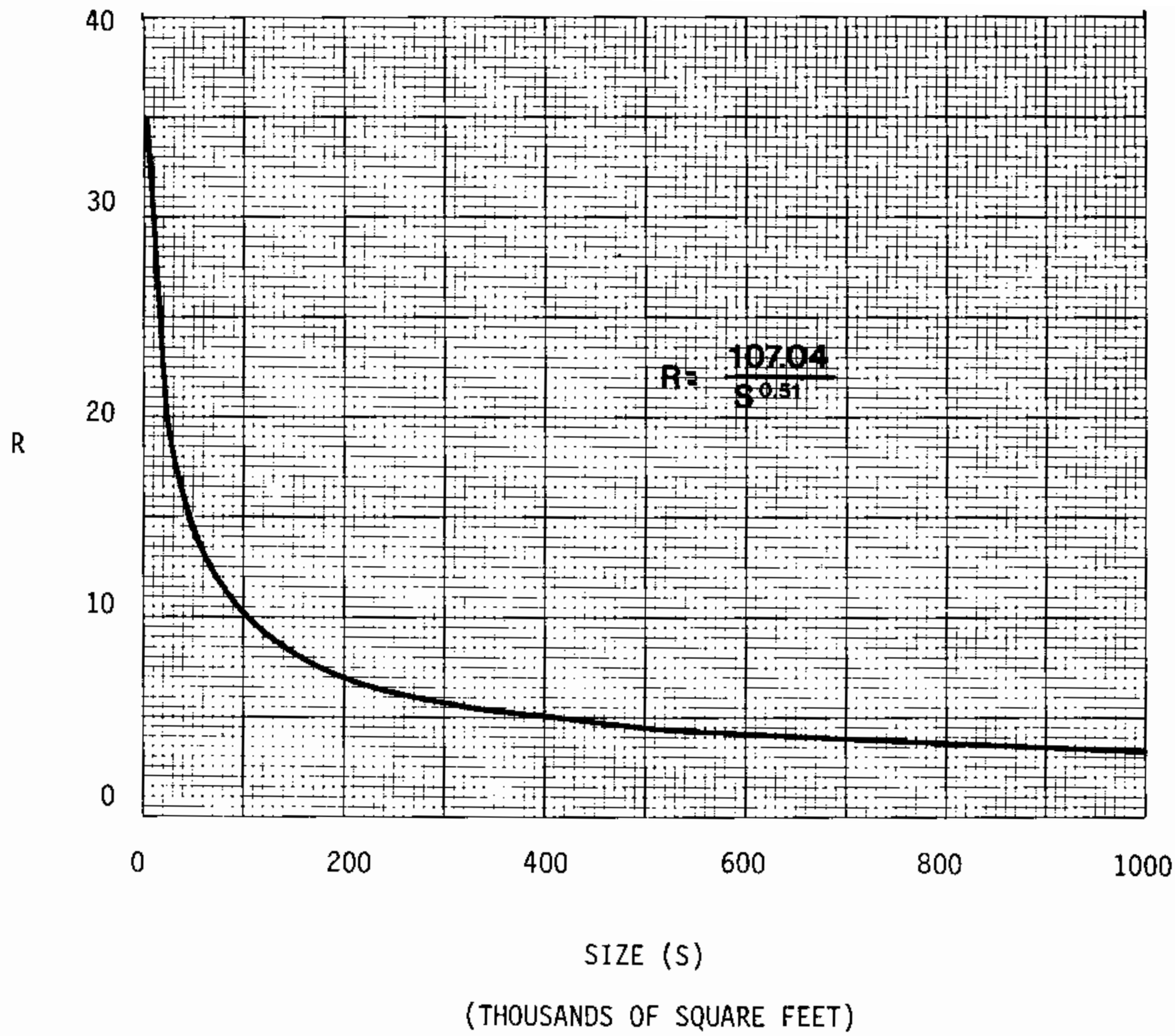


Figure 19

Relationship Between R And Building Size
For Non-Food Retailing

If the planner is uncertain about the relationship between generation levels in the study area and those provided in the manual (for example, if retailing is in decline), then peak hour counts at selected stores can provide a general factor for scaling the R-values to this particular situation.

Category	Use	Hourly Trips/ 1000 sq. ft.	Size/ 1000 sq. ft
B1 Specialty Retailing	Bookstore	54.8	2.2
	Bookstore	41.1	2.5
	Supermarket	35.7	7.5
	Shoe Store	34.2	2.9
	Women's Clothing	32.7	6.5
	Junior Dept. Store	32.1	69.6
	Supermarket	31.0	14.5
	Branch Bank*	28.6	7.8
	Office Supplies	28.2	3.6
	Boutique	25.6	3.4
	All Specialty Retailing	25.3	68
	Men's Shoes	25.3	2
	Supermarket	23.8	7.5
	Branch Bank (Savings & Loan)	23.5	-
	Office Supplies	15.2	38
	Gift Store	13.6	.8
	Men's Clothing	3.1	2
B2 General Merchandising Stores	Department Store	6.2	600
	Department Store	5.7	524
	Department Store	5.6	200
	Department Store	5.5	250
	Department Store	5.3	242
	Department Store	5.1	18
	Department Store	4.3	792
	Department Store	3.0	971

Table 5

Sample Data From Category B - Retailing

*The public floors of downtown banks have been included as B1 Retail-Private Floors internal to the bank would be considered under A2 or A3 Headquarters Buildings.

Owing to the wide range of values in the B1 category (see Fig. 14 for example), judgement will have to be exercised in the selection of R-values. Table 5 depicts some data samples which may aid in the selection. The locations surveyed to develop the data however, were in areas of intense retail activity and where activity is less intense, lower values should be used.

C. Retailing (Food-Related)

The generation factors, R, for this category of retailing are expressed as the average number of trips generated per hour of weekday operation based on two size parameters: (1) per 1,000 square feet, and (2) per seat.

Representative values of R are given in Table 6, together with measures of the standard deviations and ranges associated with the field measurements examined. These measures can be used as guidelines for adjusting R to suit local conditions.

Secondary Land Use Category	Typical Size Parameters	Average Hourly Weekday Trip Generation	
		Per 1000 Sq. Ft.	Per Seat
C1 Fast Food Carry Out	3000 Sq. Ft. or Less 100 Seats or Less	R = 128.4 Std. Dev. = 41.2 Range 88.0 to 205.0	R = 3.1 Std. Dev. = 0.7 Range 2.5 to 3.9
C2 Fast Food With Service	3000 - 5000 Sq. Ft. 100 - 200 Seats	R = 47.6 Std. Dev. = 6.7 Range 36.3 to 53.6	R = 1.4 Std. Dev. = 0.4 Range 1.0 to 1.7
C3 Full Service	5000 Sq. Ft. or More 80 Seats or More	R = 11.5 Std. Dev. = 5.2 Range 4.9 to 14.4	R = 0.43 Std. Dev. = 0.22 Range 0.10 to 0.74

Table 6

Trip Generation Factors For Food-Related Retailing (Category C)

The turnover rate of an establishment (the number of patrons served per seat per unit of time), is reflected in the trip generation factor based on seating capacity. However, the factors shown in Table 6 are based on trip ends, or two trips per patron served. Hence, the turnover rate, converted, if required, to patrons served per hour per seat, could be doubled to obtain factors comparable to those shown in Table 6. Turnover rates are data that may be available to the user.

Based on the data examined, the most reliable estimators within secondary categories are as follows:

Fast food, carry-out - trips per seat
Fast food with service - trips per 1,000 square feet
Full service - use either measure

D. Parking

The generation factors, R, for parking are expressed as the average number of trips generated per hour per parking space on an average weekday between 10:00 A.M. and 6:00 P.M. This time period was apparently chosen, in the parking studies reviewed, to encompass a peak and an off-peak period.

Representative ranges for R are given in Table 7. Users can develop estimates within these ranges to suit local conditions.

D3 - Parking Lot	0.6 to 1.1
D4 - Parking Garage	0.4 to 0.6
Average - Off Street	0.5 to 0.9

Table 7

Trip Generation Factors
For Parking (Category D)

Distinguishing short- and long-term parking may aid in interpreting the ranges in Table 7. Such data, furthermore, can be used in the exchange model where different friction factors for short- and long-term parking are provided. If this data is unavailable, the variances in site specific parking rates can be used as surrogates or failing this, simple distance from the points of high land use concentration.

Generation data on curb parking is provided in Supplement 2. This data has not been included in the procedures since its contribution to generation is usually small and evenly spread. (The planner may of course, require a count of curb parking spaces and turnover for investigating traffic management strategies in Task 17.)

E. Residential

The generation factors, R, for single family and apartment dwellings are expressed as the average daily number of trips generated per dwelling unit and per resident on an average weekday. For hotel/motels, R is expressed as the average daily number of trips generated per occupied room and per 1000 square feet.

Representative values of R are given in Table 8, together with measures of the standard deviation and range associated with the field measurements examined. All rates are for 24-hour weekday periods.

Secondary Land Use Category	Average Daily Generation	
	Per Dwelling Unit	Per Resident
E1 Single Family Dwelling	R = 15.6 Std. Dev. = 3.2 Range 10.9 to 19.4	R = 4.6 Std. Dev. = 0.8 Range 3.1 to 6.3
E2 Apartment Dwellings	R = 8.1 Std. Dev. = 2.2 Range 5.1 to 12.4	
	Per Occupied Room	
E3 Hotels and Motels	R = 13.4 Std. Dev. = 3.8 Range 6.5 to 20.5	

TABLE 8

Trip Generation Factors
For Residences (Category E)

Single family dwellings were characterized by 3.7 residents per dwelling unit, and apartments exhibited 1.8 residents per unit. For the data examined, the factors were reliable for relating trips per dwelling unit and trips per unit.

F. Modal Transfer

General factors, R, for bus stops, taxi stands, subway stations, railroad stations, bus terminals and similar facilities will have to be derived or approximated from local public transit ridership data.

4.3.3 Determine Production and Attraction Values

The generation values resulting from the multiplication of R-factors by land use size parameters represents the average, hourly number of two-way trips. Since the gravity model will, for the sake of simplicity and ease of interpretation, depict only peak period unidirectional trips, these values must be modified to reflect:

(1) The increased two-way volumes associated with the peak period under consideration.

(2) The percentage of trips out to reflect production, P(I), or trips in to reflect attraction, A(J), associated with the peak period under consideration; and

(3) The fraction of an hour represented by the peak period under consideration.

The P(I) are obtained by multiplying the average hourly two-way generation rates for each appropriate centroid by the factors given in Tables 10 through 14; that is,

$$P(I) = R \cdot PD$$

For example, consider the 15-minute peak P.M. terminal trip production of an office building with an average hourly generation (two-way) rate of 500 trips per hour. Suppose the peak 15-minute volume is double the average 15-minute volume, and that 90 percent of the flow during the peak is out of the building. Then, the specific P(I) for this centroid is:

$$P(I) = \frac{500 \text{ trips}}{\text{Hour}} \times \frac{\text{Hour}}{4} \times 2 \times 0.90$$

$$= 500 \text{ Trips} \times 0.45$$

$$= 225 \text{ Trips}$$

In the above equation, the 0.45 represents the PD factor. Estimates of these factors are provided in the succeeding sections for the major trip exchanges shown in Table 9 and described in the following sections.

Time Period	Land Use as Producer	Land Use as Attractor
Noon	Office	Retail
Noon	Office	Restaurants
Noon	Retail	Retail
PM	Office	Terminal
PM	Retail	Terminal

TABLE 9

Major Movement Components
For Which PD Factors are Provided

Since the 15-minute peak usually contains a greater amount of one-way movement than the half-hour or one hour peaks, it is recommended that the 15-minute PD factor be used in the distribution model for enhanced reliability of output. This will also facilitate the subsequent combination in Task 8 of the various movement components to create a picture of all peak hour movement.

1. Noon Office to Retailing Trips

This exchange involves the unidirectional pedestrian flow from places of employment to retail centroids including restaurants of all types, and stores and shops. Hence, a P(I) is required for each office centroid and an A(J) is required for each retail or restaurant type centroid. Tables 10 and 11 provide the relevant PD factors.

Component	Period	Factor
Noon Peak	15-Minute Peak	0.36
Places of Employment	30-Minute Peak	0.59
Trips Out	60-Minute Peak	0.99

TABLE 10

Factors for Estimating P(I)
Noon Employee Trips

Component	Period	Factor
Noon Peak	15-Minute Peak	0.50
General Merchandise Retailing	30-Minute Peak	0.49
Trips In	60-Minute Peak	0.94
Noon Peak	15-Minute Peak	0.50
Specialty Retailing	30-Minute Peak	0.71
Trips In	60-Minute Peak	1.20
Noon Peak	15-Minute Peak	0.74
Food-Related Retailing	30-Minute Peak	1.40
Trips In	60-Minute Peak	1.34

TABLE 11

Factors for Estimating A(J)
Noon Employee Trips

2. Noon Retail to Retail Trips

This exchange involves the peak noon pedestrian flow between retail centroids. Essentially this exchange covers the same retail centroids that served as destinations for the noon office to retail trip exchange treated in Section 1 above. Consideration here, however, is with the two-way flow of primary and employee lunch hour shoppers. The combination of these two trip maker elements is justified based on data that indicates that the average employee who leaves a place of employment at lunch hour makes 1.6 stops. While, for example, 40% of the employees may return to their office following only one stop, one can disregard this circumstance so as to recognize those shoppers of all types who make more than one additional stop during the peak period being considered.

An assumption is made that trips into and out of each retail centroid during the noon peak periods are equal. That is, the P(I) and the A(J) for a given C(I) will be equal; each centroid attracts the same number of trips that it produces.

To determine the P(I) and the A(J), generation rates are multiplied by the PD factors provided in Table 12.

Component	Period	Factor for Estimating P(I)	A(I)
Noon Peak	15-Minute Peak	0.45	0.45
Normal Retailing	30-Minute Peak	0.60	0.50
Two-Way Trips	60-Minute Peak	0.80	0.80
Noon Peak	15-Minute Peak	0.45	0.45
Specialty Retailing	30-Minute Peak	0.70	0.70
Two-Way Trips	60-Minute Peak	1.00	1.00
Noon Peak	15-Minute Peak	0.65	0.65
Food-Related Retailing	30-Minute Peak	0.70	0.70
Two-Way Trips	60-Minute Peak	1.27	1.27

TABLE 12

Factors for Estimating P(I) and A(J)
Noon Retail to Retail Trips

3. P.M. Employee Terminal Trips

This exchange involves the unidirectional movement of pedestrians from places of employment to mode transfer terminals such as bus stops, subway stations and parking facilities. A P(I) is required for each office, or place of employment centroid. Factors for P(I) are given in Table 13.

Component	Period	Factor
Evening (P.M.)	15-Minute Peak	0.71
Places of Employment	30-Minute Peak	1.04
Trip Out	60-Minute Peak	1.54

TABLE 13

Factors for Estimating P(I)
P.M. Employee Terminal Trips

An A(J) is required for each mode transfer centroid. Since the trip attraction characteristic of transportation terminals (mode transfer locations) are site specific and, therefore, cannot be adequately generalized, no data for estimating the A(J) can be provided. Hence, these measures must be estimated by the user as a function of the best available data.

The A(J) can, of course, be determined directly by conducting field counts at the appropriate centroid during the P.M. peak periods (usually between 4:00 and 6:00 P.M.). Alternative methods, giving less reliable estimates, but requiring less primary data, should be considered. It will be advantageous to consolidate all available information such as traffic studies, parking studies, public transit ridership studies and similar data. These data can then be used to apportion estimated trip production to appropriate points of attraction. A general method, which would be modified depending on data available, is as follows:

A(J) = Number of Trips Attracted to Mode Transfer (Terminal) Centroid J;

$$= \begin{bmatrix} \text{Relative Proportion} \\ \text{Of Trips Using} \\ \text{Mode K} \end{bmatrix} \times \begin{bmatrix} \text{Relative Proportion} \\ \text{Of Trips produced} \\ \text{by Centroid J using} \\ \text{Mode K} \end{bmatrix} \times \begin{bmatrix} \text{Total Number} \\ \text{Of} \\ \text{Trips} \end{bmatrix}$$

$$= M(K) \quad \times \quad U(J,K) \quad \times \quad P(I)$$

where $0 \leq M(K) \leq 1$ and $\sum M(K) = 1$, and
$0 \leq U(J,K) \leq 1$ and $\sum U(J,K) = 1$

The M(K) percentages can be obtained from modal split studies or responses to arrival/departure questons on pedestrian surveys, as well as from parking studies, ridership surveys, and similar sources. Also, the U(J,K) can be obtained from these same sources. Alternative means for determining the U(J,K) include estimation of relative parking centroid attraction by using shortversus long-term categorization, turnover rates, car occupancy estimates, capacity, and related information; estimation of relative transit-related attractions using estimates of ridership occupancy, loading statistics, buses per stop and/or counts. Although it is laborious, random counts of short-fixed duration can also be used to obtain the required percentage estimates.

4. P.M. Shopper Terminal Trips

This component involves the unidirectional movement of pedestrians from retail establishments such as department stores and specialty shops. A P(I) is required for each applicable retail location. An A(J) for each mode transfer location.

To determine the P(I), PD factors are provided in Table 14. The A(J) will have to be estimated by the user. Section 3 should be referred to for methods applicable to this estimating process.

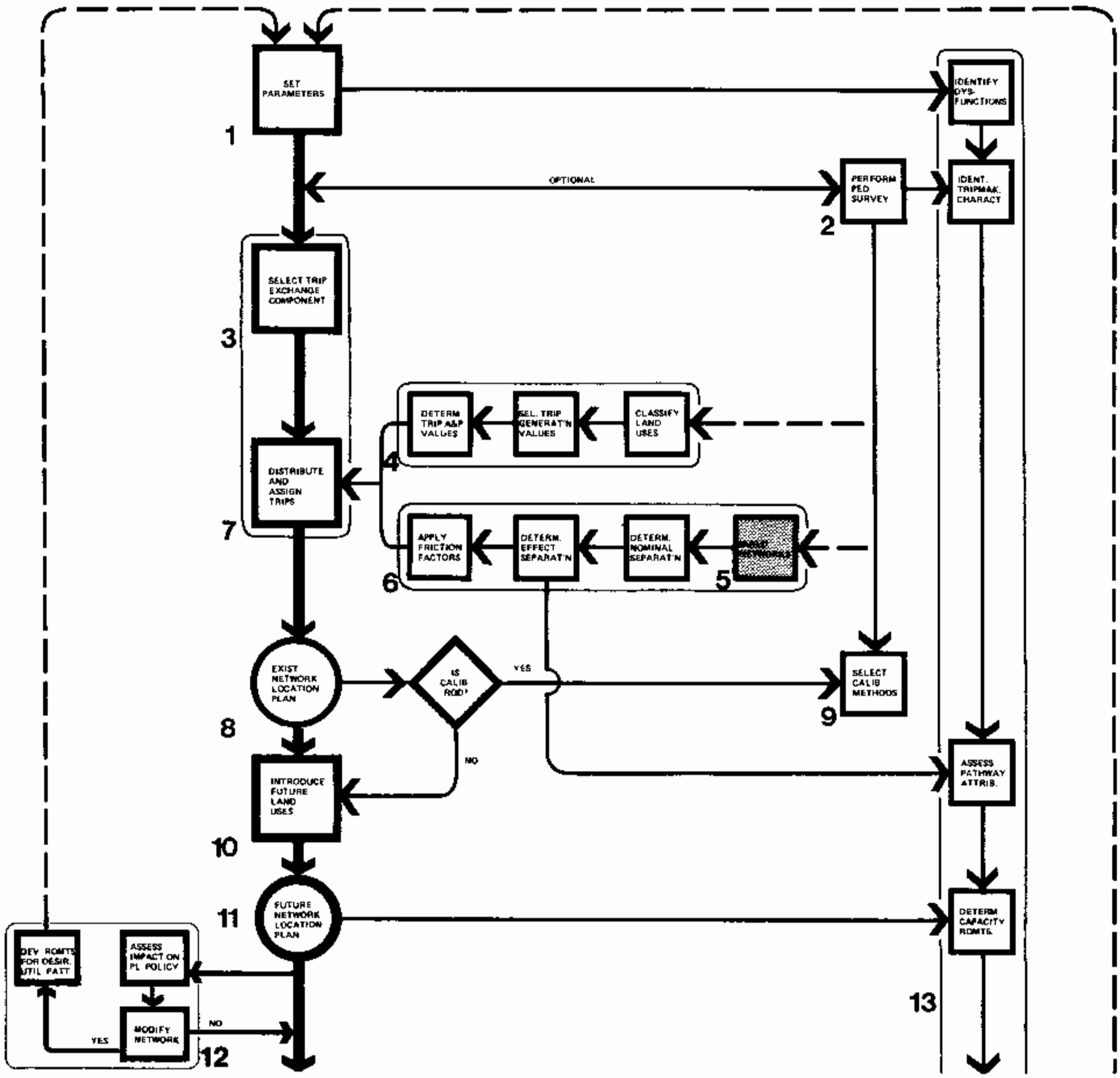
Component	Period	Factor
Evening (P.M.)	15-Minute Peak	0.40
Normal Retailing	30-Minute Peak	0.75
Trips Out	60-Minute Peak	1.40
Evening (P.M.)	15-Minute Peak	0.35
Specialty Retailing	30-Minute Peak	0.65
Trips Out	60-Minute Peak	1.20

TABLE 14

Factors for Estimating P(I)
P.M. Shopper Terminal Trips

BUILD NETWORKS

5



TASK 5

BUILD NETWORKS

5.1 Task Overview

Following classification of land uses and determination of trip generation rates for all major centroids, a graphic pedestrian network is developed for each trip purpose (movement component) being examined. The network consists of circles denoting pedestrian activity centers or centroids, connected by lines that represent the pathways between these centers. The inter-centroid pathways can, if necessary for more adequate definition, be subdivided into a series of pathway links.

The mapping of generation values (see Fig. 20 for an example) over a base map of the study area can provide a basis for delimiting the extent of network. It may also provide insight into probable trip exchange patterns and routings.

In developing a pedestrian network, the level of detail incorporated, that is, the extent to which centroids and pathways are defined and differentiated, will be a decision made by the user. However, numerous factors will affect this decision.

Basically, there is a trade-off between the considerable effort required to examine a more detailed network in order to develop refined pedestrian movement data, and the less intense effort required to examine a less detailed network which will yield a more aggregated movement data. The network is simply a tool to facilitate the analysis and can be tailored to situations ranging from a macro analysis of large urban areas to the micro scale of a single pathway facility. Hence, to a large extent, the intended application of the network will determine the level of detail that is required. However, since the computational effort described in subsequent tasks increases geometrically as the level of detail increases, the user should insure that the detail included is minimized, consistent with the requirements of the analysis. Examination of even moderately complex networks will require the application of appropriate computer programs.

The pedestrian networks produced in this task will form the basis for recordings the centroid generation rates computed in Task 4, the separation values and friction factors developed in Tasks 5 and 6, and subsequent the pedestrian trip distribution and assignment values produced by the model in Task 7 and 10.

5.2 Data

5.2.1. Data Required

1. Base map with land use generation values produced in Task 4.

2. Location of access points, or portals, to all the land use centroids in (1) above.

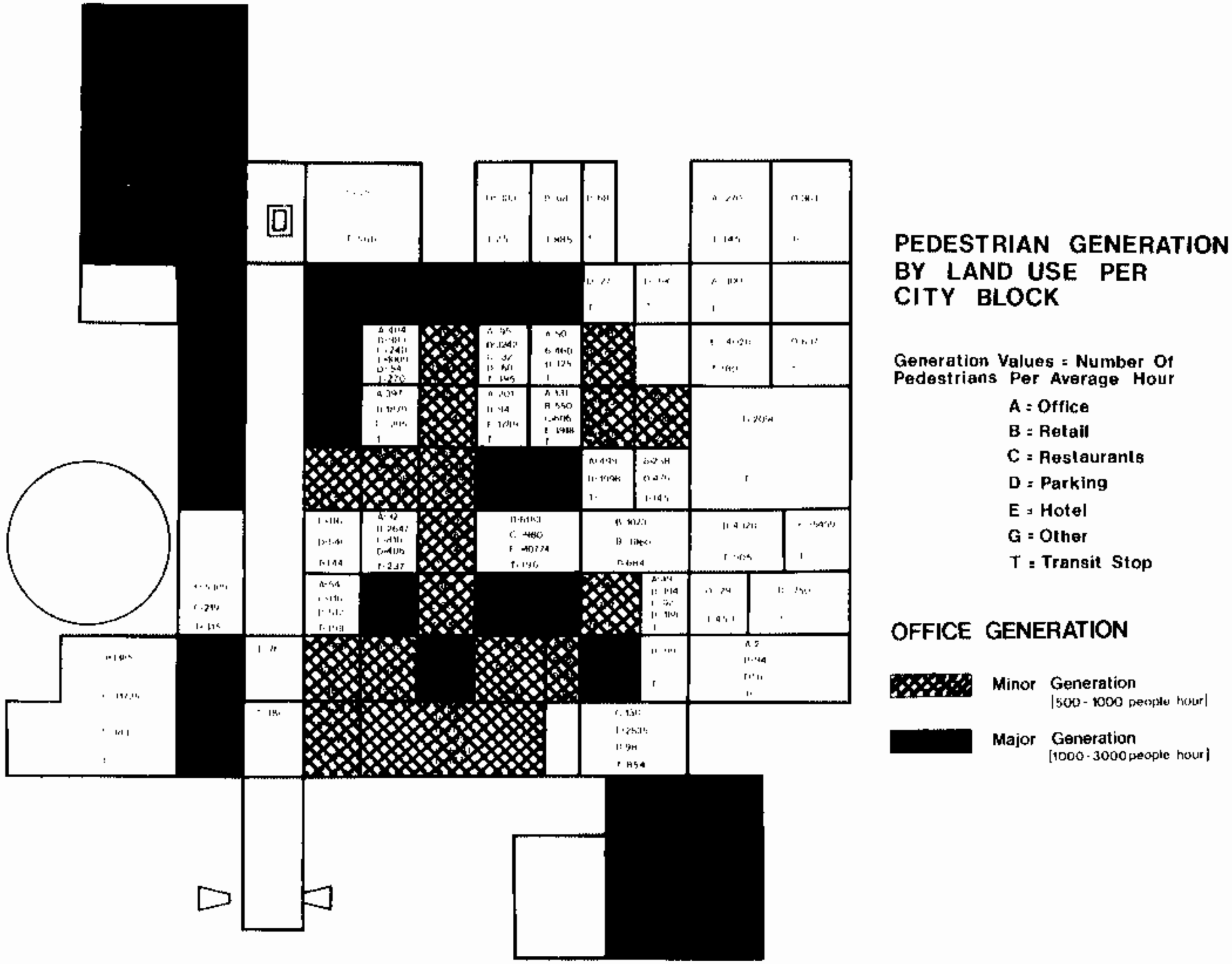
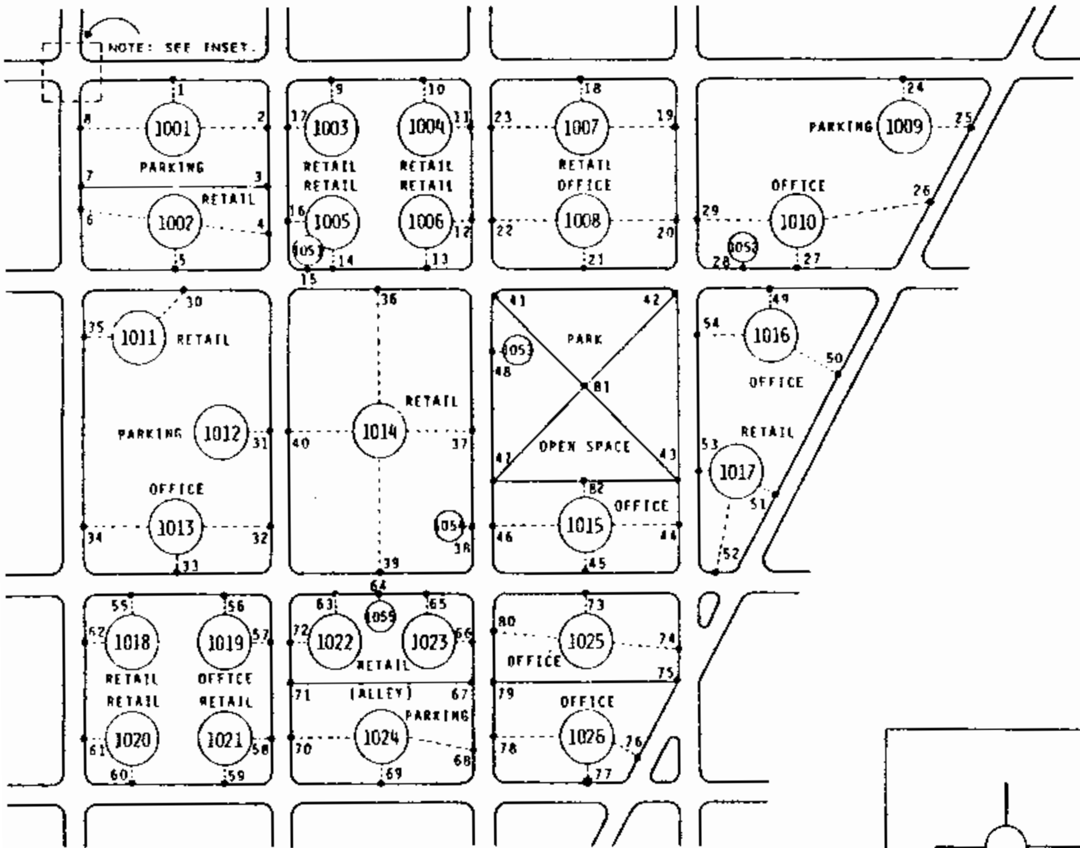


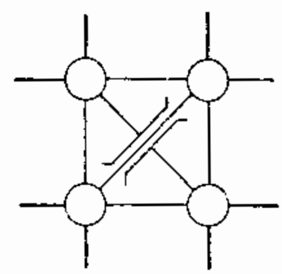
Figure 20

Sample Mapping Of Pedestrian Generation In Study Area



KEY

1. Large circles indicate origin-destination centroids.
2. Small circles indicate bus stops or mode transfer points.
3. Dots indicate nodes in the network.



INSET

NETWORK REQUIREMENTS TO MODEL PEDESTRIAN PATHS AT A SIGNALIZED INTERSECTION.

Figure 21

Hypothetical Pedestrian Network (Expanded)

NOTE: The dashed lines represent the connection of centroids to the pathway network; they cannot be used for through-trips. Also, the representation of the network at the street intersections has been omitted for simplicity. A typical intersection representation is shown in the inset, and would be assumed in tracing paths between nodes and centroids.

3. Pedestrian counts conducted within the study area, if available.

4. If the pedestrian survey was performed in Task 2, the Trip Patterns map. (See Fig. 6 and Task 13, Step 13.3.2)

5.2.2. Data Provided as References

1. Supplement 1, Section 1: Definitions and notation conventions for pedestrian networks.

2. Supplement 5: Network representation and calculation of pedestrian delays for signalized intersections and uncontrolled crossings.

5.3. Procedures

5.3.1. Determine level of detail required in network

The following guidelines are provided to assist in making a determination of the level of detail required:

a. For applications that are primarily conceptual in nature, less detail will usually be required. Long range planning studies covering large areas will usually require only a determination of future pedestrian concentrations; hence, the required degree of accuracy would be provided by a simplified network. Figure 21, on the other hand illustrates a fairly comprehensive network representation for a downtown area.

b. The more specific the application, the greater the required level of detail. Studies of specific intersections or for the implementation of specific pathway (e.g., pedestrian over-crossing) will require that a small area be modelled in detail.

When examining specific elements, the study area can be constrained to about a three-block radius since approximately 70% or more of all walking trips in urban areas are 1000 feet or less. Figures 22 and 23 illustrate a detailed network interpretation of a one-block area.

c. In many situations, a combination of the two conditions cited above might be employed. First, a simplified network could be used to isolate areas requiring special attention; then a more detailed examination could be made in those areas. Similarly, certain portions of a large simplified network could be treated in more detail. For example, when examining pedestrian movement around a subway station to determine portal locations, the immediate area could be detailed, with the level of detail reducing as a function of distance from the station.

An associated decision that will need to be made by the user is whether the analytical process will be accomplished manually or with the aid

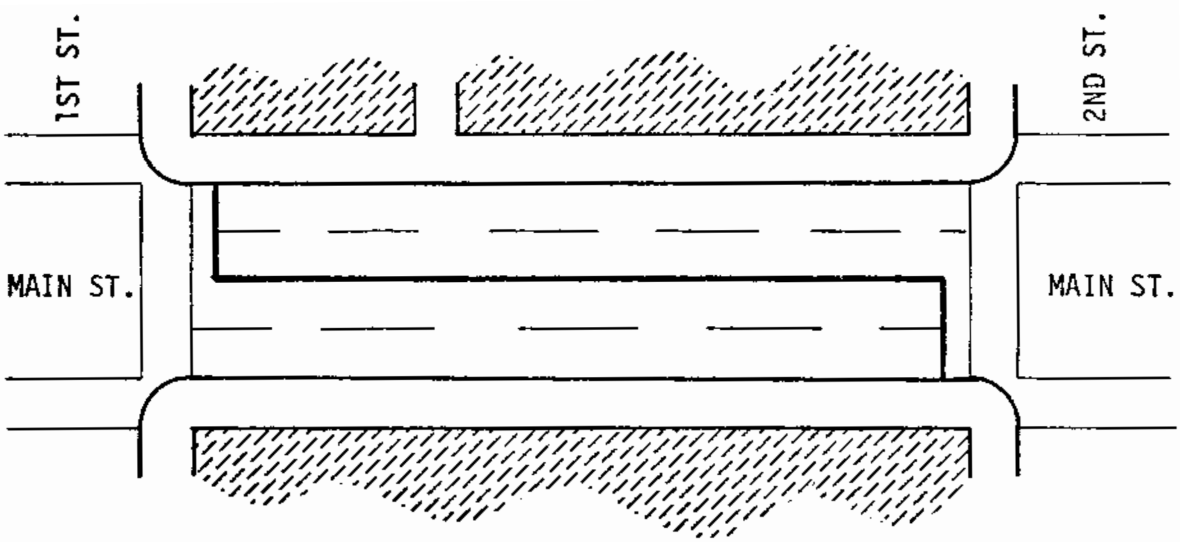


Figure 22

Hypothetical One-Block Urban Area

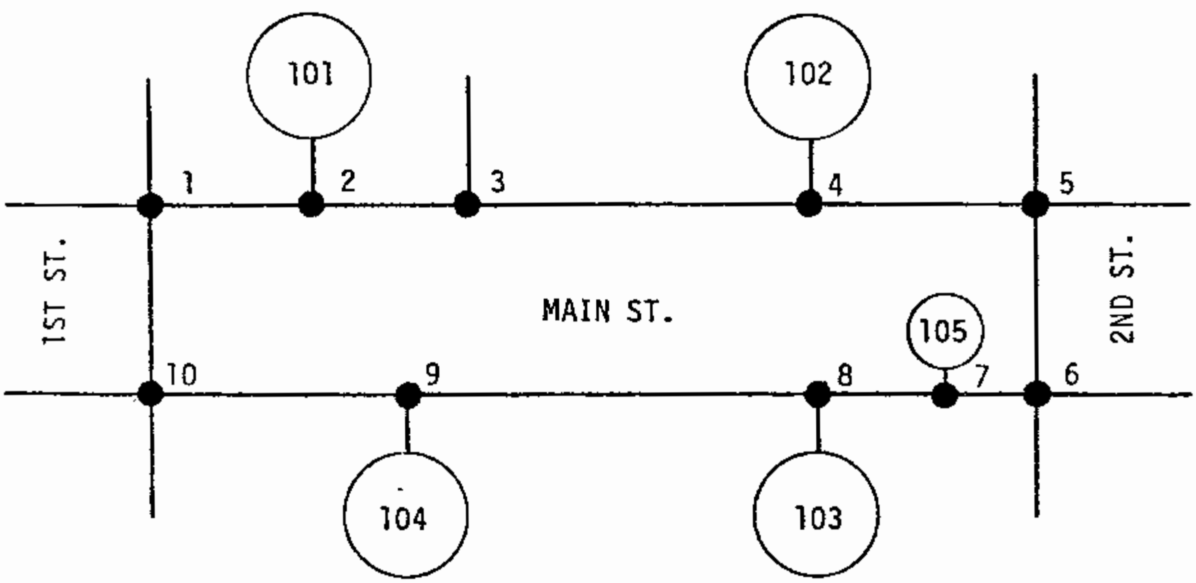


Figure 23

Pedestrian Network Representation

of a computer. The decision will depend on the level of detail and size of the pedestrian network. Many networks incorporating a general level of detail and/or limited in scope to a small area can be handled reasonably well through manual computations. Since the computations relate to pedestrian volumes on walking pathways between appropriate origin-destination pairs, the computation effort will be roughly proportional to the number of centroids. Assuming N centroids, all of which interact -

$$\text{Computational Effort} \quad \text{is proportional to} \quad \begin{cases} (N) \cdot (N-1) \; \cdots\cdots \; \text{two direction trip exchange} \\ \dfrac{(N) \cdot (N-1)}{2} \; \cdots\cdots \; \text{one direction trip exchange} \end{cases}$$

Hence, for 20 centroids, approximately 200-400 calculations will be required per iteration of the gravity model. Assuming about three iterations, the 20 centroids would be an upper limited on the size of the network that could be examined manually. If the network is larger, or if several alternatives are to be tested, it is suggested that computer methods be used.

Since it is likely that many agencies that will be doing pedestrian planning will also have been involved in vehicular planning, computer capability should be available to most users. Certainly, the availability of appropriate computer programs will: (1) ease the computation burden, (2) allow for examination of more extensive (larger and/or more detailed) networks, and (3) provide for flexible testing of alternatives. Task 7 provides the planners with more specific references regarding the use of available programs.

5.3.2. Develop Network.

1. Access points or portals to those land uses coded for generation are to be located on the base map. Where the configuration of future land uses is unknown, assumptions about probable portal locations must be made.

2. In developing the network, the user may choose to simplify the representation of centroids, portals or links. The following guidelines and cautions apply:

3. If the model computation will be done manually of if computational resources are limited (for example, the tracing of shortest routes or skim trees is to be done manually) then there are great benefits to aggregating like-use centroids that are opposite or adjacent in the network.

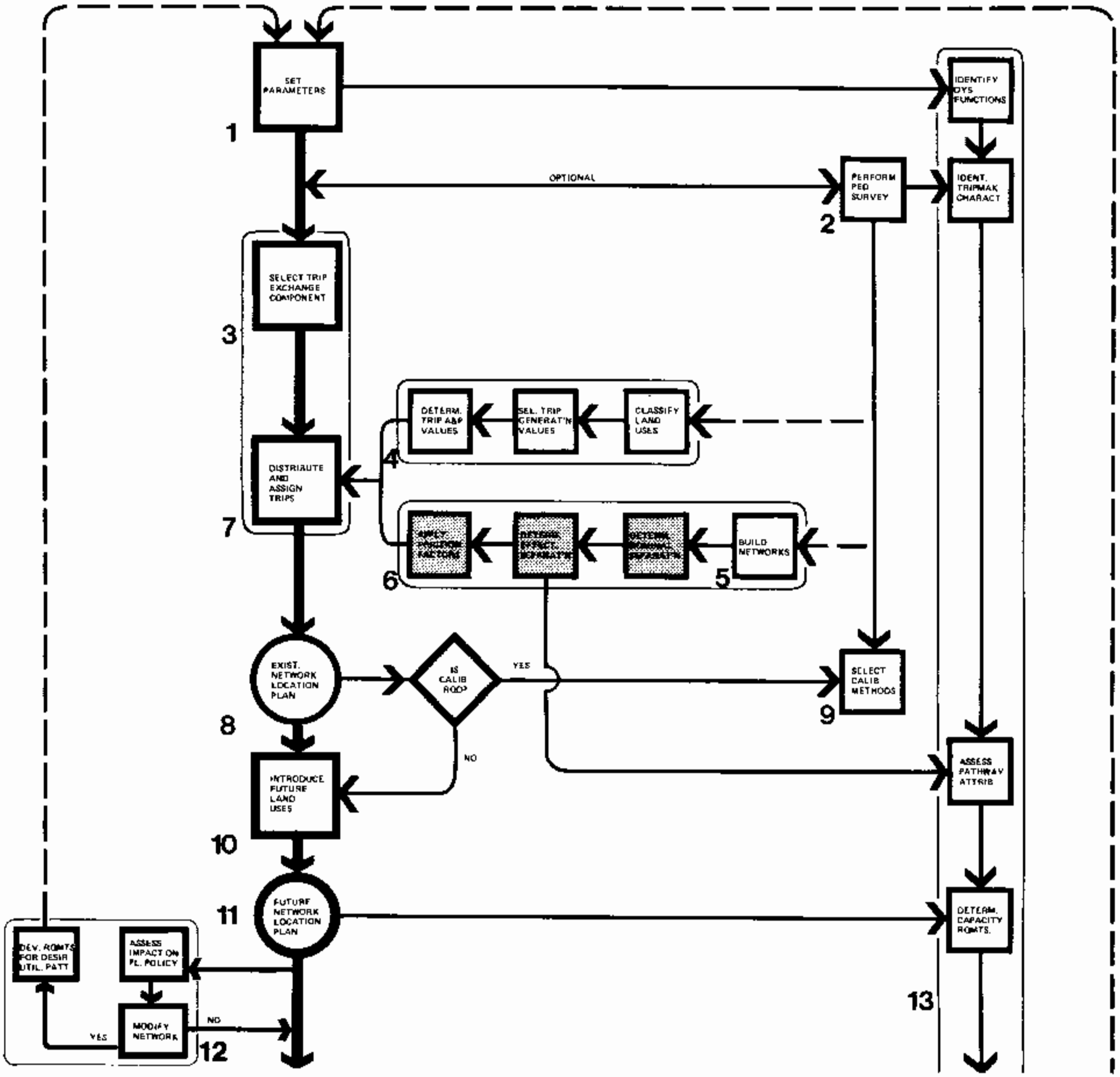
4. Simplifications to the existing land use network should not prejudice the clarity of the future land use network. For

example, if the possibility of a future upper level walkway system exists, its insertion into the existing network should be feasible.

5. If several components of movement are to be modelled, separate networks representing the different land uses involved will be required. Link-simplification efforts should retain the same link pattern for all networks for the sake of consistency, economy of effort and subsequent interpretation.

DETERMINE NOMINAL AND EFFECTIVE SEPARATION AND FRICTION FACTORS

6



TASK 6

DETERMINE NOMINAL AND EFFECTIVE INTER-CENTROID SEPARATION MEASURES, AND FRICTION FACTORS

6.1. Task Overview

Using the networks developed in Task 5, travel time along their pathways and pathway links must be determined for use in the distribution and assignment modelling tasks.

The extent to which pedestrian trips are made between centroids will depend, in part, on the "distance" between them. The real or perceived "distance" between centroids, or more generically, their separation, is a function of walking distance, trip time, pathway impedances, and various perceptual factors that influence the propensity of a pedestrian to make the trip. In this task, methods are presented for developing separation measures between centroids.

In addition to spatial separation (walking distance) and temporal separation (trip time) considerations, typical pathway elements that contribute to the real or perceived pedestrian separation between centroids are:

Vertical Displacement

- stairs
- ramps
- escalators
- elevators

Horizontal Displacement

- turning movements
- directness
- impedances

Delays

- crowding
- queues
- waits

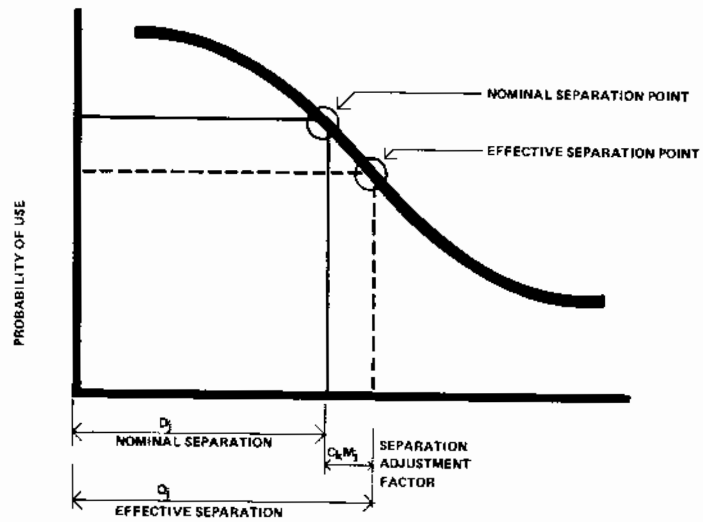
Psychological and Physiological Factors

- comfort and amenities
- security
- safety
- interest and attractiveness
- orientation, etc.

The term effective separation will be used to describe the distance between two points as perceived by pedestrians as a function of time, distance and the other influencing elements cited above.

Distance, time and energy (under average conditions) represent invariant measures of separation associated with a given pathway. These measures are used to establish a <u>nominal separation</u> that will be modified by behavioral or perceptual factors to obtain the effective separation. For example, 1000 feet of pathway, characterized by numerous points of interest, may be perceptually shorter than 1000 feet to a pedestrian on a recreational trip; but may still appear as 1000 feet to a commuter going from a bus stop to a place of employment.

Nominal separation measures are expressed in terms of time, usually as minutes. Distance and energy are converted to time using pedestrian movement on level, unimpeded pathways as the normative condition. To convert the nominal travel times to effective travel times, the planner must conduct a field survey of existing streets and rate specific aspects, or attributes, of the street environment. These site specific ratings are combined with generic ratings based on research findings for the same attributes so as to provide a final trip-purpose-contingent weighting. Figure 24 illustrates these concepts. Work sheets integrating the planner's rating with precalculated weights are provided.



$$Q_j = D_j \left[C_k M_j \right]$$

where

C_k = CONSTANT VALUE (NORMALIZING)

M_j = TOTAL DISTANCE MOVED FROM NOMINAL DUE TO THE INFLUENCE OF ALL ATTRIBUTES WITH RESPECT TO TRIP PURPOSE

$$= \left[\frac{r_j - 5}{10} \right] \left[G_i \right] \text{ OR } \left[\text{FIELD SURVEY RATING} \right] \left[\text{ASSIGNED WEIGHT} \right]$$

PATHWAY ANALYSIS INTEGRATING PERCEPTUAL VARIABLES AND INTERCENTROID SEPARATION

Figure 24

Nominal And Effective Separation

The effective separation measures represent the perceived pedestrian travel times between centroids. The probability that a pedestrian will choose to make a trip, or the trip propensity, is related to the magnitude of the perceived travel time. As the perceived travel time increases, the propensity to make the trip is reduced, or attenuated. By examining the marginal probabilities on trip attenuation curves developed from empirical data, it is possible to obtain estimates of the probability that a pedestrian trip, requiring a given travel time, will be made. These probabilities, known as friction factors, or travel time factors, are developed in this task and provided as input to the gravity model where they influence the trip distribution within the network.

Figures 25 through 28 present a sequence of sample graphics as a visual summary of key products from Tasks 5 and 6.

6.2 Data

6.2.1. Data Required

1. Network developed in Task 5.
2. Base map(s) from which horizontal measures of distance along the network can be made.
3. Map(s) indicating Topographic change, if significant.
4. Data on existing traffic signal cycles and splits at network intersections.
5. Traffic volume counts, or estimates, on network streets where uncontrolled ped crossings take place.
6. If available, graphic material illustrating modifications to the street environment resulting from future land use changes.
7. If available, site-specific friction factors from the frequency distribution of trip lengths.

6.2.2. Data Provided as References

Supplement 5: Network representation and calculation of pedestrian time delays for signalized intersections and uncontrolled crossings.

Supplement 6: Report on the effect of pathway elements on pedestrian tripmaking.

Supplement 7: The impact of vertical displacement pathway elements on inter-centroid separation.

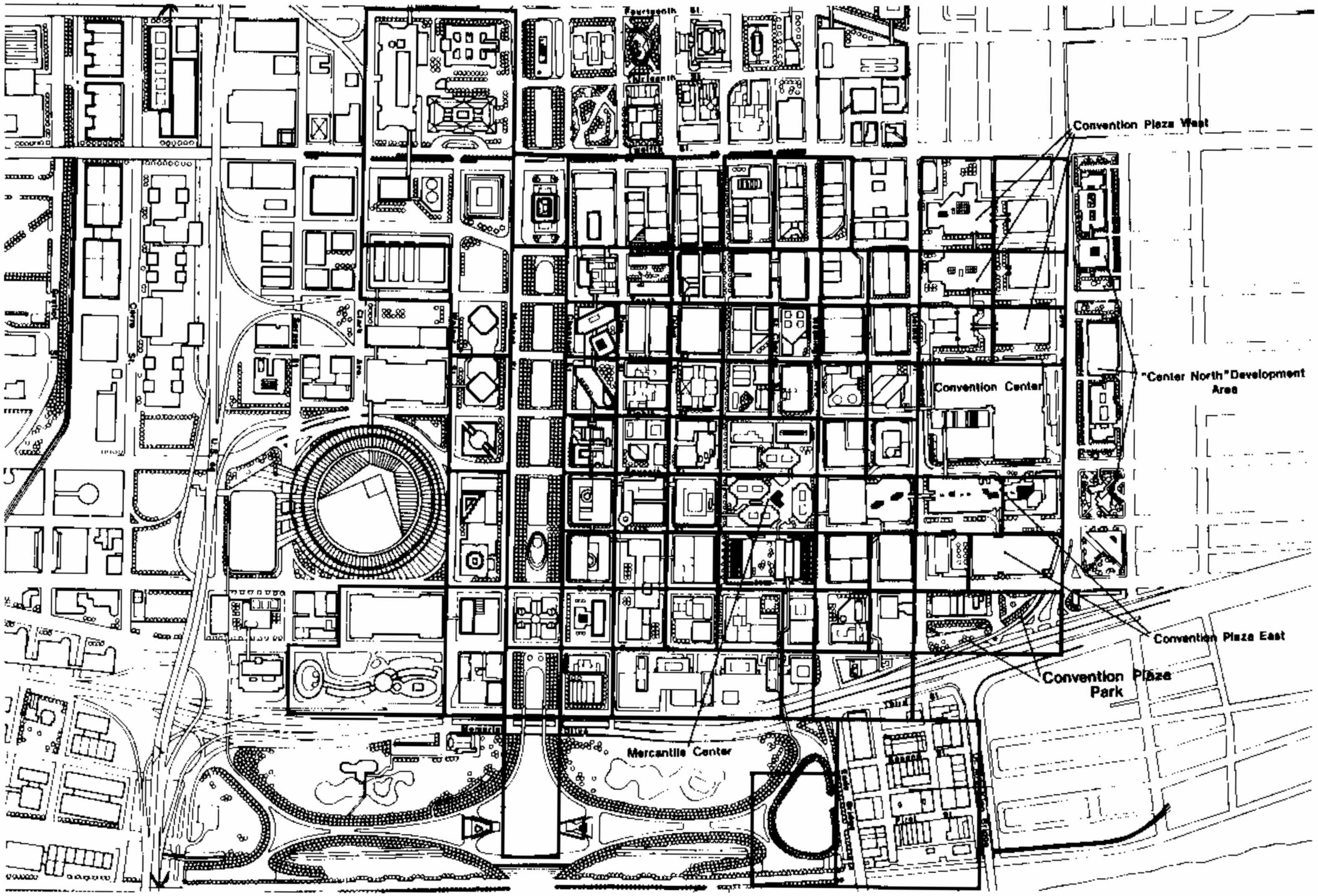


Figure 25

Base Map With Overlay Of Generation Cells

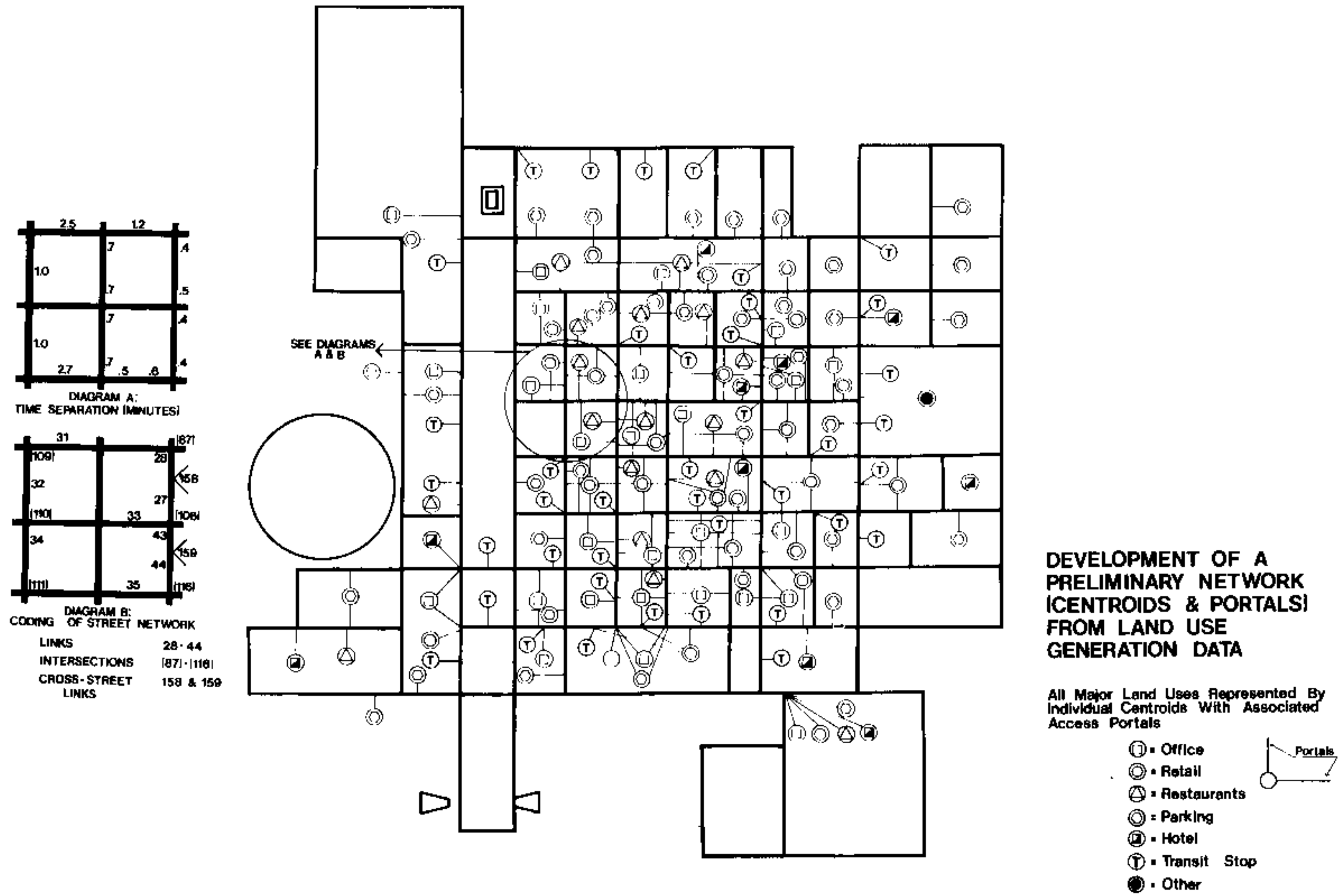


Figure 26

Development Of Preliminary Network

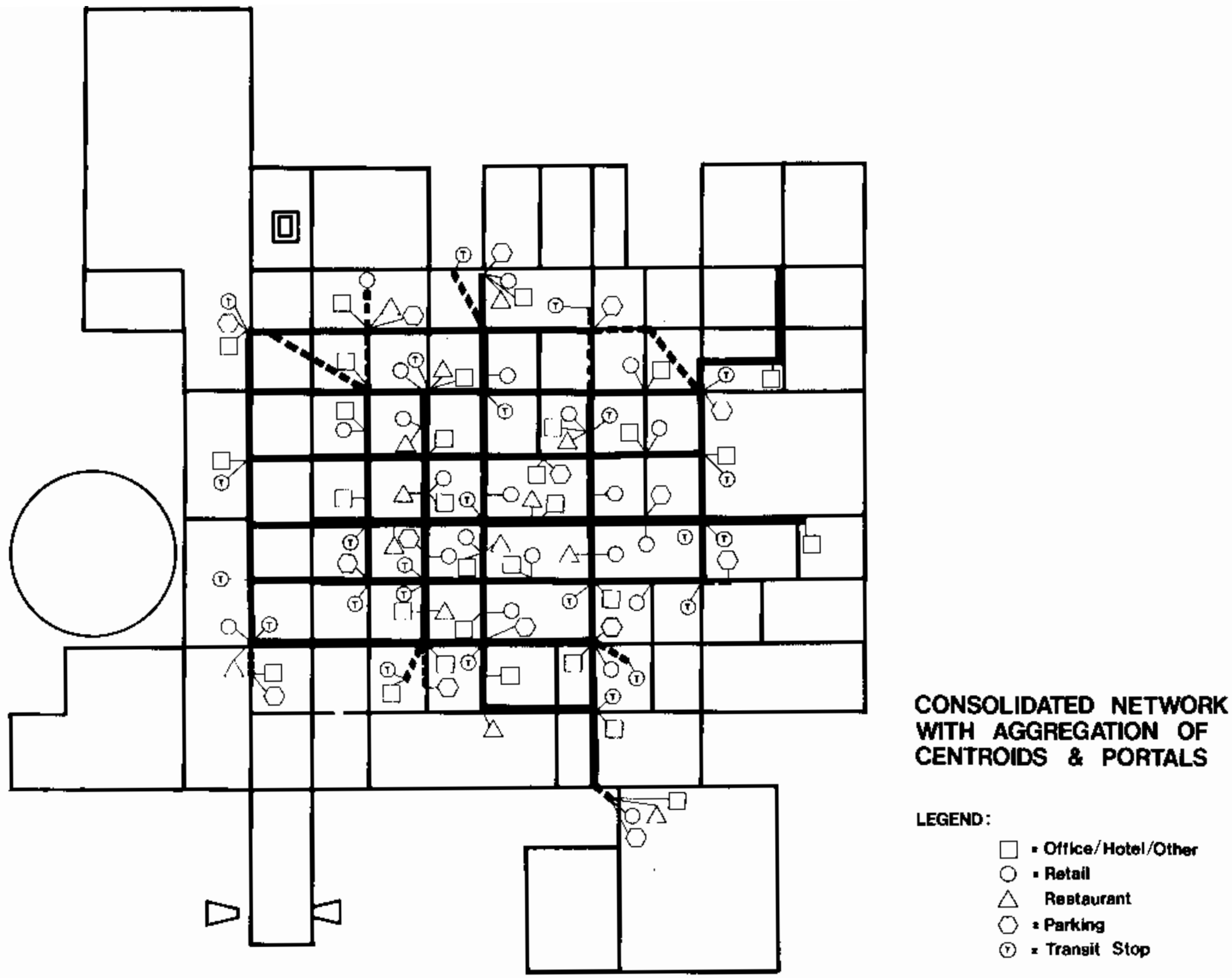


Figure 27

Consolidated Network

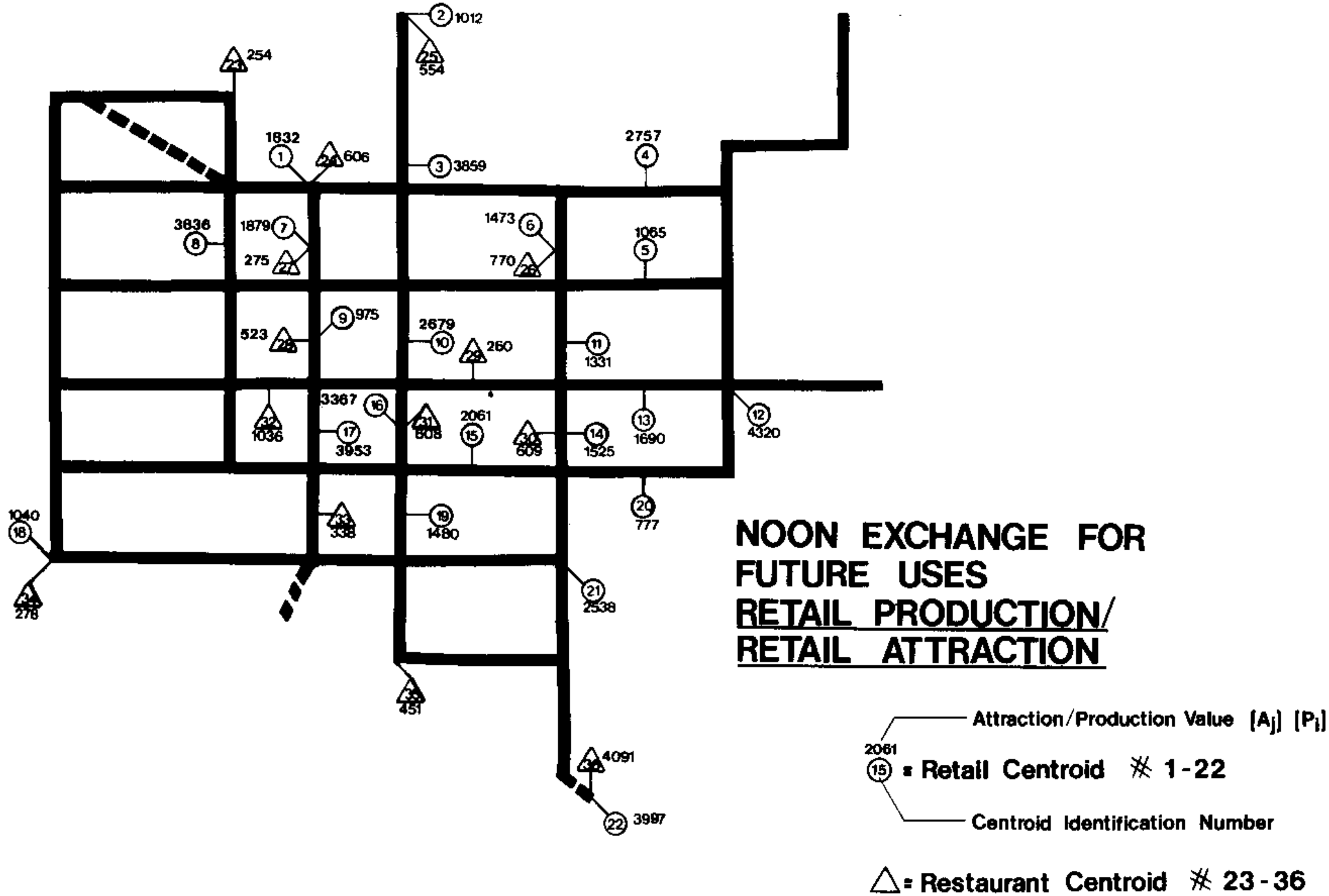


Figure 28

Network Coded For Noon Office To Retail Exchange

Supplement 8: The development of effective separation measures.

Supplement 9: Pedestrian tripmaking propensity considerations.

6.3 Procedures

The procedures presented in this task are divided into three parts:

- Determination of inter-centroid nominal separation measures;
- Modification of nominal separation measures to obtain inter-centroid effective separation measures; and
- Conversion of effective separation measures to tripmaking friction factors.

6.3.1. Determination Of Nominal Separation Measures

The nominal separation of pathway i denoted as D_i, that connects centroids is a function of the physical time, distance and/or energy expenditure required to make the pedestrian trip. Given any two points, the Di is considered to be invariant, that is, nominal separation is fully specified in terms of time, distance and energy and does not vary due to trip maker characteristics, behavior or perception. However, obvious exceptions to this concept may exist even though they are not treated here. For example, a pedestrian population consisting primarily of the aged, the young or the physically handicapped would necessitate a departure from the following approach. In these cases, the user may wish to make appropriate adjustments within the contextual approach presented here.

The nominal separation between centroids is determined by the following sequence of steps:

(1) Measure <u>all</u> horizontal components of the pathway, including street crossings and the horizontal components of stairs, ramp and escalators, and convert to time equivalents using 265 feet = 1 minute;

(2) Add the time equivalents associated with average delays at signalized street crossings;

(3) Add the time equivalents associated with average delays at uncontrolled street crossings;

(4) Add or subtract the time equivalents associated with modifications to walking rates and energy expenditure due to vertical separation elements;

(5) Add the time equivalents associated with modifications to walking rates due to known conditions of crowding on specific links;

The measures resulting from the above steps could be directional; that is the D_i measured by going from centroid A to centroid B may differ from that measured for the trip from B to A. Topographic change is an obvious reason for such differences. Since it is proposed that exchange inputs to the distribution and assignment model be uni-directional, the user might be required to perform some averaging of the two-directional separation times where their differences are significant, so that the "impact" of return trips can be captured in the modelling exercise.

The five components, or steps, cited above are discussed below.

1. <u>Horizontal Travel Time</u>

Tests have shown that the average pedestrian walks at a rate of 265 feet per minute, and in doing so, expends 4.38 calories per minute. Hence, for converting distance and energy to time, the following equivalents will be used:

1 Minutes = 265 feet = 4.38 calories

Departures from this normative condition will be necessary if the pedestrian group under consideration is composed of children, the aged, the handicapped or have similar characteristics. In such cases, the user can modify the procedures presented here to suit the specific situation.

The entire horizontal components of the pathway is measured and converted to an equivalent time using the one minute = 265 feet relationship. Connections between centroids and their portal nodes on the network should be excluded from this measurement exercise.

2. <u>Signalized Intersection Crossing Delays</u>

Signalized intersections represent an impedance to pedestrian movement in the form of actual, potential, and perceived delays that add to overall trip time. For any given condition, the magnitude of the delay will be a complex function of numerous factors including:

- <u>Type of Pedestrian Crossing</u> - A right-angle crossing of a single street, or a diagonal crossing involving two streets;
- <u>Signal Cycle Time and Phasing</u> - Percent of cycle time allowing pedestrian crossing, inclusion of a pedestrian phase;
- <u>Street Widths</u> - Widths of the vehicular streets;
- <u>Pedestrian Arrival Distribution</u> - The pattern of pedestrian arrivals at the intersection crossing point (uniform, random or non-random such as platooning); and
- <u>Vehicular Movement</u> - One-way patterns, turning movements.

Supplement 5 contains a derivation of the average pedestrian delay expected as a function of various street widths, crossing types and signal times, assuming uniform random arrivals of pedestrians at intersections. Graphic results for typical conditions are also presented.

For overall planning purposes, however, it is often advantageous to represent this pedestrian delay component in terms of a single, average delay per pedestrian crossing. This simplified approach can eliminate the necessity for a detailed examination and modelling of each signalized intersection in the network.

There are various ways in which a single, representative measure of delay can be determined, depending on the adequacy of available data. This would range from direct observation to utilization of the results provided in Supplement 5. In general, however, the application of some site-specific data together with information contained in Supplement 5 will suffice. For example, if information is available that indicates (even roughly) the probability with which conditions such as right-angle and diagonal crossings occur, then the results in Supplement 5 can be applied. The average delay would be the weighted sum of the delays associated with each condition, where the weights are the probabilities that each condition occurs.

In the absence of any more detailed examination (due to lack of resources, information or similar reasons), an average pedestrian crossing delay of 20 seconds should be considered as applicable to all conditions. This figure is based on the following -

- An 80-second signal cycle;
- A 50-50 signal split;
- Equal 80-foot street widths;
- Equal probabilities of right-angle and diagonal crossings; and
- Random arrival of pedestrians.

The 20-second figure represents only pedestrian delay caused by signalized intersections. It does not include pedestrian walking time required to cross the intersection, to which the 20 seconds should be added.

Hence, for a given pathway, all delays due to signalized intersections would be summed and added to the horizontal time component computed in the previous step.

3. Uncontrolled Crossing Delays

Pedestrian average delay (in seconds) can be estimated using the data provided in Table 15.

Vehicles Per Hour Both Directions	Street Width (Feet)			
	24'	36'	48'	60'
200	3	3	4	5
400	3	5	8	12
600	5	9	13	21
800	7	13	21	35
1,000	9	18	33	63
1,200	12	24	52	96

Table 15

Average Pedestrian Delay (In Seconds)
At Uncontrolled Crossings

As in the case of signalized intersection delays, the total time delays for uncontrolled crossings are added to the total time previously computed.

4. <u>Delays Due To Vertical Separation Elements</u>

<u>Stairs</u>

Time equivalents (given in seconds) for <u>delays due to changes</u> in walking speed and energy consumption at stairs are shown in Table 16. The factors shown are for each ten feet of change in grade. The derivation of this data and some ranges associated with it are given in Supplement 6.

Direction	Stair Angle		
	30°	35°	40°
Up	18.4	15.2	12.7
Down	3.6	3.0	2.5

Table 16

Mean Delays (In Seconds) Due To Changes In Walking
Speeds And Energy Expenditure On Stairs
For Each 10 Feet Change In Grade

Ramps

Time equivalents (given in seconds) for delays due to changes in walking speed at ramps are shown in Table 17. The factors shown are for each ten feet of change in grade.

Direction	Gradient	Time Equivalents (Seconds)	
		Walking Speed Component	Energy Component
UP	+30	3.3	14.2
	+20	2.6	12.1
	+15	1.9	11.0
	+10	1.3	9.3
	+ 5	0.8	7.5
	0	0	0
DOWN	- 5	0	-5.8
	-10	0	-5.7
	-15	0	-2.4
	-20	0	-1.0
	-30	0	+2.0

Table 17

Time Delays And Savings On Ramps Due To Changes In Walking Speed And Energy Consumption For Each 10 Feet Of Change In Grade

5. Delays Due to Crowding

Where crowded conditions are known to exist on network links during peak periods, then the relevant delay caused by reduced walking speeds should be added to the link's separation time. Knowledge of congestion can be based on a combination of observation, photographic records and peak hour counts. Table 18 below provides data for adding delay times. Fig. 44 in Task 13 provides a further description of levels of service.

Occupancy (Sq. Ft./Ped.)	Level of Service	Walking Speed (FPM)	Delay (in seconds) For Each 100 Feet of Crowding
25 or more	B	265	0.0
15	C	225	4.0
10	D	200	7.4
7.5	E	175	11.6
5	F	110	31.9

Table 18

Time Delays On Walkways Due To Crowding

The resutant time obtained as the summation of the five components cited above, for a given pathway i connecting centroids, is the nominal separation; Di; for that pathway.

Some examples demonstrating the calculation of nominal separation are included in Supplement 6.

6.3.2. Determination Of Effective Separation Measures

The calculation to obtain effective separation measures, using the nominal separation measures as determined by the approach presented in the previous section, consists of three steps:

- Each pathway is rated (using worksheets provided) based upon attributes which affect the pedestrian perception of trip time;
- These ratings are then converted to scores, using pretabulated worksheets, to obtain an adjustment factor; and
- The adjustment factor in applied, as indicated, to the nominal separation of the pathway to obtain a measure of effective separation. The three steps are discussed below:

1. <u>Rating The Pathways</u>

Using Table 19 walk the network and apply ratings on a scale of 0 to 10 for each attribute to the streets. Depending on the level of detail desired and whether the network represents both sidewalks as two links or one "composite" link, the planner will either rate each sidewalk separately or "average" the overall environment. The length of the links to be evaluated will likewise depend on the fineness of detail desired in the model's output. Scoring links on a block-by-block basis would be a reasonable scale for most downtown cores.

Definitions of the attributes are provided in Table 19.

It should be noted that the rating assigned should be relative to the environment being studied rather than relative to any fixed notions of what constitute "high-quality" or "poor" environments.

Graphic material representing future land uses and environments should be reviewed to develop ratings to be used when exercising the distribution model under future conditions in Task 10.

2. <u>Computing The Adjustment Factor</u>

The basis for computing the effective separation for a pathway (or pathway link) is as follows. Let --

Qij = Effective separation on pathway i for trip purpose j;

$= (1 + A_{ij}) \times D_i$;

where D_i = nominal separation on pathway i,
and A_{ij} = separation adjustment factor on pathway i for trip purpose j.

The adjustment factor, A_{ij}, is computed as follows:

$$A_{ij} = (C \times W_{jk} \times S_{ik})$$

where S_{ik} = a score assigned to pathway i for attribute k;
W_{jk} = the weight assigned to attribute k for trip purpose j and
C = a scaling factor.

The score, S_{ik}, is based on the planner's rating in Step 1 above.

The W-weights shown in Table 20 were derived from a sampling of pathway attributes conducted as part of the research for the Manual. (Amplification of this research exercise and the derivation of formulae are contained in Supplement8.) The scaling factor, C, was developed to ensure that the A_{ij} were consistent with D_i, the maximum A_{ij} being scaled so that for the shopping trip --

EVALUATION WORKSHEET INSTRUCTIONS: Circle the Scores Selected for Particular Attributes. On completion, convert these scores using Table 20 to fill out Table 21 and derive effective separation.	PATHWAY BEING EVALUATED	

ATTRIBUTE	DEFINITION	HIGH SCORE					AVERAGE SCORE					LOW SCORE
1. ACCESSIBILITY	How accessible is this street to major activity locations such as shops, dept. stores, office concentrations, restaurants, parks?	0	1	2	3	4	5	6	7	8	9	10
2. AMENITIES	Amenities refers to features which might add to your pleasure or convenience such as benches, water fountains, rest rooms, shaded rest areas, news stands, escalators, water fountains.	0	1	2	3	4	5	6	7	8	9	10
3. ATTRACTIVENESS	This factor refers to certain physical and activity attributes of a pathway and its surrounding environment (landscape elements and buildings). To what extent is this pathway aesthetically appealing, interesting, active, well-organized, well-maintained, etc. In assessing this factor you might ask yourself if it is a place you would be willing to go out of your way to experience.	0	1	2	3	4	5	6	7	8	9	10
4. INFORMATION	You might be inclined to select a pathway familiar to you to avoid the risk of getting lost, in spite of the possibility of favorable features on alternate routes. To what extent would your use of this pathway be based on your knowledge of the downtown area generally and of alternate walking routes in particular. To what degree does the pathway provide orientation through distinctive features such as signage, unique buildings, vistas, landmarks, etc.	0	1	2	3	4	5	6	7	8	9	10
5. PHYSICAL COMFORT	This factor refers to your perception of physical comfort. Examples of elements causing physical discomfort might include: excessive street noise (from automobiles, trucks, machinery), excessive exposure to the elements (cold, hot, snow, rain, wind), long stairways, very crowded conditions, steep hills, or uneven walking surfaces. This factor includes certain elements you encounter which could delay your trip, such as signal lights, busy street crossings, stairways, turns, buildings, or other obstructions.	0	1	2	3	4	5	6	7	8	9	10
6. PSYCHOLOGICAL COMFORT	Examples of pathway features which might produce psychological discomfort include: crowded conditions or the presence of people quite different from yourself (in terms of socioeconomic status, ethnic origin, styles of behavior), or the potential for disturbing or threatening encounters with other people.	0	1	2	3	4	5	6	7	8	9	10
7. SAFETY	This factor refers to your perception of the physical safety hazards you might encounter along the pathway. Such threats include the possibility of being struck by automobiles or other vehicles when crossing an intersection, dangerous stairways, etc.	0	1	2	3	4	5	6	7	8	9	10

Table 19

Attribute Definition And Rating Worksheet

ATTRIBUTE	WEIGHTS (Wjk)			ATTRIBUTE RATINGS (Sik)														
				0			1			2			3			4		
	W	S	SR	W	S	SR	W	S	SR	W	S	SR	W	S	SR	W	S	SR
ACCESSIBILITY	0.8	1.5	1.4	-5.7	-10.7	-10.0	-4.6	-8.7	-8.0	-3.4	-6.4	-6.0	-2.3	-4.3	-4.0	-1.1	-2.1	-2.0
AMENITIES	0.4	0.8	1.8	-2.9	-5.7	-12.9	-2.3	-4.6	-10.3	-1.7	-3.4	-7.7	-1.1	-2.3	-5.1	-0.6	-1.1	-2.6
ATTRACTIVENESS	0.6	0.8	1.8	-4.3	-5.7	-12.9	-3.4	-4.6	-10.3	-2.6	-3.4	-7.7	-1.7	-2.3	-5.1	-0.9	-1.1	-2.6
PHYSICAL COMFORT	0.8	0.8	1.8	-5.7	-5.7	-12.9	-4.6	-4.6	-10.3	-3.4	-3.4	-7.7	-2.3	-2.3	-5.1	-1.1	-1.1	-2.6
PSYCHOLOGICAL COMFORT	0.8	1.1	1.8	-5.7	-7.9	-12.9	-4.6	-6.3	-10.3	-3.4	-4.7	-7.7	-2.3	-3.1	-5.1	-1.1	-1.6	-2.6
INFORMATION	0.7	1.0	1.1	-5.0	-7.2	-7.9	-4.0	-5.7	-6.3	-3.0	-4.3	-4.7	-2.0	-2.9	-3.1	-1.0	-1.4	-1.6
SAFETY	0.7	1.0	1.5	-5.0	-7.2	-10.7	-4.0	-5.7	-8.6	-3.0	-4.3	-6.4	-2.0	-2.9	-4.3	-1.0	-1.4	-2.1

Table 20

Attribute Modification Factors $(C \times W_{jk} \times S_{ik})$

ATTRIBUTE RATINGS (CONT'D.)																		
5			6			7			8			9			10			ATTRIBUTE
W	S	SR	W	S	SR	W	S	SR	W	S	SR	W	S	SR	W	S	SR	
0	0	0	1.1	2.1	2.0	2.3	4.3	4.0	3.4	6.4	7.7	4.6	8.7	8.0	5.7	10.7	10	ACCESSIBILITY
0	0	0	0.6	1.1	2.6	1.1	2.3	5.1	1.7	3.4	7.7	2.3	4.6	10.3	2.9	5.7	12.9	AMENITIES
0	0	0	0.9	1.1	2.6	1.7	2.3	5.1	2.6	3.4	7.7	3.4	4.6	10.3	4.3	5.7	12.9	ATTRACTIVENESS
0	0	0	1.1	1.1	2.6	2.3	2.3	5.1	3.4	3.4	7.7	4.6	4.6	10.3	5.7	5.7	12.9	PHYSICAL COMFORT
0	0	0	1.1	1.6	2.6	2.3	3.1	5.1	3.4	4.7	7.7	4.6	6.3	10.3	5.7	7.9	12.9	PSYCHOLOGICAL COMFORT
0	0	0	1.0	1.4	1.6	2.0	2.9	3.1	3.0	4.3	4.7	4.0	5.7	6.3	5.0	7.2	7.9	INFORMATION
0	0	0	1.0	1.4	2.1	2.0	2.9	4.3	3.0	4.3	6.4	4.0	5.7	8.6	5.0	7.2	10.7	SAFETY

Table 20 (Cont'd)

Attribute Modification Factors $(C \times W_{jk} \times S_{ik})$

$0.5\ D_i \leq Q_{ij} \leq 1.5\ D_i$;

That is, the combined pathway attributes for the shopping trip purpose could only effect a maximum change of 50% in the nominal separation. In practice, it has been found that due to the mutually "balancing" effects of the separate attribute scores, their total rarely tends towards extreme changes in the nominal separation. The scaling factor, C, so determined yielded a

$C = 0.143$

when C = 0.143 was applied to the other trip purposes, the results were --

Work Trip	$.66\ D_i \leq Q_{ij} \leq 1.34\ D_i$;
Shopping Trip	$.5\ D_i \leq Q_{ij} \leq 1.5\ D_i$; and
Social Recreation	$.21\ D_i \leq Q_{ij} \leq 1.79\ D_i$.

The values of C x W_{ik} x S_{ik} have been precalculated for the user's convenience for the different ratings and are provided in Table 20 for Work (W), Shopping (S), and Social Recreational (S/R) trips. Depending on the rating scores assigned on Table 19, the adjustment factor value is selected from Table 20 and recorded under the appropriate trip purpose in Table 21. The scores for all seven attributes are totaled and this score divided by 100, as the worksheet indicates before being used to calculate Q_{ij}.

3. Computing The Effective Separation

The adjustment factor, A_{ij}, is used to compute the effective separation as given by the last equation shown on Table 21.

This approach to effective separation was arrived at after extensive analysis of the representative sample data, and is typical of the results that apply to standard, or average, conditions. Site specific situations, however, could operate to modify these conditions, and the user is urged to review the weights for reasonableness and applicability to these site-specific conditions. In the event that it is required, new weights can be applied based upon the best information (sample survey results, observation, etc.) available.

6.3.3. Development Of Friction Factors

The friction factor associated with the pathway from centroid I to centroid J, reflects the way in which trip-making is attenuated as a function of inter-centroid separation. Basically, a relationship as shown in Figure 29 holds.

LINK NUMBER		NOMINAL DISTANCE (D_i)	

ATTRIBUTE	RATING (0 to 10) (S_{ik})	SEPARATION ADJUSTMENT FACTOR ($C \times W_{jk} \times S_{ik}$)		
		WORK	SHOPPING	SOC/REC
ACCESSIBILITY				
AMENITIES				
ATTRACTIVENESS				
PHYSICALOGICAL COMFORT				
PSYCHOLOGICAL COMFORT				
INFORMATION				
SAFETY				
ADJUSTMENT FACTOR FOR ALL ATTRIBUTES(A_{ij}) = $\sum (C \times W_{jk} \times S_{ik})$				
EFFECTIVE SEPARATION $Q_{ij} = D_i \times (1 + A_{ij})$				

Table 21

Effective Separation Worksheet

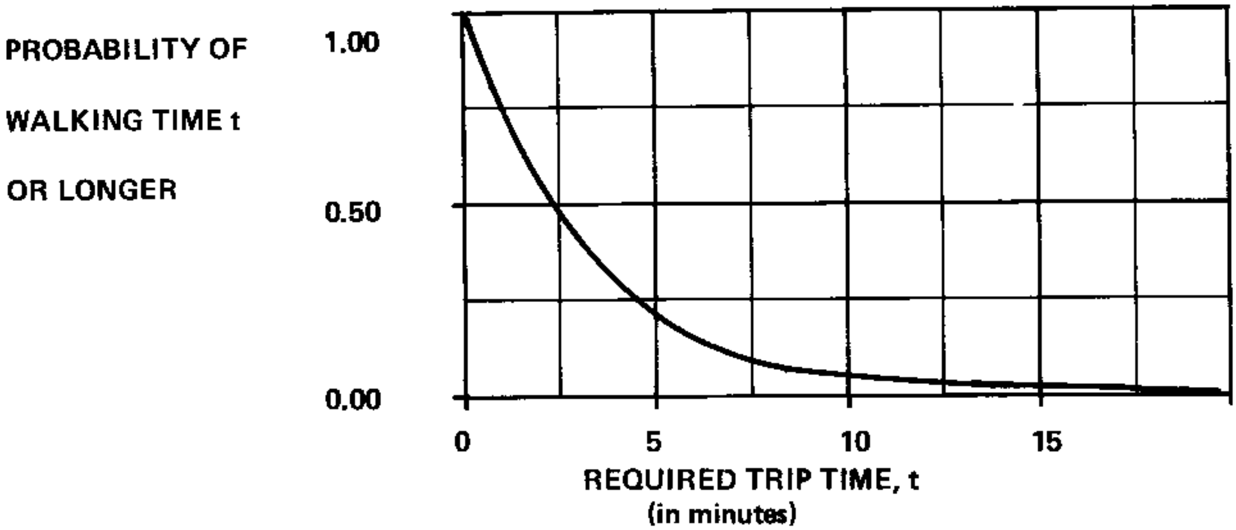


Figure 29

Relationship Of Friction Factors To Intercentroid Separation

By examining the marginal probabilities embodied in the trip attentuation curves, factors can be derived that reflect the probability that a trip requiring a given trip time will be made. Available experience for various trip purposes has been examined, and is summarized below. The inter-centroid effective separation times developed in Task 6 are used, in conjunction with the data provided below, to obtain the F(I,J) required as input to the distribution and assignment model.

It should be noted that the data provided in the procedures have been developed from all available, but limited, sources. Hence, in the absence of more extensive field data to support the development of these measures, their use in estimating the F(I,J) becomes partly technical and partly judgmental. Of course, applicable site-specific data (derived for example, from the pedestrian survey) will improve the results.

During the calibration exercise, conducted in Task 9, an opportunity exists to modify the friction factor curves selected initially.

This part of Task 6 is conducted in two steps, each of which is expanded below:

- Development of minimum time paths; and

- Determination of the appropriate friction factor curves.

1. <u>Development Of Minimum Time Paths</u> (Skim Trees)

The shortest effective travel times across the network links or routes from any given producing centroid to all other attracting centroids must be established for the movement component being modelled. This operation can be performed manually; however, if a battery of standard computer programs is being used for the modelling process, it will in all likelihood include a program for building and checking Minimum Time Path Trees. This operaton is similar to that used in conventional transportation planning.

Travel time for a given centroid to its link node (the equivalent of 'terminal time' in vehicular transportation modelling) is ignored in this computation.

Where private parking facilities absorb the majority of terminal trips for any office centroid, these trips need not be represented in the AM or PM exchange since they occur within the centroid and do not impact the ped network. (These trips are the equivalent of intrazonal trips in vehicular transportation planning.)

If minimum time paths are determined manually, the user must record the nature of the movement component, the exchanging centroids, the link numbers from origin to destination, and the total effective separation between the origin centroid and destination centroid.

These total travel times are converted in the following step into friction or travel time factors which express the related trip making propensity between centroids.

2. <u>Select Friction Factor Curves</u> (Travel Time Factors)

The friction factor curves provided in this section were derived by aggregating trip propensity data from several sources. Hence, while they are representative, they may not be directly applicable to a given situation. Depending on site-specific conditions, the appropriate friction factor curves will reflect the pedestrian tripmaking opportunities of the area. For example, compact employment centers, within which there is an abundance of retailing, including restaurants, will be characterized by a "steep" friction factor curve for noon trips. The steepness of the curve will tend to limit the length of pedestrian trips, since the opportunities within the area do not necessitate longer trips. Conversely, for situations where these same land use activities do not occur together, a friction factor curve that is less steep may apply. Therefore, the user is encouraged to examine the applicability of the data and, if appropriate, modify the curves to suit local conditions.

Guidance for choosing an appropriate friction factor curve can be obtained in several ways. If a pedestrian survey is conducted, information can be obtained on trip length for various trip purposes, and the data examined. Mapping of pedestrians in the survey can provide similar guidance. Also, the curves can be modified during calibration of the gravity model analysis until the model output approximates known trip making patterns for the area. The following discussion provides additional guidance on using the curves.

Nearly all the pedestrian trip propensity data examined yielded friction factor curves with a characteristic shape. When plotted on log-log graph paper, the curves have a level, horizontal portion that remains flat as separation increases, followed by a downward sloping, linear portion as separation increases further. For separation below the point at which the curve breaks downward, the friction factor (or trip propensity) remains constant. Typically, this point occurs below five minutes and reflects the notion that trips below that duration are all perceived to be the same length. The pedestrian is indifferent to the short trip lengths. As separation increase, however, the propensity to make the trip decreases as characterized by the sloping portion of the curve. The slope of the curve will vary depending on trip purpose, site-specific conditions, perception and numerous other factors; the steeper the slope the shorter the trips.

The sloping portion of the curve can be characterized by a slope coefficient derived from the curves equation:

$$F = aS^b \text{ or } LN\ F = (LN\ a) - (b\ LN\ S)$$

where S is the separation, F is the friction factor, and a and b are shape constants for the curve. The coefficient, b, is the slope of the curve in log-log form. Typically, the slope co efficients range from a value of 2 indicating a propensity for longer trips, to a value of 8 for short tripmaking situations. For example, in the St. Louis CBD, the slope coefficient for noon trips is about 7 or 8, reflecting the density of the core and the shortness of most pedestrian trips. In Baltimore and Toronto, the value is about 2.5 to 4, due to longer trips that are made. Hence, while no explicit relationship between the slope of the curve and the density of the core area can be made, the user should examine factors such as the distribution of pedestrian activities, land use densities and opportunities (proximity of retailing to employment, for example), and modify the curves appropriately.

Typical values for the different trip exchanges are shown on Figures 30, 31 and 32. These curves reflect experience in larger cities (pop.>500,000).

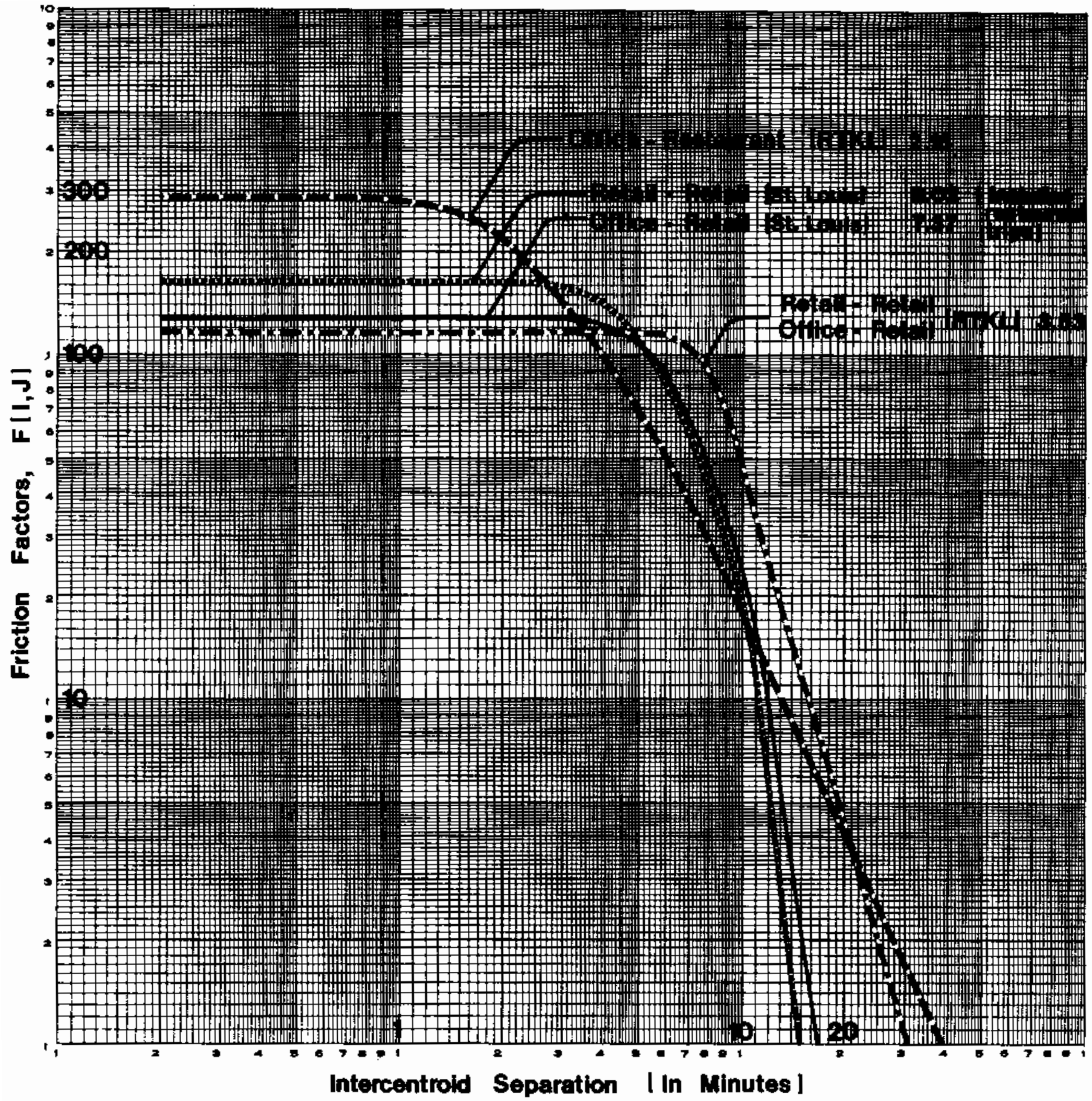


Figure 30

Friction Factor Curves - Noon Exchanges (Components)

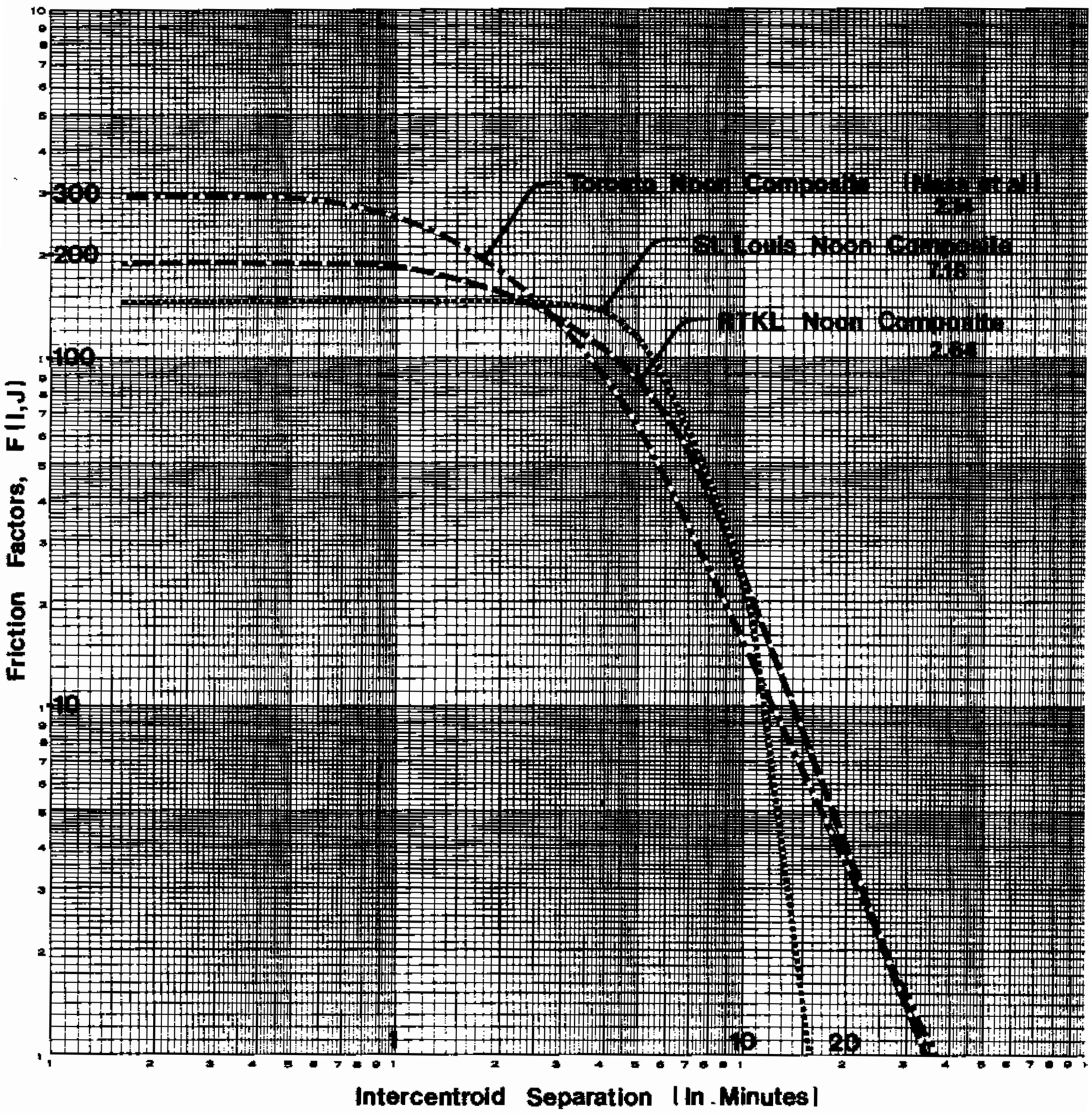


Figure 31

Friction Factor Curves - Noon Exchanges (Composites)

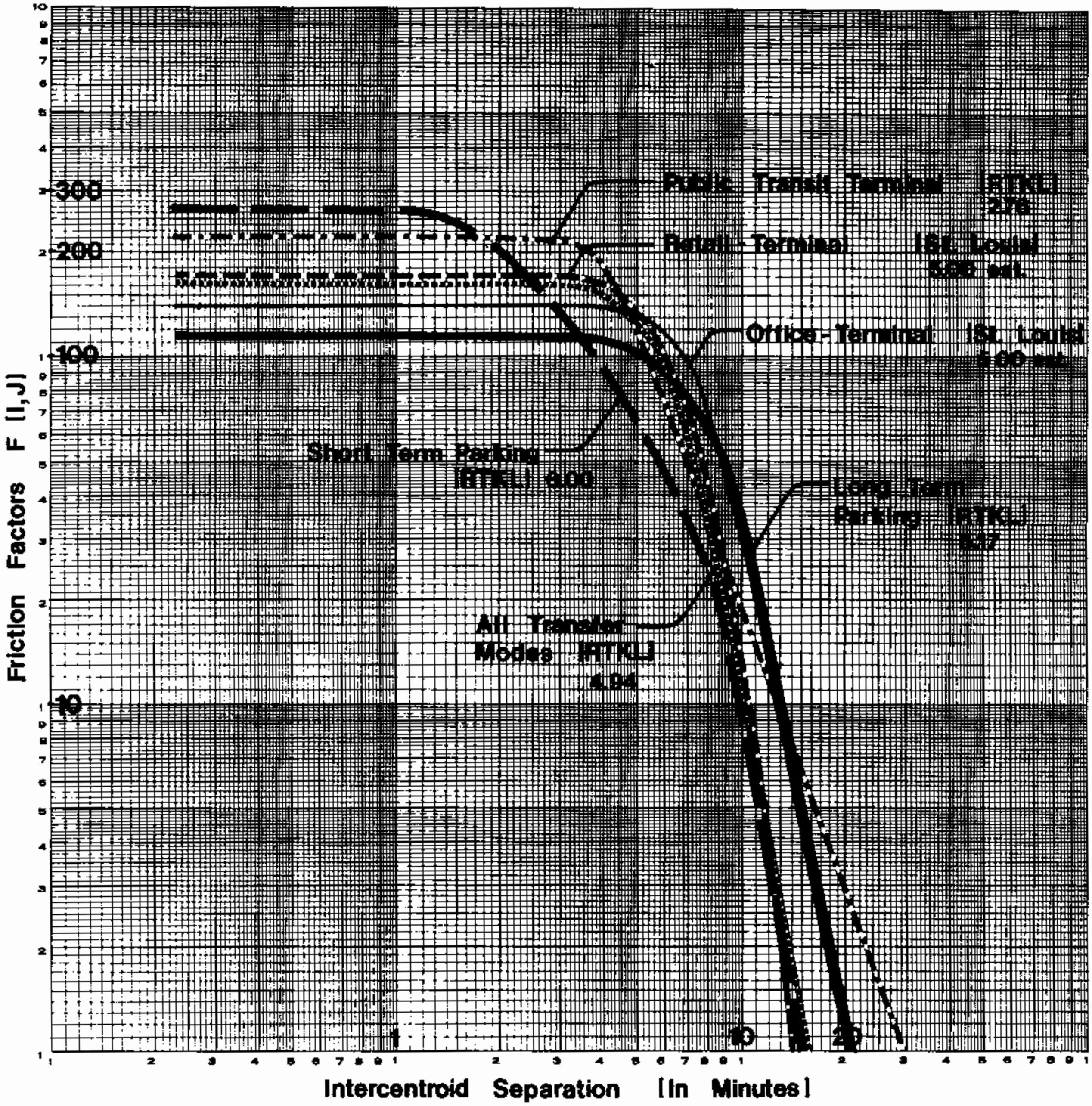


Figure 32

Friction Factor Curves - PM Exchanges

Fig. 31 aggregates the various noon exchange components shown in separately in Fig. 30 as derived from various sources. In the PM terminal curves of Fig. 32, the F(I,J) will be estimated as a function of the mode transfer type; that is parking facilities, for example, will result in a different set of F(I,J) than a bus stop.

Modes not readily classified can be approximated using the overall (all modes) terminal trip or by some combination of the data.

Data on friction factors for terminal trips with residential land uses as their termini has not been developed in this Manual. Data in Fig. 32 should not be used to represent these trips which are considerably longer than any other trips associated with the PM peak, as indicated in Fig. 33. If office/retail to residence trips impact PM or noon tripmaking patterns in a given situation, friction factors must be developed from site-specific data.

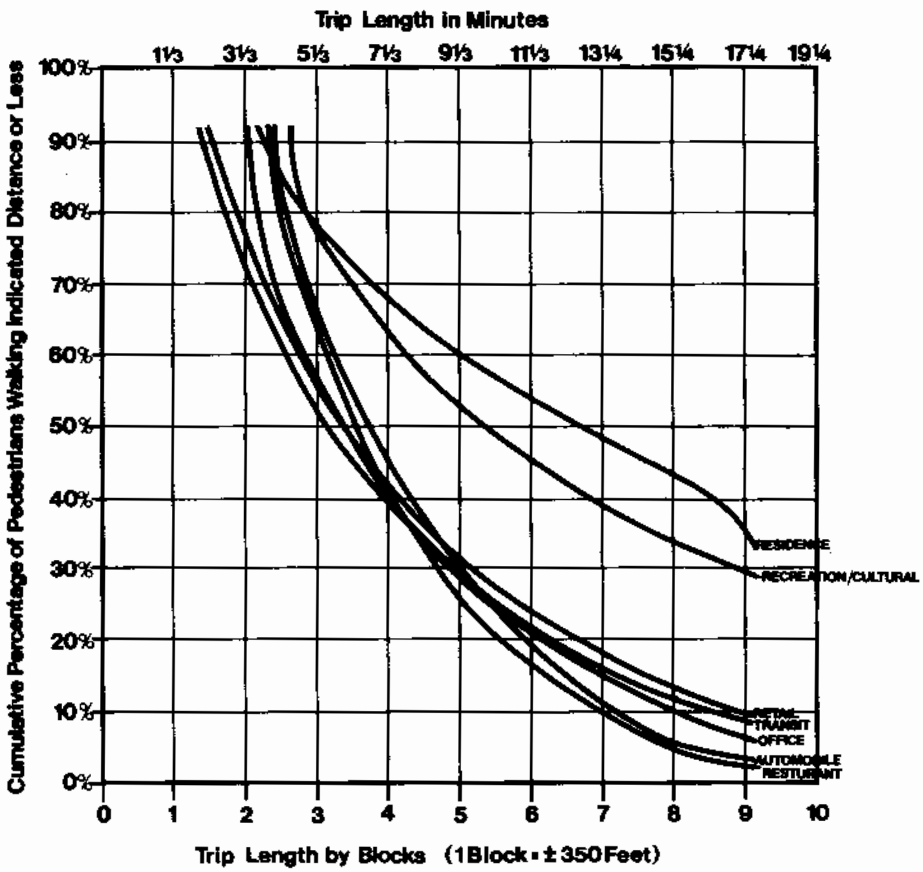


Figure 33

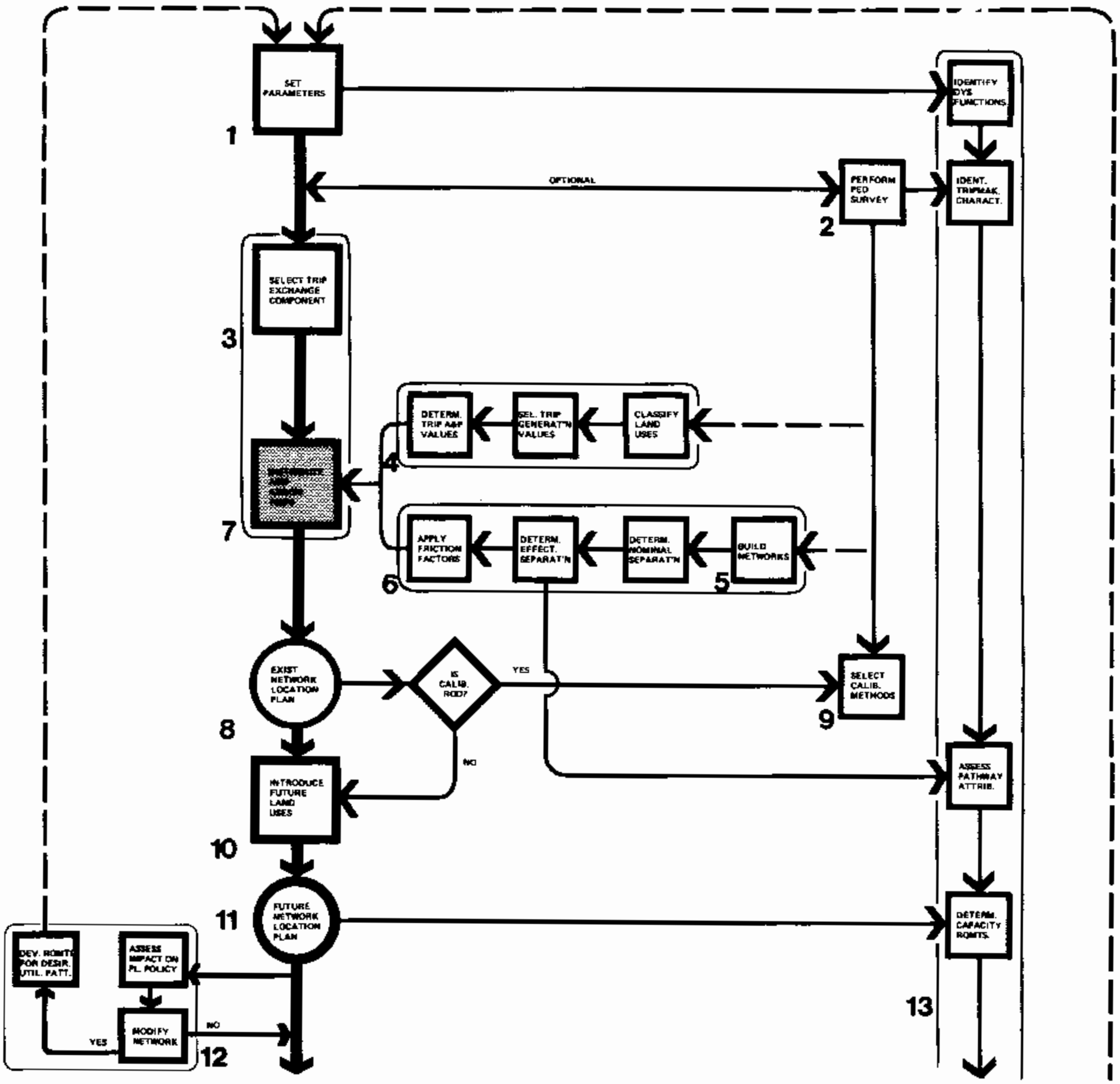
Cumulative Distribution Of Trip Length By Purpose - Baltimore

Once the appropriate friction factor curve has been selected, the determination of friction factors for given values of effective separation follows directly. The factors can either be determined from the curves for use in the next task, or alternatively, the curve(s) can be specified, in either equation or tabular form, for direct use by the computer program being utilized.

The output of this step, the friction factors, together with the production and attraction measures computed in Step 4 constitute the quantitative input required for the next task in which the distribution and assignment model is exercised.

DISTRIBUTE AND ASSIGN TRIPS

7



TASK 7

DISTRIBUTE AND ASSIGN TRIPS

7.1 Task Overview

In this task, existing pedestrian movement associated with the peak period trip exchange category being examined is simulated using a gravity model approach similar to that employed in the analysis of vehicular demand requirements. Each exchange category is analyzed separately and the results aggregated, as appropriate in Task 8.

This task has two major steps:

- Distribution of trips produced to centroids that attract these trips using the gravity model; and
- Assignment of this trip exchange to network pathways and links.

The gravity model input consists of the pathway friction factors, and pedestrian volumes produced and attracted at each centroid. The model consists of an iterative procedure that balances the trip attraction strength of network centroids against trip propensities (friction factors) representing their distances from centroids of trip production. After several interations, the model achieves a stable, balanced distribution of trips (equilibrium) within the network. When this condition results, the model produces output that shows the number of trips produced at each centroid and attracted to each centroid. For example, if 100 trips are produced at centroid A, the model will show that 75 are attracted by B, and 25 are attracted by C. This distribution will be influenced by the relative attractiveness of B and C, their travel time as measured from A, and the complex interaction of all other centroids.

Once the intercentroid distribution of trips is known, the trips can then be assigned to one or more competing pathways connecting the centroids. The least complex method of assigning trips is to assign all trips (between A and B) to that pathway with the minimal travel time; this is known as an "all-or-nothing" assignment. However, the user has the option, given adequate resources and need, to assign trips using more complex methods such as a stochastic assignment based on the relative travel times on competing paths.

The above steps are repeated for each exchange category. The results are aggregated in Task 8, and if necessary, re-examined using methods suggested in Task 9.

7.2 Data

7.2.1 Data Required

If the ped survey was performed, the following data can be derived for use in this task from an analysis of relevant questions (see Task 2, Figure 6):

- Modal splits between auto vs. transit vs. other arrival modes for employees and shoppers during the AM or PM peaks
- Sequence of visits for noon peak employees and shoppers

Data to be used from previous tasks:

- A and P centroid values from Task 4 for the different movement components
- Friction factors (representing intercentroid separation times) between each producing centroid and all attracting centroids for the various exchange components developed in Task 6.

7.3 Procedures

This task consists of two basic functional elements which are performed for each movement component being examined:

- Trips are distributed between centroid pairs within the network; and
- Trips are assigned to specific pathways connecting centroid pairs.

Together these elements comprise the pedestrian trip distribution and assignment model.

Given a movement component to be examined, input to the distribution and assignment model, in general, consists of the following (input is defined in more detail in subsequent section):

- A specification of pedestrian activity centroids with appropriate identification, and their pedestrian trip production and/or trip attraction potential, expressed in terms of the numbers of pedestrian trips (trip volumes) generated during a specified peak period;
- Measures that represent the trip making propensity for each production-attraction centroid pair, expressed either as friction factors directly, or as effective inter-centroid separations from which friction factors can be computed; and

A description of the pathway network connecting centroid pairs expressed in terms of the links comprising one or more alternative pathways for each centroid pair.

The manner in which these data interact will depend largely on the extent to which computer capability is utilized. The following brief description is intended to indicate possible differences between a manual and a computerized approach.

In a manual approach, the pathway network will be examined to ascertain that set of connected pathway links whose sum of effective separation measures produces the minimum separation for each centroid pair. From these minimum paths, appropriate friction factors will be obtained; these steps were covered at the end of Task 6. The friction factors, together with the trip production and attraction measures would then be exercised in a gravity model, described below, to obtain the trip distribution - the number of trips exchanged between each production centroid and attraction centroid. This number of trips will then be assigned to all links comprising the minimum path connecting a given centroid pair, and by repeating this step for each centroid pair, the cumulative effect of trips assigned to each link, which may serve several minimum path routes, is determined.

Conversely, in a computerized approach, depending on the capability of the process used, the minimum paths will be computed, and the appropriate friction factors calculated internally. The gravity model will then produce trip exchange. The exchanged volumes will then assigned to links using one or more optional policies, and the completed output produced without need for manual interaction.

Hence, a manual approach will require extensive bookkeeping to keep track of routes, links, trips exchanged, assignment and related values. Since the margin for error is high, considerable care is necessary. Using a computer-aided approach, much of this chance for error is reduced; efficiency is increased; and the opportunity to examine alternatives is made available to the user.

The gravity model which forms the heart of the trip distribution process is described below. The trip assignment process consists simply of assigning the output of the gravity model to those links which make up the minimum paths between centroids.

The following notation is used to describe the trip distribution process:

C(I) = A given trip production centroid

C(J) = A given trip attraction centroid

P(I) = The trips produced by C(I)

A(J)	=	The trip attraction strength of C(J)
F(I,J)	=	The friction factor expressing the separation from C(I) to C(J)
T(I,J)	=	The number of trps exchanged from C(I) to C(J)
K	=	The iteration number
A(J,K)	=	The adjusted trip attraction of C(J) used in computations performed during iteration K
T(I,J,K)	=	The number of trips exchanged from C(I) to C(J) computed during iteration K
S(J,K)	=	The sum of the trps attracted to C(J) resulting from the computations during iteration K
X	=	Acceptable tolerance for T(I,J).

The process of trip distribution is shown graphically in Figure 34.

At the beginning of the process, on the first iteration (K = 1), the T(I,J,K) can be computed immediately with A(J,K) = A(J). The resultant T(I,J,K) are then arrayed into a matrix where the C(I) form the rows and the C(J) form the columns. The column sums, S(J,K), are then compared with those of the previous iteration to determine if the iterative process can be terminated. At the end of the first iteration, the comparison is made with the A(J) directly. The acceptable tolerance, X, is the maximum percentage of allowable change from iteration to iteration. When all of the column sums exhibit a change within this tolerance limit, the process is terminated. The specificaton of the tolerance should reflect a tradeoff between computational effort and accuracy of the results; if the tolerance is large, the effort will be reduced, but the accuracy of the results is also reduced.

In the event the process cannot be terminated, an adjusted A(J,K) is computed for each C(J) and used to calculate a new set of T(I,J,K). These new values are arrayed as before, are tested against the results of the previous iteration, and the process terminated or continued.

The assignment of trips to links is assumed to be of the "all or nothing" type in which all the trips exchanging between any two centroids are assigned to the shortest route connecting them. If the user is assigning trips via a computer program, it may contain an option in which trips are assigned to links in proportion with the separation relationship between several competing routes. To enhance the planner's understanding of

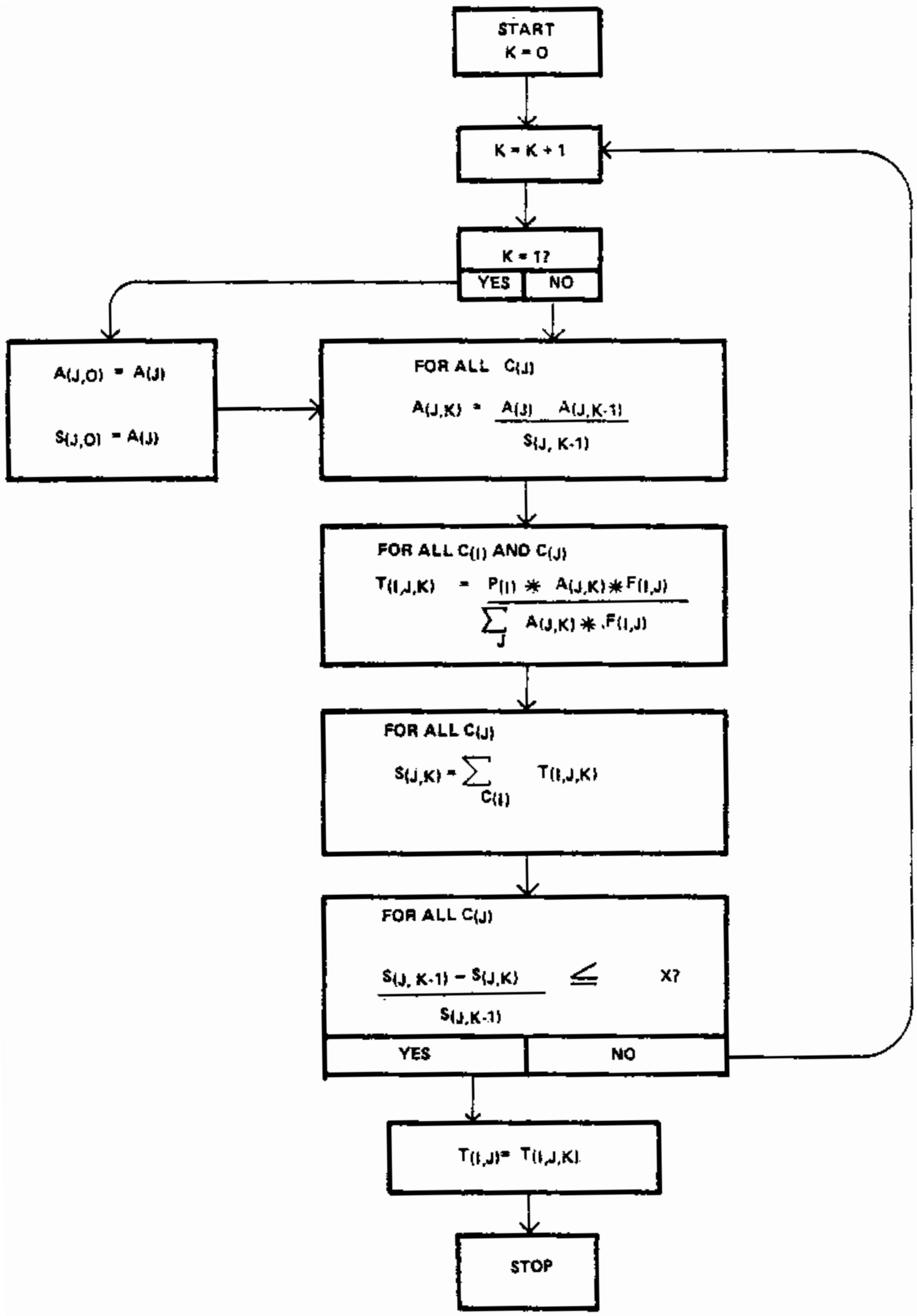


Figure 34

Flowchart Of The Trip Distribution Process the process shown in Figure 34, a numerical example showing the computation of trip distribution and assignment for a small network is presented in the next section.

A manual approach to computing trip distributing and assignment will be feasible for small networks and/or where only one or two components of movement need to be examined. In other situations, the computation effort will require the use of a high speed computer. Due to its widespread availability and use, the improved Urban Transportation Planning System (UTPS) package is recommended for application. Use of the UTPS programs will involve the following steps:

Step	Program
1	Program HR is used to transform the network link data cards into a network description compatible with subsequent programs. The program performs some limited basic editing of the input data.
2	Program UROAD is used to compute "skim trees" or travel time between all centroids. If travel times are input on individual links as perceived travel time, then the skim trees output will be in perceived travel time.
3	Program AGM in conjunction with input trip production, travel time function factors (also known as friction factors or propensity curves), and the skim trees will compute the volume of trip interchange between all centroids.
4	Program UROAD is used for a second time, but is now used to place the trips between centroids determined in 3 above on the specific links in the network comprising the shortest paths between centroids. Alternative assignments of trips to the networks may be used.

The above steps are repeated for each movement component being examined.

Following application of either the manual or the computerized approach, the outputs of this task will be:

From the trip distribution process

- trip tables with one or more sets of T(I,J) values which represent the number of trips exchanged from C(I) to C(J) and

From the trip assignment process

- pedestrian volumes assigned to network links during the peak period under consideration.

By examining the trip tables, the user can gain an understanding of the functional relationships between land uses in the study area on a centroid by centroid basis. This insight is often useful in making policy, strategy and design decisions.

Numerical example

The following steps illustrate the way in which the trip distribution and assignment model would be executed manually. This example simulates a simple situation involving two-way trips such as that found in the peak 15-minute retail-to-retail exchange.

Preparaton of input

(1) A schematic of the movement component network is developed as shown in Figure 35.

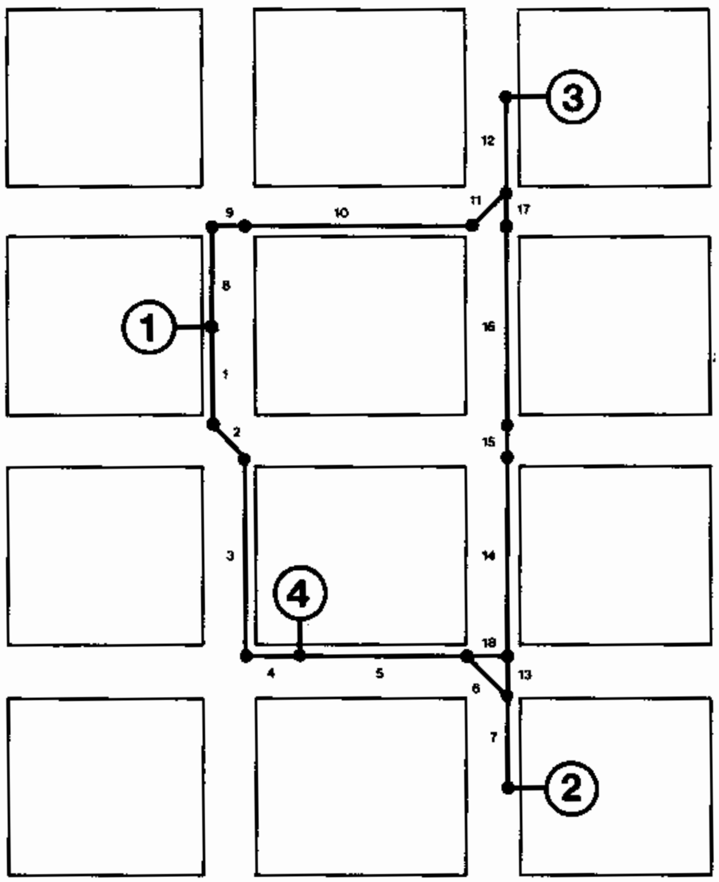


Figure 35

Movement Component Network

(2) Effective separation is computed for each network link as shown in Table 22.

LINK	EFFECTIVE SEPARATION (In Minutes)
1	1.5
2	0.5
3	3.0
4	1.5
5	3.0
6	1.0
7	1.5
8	1.5
9	0.3
10	3.0
11	0.5
12	1.5
13	0.7
14	3.0
15	0.3
16	3.0
17	0.3
18	0.3

Table 22

Effective Separations On Links

(3) The link and effective separations are summarized and the appropriate friction factors read off from Figure 30, as shown in Table 23.

CENTROID P I	A J	LINKS	EFFECTIVE SEP. (MIN)	FRICTION FACTOR
1	2	1, 2, 3, 4, 5, 6, 7	12.0	3
1	3	8, 9, 10, 11, 12	6.8	55
1	4	1, 2, 3, 4	6.5	65
2	1	7, 6, 5, 4, 3, 2, 1	12.0	3
2	3	7, 13, 14, 15, 16, 17, 12	10.3	6
2	4	7, 6, 5	5.5	170
3	1	12, 11, 10, 9, 8	6.8	55
3	2	12, 17, 16, 15, 14, 13, 7	10.3	6
3	4	12, 17, 16, 15, 14, 18, 5	12.9	2
4	1	4, 3, 2, 1	6.5	65
4	2	5, 6, 7	5.5	170
4	3	5, 18, 14, 15, 16, 17, 12	12.9	2

Table 23

Route Links And Friction Factors

(4) Centroid trip production and/or attraction volumes are computed. The values shown in Table 24 are hypothetical and have been purposefully "unbalanced" to provide a more instructive and extended example. (Normally in this retail-to-retail exchange the P (I) and A (J) values would be equal - based on the PD factors in Table 12 - and the gravity model would converge after only one or two iterations.)

	PEAK 15-MINUTE PEDESTRIAN TRIP	
CENTROID (I)	P(I)	A(J)
1	600	400
3	400	400
4	1200	2000

Table 24

Trip Attraction And Production Volumes

(5) The data required for the distribution model component are summarized in Figure 36.

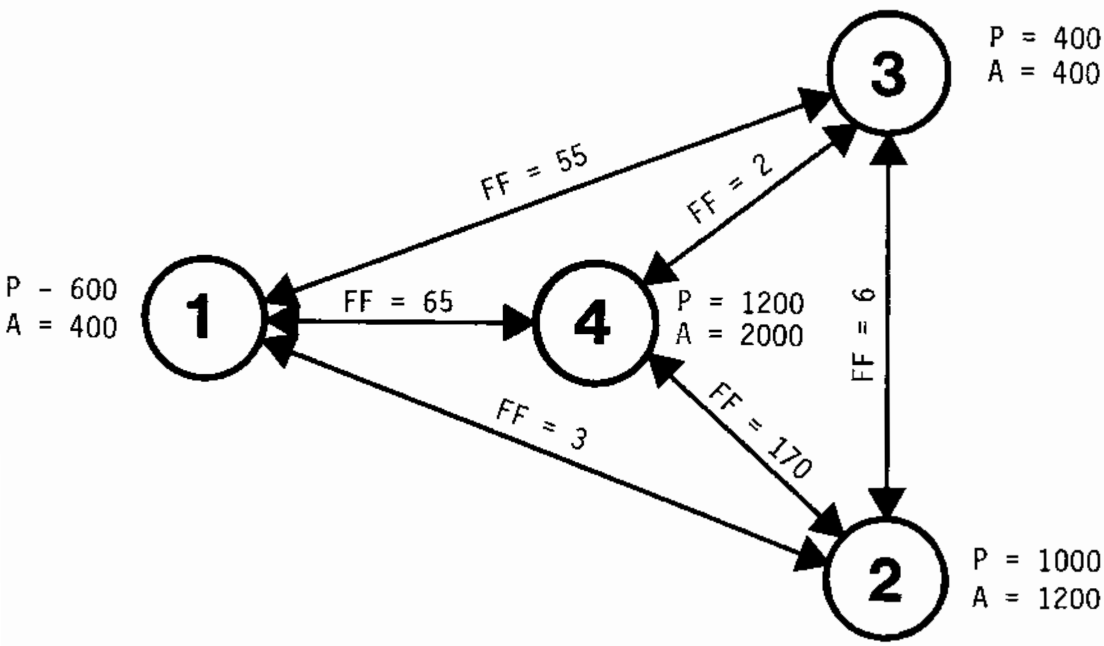


Figure 36

Summary Of Distribution Model Input

The following steps comprise the computational trip distribution process shown in Figure 34, and should be read together with reference to that diagram.

(6) Develop the following matrix as a condensed statement of the problem; the matrix elements are the friction factors, F(I,J) -

F-MATRIX

	A(J)	400	1200	400	2000
P(I)	I \ J	1	2	3	4
600	1	0	3	55	65
1000	2	3	0	6	170
400	3	55	6	0	2
1200	4	65	170	2	0

(7) Multiply each column of the F-Matrix by its corresponding A(J) giving a matrix of A(J) * F(I,J) elements -

(AF-MATRIX)

I \ J	1	2	3	4
1	0	3600	22000	130000
2	1200	0	2400	340000
3	22000	7200	0	4000
4	26000	204000	800	0

(8) Sum the first row (I=1) of the AF-Matrix and divide the corresponding value of P(I) by this sum -

A(J) * F(I,J) = 155600, and I = 1

P(1)/ A(J) * F(I,J) = 600/155600 = 0.003856

(9) The value of P(1)/ A(J) * F(I,J) is multiplied by each element in the first row of the AF-Matrix to obtain the first row of T(I,J) -

∑A(J) * ∑F(I,J)	P(I)	T(I,J)			
	∑A(J) * ∑F(I,J)	1	2	3	4
155600	0.003856	0	14	85	501

(10) Steps (8) and (9) are repeated for the remain rows of the AF-Matrix; the resultant tableau for this first iteration is -

	A(J) * F(I,J) (AF-MATRIX)						T(I,J) (T-MATRIX)			
I \ J	1	2	3	4	∑A*F	P/ ∑A*F	1	2	3	4
1	0	3600	22000	130000	155600	0.003856	0	14	85	501
2	1200	0	2400	340000	343600	0.002910	3	0	7	990
3	22000	7200	0	4000	33200	0.01205	265	87	0	48
4	26000	204000	800	0	230800	0.005199	135	1061	4	0

AF-MATRIX T-MATRIX

(11) Sum the columns of the T-Matrix to get S(J)

	1	2	3	4
1	0	14	85	501
2	3	0	7	990
3	265	87	0	48
4	135	1061	4	0
S(J)	404	1161	96	1539

(12) The S(J,K) for this iteration are compared to the S(J,K-1) for the last iteration; since this is the first iteration, the S(J) from step (11) are compared to A(J). If the difference exceeds 5% (set for this example), the process continues.

J	1	2	3	4
S(J,K)	404	1161	96	1539
S(J,K-1)	400	1200	400	2000
% Diff.	1.0	3.3	76.0	23.1

Since the difference for J=3 and J=4 is greater than 5%, the process continues.

(13) Step (12) concludes the first iteration. At the initiation of the second iteration, the original A(J)'s are adjusted using -

$$A(J,K) = \frac{A(J) * A(J, K-1)}{S(J, K-1)}$$

Hence, for iteration 2 (K=2),

$$A(1, 2) = \frac{400 * 400}{404} = 396.3;$$

or -

J	1	2	3	4
A(J,2)	396.3	1240	1667	2599

(14) Steps (6) through (12) are repeated until convergence, as specified by the value assigned to X, is achieved. The sample problem converged after four iterations. The results of each iteration are shown in Tables 25, 26, 27, and 28.

For iterations 2, 3 and 4, some figures are shown in scientific notation; for example 1.189E3 which equals 1189, or 2.270E-3 which equal 0.002270. Also, column and row totals may not be exact due to rounding.

K = 1

	A(J)	400	1200	400	2000
P(I)	I \ J	1	2	3	4
600	1	0	3	55	65
1000	2	3	0	6	170
400	3	55	6	0	2
1200	4	65	170	2	0

F(I,J)
(F-MATRIX)

I \ J	A(J) * F(I,J) (AF-MATRIX) 1	2	3	4	Σ A*F	P/ΣA*F	T(I,J) (T-MATRIX) 1	2	3	4
1	0	3600	22000	130000	155600	0.003856	0	14	85	501
2	1200	0	2400	340000	343600	0.002910	3	0	7	990
3	22000	7200	0	4000	33200	0.01205	265	87	0	48
4	26000	204000	800	0	230800	0.005199	135	1061	4	0
						S(J,K)	404	1161	96	1539
						S(J,K-1)	400	1200	400	2000
						% DIFF.	1.0	3.3	76.0	23.1

NOTE: For Iteration 1 (K=1) Only,

S(J, K-1) = S(J,0) = A(J)

Table 25

Distribution Model Computation
Iteration 1

K = 2

	A(J)	3.963E2	1.240E3	1.667E3	2.599E3	
P(I)	I \ J	1	2	3	4	
600	1	0	3	55	65	F(I,J)
1000	2	3	0	6	170	(F-MATRIX)
400	3	55	6	0	2	
1200	4	65	170	2	0	

	(A(J) * F(I,J) (AF-MATRIX)						T(I,J) (T-MATRIX)			
I \ J	1	2	3	4	Σ A*F	P/ Σ A*F	1	2	3	4
1	0	3.720E3	9.169E4	1.689E5	2.643E5	2.270E-3	0	8	208	383
2	1.189E3	0	1.000E4	4.418E5	4.530E5	2.207E-3	3	0	22	975
3	2.180E4	7.440E3	0	5.198E3	3.443E4	1.162E-2	253	86	0	60
4	2.576E4	2.108E5	3.334E3	0	2.399E5	5.002E-3	129	1054	17	0
						S(J,K)	385	1149	247	1419
						S(J,K-1)	404	1161	96	1539
						% DIFF.	4.7	1.0	157.3	7.8

Table 26

Iteration 2

K = 3

	A(J)	4.121E2	1.295E3	2.701E3	3.663E3	
P(I)	I \ J	1	2	3	4	
600	1	0	3	55	65	
1000	2	3	0	6	170	F(I,J)
400	3	55	6	0	2	(F-MATRIX)
1200	4	65	170	2	0	

	A(J) * F(I,J) (AF-MATRIX)						T(I,J) (T-MATRIX)			
I \ J	1	2	3	4	Σ A*F	P/ Σ A*F	1	2	3	4
1	0	3.884E3	1.486E5	2.381E5	3.905E5	1.536E-3	0	6	228	366
2	1.236E3	0	1.621E4	6.227E5	6.401E5	1.562E-3	2	0	25	973
3	2.267E4	7.768E3	0	7.326E3	3.776E4	1.059E-2	240	82	0	78
4	2.679E4	2.201E5	5.402E3	0	2.523E5	4.757E-3	127	1047	26	0
						S(J,K)	369	1135	279	1416
						S(J,K-1)	385	1149	247	1419
						% DIFF.	4.2	1.2	13.0	0.2

Table 27

Iteration 3

K = 4

	A(J)	4.462E2	1.369E3	3.8969E3	5.173E3
P(I)	I \ J	1	2	3	4
600	1	0	3	55	65
1000	2	3	0	6	170
400	2	55	6	0	2
1200	4	65	170	2	0

F(I,J)

(F-MATRIX)

	A(J) * F(I,J) (AF-MATRIX)						T(I,J) (T-MATRIX)			
I \ J	1	2	3	4	Σ A*F	P/ Σ A*F	1	2	3	4
1	0	4.106E3	2.128E5	3.363E5	5.532E5	1.085E-3	0	4	231	365
2	1.339E3	0	2.321E4	8.794E5	9.040E5	1.106E-3	1	0	26	973
3	2.454E4	8.212E3	0	1.035E4	4.310E4	9.281E-3	228	76	0	96
4	2.900E4	2.327E5	7.738E3	0	2.694E5	4.454E-3	130	1036	34	0
						S(J,K)	359	1117	291	1434
						S(J,K-1)	369	1135	279	1416
						% DIFF.	3.0	1.6	4.3	1.3

*Convergence Within 5% Tolerance

Table 28

Iteration 4

(15) Assign the T(I,J) from Iteration 4 (Table 28) to individual links using the link to route designations given in Figure 4; for example, T(3,2) = 76 is assigned to links 12, 17, 16, 15, 14, 13, and 7. The results of this step are shown in Table 29.

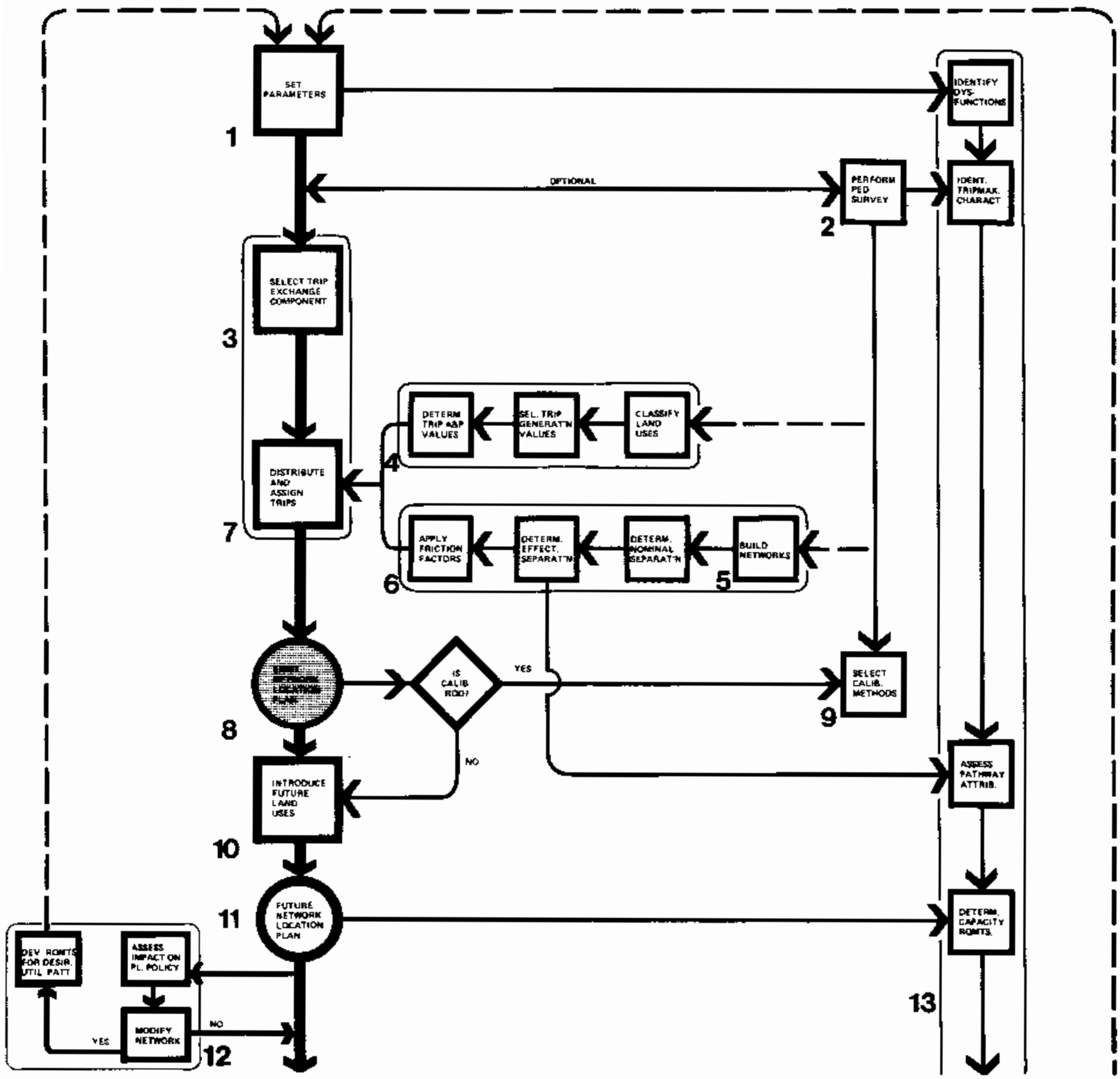
LINK	TRIPS	TOTAL TRIPS
1	4, 365, 1, 130	500
2	4, 365, 1, 130	500
3	4, 365, 1, 130	500
4	4, 365, 1, 130	500
5	4, 365, 1, 130	2144
6	4, 1, 973, 1036	2014
7	4, 1, 26, 973, 76, 1036	2116
8	231, 228	459
9	231, 228	459
10	231, 228	459
11	231, 228	459
12	231, 26, 228, 76, 96, 34	691
13	26, 76	102
14	26, 76, 96, 34	232
15	26, 76, 96, 34	232
16	26, 76, 96, 34	232
17	26, 76, 96, 34	232
18	96, 34	130

Table 29

Link Assignment Volumes

PRODUCE EXISTING NETWORK LOCATION PLAN

8



TASK 8

PRODUCE EXISTING NETWORK LOCATION PLAN

8.1. Task Overview

By transferring data on link volumes, obtained from Task 7, to the pedestrian network graphic or to the base map, utilization maps are produced which are used for several purposes:

(1) All of the link volumes for the different exchange components can be summed to obtain a profile of relative daily utilization on network links.

The links or corridors of high utilization represent existing situations with potential for pedestrianization of one form or another, provided that the requirements of other movement modes in the same corridor can also be accommodated.

Fig. 37 illustrates a potential corridor utilization map. This kind of map will be a primary input for examining considerations in subsequent tasks.

(2) A composite of several movement components that occur during a coincident peak hour can be created to use for comparison with pedestrian count data in the subsequent calibration task.

When future land uses are being considered in Task 11, this composite for future conditions will also enable identification and examination of potential short-term capacity problems and similar aspects of the design. Also, depending on the peak period that yields the maximum volume, potential requirements for pedestrian treatment will be defined; for example, if the maximum utilization is associated with employee terminal trips, then requirements for directness and other attributes that minimize trip time become important.

8.2 Data

8.2.1. Data Required

1. Link volumes produced in Task 7.

2. Network plan and base map.

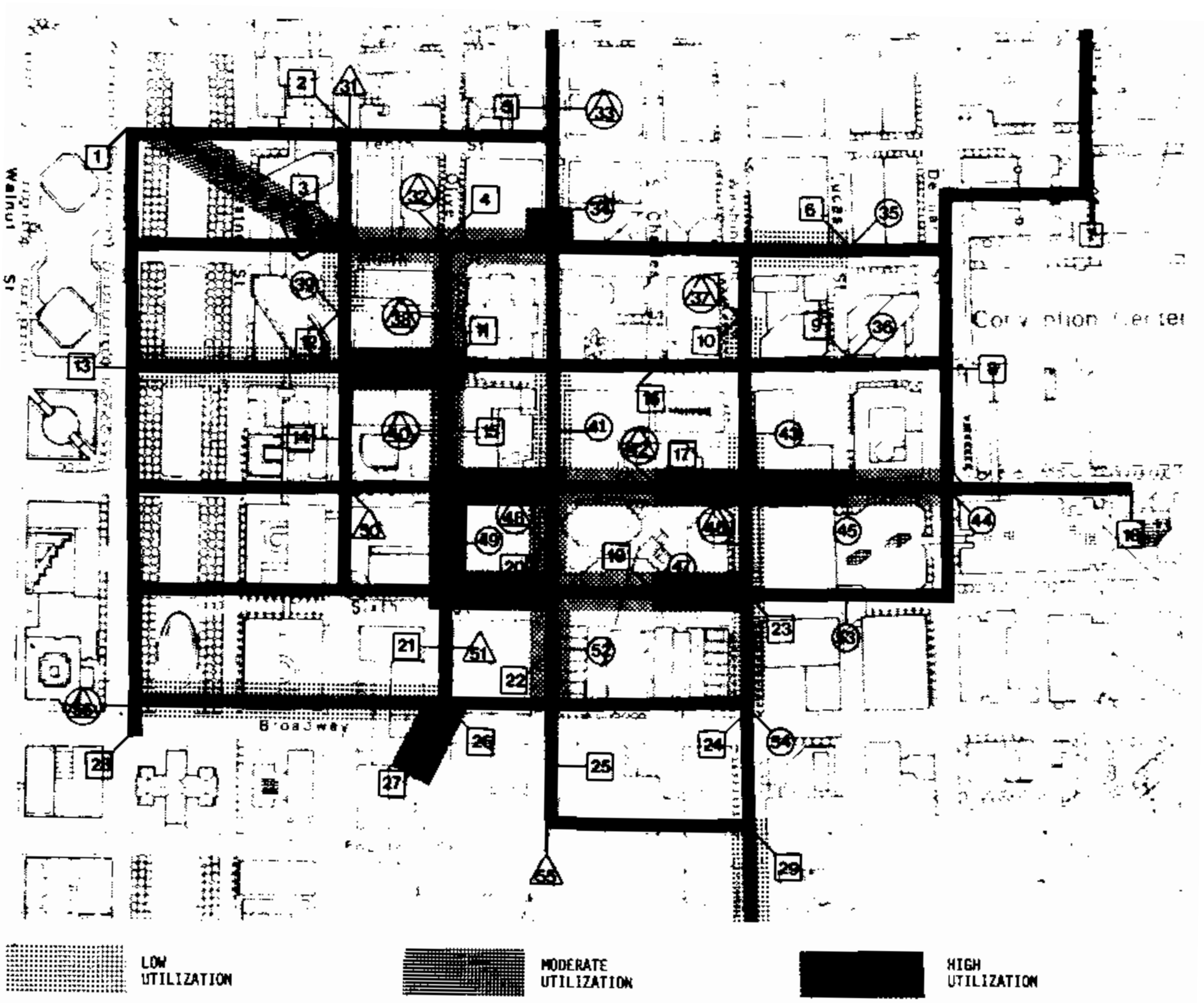


Figure 37

Potential Corridor Utilization Map

8.3 Procedures

8.3.1 Sum link volumes for the different trip exchange components to obtain a profile of daily pedestrian volumes.

Since it would be impractical to attempt to model all components of daily movement, the aggregated profile would not include all trips. However, it would provide a profile of the relative magnitude of utilization for each network link.

These data can be further analyzed and simplified by developing a high, medium and low discrimination of the daily (or specific peak component) network utilization. Thresholds for categorizing volumes will in some cases be obvious from the way the volume numbers cluster. Where no clear line can be drawn, high utilization can be distinguished from moderate by comparing the capacity of existing sidewalks (using Fig. 47 in Task 13.7.1) with the model's output. The threshold above which the modelled volumes would exceed the capacity of the effective sidewalk width, would determine the numerical cutoff for high utilization links. In subsequent tasks, the focus of attention will be that network composed of high utiliza tion links or, if continuous, corridors. This product will probably not be a network in the strict sense of a continuous pattern of links. There will in all likelihood be points or areas of discontinuity.

There is a specific utility in identifying the above discontinuities. These areas of discontinuity can be the result of various site specific conditions which do not support pedestrian trip-making (e.g., high crime, topography, physical barriers, pathway indirectness, impedance and a high degree of pedestrian/vehicle conflict). In later steps, travel patterns will be examined and a determination made as to whether increased exchange between two areas is required (assuming that no exchange or minimal exchange presently exists). In order to support trip-making between these areas, significant provisions regarding pedestrian generators, attrac tors, pathway attributes and pedestrian countermeasures will need to be provided, as described in Task 12.

If, however, the examination of travel patterns illustrates that other viable alternative routes are currently used in exchange between the two areas under consideration, then the provision of connectivity may not be viable. In this case, effort should be made to reinforce and consolidate trip-making along one or more of the alternative pathways under review where such consideration is consistent with general planning policy. In this case, countermeasures may be applied to pathway routes where movement is to be reconstituted for the purpose of reducing utilization in these areas.

8.3.2 Add those movement components that occur during a peak hour with a view to comparing the results with observed volume counts.

The development of this composite for comparison with peak hour data is more complex than the simple addition of the constituent movement components. A direct comparison of model results with observed street counts is made difficult by several factors:

- The model can only provide a peak period "snapshot" of pedestrian movement;
- it cannot adequately describe multiple stops, changes in direction, or other complexities of pedestrian behavior; and
- it is most applicable to major, well-defined components of pedestrian trip-making, and least useful for predicting more specialized movement purposes.

Hence, while the model predicts movement patterns at peak points in time, it is basically incompatible with locationally specific counts which usually resolve movement on an hourly basis. The counts may, and often do, reflect multiple counting of a single pedestrian (by different observers or at separate points in time), tend to smooth out the effects of peaking conditions, and include specialized trip purposes not appropriately addressed in the modelling process.

The most difficult problem is how to adjust either the count data or the model output to a common basis for comparison. For example, suppose the model is used to determine an estimate of the peak trip exchange patterns for the initial office to retail component of the noon trip and for the retail component which usually occurs later in the noon peak hour. To minimize the effects of double counting and peak period smoothing, the models were executed for the short 15-minute period ("the peak period snapshot"). The problem is now one of adjusting data for comparison.

First, the two model components must be combined. A situation similar to the following usually occurs, as illustrated in Figure 38.

The peak periods for (1) and (2) do not coincide, and although the peak periods for (1) and (3) do coincide, no clear relationship exists between the average peak hour for (3) and similar measures for (1) and (2). However, if information is available (from the survey, for example) regarding the temporal distributions of (1) and (2), an estimate of the peak combined average can be derived. Lacking this kind of information, the user is faced with having to apply judgement. In most cases, the model results (15-minute peaks) should not simply be added for comparison to peak hour counts. It may be reasonable to assume that the combined peak hour average can be estimated from the sum of the peak hour averages for (1) and (2). Typical relationship between peak hourly and peak 15-minute are shown in Table 30.

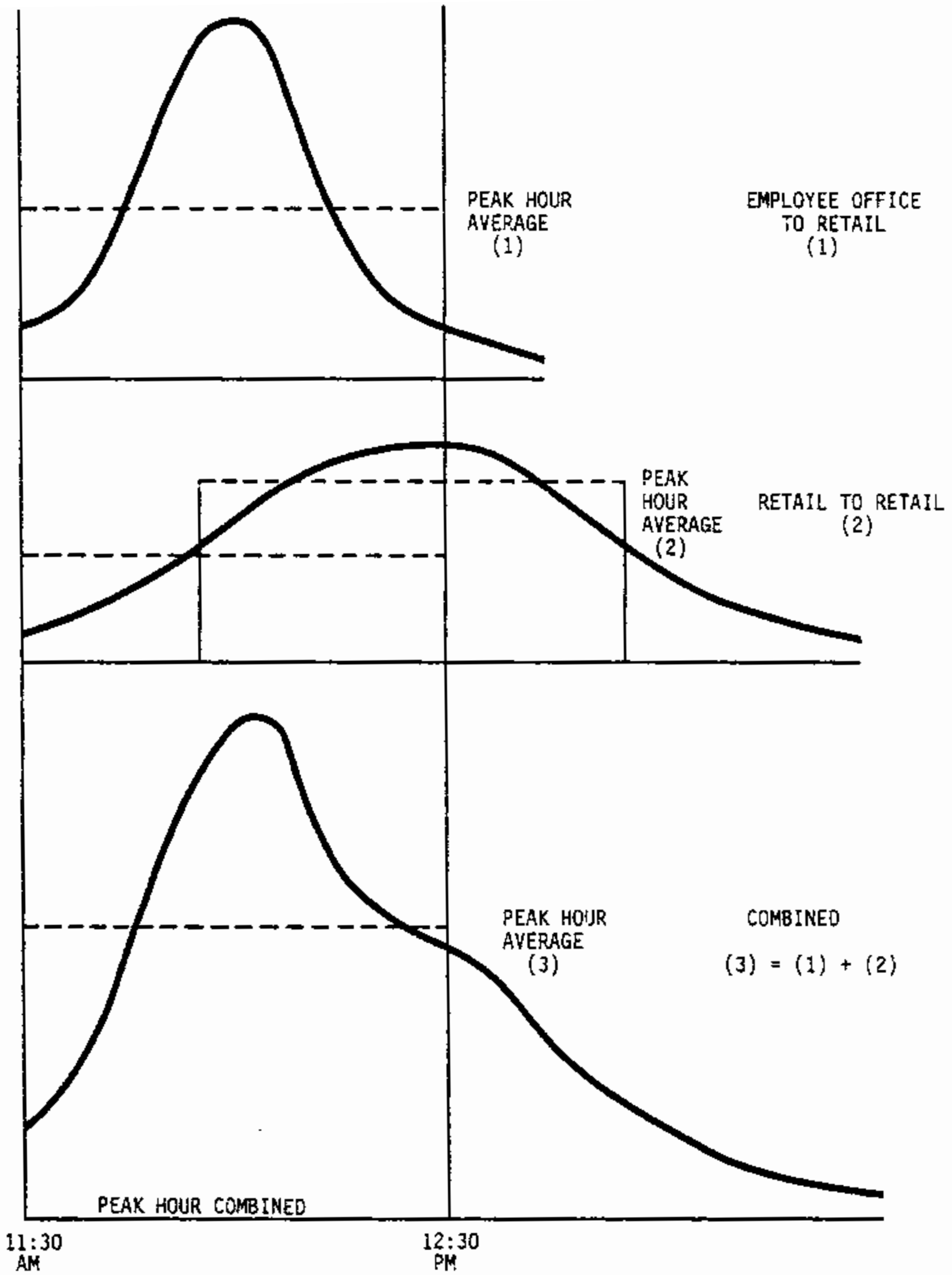


Figure 38

Adjustment Of Model Output And Reserved Peak Volume Count Data

Trip Purpose		Peak Hour to Peak 15-minute Ratio
-	Employee Office to Retail (Noon)	1.20 to 1.50
-	Retail to Retail (Noon)	1.00 to 1.30
-	Employee to Terminal (Noon)	1.50 to 1.75
-	Shopper to Terminal (Noon)	1.00 to 1.45

Table 30

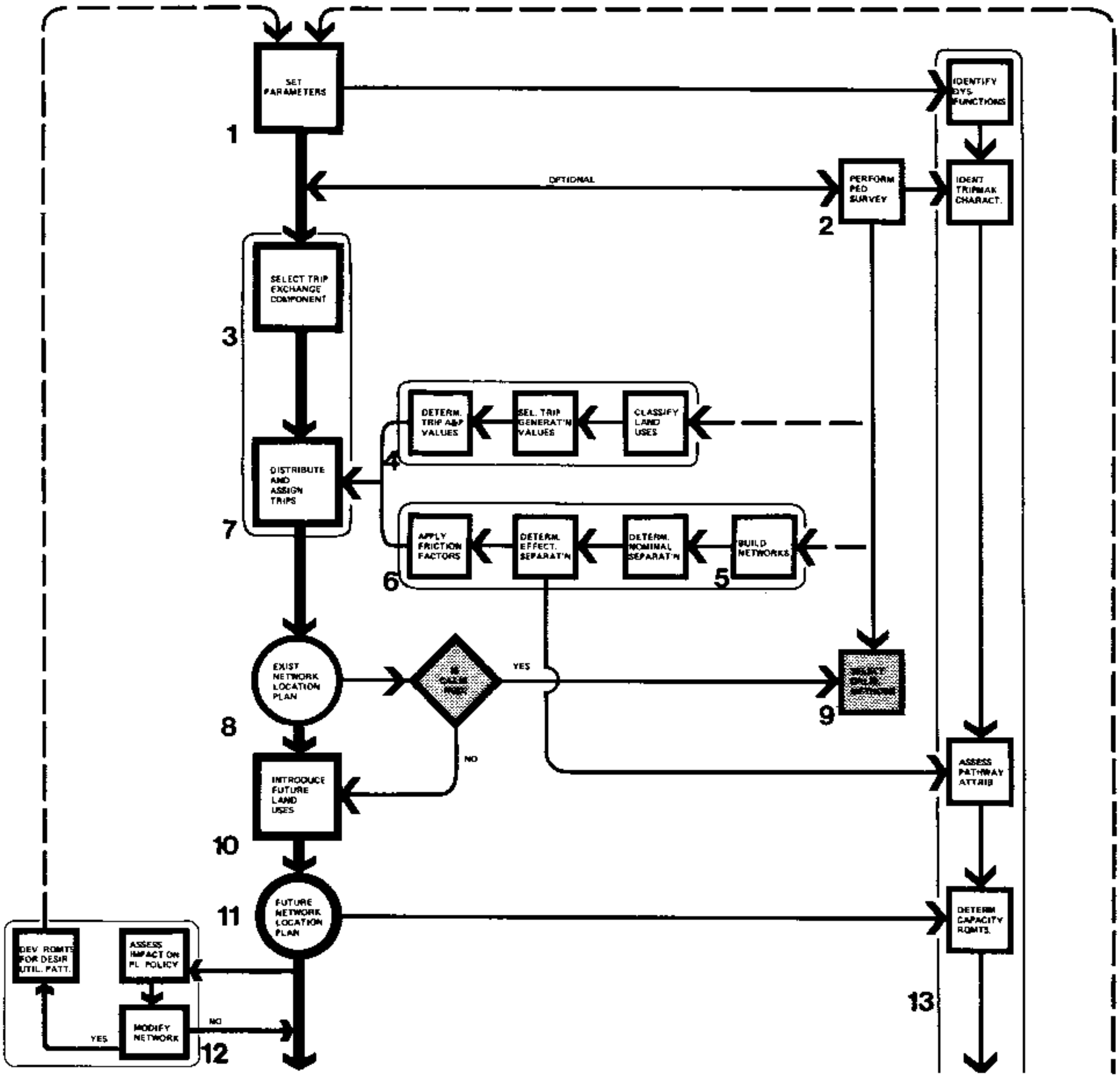
Typical Ranges of the Ratio:

$$\frac{\text{Peak 15-Minute Average}}{\text{Peak Hourly Average}}$$

The resultant peak hour composite derived from the model can be thought of as the "design peak hour." This composite, once the model in calibrated in Task 9, may be used as the basis for capacity calculations in Task 13.

CALIBRATE TRIP DISTRIBUTION AND ASSIGNMENT MODEL

9



TASK 9

CALIBRATE TRIP DISTRIBUTION AND ASSIGNMENT MODEL

9.1. Task Overview

The pedestrian trips distributed and assigned to the network in the previous task should be checked for consistency with actually measured pedestrian peak hour volumes.

The purpose of this excercise is to allow the planner to develop a reasonable level of confidence in the model's proportional replication or simulation of actual existing trips on those links with high potential utilization. Since exact numerical correspondence between modelled and observed volumes across the whole network is not being sought but rather a degree of proportional consistency on significant links, calibration within the PPP is not viewed as a major exercise.

If discrepancies are such that calibration is deemed necessary, the planner can then manipulate any or several of the following model inputs:

- generation values
- network construction
- peak directional factors
- friction factors
- exchange components
- trip assignment process

If the pedestrian survey has been performed, an analysis of the relevant questions will provide invaluable guidelines and data for the calibration exercise. If not, selective site-specific tests might be required to generate calibration data. Generic guidelines are provided in reference material to aid in the calibration.

9.2. Data

9.2.1. Data Required

1. Reliable peak hour ped counts. At a minimum, these counts should cover those network links with high potential utilization.

2. (Optional) An analysis of the pedestrian survey. Specific references to the relevant questions in the prototype survey (Fig. 5) are cited in the Procedures.

9.2.2. Data Provided As References

1. Guidance and references on doing a pedestrian count are provided in Supplement 10.

2. Data in Supplements referred to in other tasks dealing with trip generation, peak directional factors, and tripmaking propensities may be useful in this task.

9.3. Procedures

9.3.1. Determine Whether Calibration Is Required

The criteria for determination are related to the planner's objectives for the study. If only a gross approximation of relative movement is desired so as to distinguish between the potential utilization of competing corridors, then a high tolerance for discrepancy between modelled and observed volumes will be acceptable. If there is reason to believe that capacity problems might occur, a lower tolerance will be required.

It is difficult to specify these tolerances since the planner will be in the best position, at this stage, to know what degree of cumulative error might have been built into the model because of various assumptions made along the way. Examples of areas where such numerical "error" might have accrued are the following:

- Site specific count data may vary by day of the week, month and year. In many cities, for example, shopping trips peak on Saturday. Similarly, rainy and/or cold weather vs. warm, sunny weather can cause ped volume differences of between 25% and 50%. The observed counts themselves thus, might be associated with a margin of error.

- Only selected, higher-generation land uses may have been included in the exchange model.

- Generation values selected in land use categories with large R-value ranges might differ substantially from the actual generation.

- In the process of network building, certain convenient simplifications of land use and access portals might have distorted trip patterns.

- Peak-directional and friction factors in the study area might differ due to site specific conditions from those suggested in the manual.

- The gravity model presented in the Manual is of the production-constrained type (i.e. the initially estimated attraction values are "balanced" with the production values). For any exchange being modelled then, there are two possible "valid" outcomes, depending on the direction of the trip exchange. For example, the trips distributed from offices to parking will be different than those that would be exchanged from parking to offices since the total number of trips produced and attracted will in all likelihood be rather different.

9.3.2. Select and Apply Calibration Method(s)

If the decision to calibrate is made, the planner must select the calibration option(s) most relevant to his particular situation. These options are presented in the following sections:

1. Modify R-Values

Of all the model's inputs, the generation values will probably have the greatest impact on the volume of trips distributed and assigned within the network. The planner may thus:

- Reassign ambiguously classifiable buildings to other, equally valid, land use generation categories.

- Revise the generation rates (R-vals) choosing values higher or lower than the initial rates for selected land uses. This can affect both the absolute number of trips in the system as well as their distribution depending on the disposition of land uses.

If resources allow, the planner can perform actual portal counts at selected major building generator to establish appropriate generation values. One objective of such an exercise may be to test whether buildings with like uses generate at different rates depending on their general accessibility to attractive destinations, thus allowing "generation rate contours" to be mapped over the Study Area.

2. Modify Peak-Directional Factors

If the ped survey was performed but no PD factors were developed from an analysis of Question B11 and C13, then this could be done and the survey-based factors could substitute for the Manual's generic factors in a rerun of the model.

If the survey was not performed, surrogate peaking and directional factors for land uses can be derived from pedestrian counts, if available, on office and retail streets; research has shown that the temporal pattern of ped generation from office and retail buildings parallels the temporal movement on streets that are predominantly office and predominantly retail. For such counts to be useful, they must be reliable, daylong, and on a fifteen minute or half-hourly basis over the peak period so that peak and directional ratios can be clearly established. If such counts are unavailable and the planner suspects that PD factors in his particular city differ substantially from the factors provided in the Manual, half-hourly directional portal counts at selected sites can be performed over a twelve hour period.

One cautionary note: peaking factors developed in the Manual were based for the most part, on counts in the downtowns of large metropolitan areas such as Minneapolis, Seattle, Washington, Baltimore and New York. All these cities have a substantial percentage of their downtown floor space in offices. In such situations, the noon and evening peak street counts seem to be largely attributable to the influx of employee shoppers during lunch and at the end of the working day which augments the more normal distribution of the "remaining" primary shoppers. In smaller cities, with populations generally under 200,000 people, the percentage of retail floor space will typically dominate that of office floor space, and consequently, the pattern and composition of the peak hour movement may differ from the data provided in the manual.

3. Modify Exchange Components

The planner may review assumptions that have been made regarding the temporal behavior of certain components of the model. Residential and hotel uses, for example, tend to behave temporally in a site-specific manner and might be checked onsite at this point to determine whether assumptions about Noon and PM exchange pairings do, in fact, hold true.

4. Reverse Direction Of Exchange

Since the Manual's gravity model hold production values constant and modifies the attraction values, provided that the totals of these values are sufficiently different, the planner can treat attractors as producers and vice versa, if the assigned volumes yielded promise to reduce numerical discrepancies in the right direction.

5. Modify Network

Discrepancies between modelled and observed distribution may be due to network delimitation or construction. Zones of production or attraction, for example, that were considered external to the cordon area and thus discounted, might in fact have an impact on tripmaking within the study area. Alternatively, network simplifications, like the elimination of some peripheral links, could have had the effect of "channelling" trips to specific links. Discrepancies due to such factors usually produce an imbalance in the network. If distribution on significant links has been impacted, the degree of error introduced by such factors can be reduced by appropriate restructuring of the network. If, however, only the distribution on less important links appears to have been affected, such discrepancies, provided they can be clearly accounted for, may be ignored, especially where a sufficient number of other unaffected links can be used for calibration purposes.

6. Modify Friction Factors

If the user suspects that unique tripmaking propensities exist in the study area that invalidate use of the generic friction factor data provided in the manual, then several possible approaches exist:

- If a pedestrian survey was performed, questions 8.12 and 15A can be analyzed and the resultant data used to correct the friction factor relationships;

- If a pedestrian survey was not performed then one of the following actions might be initiated -

  - performance of only that part of the survey which could yield F-curves - i.e., mapping of routes
  - some tracking studies
  - modification of the F-curves based on planner's knowledge of land use disposition (compaction vs. dispersion, etc.) and trip patterns.

7. Modify The Trip Assignment Process

In Task 8, it was recommended that trip assignment be based on an "all-or-nothing" principle. While this approach is simple to implement, it may not effectively simulate reality. If the user suspects this to be the case, particularly if the effort in Task 8 was conducted using a computer, then some modification of the assignment process may be examined. Alternatives would be to assign trips to alternative competing routes connecting the same centroid pair (and their respective links) using, for example, the effective separation measure for each route as a means of proportioning trips. For example, the shortest route could be assigned 75% of the trips, with the remainder split, if appropriate, to alternative routes. This modified assignment process can be as complex or as simple as required to suit site-specific conditions and availability of resources.

9.3.3. Establish Ratios Between Modelled and Observed Distribution

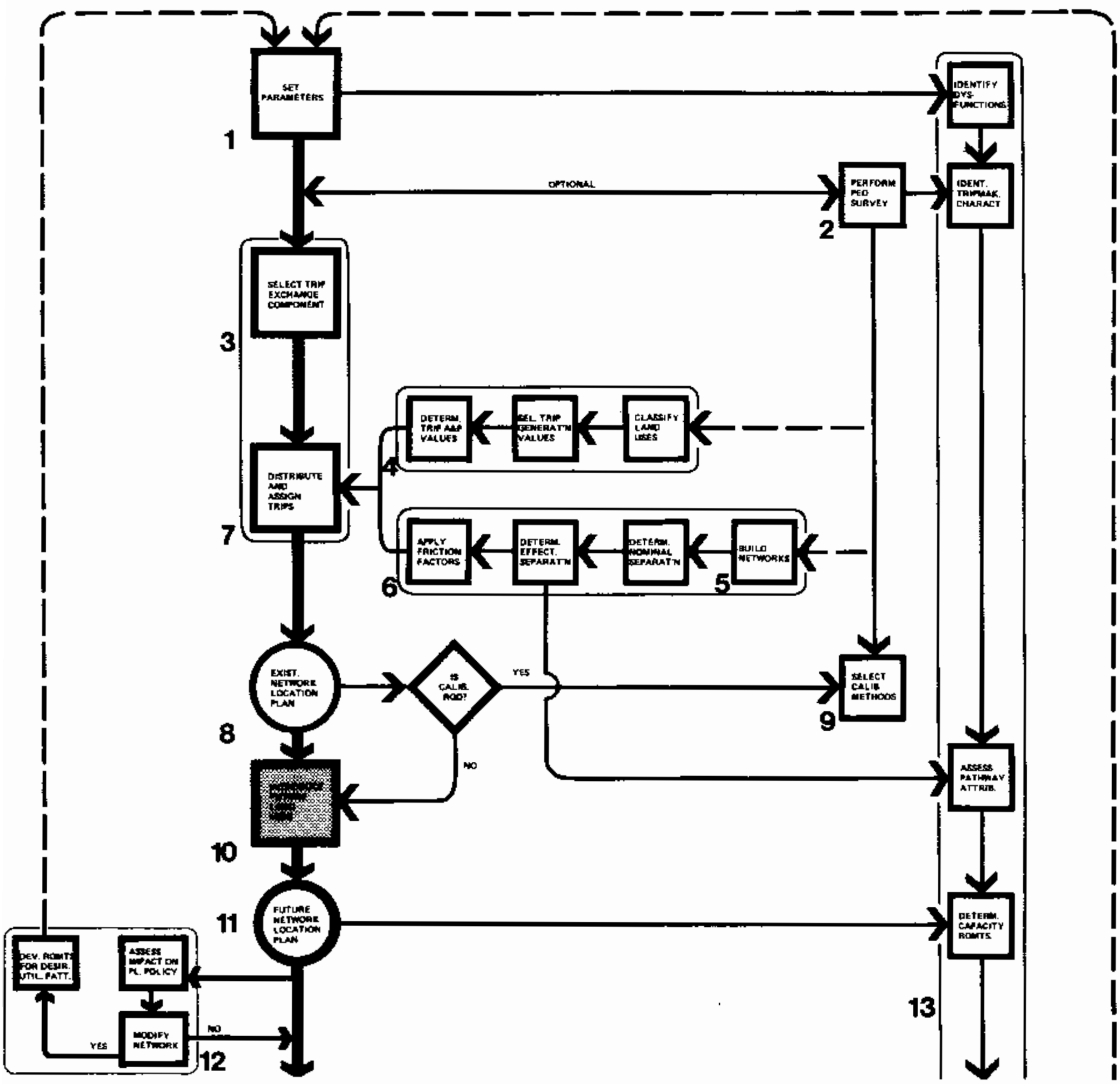
Once a distribution pattern is obtained which replicates existing conditions with reasonable consistency, the proportional relationships between the observed and modelled link volumes can be applied for the later ped facility capacity calculations based on existing and future land use conditions.

If a greater degree of accuracy is desired in which actual numerical calibration is achieved, then, at a minimum, the ped survey would have to be implemented in an expanded form to ensure that appropriate calibration data is obtained. Other field tests referred to in 1, 2, 3, and 6 above will also be required. It should be emphasized, however, that the intention of the calibration exercise in the PPP is only to assure the planner that the model's distinction between utilization along alternative movement corridors corresponds in a relative way with the actual utilization pattern. Experience in applying the model suggests that throughout the calibration exercise, the relative distribution pattern produced is unlikely to change.

Once calibration based on existing conditions is achieved to the planner's satisfaction, the process of generation, distribution and assignment of ped trips based on future land use and environmental conditions can be undertaken.

INTRODUCE FUTURE LAND USES

10



TASK 10

INTRODUCTION OF FUTURE LAND USES

10.1. Task Overview

Through Task 9, the process has primarily addressed existing land use generation. In this task, however, the data associated with future land uses is introduced into the calibrated model that produced the satisfactory network location plan in Task 9. Centroid production and attraction values for future uses were developed in Task 4 and appropriate friction factors in Task 6.

These inputs are now used to cycle through the distribution and assignment process to yield modified patterns of forecasted utilization resulting from future conditions.

In this task, and depending on the user's resources, the impact on tripmaking of different land use configurations and time horizons can be investigated. Similarly, the validity of any preconceived pedestrian facilities or policies can be tested by modelling a "before and after" condition, each with its appropriate separation times and routings.

10.2. Data Required

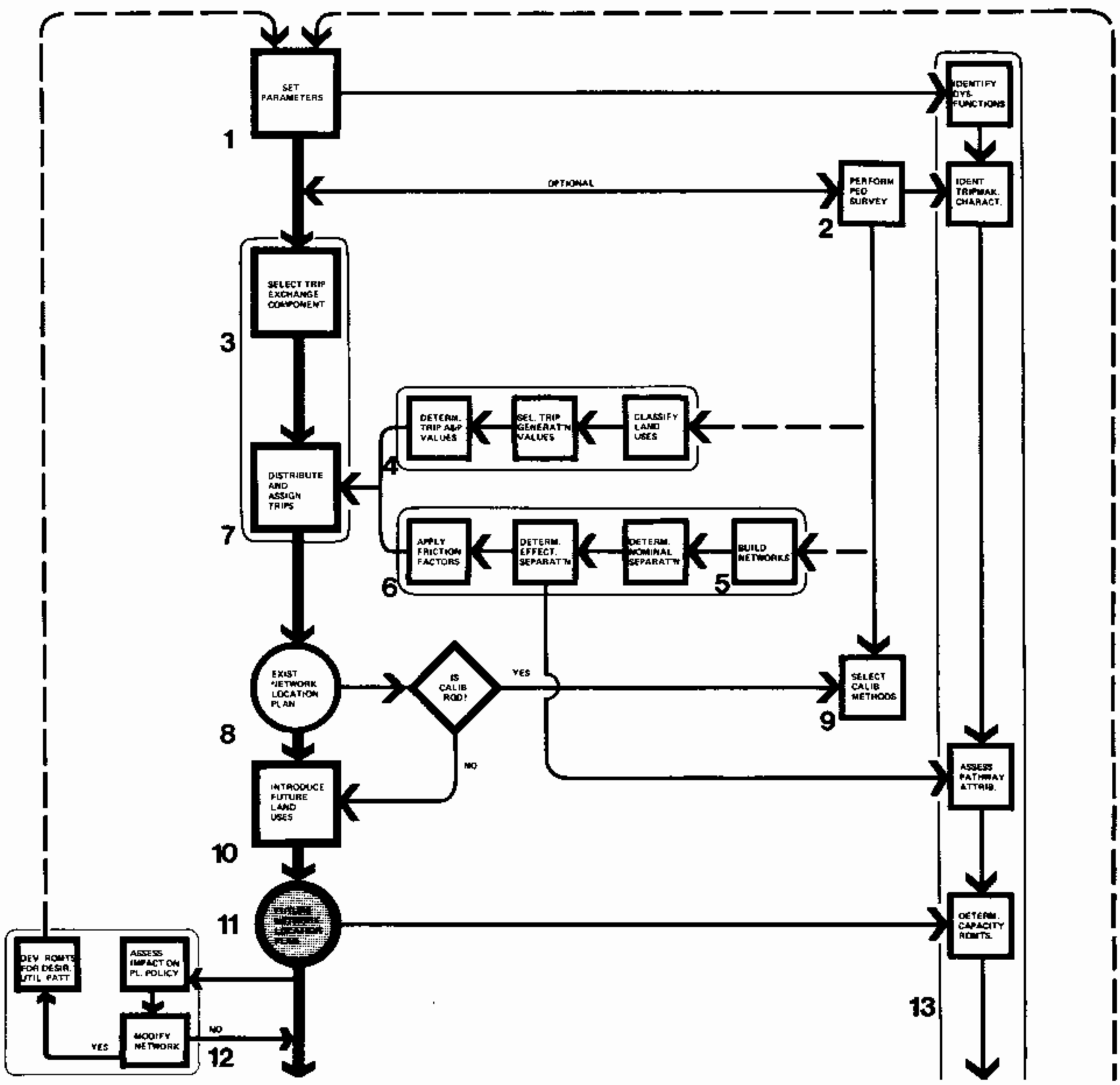
The relevant data will have been gathered in Tasks 4 and 6.

10.3. Procedures

The technical procedures in this task are identical with those of Task 7. However, the user may elect to use different generation rates in developing the A and P values for future conditions if the extent or quality of proposed future projects or redevelopment suggest that an increased intensity of foot traffic generation may be warranted. Similarly, the user may vary the friction factor curves used in the initial modelling of existing conditions if the disposition of future projects suggests a decidedly different overall pattern of land uses.

PRODUCE FUTURE NETWORK LOCATION PLAN

11



TASK 11

PRODUCE FUTURE NETWORK LOCATION PLAN

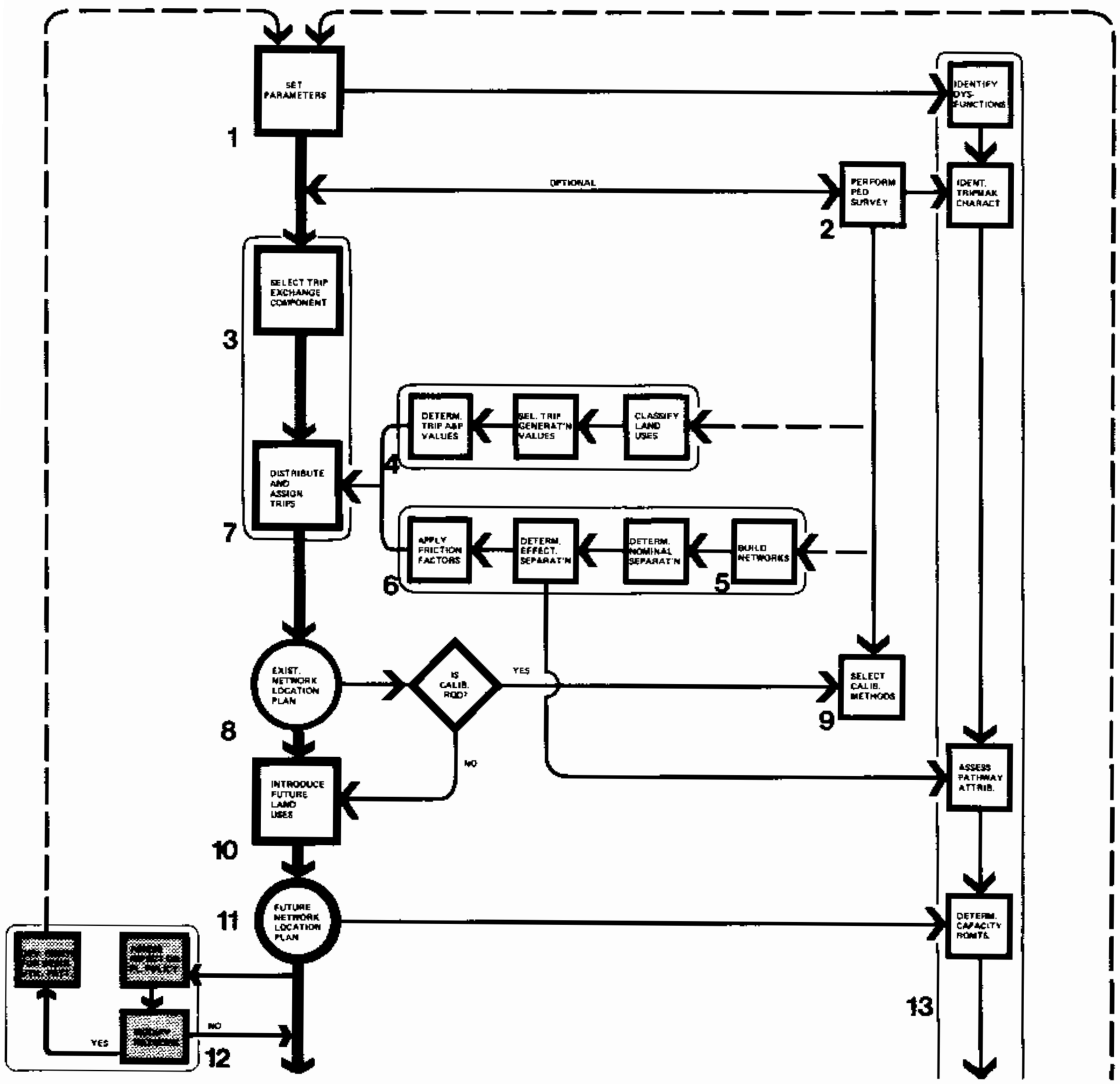
11.1 Task Overview

This task duplicates Task 8, to which the planner is referred, except that a future condition is being represented by the network.

Those corridors with high utilization potential will in subsequent Tasks be examined to determine the degree to which they warrant some form of pedestrianization for the purpose of accommodating and fostering aggregate trip-making.

ASSESS NETWORK LOCATION PLAN IMPLICATIONS FOR PLANNING POLICY

12



TASK 12

12.0 ASSESS AND RESOLVE POTENTIAL NETWORK IMPLICATIONS FOR PLANNING POLICY

12.1. Task Overview

The future development or redevelopment of downtown land parcels is guided and controlled by planning policy. Such policy is usually embodied in and reflected through master plans, various zoning ordinances, and capital improvements programs. The impact of future development or redevelopment on pedestrian trip making patterns and the implications of these patterns in terms of available rights-of-way, adjacent land use impacts, etc., is generally not examined as part of planning policy decision making. The trip making impacts of future land use decisions, while initially known or unforeseen, may nevertheless be significant. For example a general policy to revitalize a deteriorating retail street may be unknowingly negated through the displacement of existing and future pedestrian traffic along that street to another route as the result of the location of a major new pedestrian attractor.

This step in the Pedestrian Planning Process allows the impacts of the potential utilization network on planning policy to be assessed and, if desired, permits the recreation of alternative potential network segments more consistent with current policy intentions.

This step in the procedures is a significant point of interface between the city as "client", various interest groups and the planning team undertaking the Pedestrian Planning Process.

Figure 39 illustrates the sequence of procedures that follows:

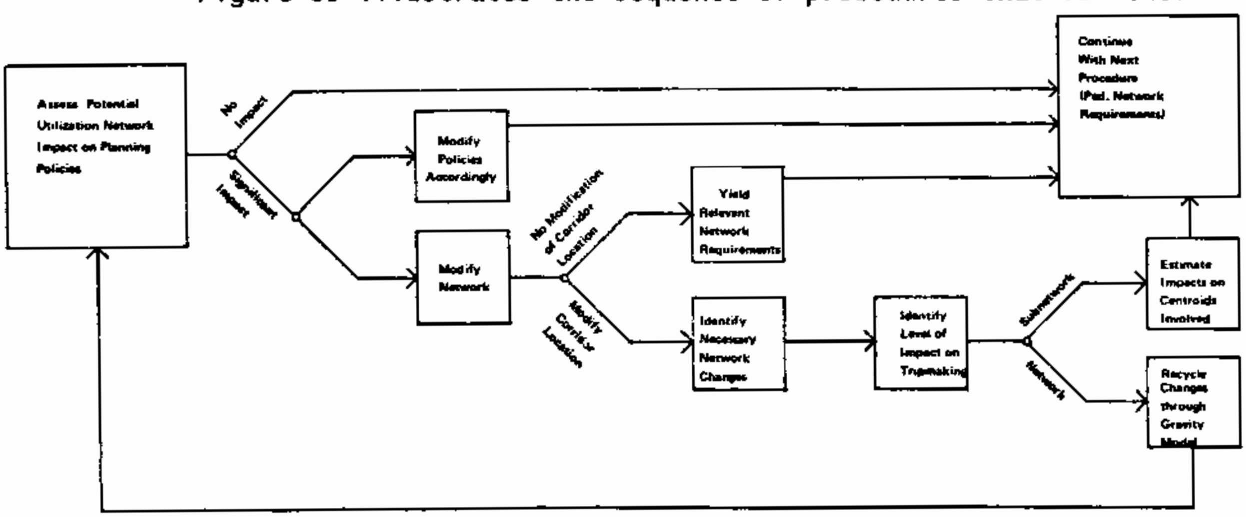


Figure 39

Assessment Of Pedestrian Network Impacts On Planning Policy

12.2 Data Required

1. Network location plan from Task 11.

2. Statements and/or graphic interpretations of planning policy (also required for Task 1).

These general policy goals as well as specific strategies are often found for example, in Center City Development Plans and may require updating or reformulation by the appropriate decision-making bodies in response to future pedestrian trip making issues.

12.3. Procedures

12.3.1. Assess Impact Of Pedestrian Network Upon Planning Policy

If none exist or were formulated in Task 1, a statement (or statements) of planning policy must be developed relevant to the study area for the plan's time frame.

Examine the implications of pedestrian network corridor locations relative to general or specific planning policies identified above in terms of the following possibilities:

1. Utilization on potential corridors may not support further land use development/redevelopment opportunities envisioned by the policies.

   For example, in the time frame beyond that used for the plan, planning policy could envisage the location of a civic open space on a segment that is not heavily utilized since it contains no attractors or generators.

2. Potential corridor locations may function in response to overall network considerations which may potentially conflict with policy intentions and other issues regarding the specific corridor environment (subnetwork).

   For example, a segment which serves purely as a link for work trips might be part of an overall streetscape program providing benches, trees, etc. For such a link these provisions might be both unnecessary and counter to its functioning as an unimpeded pathway.

3. Trip exchange may be desired between two areas across which movement is currently discontinuous (trips are not made).

   For example, in a downtown that is functionally zones, an office zone might not be exchanging noon hour shopping trips with a retail zone for a variety of reasons (distances too great, retail area does not offer range and quality desired by office workers, inadequate accessibility or excessive impedances, etc.)

12.3.2. Identify Degree Of Conflict And Need For Network Modifications

There are two outcomes regarding potential policy impacts.

1. The pedestrian network corridor locations have no impact upon existing or future planning policies in which case the first approximation remains unchanged (does not require modification) and the process continues to the next sequence of procedures, (Step 13.0) or

2. The pedestrian network corridors have a significant impact upon established planning policies in which case alternative means of resolving these conflicts must be determined. If this is the case then proceed to 12.3.3.

12.3.3. Identify The Means Of Impact Resolution

There are two alternatives:

1. Modifications to policy (which do not require network modifications) to accord with impacts. If this is the case, the process continues at Step 13.0.

2. Network modifications.

12.3.4. Identify The Nature Of Network Modifications

There are two possible outcomes regarding network modifications.

1. No modifications to corridor locations are required.

   It is possible under this outcome that network modifications other than corridor relocation (i.e., other than the shifting of pedestrian trips from one right-of-way to another) may be necessary such as the requirement for the creation of a new corridor where none formerly existed, or the further reinforcement of an existing corridor. These kinds of requirements are taken up and recorded under Pedestrian Network Requirements in Step. 13.

   In this case, the first approximation remains basically unchanged and the process continues to the next sequence of procedures, or

2. Corridors require relocation.

   If this is the case, then proceed to 12.3.5.

12.3.5. Develop Requirements For Achieving The Desired Level Of Pedestrian Utilization

These requirements for modifying pedestrian trip making are based upon the following criteria: (in order of importance):

(a) Provision of activities which have the ability to produce pedestrian trips

(b) Provision of activities which have the ability to attract pedestrian trips

(c) Provision of pathway attributes or amenities which induce increased utilization and maximum perception of benefits to trip makers and the

(d) Introduction of pedestrian movement constraints which will reduce utilization of alternative pathways.

If the above requirements can be sufficiently realized so that, in the judgement of the planner, trip making patterns will be modified, then the impact of this change must be further assessed.

12.3.6. Identify The Impact Of Corridor Relocation Upon Trip Making

1. Determine the nature of the impact on

   - Pathway choice
   - Trip generation

Based upon the selected requirements for modification, new inputs to both the determination of trip generation as well as those factors which affect pathway choice must be identified. Thus, for example, if a new generator and new attributes are inserted into the network, the associated generation factors for that land use must be determined.

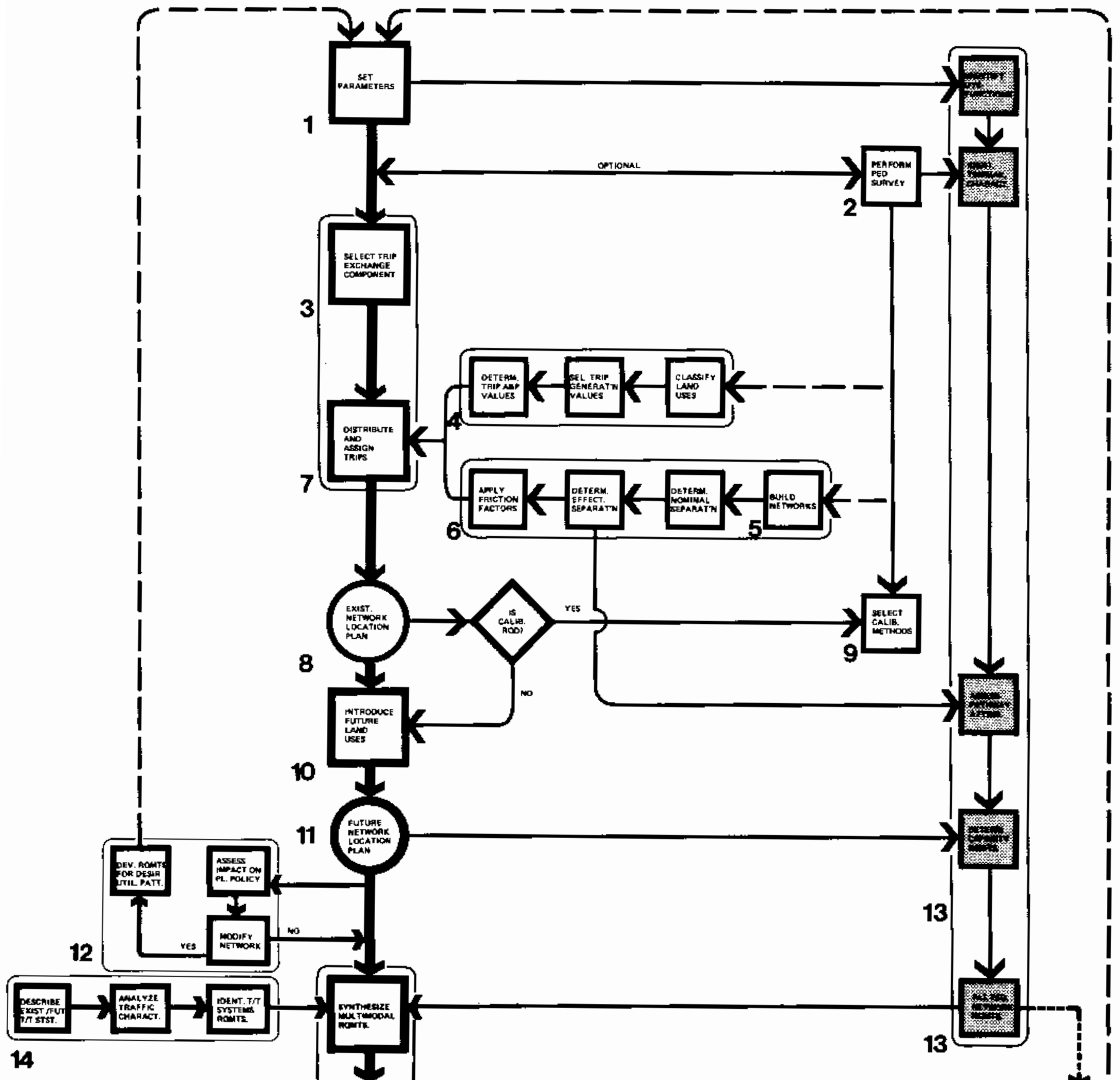
2. Determine whether the level of impact is either

   - Subnetwork
   - Network

In most cases the modifications will be localized, and will affect a small subset of the original network elements. The impacts of these local network changes on outlying network elements will be small, due to the attenuation of pedestrian trip propensity with time or distance. The converse is also true; that is, outlying network elements will not greatly affect movement within a local area. Hence, in the examination of the movement impacts of local modifications, the majority of the effect can be determined by looking at only a subnetwork area without a reiteration of the exchange/distribution model. In such cases an estimation of the impact on the centroids affected will probably suffice.

Where, however, a corridor or a series of corridors relating to numerous centroids is to be relocated, then the relocation is likely to have impacts for trip making across a major portion of the network, and the exchange model must be reiterated. This iteration will result in establishing a new potential utilization network more consistent with planning policy.

DEVELOP PEDESTRIAN NETWORK REQUIREMENTS 13



TASK 13
DEVELOP PEDESTRIAN NETWORK REQUIREMENTS

13.1 Task Description and Overview

The application of the distribution and assignment models in Tasks 3 through 12 have allowed the planner to isolate those pathways or corridors with high potential utilization. In the procedural Tasks that now follow, these selected corridors will be the focus of detailed attention in the development of a requirements program for the walking environment.

Elements of this program will have already been developed (as indicated in the process diagram, Fig. 1) as a result of:

- the preliminary analysis of problems of issues in Task 1,
- the pedestrian survey, if performed, in Task 2 and
- the rating of pathway attributes in Task 6.

This task expands the requirements program and provides appropriate recording formats.

The network location plan merely indicates those paths along which pedestrians would tend to move given the distribution of land uses and the existing pathway attributes. Whether or not these preferred pathways do or can, in fact, accommodate their potential utilization is an issue that is faced in this section under the "Examination of Capacity Requirements" (13.4 through 13.7).

The PPP, however, goes beyond the capacity - availability question. Its orientation is towards the improvement of the pedestrian environment, where demand may warrant it. An issue to be faced thus, is whether the existing pedestrain environment can be further improved along those corridors of high potential. Such improvements would be in response to existing functions or dysfunctions of the network. The development of such requirements for pathway modification constitutes in fact a program of network requirements. Guidelines for the creation of this program are provided in Section 13.3.

The street environment, however, consists of both the pedestrian network domain of sidewalks as well as the vehicular system of rights-of-way. While this section will deal with the pedestrian network requirements which seek to improve its environment (i.e., to provide a program for what the pedestrian network should be) the vehicular R.O.W. is also associated with dimensional and functional requirements. These must be matched with the pedestrian requirements to ascertain whether the desired ped network modifications are feasible (i.e., to establish whether that program can be).

The development of the vehicular R.O.W. requirements program is discussed in Section 14.0 under "Traffic and Transit Requirements." The orientation of the traffic and transit section is towards insuring that existing levels of service are not prejudiced by pedestrian network requirements rather than better accommodating or fostering vehicular traffic, although obviously where improvements to the vehicular system can be achieved within the scope of the PPP, this is a desirable objective. As a result of the multi-modal evaluation, either or both the pedestrian network and T/T system may be modified, and thus the pedestrian network requirements program augmented. The program may be further augmented by new requirements resulting from the introduction of methods of pedestrian/vehicular separation.

The resultant pedestrian network program is combined with general planning requirements which affect the pedestrian environment (related, for e.g., to traffic and transit, planning policy and site specific considerations) and this entire program is used in the selection of design treatments as discussed in Section 25.0.

Diagrammatically, the processes we have been describing above can be represented as follows (figure 40):

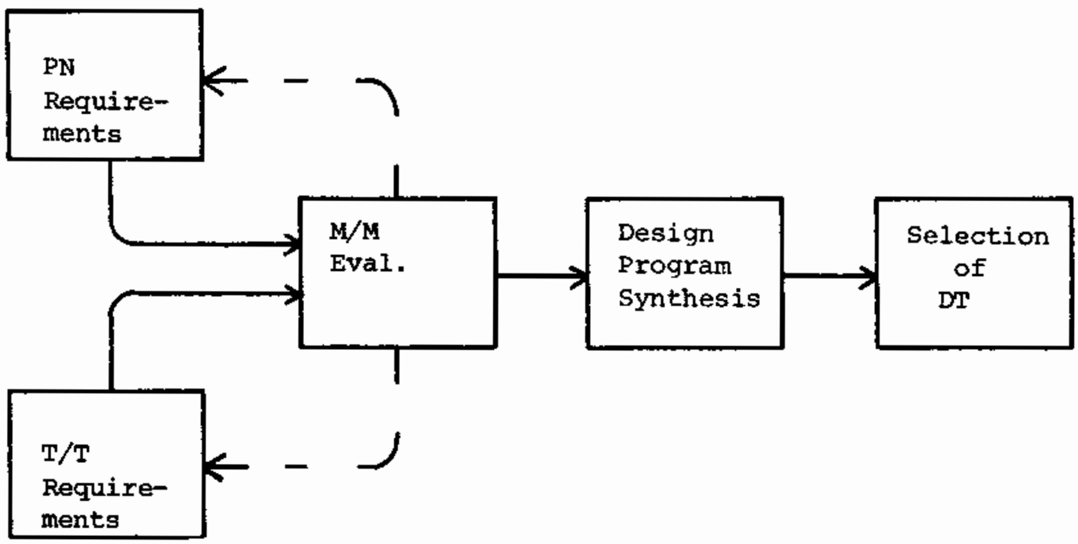


Figure 40

Overview Of Network Requirements And Subsequent Tasks

The pedestrian network requirements program, while it is developed in response to specific network functions or dysfunctions, is expressed in terms of desired pathway <u>attributes</u>, since it is largely these that the planner or designer can manipulate in the design process. One of the major tasks in this section thus will be the correlation of assembled data on tripmaking characteristics with pathway attributes. The remainder of this section will be task-like in nature, providing procedures for the initial identification of network segments for subsequent analysis, the inventorying, and where required, analysis of tripmaking characteristics, leading to the development of network requirements and their expression as pathway attributes. Finally, procedures for dealing with the somewhat separable issue of capacity or required pedestrian space are provided.

13.2 References

Section 13 in the Overview and Supplement 1, section 1.5 - 1.7 define and discuss trip making characteristics and pathway attributes.

13.3 Procedures

13.3.1 Identify Network Segments

1. A network segment is defined as those portions of the high utilization pathway network which exhibit significant common characteristics.

   The purpose of identifying segments is to simplify the large number of links in the high utilization network through their aggregation into a manageable number of similar units for subsequent analysis and design.

2. Criteria for Identifying Network Segments

   The identification of specific segments is based upon an evaluation of numerous site specific conditions. For the most part identification of network segments is a function of:

   - Commonality among trip making characteristics (e.g., volumes, trip purpose)
   - Major physical boundaries (topographic and environmental)
   - Commonalities in land use patterns
   - Street patterns

3. Analysis of Network

   The network is assessed based upon the above criteria for the purpose of identifying specific network segments.

13.3.2 Inventory Trip Making Characteristics

Table 31 lists the data sources and output format for those trip making characteristics relevant to this analysis. (The characteristics themselves have been defined and discussed in the Overview and Supplement 1.) A description of the analysis that can be applied to selected trip making characteristics follows.

TRIPMAKING CHARACTERISTICS	DATA SOURCES						OUTPUT FORMAT	
	Secondary Sources	Survey	Field Obser.	Distrib. Model	Referred in Manual	Data In Manual	Map	Recorded on Reqmts. Worksheets
1. Tripmaker					X			
2. Attitudes & Perceptions	X	X						X
3. Trip Purpose		X		X			X	X
4. Trip Volume			X	X			X	X
5. Trip Patterns		X	X	X			X	
6. Trip Length		X						
7. Pathway Attributes								
Directness		X	X			X		
Continuity		X	X			X		
Capacity		X	X			X		
Safety	X	X	X			X		
Accessibility		X	X			X		
Env.Protection		X	X			X		
Amenities		X	X			X		
Attractiveness		X	X			X		
Coherence		X	X			X		
Security	X	X	X			X		
8. Impedances		X	X				X	X
9. Modal Interface	X		X				X	X

Table 31

Tripmaking Characteristics Data Source And Output Format Summary

1. <u>Attitudes and Perceptions - Needs and Desires</u>

Needs and desires are articulated in response to perceived problems or dysfunctions. As understood here, they may be articulated by either the street users, or observers such as the planners. Such needs or desires can cover a wide range of issues. Examples might be a need for open space, a desire to connect two functionally interdependent land uses, a need for interaction, etc.

They are to be classified in terms of existing negative social, economic and environmental (physical) impacts:

a. Negative social impacts to be reduced include crime, pedestrian/vehicular accidents, insufficient privacy to residential land uses, etc.

b. Negative economic impacts to be addressed include lack of access to pedestrian-dependent land uses, lack of visibility or poor orientation to land uses, impedances which increase travel time and other costs, etc.

c. Negative environmental impacts include excessive noise and air pollution, non-functional space*, etc.

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*Non-functional space is a dysfunction as defined by any one of the following conditions; however, it represents a resource that could be exploited for accommodating pedestrian movement.

a. An existing vehicular right-of-way that is unnecessary to the functioning of the vehicular circulation network.
b. A vehicular right-of-way that is considerably underutilized in terms of its available right-of-way.
c. Vacant sites.
d. Functionally obsolete land uses or structures.

2. Trip Volume

The conversion of volume data to spatial requirements is dealt with in Sections 13.4 through 13.7.

3. Trip Patterns

Identify and map the extent and purpose (e.g., shopping trips, work trips) of the major trip patterns in the network. Also record the major origins and destinations that are related to the trip patterns. These may be zones (e.g., an entire retail street) or points (e.g., a subway station). The product of this exercise is called the Trip Patterns map. Figs. 41 and 42 are illustrative examples of such maps.

4. Trip Length

a. If the survey was performed, aggregate responses to the hypothetical question dealing with desired destinations (question Number 25). This yields data on land uses which could potentially exchange trips but for excessive trip length.

   These potential patterns are overlaid on and distinguished from the trip patterns maps.

b. Examine the existing and potential trip pattern maps to identify trips of greater than average length for the given trip purpose. (Average lengths can be derived from an analysis of the relevant survey questions.)

c. Relate the above trips to the specific reason/s for their being undertaken - for example, the quality of the given destination, its uniqueness, importance, non-availability of close-in parking, etc. (This may require an aggregation of responses to survey questions dealing with the reasons for making actual or hypothetical trips of greater than normal length.)

d. Make a judgement as to whether the creation, facilitation, or increase in such actual or potential trips is desirable in terms of their overall impact on existing and future land uses and planning policy generally.

e. Establish the feasibility of inserting an intervening activity node in terms of:

   Site opportunities (land use adjacencies, land use availability, etc.)

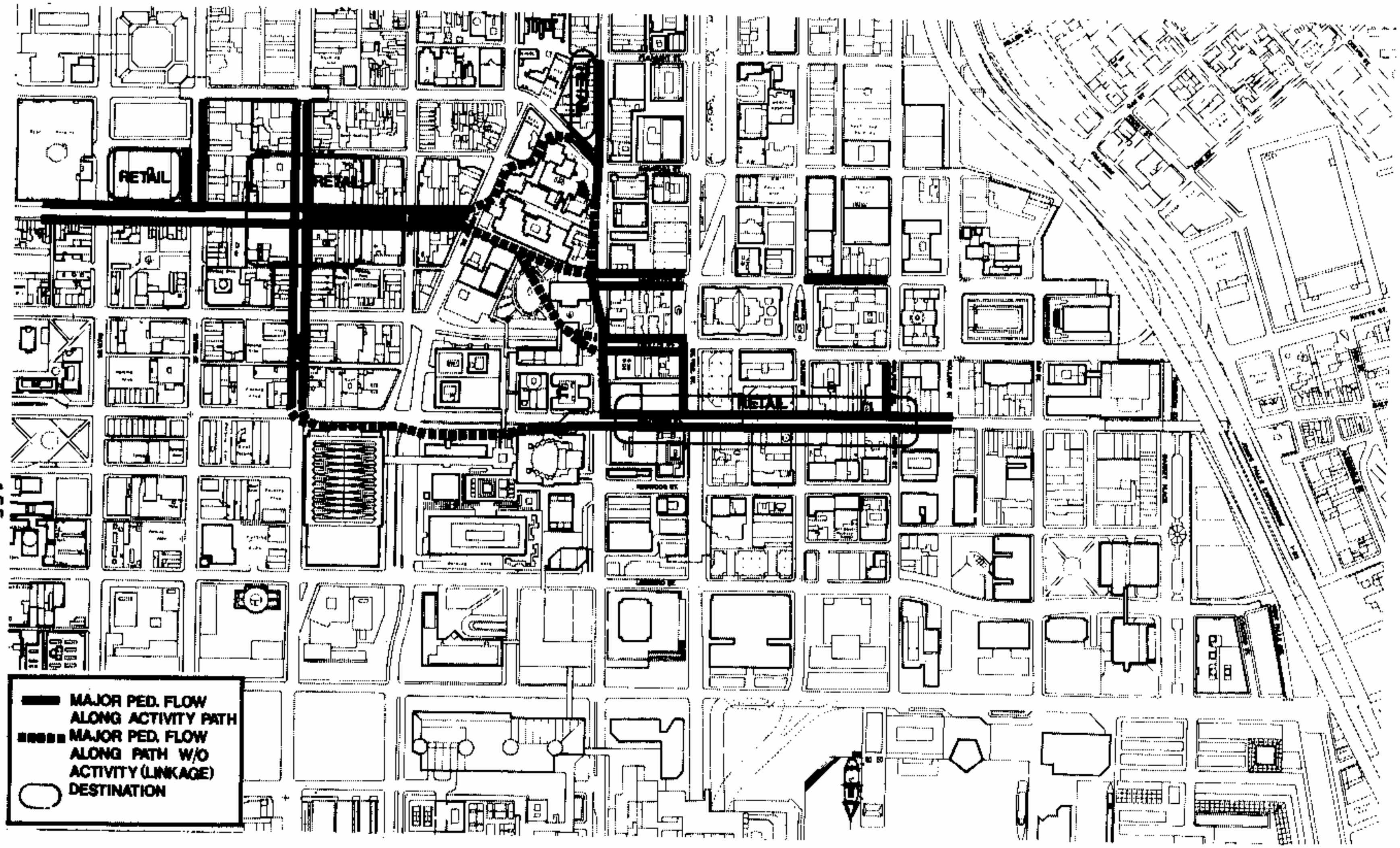

Figure 41

Sample Trip Patterns Map - Noon Movement

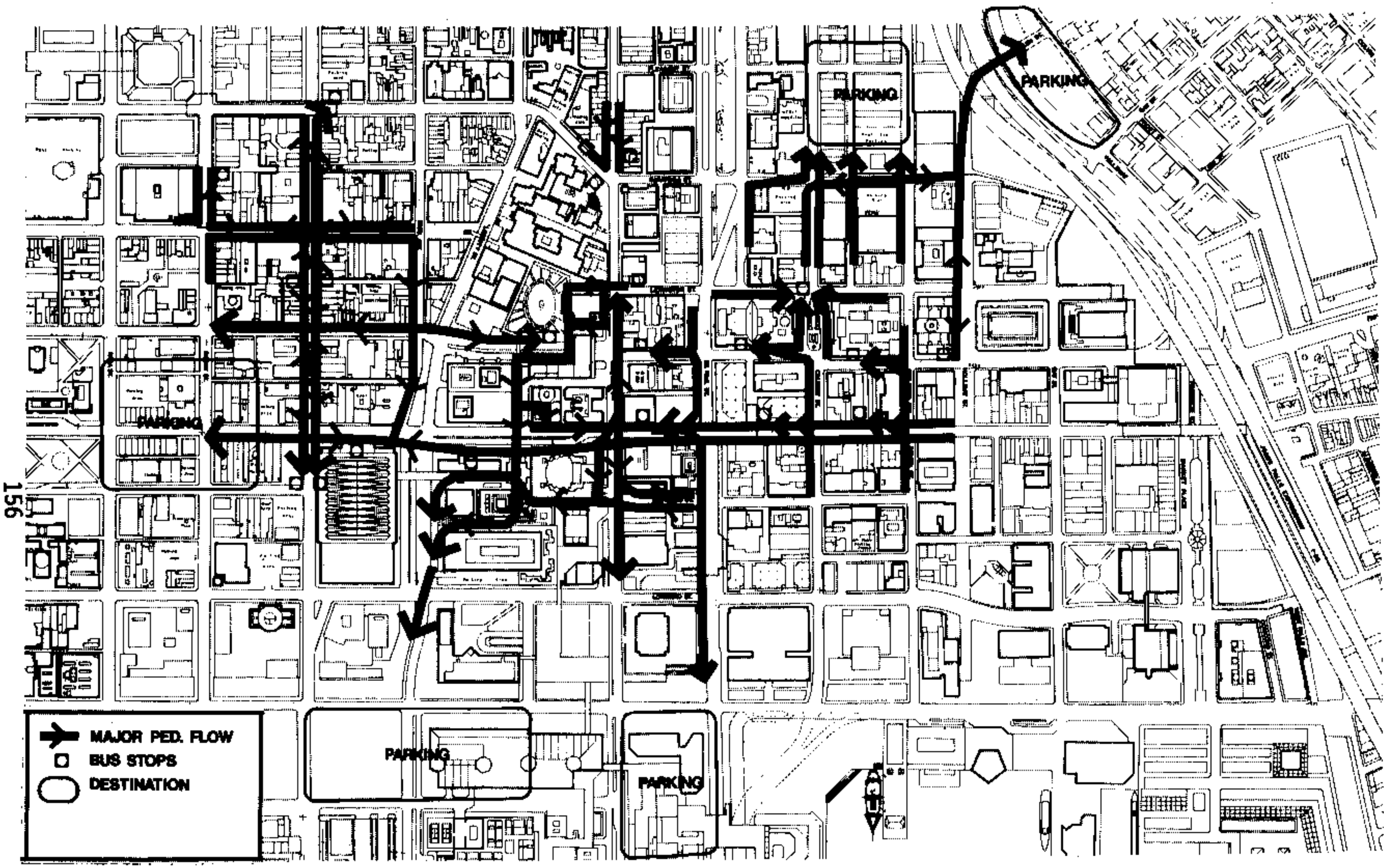

Figure 42

Sample Trip Patterns Map - P.M. Movement

- Alternative modes to satisfy such trips (shuttle buses, "downtown loop bus", etc.)
- A comparison between the cost/benefits of feasible alternative modes and the creation of the intervening activity node.

5. Pathway Impedances

The responses to those survey questions which relate to pathway impedances (questions 21 through 27 in the sample survey) must be scanned to determine whether they support, augment or modify onsite observations. The survey responses could also help establish the degree of perceived seriousness of given impedances and thus inform judgements on the provision of countermeasures to or the elimination of impedances. Fig. 43 illustrates the mapped product of such an analysis.

The above analysis is also used as a reference in maximizing the effective width of existing pathways through the relocation of impeding elements.

6. Modal Interface

For the purposes of gathering data for the trip exchange model, all the modal transfer points including automobile termini (parking lots, garages), bus stops, subway stations, taxi stands, and train stations, will already have been located and mapped through the use of

a. Onsite observation

b. Secondary sources (bus and subway route maps, transportation plans, etc.)

Additionally, data will have been gathered and recorded for each transfer point in terms of

- trip generation and attraction capabilities

- terminal capacity and related pedestrian behavior (queuing, parking conditions, etc.)

Questions 4, 8, and 14 of the pedestrian survey can yield responses which identify modal interface dysfunctions (e.g., non-awareness of modal opportunity through insufficient signage or accessibility).

Dysfunctions associated with the location or accessibility of modal transfer points must now be identified.

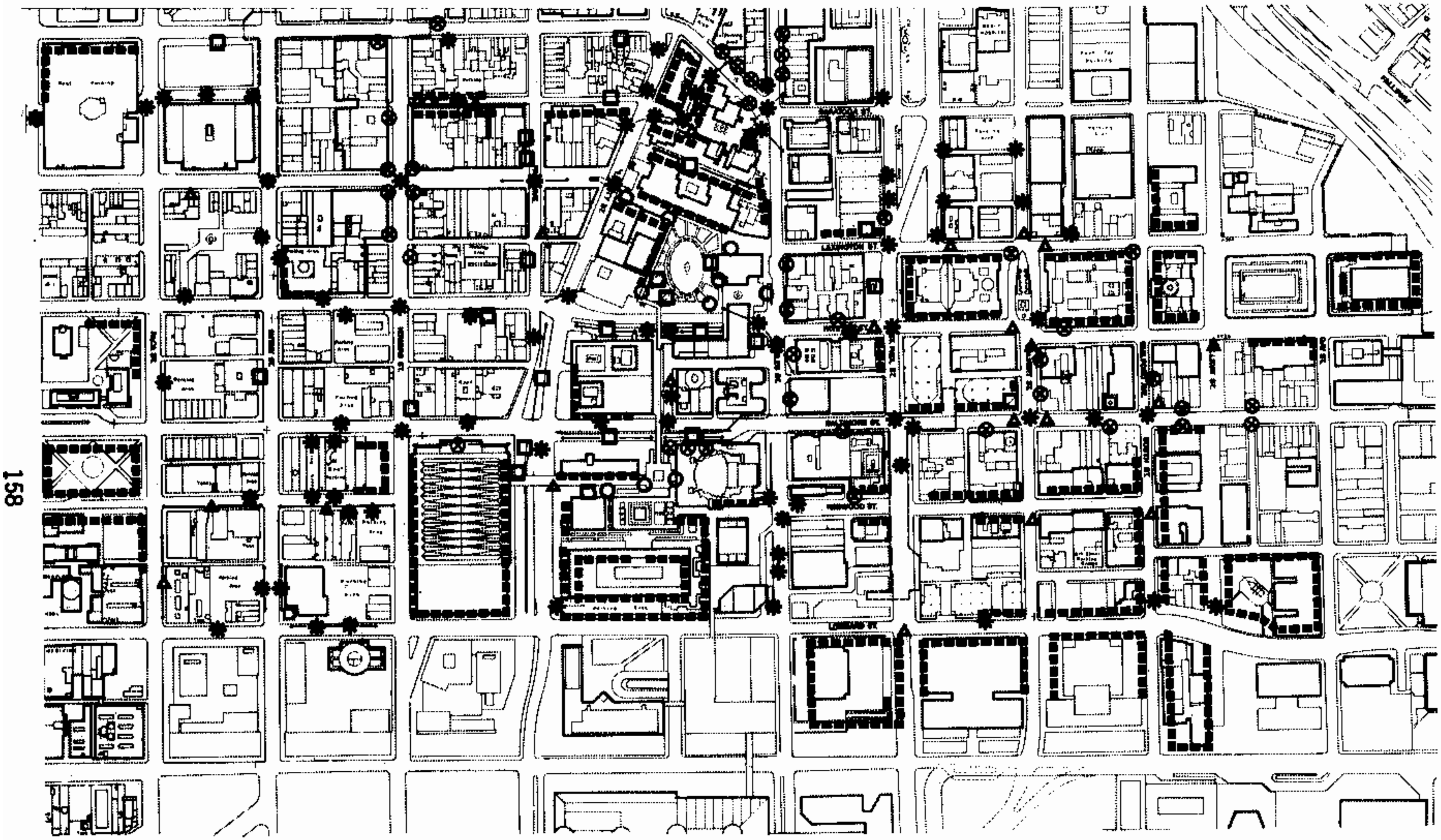

Figure 43

Mapping Of Selected Pedestrian Network Requirements And Dysfunctions

Major AM and PM work related trip patterns have been recorded on the trip patterns map together with the important related modal transfer termini which are their origin or destination.

a. Through examination of the trip patterns map determine whether the location of transit stops induce excessive walking trip lengths relative to major work and shopping destinations.

b. Record any dysfunctions related to modal interface that result from the pedestrian survey.

Performance of the above completes one part of the analysis of trip making characteristics, yielding certain requirements and providing a basis for the following step.

13.3.3 Develop Pedestrian Network Requirements Program

Prototypical relationships exist between pathway attributes and trip making characteristics. For example, depending on the trip maker's trip purpose, he will value the various attributes differently - the primary work trip attribute would be directness, that for a social/recreational trip would be the amenities provided, etc. Another example might be the relationship between the requirement to provide accessibility and stores suffering economically through lack of access. A list of prototypical requirement statements that define and explain the relationship between characteristics and attributes has been developed and is presented in Table 32. These statements are, of necessity, general in nature and the planner is encouraged to interpret their relevance in site-specific terms and to add new statements as appropriate.

Any single requirement statement can relate to several trip making characteristics. For example, the requirement statement: "Modify or eliminate elements which impede movement or trip making for the purpose of increasing pathway directness (i.e., time, distance)" is relevant to environmental dysfunctions as well as pathway impedances. Similarly, a requirement statement can relate to several attributes, as in the following: "Provide activity node to create attributes like interest, activity and amenity which reduce effective trip length." Worksheet Table 33 relates the characteristics to the attributes via the requirement statements. The coding in the table relates to the numbered list in Table 32.

These two tables are to be used together with the trip making characteristics data that has been mapped for the network. For each network segment, the various trip making characteristics are to be reviewed across all attributes and a determination made as to whether any of the potentially relevant requirement statements do, in fact, apply. Such correlations are checked or marked on the matrix for that segment, together with any related explanatory notes.

TABLE 32
LIST OF PEDESTRIAN NETWORK
REQUIREMENT STATEMENTS

1. Position and locate special design treatments for the facilitation of movement by the handicapped, elderly, and children (curb cuts, ramps, special signage, pedestrian-activated crosswalk signals, etc.)

2. Provide pathway attributes related to increased security and safety.

3. Provide pathway attributes related to maintaining privacy of abutting property in areas of residential trip-making.

4. Provide or modify access to land use activity (which is dependent upon pedestrian trip-making) for the purpose of increasing economic benefit.

5. Modify or eliminate elements which impede movement or trip-making for the purpose of increasing linkage.

6. Provide or modify exposure and visibility to land use activity (which is dependent upon pedestrian trip-making) for the purpose of increased economic benefit through increased orientation.

7. Provide countermeasures to pathway route for the purpose of increasing safety, reducing impedance and channeling movement, such as signal phasing, mid-block crossings, etc.

8. Modify or eliminate elements which impede movement or trip-making for the purpose of increasing pathway directness (i.e., time, distance).

9. Provide shelters/barriers (countermeasures) for the purpose of increasing utilization.

10. Modify and/or reconstitute non-functional elements related to the pathway environment for the purpose of increasing access and/or amenity.

11. Provide activity node to create attributes like interest, activity and amenity which reduce effective trip length (i.e., time and distance).

12. Provide effective pathway width based upon desired level of service for the purpose of providing adequate capacity for trip-making.

13. Maximize effective width of existing R.O.W. by manipulation of streetscape elements to increase capacity and avoid conflicts with vehicular R.O.W.

14. Provide area required (square feet) for various special pathway conditions such as intersections, queuing, crosswalks, window shopping, access portals, street furniture, landscaping, special provisions for the handicapped and elderly, etc.

(Table 32 Continued)

15. Provide countermeasures to pathway route for the purpose of reducing utilization where pedestrian movement is to be reallocated to other pathways.

16. Provide connectivity between land use activities which require trip exchange for the purpose of increasing accessibility.

17. Provide or modify access to other modes for the purpose of increasing modal availability through increased orientation.

18. Provide or reconstitute facility in terms of location for the purpose of increasing modal availability.

OTHER REQUIREMENTS NOT EXPRESSED IN 1-18 ABOVE THAT MAY DERIVE FROM THE SURVEY, ONSITE OBSERVATIONS, ETC. ARE TO BE LISTED BELOW AND THE USER MAY LOCATE THEM IN WORKSHEET.

19.

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SEGMENT

PATHWAY ATTRIBUTES			1 Tripmaker	2 Social Dysf. (Needs, Attitudes & Perceptions)	3 Economic Dysf. (Needs, Attitudes & Perceptions)	4 Environmt. Dysf. (Needs, Attitudes & Perceptions)	5 Trip Volume	6 Trip Patterns	7 Trip Length	8 Pathway Impedance	9 Modal Interface	Frequency of Attribute Relevance	Ranking of Attribute by Frequency
Accessibility		A	1		4	7, 10	14	4,15,16		5	18		
Directness	Distance	B			4	8			11	8			
Directness	Time	C			4	8			11	8			
Continuity		D	1		5			16		5			
Capacity*		E					12,13,14						
Safety		F		2		2,7				2,7			
Security		G		2									
Information	Coherence	H											
Information	Orientation	I	1		6			17			17		
Env. Protection		J				9				9			
Amenities		K		3		10			11				
Attractiveness	Interest	L							11				
Attractiveness	Activity	M							11				

Table 33

Segment Pedestrian Requirements Worksheet

The matrix is basically a framework for generating and synthesizing ideas on the existence or deficiency of site specific elements or attributes that foster utilization and the priorities amongst them.

The frequency of mention of any attribute is summed and the results ranked in the spaces provided on the worksheet.

It will be noted that the trip making characteristic of <u>trip purpose</u> is omitted from the Worksheet 33. Trip purpose, as has been mentioned, will invoke different attributes to varying degrees depending on the particular purpose. These relationships have been the subject of special study, both for the purposes of adjusting intercentroid separation in the gravity model as well as for the provision of appropriate attributes in the design requirements program. The requirements and their related attributes that have been developed to date in these procedures are responses to specific problems or opportunities. The trip purpose related requirements that are to be developed next are more general in nature and constitute the necessary environmental context or ambiance for the pathway's trip purpose. These attributes will exist or be deficient in the actual environment in varying degrees.

Worksheet 34 includes a trip purpose related scoring of attributes. These are to be multiplied by the volume percentage of the like trip purpose on the segment. The results are totalled across all three trip purposes and then ranked.

The attribute ranking from worksheet 33 is then entered alongside the trip purpose ranking. The two rankings for each segment and associated notes are an interpretation of the pedestrian network program requirements. They are used directly in the selection of design treatments which are interfaced with the required attributes in Section 25.2.

The next and final component of the design requirements program to be addressed is that of the necessary pathway dimensions to accommodate for pedestrian volumes.

13.4 Examination of Network Capacity Requirements

13.5 Task Description

An important aspect of designing pedestrian networks is the proper sizing of facilities. Pedestrian components should be designed and sized to provide adequate capacity to handle projected volumes in a comfortable and convenient, as well as economical manner. Capacity design should provide for a balance between undersizing, which could lead to excessive congestion, and oversizing, which would lead to uneconomical solutions.

In the following sections, procedures are provided to facilitate the determination of pedestrian network capacity requirements. The design standards proposed in this manual are based on a "level-of-

Pathway Attributes		Trip Purpose: Enter./Soc./Rec.	Trip Purpose: Shopping	Trip Purpose: Work		Trip Purpose by Percentage			Totals	Rank	Attribute Rank from Worksheet 13.3.3.2
ACCESSIBILITY		18.7	31.0	22.1							
DIRECTNESS	DISTANCE	13.3	21.5	28.3							
	TIME	35.9	20.6	28.3							
CONTINUITY IMPEDANCE		16.3	19.1	22.7							
SAFETY		52.9	21.7	20.5							
SECURITY		52.9	21.7	20.5							
INFORMATION	COHERENCE	41.1	20.1	20.6							
	ORIENTATION	41.1	20.1	20.6							
ENV. PROTECTION PHYSICAL COMFORT		59.5	15.8	21.1							
AMENITIES		58.9	16.0	12.7							
ATTRACTIVENESS	INTEREST	61.1	15.9	16.8							
	ACTIVITY	61.1	15.9	16.8							

Table 34

Worksheet For Trip Purpose-Related Pathway Attributes service" concept similar to that employed in vehicular facility planning. Pedestrian level of service descriptions for walkways, stairways and queuing areas are illustrated in Figures 44, 45 and 46, respectively. The level-of-service standards define the quality of pedestrian movement as a function of inter-personal space, and reflect the fact that as inter-personal distances decrease, the density of pedestrian traffic is increased, and the pedestrian's freedom of movement, in terms of speed and maneuverability, becomes more constrained to the point of intolerable congestion. Hence, the level-of-service becomes an important factor in establishing capacity requirements.

Another important factor derives from the cyclical variation in pedestrian traffic flow. The cyclical variations have periods which are influenced by time of day, purpose of the trip, day of the week, and season of the year. For the purpose of determining capacity requirements for typical CBD situations, the critical components of pedestrian traffic flow are the peaks in volume that occur during a week (work) day at the morning, noon or evening rush. In addition to the peaking, the traffic flows during these peak periods is not likely to be uniform, but is apt to exhibit random unevenness and bunching of pedestrians known as platooning. In developing the spatial design standards in response to volumes, the possible effects of platooning within the peak period must be taken into account.

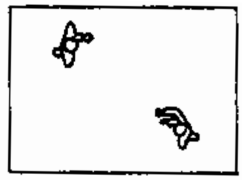
The pedestrian network plan is composed of a number of components or facilities, including walkways, stairways, street crossings, bus stops, etc. These facilities accommodate pedestrians not only in locomotion but also in queuing situations. Generally the most concentrated area of pedestrian traffic occurs at street intersection points where two sidewalk corridors intersect, and flow alone one of these corridors is interrupted by the traffic signal phasing that regulates street crossing. These intersection areas within the pedestrian network plan can be generally characterized as the "weakest link in the chain." They are the least desirable location for sidewalk impediments that could further constrict traffic flow.

The procedures that follow translate established level-of-service standards derived from prior research, together with estimates of peak period pedestrian volumes, into spatial design requirements for pedestrian network requirements. Procedures have been developed for 5 prototypical network situations commonly found in downtown area pedestrian plans:

1) walkway width requirements
2) sidewalk intersection area requirements at signalized intersections (See also Supplement 11)
3) stairway width requirements
4) escalator design capacity requirements
5) other queuing area requirements (bus stops, interface areas of pathway segments with different flow capacities, etc.)

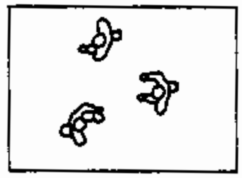
WALKWAY LEVEL OF SERVICE A

Average Flow Volume: 7 PFM* or less
Average Speed: 260 ft/min.
Average Pedestrian Area Occupancy: 35 sq.ft./person or greater
Description: Virtually unrestricted choice of speed; minimum maneuvering to pass; crossing and reverse movements are unrestricted; flow is approximately 25% of maximum capacity.



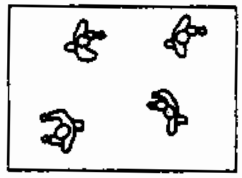
WALKWAY LEVEL OF SERVICE B

Average Flow Volume: 7-10 PFM
Average Speed: 250-260 ft/min.
Average Pedestrian Area Occupancy: 25-35 sq.ft./person
Description: normal walking speeds only occasionally restricted; some occasional interference in passing; crossing and reverse movements are possible with occasional conflict; flow is approximately 35% of maximum capacity.



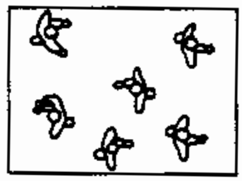
WALKWAY LEVEL OF SERVICE C

Average Flow Volume: 10-15 PFM
Average Speed: 230-250 ft/min
Average Pedestrian Area Occupancy: 15-25 sq.ft./person
Description: walking speeds are partially restricted; passing is restricted but possible with maneuvering; crossing and reverse movements are restricted and require significant maneuvering to avoid conflict; flow is reasonably fluid and is about 40-65% of maximum capacity.



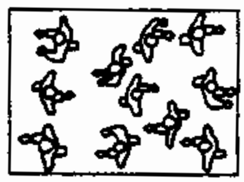
WALKWAY LEVEL OF SERVICE D

Average Flow Volume: 15-20 PFM
Average Speed: 200-230 ft/min.
Average Pedestrian Area Occupancy: 10-15 sq.ft./person
Description: walking speeds are restricted and reduced, passing is rarely possible without conflict; crossing and reverse movements are severely restricted with multiple conflicts; some probability of momentary flow stoppages when critical densities might be intermittently reached; flow is approximately 65-80% of maximum capacity.



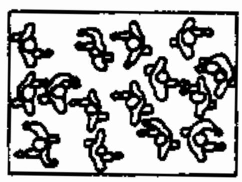
WALKWAY LEVEL OF SERVICE E

Average Flow Volume: 20-25 PFM
Average Speed: 110-200 ft./min.
Average Pedestrian Area Occupancy: 50-10 sq.ft./person
Description: walking speeds are restricted and frequently reduced to shuffling; frequent adjustment of gait required; passing is impossible without conflict; crossing and reverse movements are severely restricted with unavoidable conflicts; flows attain maximum capacity under pressure, but with frequent stoppages and interruptions of flow.



WALKWAY LEVEL OF SERVICE F

Average Flow Volume: 25 PFM or more
Average Speed: 0-110 ft./min.
Average Pedestrian Area Occupancy: 5 sq.ft./person or less
Description: walking speed is reduced to shuffling; passing is impossible; crossing and reverse movements are impossible; physical contact is frequent and unavoidable; flow is sporadic and on the verge of complete breakdown and stoppage.



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

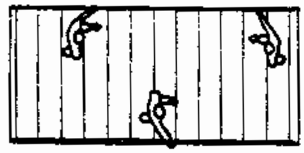
Source: Fruin, John J., Pedestrian Planning and Design, MAUDEP Inc., 1971.

Figure 44

Walkway Level Of Service Descriptions

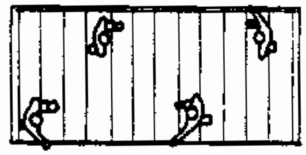
STAIRWAY LEVEL OF SERVICE A

Average Flow Volume: 5 PFM* or less
Average Speed: 125 ft/min. or more
Average Pedestrian Occupancy Area: 20 sq.ft./person
Description: unrestricted choice of speed; relatively free to pass; no serious difficulties with reverse traffic movements; flow is approximately 30% of maximum capacity.



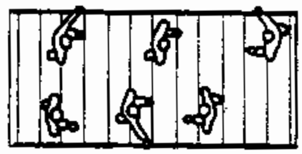
STAIRWAY LEVEL OF SERVICE B

Average Flow Volume: 5-7 PFM
Average Speed: 120-125 ft/min.
Average Pedestrian Occupancy Area: 15-20 sq.ft./person
Description: restricted choice of speed; passing encounters interference; reverse flows create occasional conflicts; flow is approximately 34% of maximum capacity.



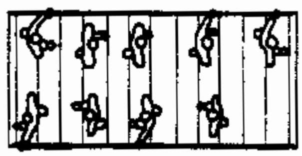
STAIRWAY LEVEL OF SERVICE C

Average Flow Volume: 7-10 PFM
Average Speed: 115-120 ft/min.
Average Pedestrian Area Occupancy: 10-15 sq.ft./person
Description: speeds are partially restricted; passing is restricted; reverse flows are partially restricted; flow is approximately 50 percent of maximum capacity.



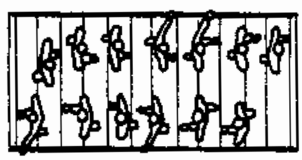
STAIRWAY LEVEL OF SERVICE D

Average Flow Volume: 10-13 PFM
Average Speed: 105-115 ft/min.
Average Pedestrian Area Occupancy: 7 - 10 sq.ft./person
Description: speeds are restricted; passing is virtually impossible; reverse flows are severely restricted; flows are approximately 50-65% of maximum capacity.



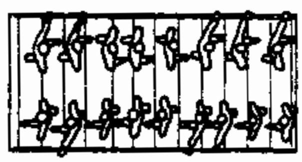
STAIRWAY LEVEL OF SERVICE E

Average Flow Volume: 13-17 PFM
Average Speed: 85-115 ft/min.
Average Pedestrian Area Occupancy: 4-7 sq.ft./person
Description: speeds are severely restricted; passing is impossible; reverse traffic flows are severely restricted; intermittent stoppages of flow are likely to occur; flows are approximately 65-85% of maximum capacity.



STAIRWAY LEVEL OF SERVICE F

Average Flow Volume: 17 PFM or greater
Average Speed: 0 - 85 ft./min.
Average Pedestrian Area Occupancy: 4 sq.ft./person or less
Description: speed is severely restricted; flow is subject to complete breakdown with many stoppages; passing as well as reverse flows are impossible.



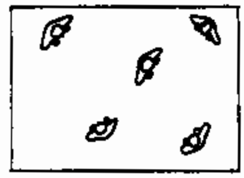
*PFM = Pedestrians per foot width of stairway, per minute.

Source: Fruin, John J., Pedestrian Planning and Design, MAUDEP Inc., 1971.

Figure 45

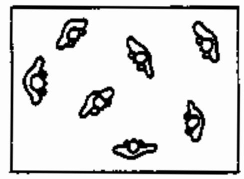
Stairway Level Of Service Descriptions

QUEUING LEVEL OF SERVICE A



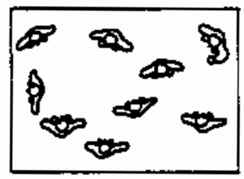
Average Pedestrian Area Occupancy: 13 sq.ft./person or more
Average Inter-person Spacing: 4 ft., or more
Description: standing and free circulation through the queuing area is possible without disturbing others within the queue.

QUEUING LEVEL OF SERVICE B



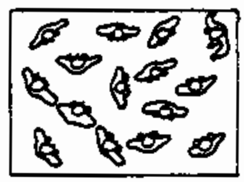
Average Pedestrian Area Occupancy: 10-13 sq.ft./person
Average Inter-person Spacing: 3.5-4.0 ft.
Description: standing and partially restricted circulation to avoid disturbing others within the queue is possible.

QUEUING LEVEL OF SERVICE C



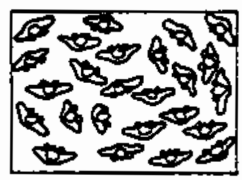
Average Pedestrian Area Occupancy: 7 - 10 sq.ft./person
Average Inter-person Spacing: 3.0 - 3.5 ft.
Description: standing and restricted circulation through the queuing area by disturbing others within the queue is possible; this density is within the range of personal comfort.

QUEUING LEVEL OF SERVICE D



Average Pedestrian Area Occupancy: 3 - 7 sq.ft./person
Average Inter-person Spacing: 2 - 3 ft.
Description: standing without touching is possible; circulation is severely restricted within the queue and forward movement is only possible as a group; long term waiting at this density is discomforting.

QUEUING LEVEL OF SERVICE E



Average Pedestrian Area Occupancy: 2 - 3 sq.ft./person
Average Inter-person Spacing: 2 ft. or less
Description: standing in physical contact with others is unavoidable; circulation within the queue is not possible; queuing at this density can only be sustained for a short period without serious discomfort.

QUEUING LEVEL OF SERVICE F

Average Pedestrian Area Occupancy: 2 sq.ft./person or less
Average Inter-person Spacing: close contact with persons
Description: virtually all persons within the queue are standing in direct physical contact with those surrounding them; this density is extremely discomforting; no movement is possible within the queue; the potential for panic exists in large crowds at this density.

Source: Fruin, John J., Pedestrian Planning and Design, MAUDEP Inc., 1971.

Figure 46

Queuing Level Of Service Descriptions

13.6 References

Supplement 11 provides in Part I a worked example based on the procedures in Section 13.7.2 and in Part II provides Procedures for computing intersection area requirements for standard signal phases.

13.7 Procedures

13.7.1 Walkway Width Requirements

The design width, that is, the actual dimensional characteristic of a walkway component, can be viewed as the sum of two components:

- The effective width (EWW) - that portion of the walkway actually available for pedestrian travel, free from any physical obstruction or impedance, and
- The ancillary width (AWW) - that portion of the walkway occupied by impediments, or otherwise not available for pedestrian travel such as areas for window shopping, queuing and street furniture.

With regard to the effective width, this physical dimension is a function of:

- The number of pedestrians (volume) passing a fixed point on the walkway per unit of time (this is usually referred to as the demand volume expressed in pedestrians per minute, or per hour);
- The average pedestrian walking speed along the walkway component; and
- The average pedestrian space module or area, expressed as square feet per pedestrian.

The last factor, the pedestrian space module, is established as a design standard, and is the basis for describing level-of-service standards. Given estimated pedestrian volumes and walking speeds, and specified space modules or level-of-service standards, the computation of effective walkway width is accomplished using traditional flow theory. For example, using volumes expressed in minutes:

EWW (FT) = effective walkway width, in feet

$$= \frac{V\left[\frac{\text{Peds}}{\text{Min}}\right] \quad M\left[\frac{\text{Sq. Ft.}}{\text{Ped}}\right]}{S\left[\frac{\text{Ft.}}{\text{Min.}}\right]}$$

where -

V = demand volume, in pedestrians per minute;
M = specified space module, in square feet per pedestrian; and
S = walking speed, in feet per minute

The above equation can be rewritten in the following form:

$$\frac{V}{EWW} \qquad \frac{Peds}{Ft.\ Min.} \quad = \quad \frac{S}{M} \quad = \quad P$$

Where P equals the pedestrian flow per minute per foot of walkway width. The measure, P, in pedestrians per foot per minute or PFM, is a convenient measure of walkway capacity.

To obtain the design walkway width (DWW), the effective walkway width (EWW) must be augmented, as required, by the ancillary walkway width (AWW). Factors that will affect the dimension of AWW are:

- Clearance requirements for buildings, walls fences, or curbs;
- Clearance requirements for window shoppers, pedestrian queues at bus stop or building entrances, and similar fixed pedestrians; and
- Clearance requirements for trees, parking meters, fire hydrants, newsstands, benches, and similar fixed objects.

Recommended walkway width standards are provided in Figure 47. The curve for effective walkway width is expressed as a function of the volume of pedestrians per hour, as factored up to account for the peak fifteen minutes within the hour. The ancillary walkway width is given a fixed dimension line for minimum setback requirements from curbs and building lines.

The standards in Figure 47 do not uniformly apply level-of-service standards to all demand volumes. Instead, the concepts inherent in these standards have been combined with considerations of peaking and the dynamic acceptance by pedestrians of reduced levels of service when volumes are high,* to produce a single, practical requirement. For example, the threshold of level of service A at 7 PFM provides a practical flow standard and walkway width requirement for peak demand flows of 5000 pedestrians/hour. As demand flows decrease from this point, level of service A at 7 PFM becomes an increasingly inappropriate standard that can lead to insufficient walkway widths. As demand flows increase above 5000 peds/hour, level of service A at 7 PFM begins to yield excessive, costly and impractical width requirements.

At lower flow demand levels, effective walkway width requirements become less a function of theoretical flow capacity and more a function of pedestrians desiring to walk abreast of each other in voluntary groups or to pass each other. Where low peak demand flows occur (below 500 pedestrians/hour) the minimum effective walkway width for any segment of the pedestrian network plan should not fall below 5 feet. This standard has been set to allow two pedestrians to pass each other without unreason-

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*In shopping environments one may indeed argue that some degree of crowding is desirable for the creation of an appropriately lively atmosphere.

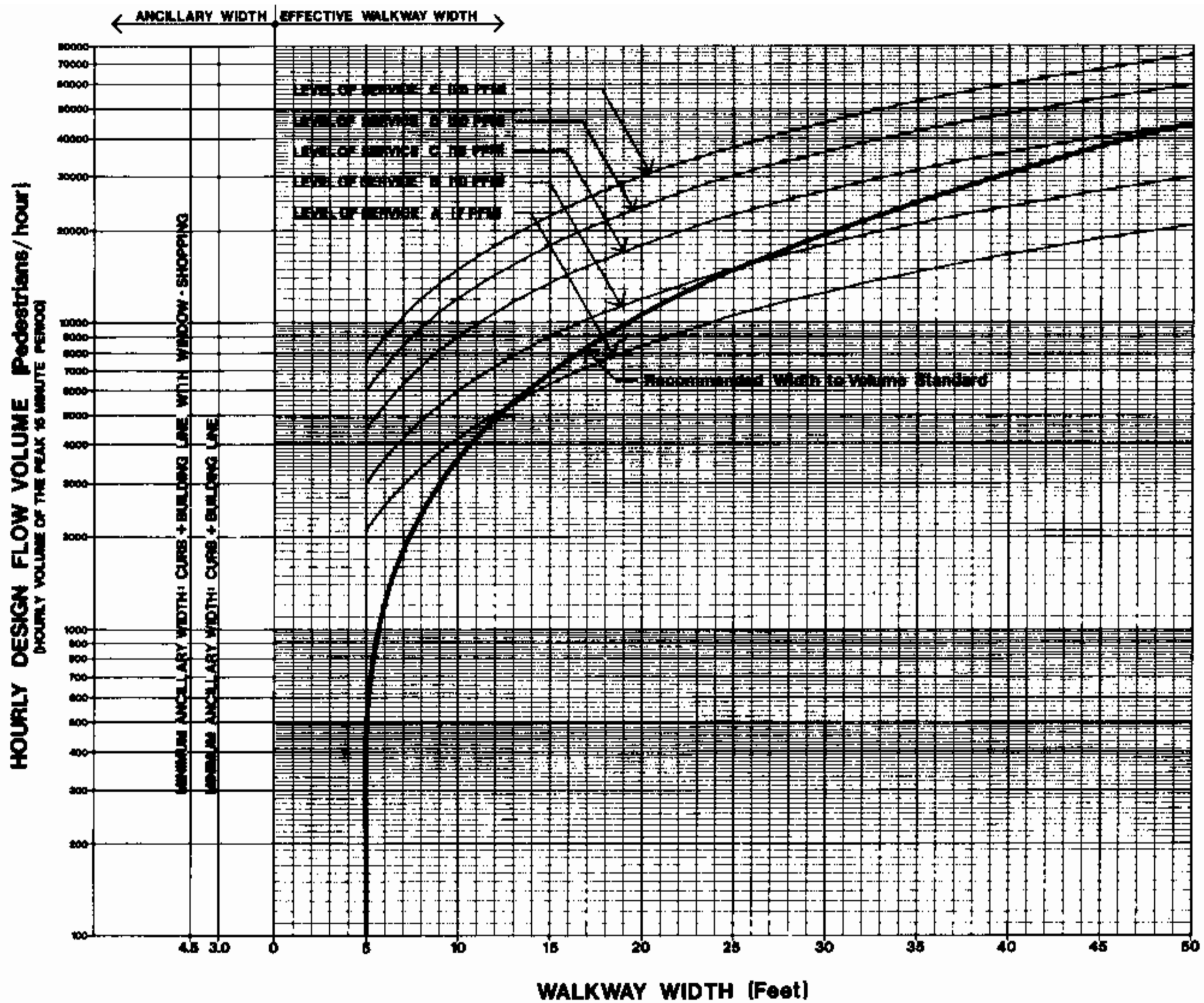


Figure 47

Recommended Walkway Width Standards

able evasive maneuvering. At flow demands above 5000 pedestrians/hour, less spacious design standards than Level of Service A at 7 PFM are acceptable and necessary to provide practical solutions. When demand flow reach 45,000 pedestrians/hour (a highly unusual occurrence such as mass exiting from a major stadium event), the acceptable standard has been set at the threshold of level of service C (15 PFM). This standard has been established at this extreme, based upon the potential impact during a one minute peak, which would produce an hourly demand flow rate of 60,000 peds/hour, which on the recommended effective walkway width would result in a level of service D (20 PFM) during the one minute peak. For design purposes, level of service D at 20 PFM is the maximum acceptable flow standard.

In conclusion, the recommended effective walkway width standards for peak demand flows ranging from 100 to 45,000 pedestrians/hour have been graphically depicted in Figure 47. These standards* provide practical effective walkway width requirements for two-directional flow on a walkway segment of the pedestrian network.

To utilize the recommended standard in Figure 47.

(1) Convert peak 15-minute volumes (assigned by the model in Task 11) to hourly design flow by multiplying by four(4), or of peak hour volumes were used, multiply by 1.33 to account for the 15-minute peak within the hour;
(2) Determine (EWW) using the standard recommended by the curve in Figure 13.7.1.1;
(3) Determine (AWW) requirements using standards in Fig. 48.
(4) Compute the final design walkway width by adding EWW to AWW.

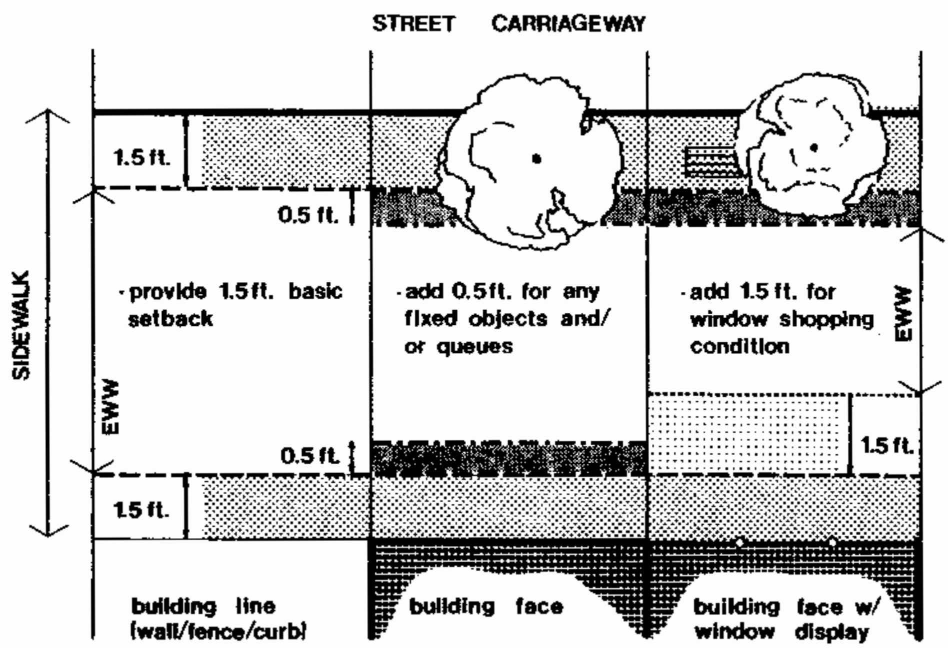


Figure 48

Ancillary Walkway Width Requirements

13.7.2 Walkway Intersection Area Requirements

Generally, the most concentrated area of pedestrian activity within the downtown walkway network occurs at signalized street intersections. At these intersection areas, pedestrian flows along two sidewalk corridors intersect each other and one of these flows is interrupted by the traffic signal phasing which regulates street crossing. Since these areas have higher concentrations of pedestrians and cross trafficking, they are the least desirable place for sidewalk impedimenta that could further constrict traffic flow.

Unless the critical network intersections were depicted in adquate detail in the network (Task Five), sufficient data to calculate intersection area requirements will not be yielded by the assignment model and its output must be augmented by onsite intersection counts and some interpretation and/or projection from these.

Area requirements for the walkway system at signalized street crossing areas are of two types: 1) Circulation Area and 2) Holding Area. Circulation Area is necessary to accommodate traffic flow not interrupted by the signal cycle phase, while Holding Area is necessary to accommodate the maximum build-up of those pedestrians waiting for the traffic signal to change in favor of their desired crossing. (See Figs. 49, 50 for an illustration of the above concepts.)

Recommended standards for circulation area requirements at intersections reflect the same logic employed for sizing walkways -- namely that at higher volumes, less spacious yet acceptable area standards are needed. The methodology employed to calculate circulation area requirements at intersections entails the summation of area requirements for each set of incoming circulation vectors that intersect each other perpendicularly during a particular light phase. The resulting area requirement for circulation reflects the density standards of incoming traffic flow but at a higher acceptable density than found on the incoming sidewalks at midblock.

Holding area requirements at intersections are determined by applying a queuing space standard to the projected peak build-up of pedestrians waiting at the intersection for the signal phase to change in favor of their desired street crossing. The minimum recommended space module for queuing in holding areas is 5 sq. ft./person (queuing level of service D).

Total area required at the sidewalk intersection area is the sum of the required circulation area and holding area at that intersection. However, the area requirements at a sidewalk intersection will vary depending upon the particular phase of the signal cycle. Therefore, calculations are necessary for each phase of the light cycle to determine which phase requires the maximum area (most space consuming phase of the total signal cycle).

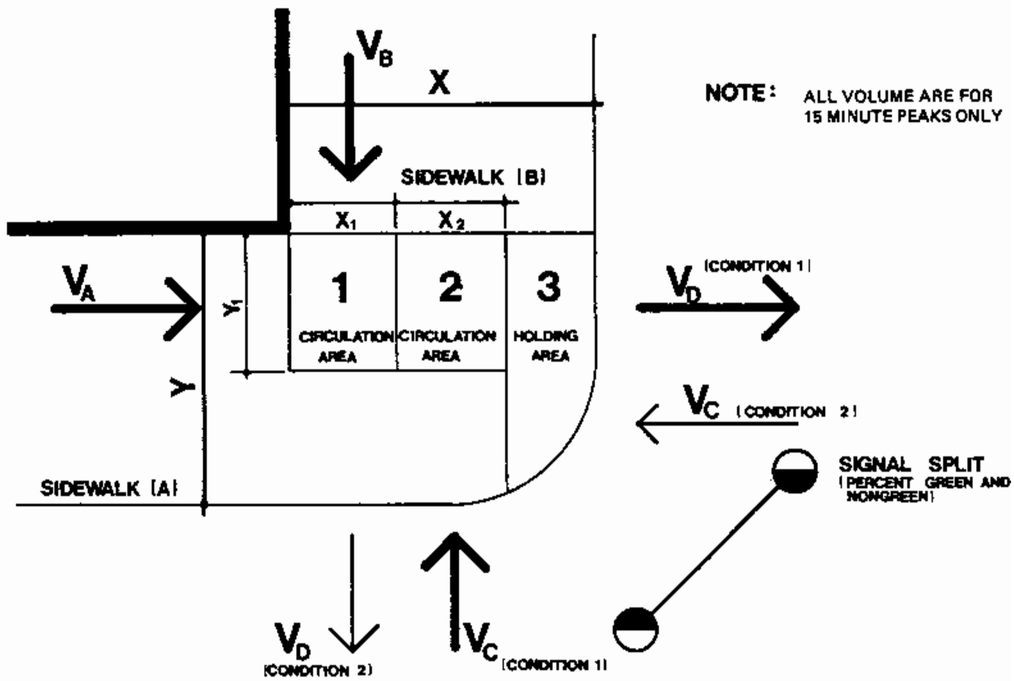


Figure 49

Area Required For Condition 1 Movement Vectors

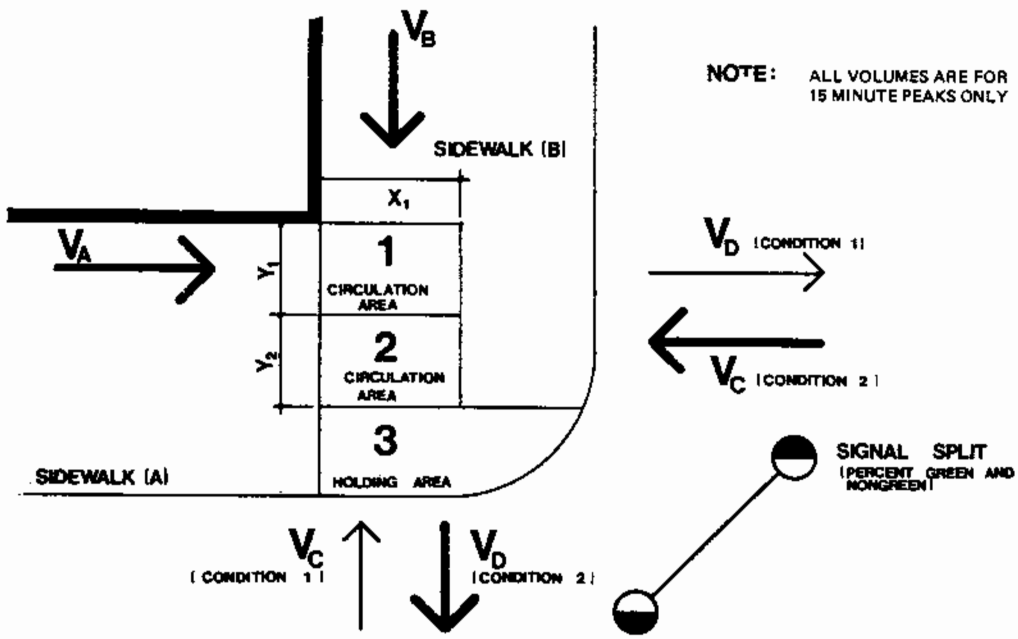


Figure 50

Area Required For Condition 2 Movement Vectors

An overview of the procedure for determining walkway requirements at signalized intersections is shown in Figure 51. The nomenclature of movement vectors and area designations is shown in Figures 49, and 50. Note that the two conditions, corresponding to the typical two phase signal cycle, are shown in the figure. The procedures described below are repeated twice - once for each condition. The two resultant area requirements are then compared to determine the maximum.

Following Figure 51, the procedures are as follows:

(1) Initialize Movement Vectors

Using Fig. 49 or Fig. 50 for guidance, assign 15-minute peak pedestrian volumes to the appropriate movement vectors;

(2) Adjust Volumes to Account for Peaking and Surging Conditions

Since the pedestrian traffic at signalized intersections is apt to be characterized by momentary peaks and surges of activity, the 15-minute volumes assigned to the movement vectors are adjusted to reflect this increased requirement and then converted to hourly volumes, using -

VA (ADJ) = Hourly peak pedestrian volume for Vector V_A

$$= \frac{V_A}{15}\left[\frac{\text{Peds}}{\text{Min}}\right] \quad 1.33 \quad 60\left[\frac{\text{Min}}{\text{Hr}}\right]$$

Where VA is the 15-minute peak incoming volume (which is not the total sidewalk volume in both directions), (ADJ) represents an adjustment factor, and 1.33 is the surging factor.

Similarly -

$$V_B\ (\text{ADJ}) = \frac{V_B}{15} \quad 1.33 \quad 60$$

The Vector, V_c, represents a special case. The actual peak demand for the incoming sidewalk vector will be relatively greater than the peaks for the other three vectors, because the measurement period for crossing is considerably less than the total time for the measurement period. The hourly peak for V_c is proportional to the raio of total signal cycle time (in seconds) to the total green time (in seconds) for the crossing minus three seconds associated with pedestrian start-up delay prior to beginning to cross. The composition for V_c is:

$$V_c\ (\text{ADJ}) = \frac{V_c}{15}\left[\frac{\text{PEDS}}{\text{MIN}}\right] \quad \frac{\text{TS}}{\text{TG-3}}\left[\frac{\text{SEC}}{\text{SEC}}\right]$$

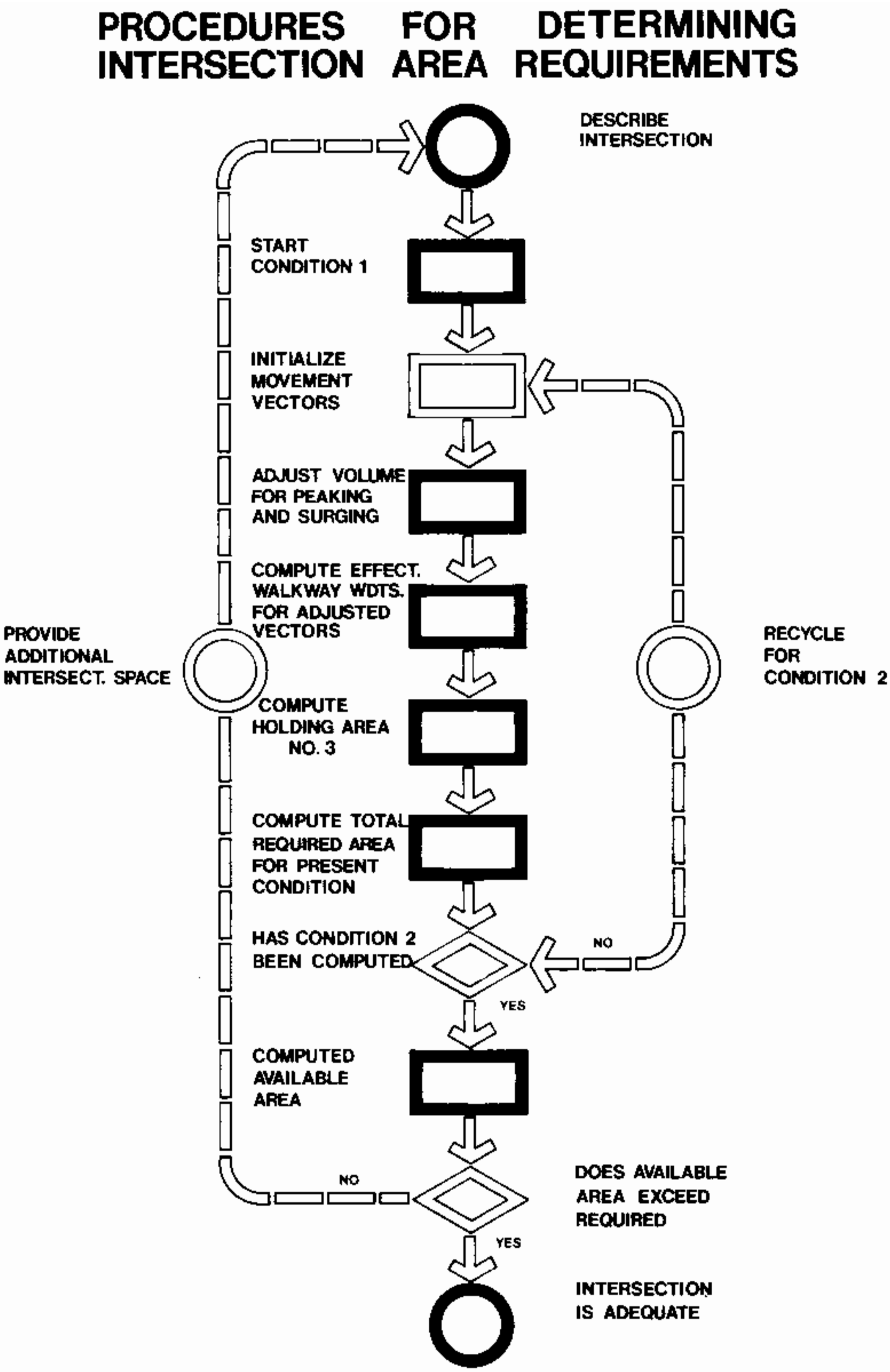


Figure 51

Overview Of Procedures For Determining Intersection Area Requirements

Vector	Cycle Time (TS)	Green Time (TG)	Adjustment Multiplier
V_A	NA	NA	5.33
V_B	"	"	"
V_D	NA	NA	0.09
V_C	All conditions*	All conditions*	$\frac{4 \cdot TS^*}{TG-3}$
V_C	80 sec	40 sec (50/50)	8.65
V_C	80 sec	32 sec (40/60)	11.03
V_C	80 sec	48 sec (60/40)	7.11

Table 35

Movement Vector Adjustment Factors
(15-minute Peak To Hourly Peak)

Where TS is the total signal cycle time in seconds, and TG-3 equals the total green time minus the 3 second start-up delay.

The Vector, V_D, for each condition is adjusted in the same manner as V_A and V_B, except that V_D is not converted to an hourly peak. Instead V_D is converted from a peak 15-minute volume to a peak one-minute volume, using -

$$V_D \text{ (ADJ)} = \frac{V_D}{15} \left[\frac{\text{Peds}}{\text{Min}}\right] \quad 1.33;$$

$$= 0.09\ V_D$$

The adjustments for Vectors V_A, V_B, V_C and V_D are summarized in Table 35. The adjusted V_C is shown for several cases involving standard signal phases.

(3) Compute EWW's for Adjusted Movement Vectors

Using Figure 13.1.4, determine the following effective walkway widths -

$(EWW)_A$ using V_A (ADJ);
$(EWW)_B$ using V_B (ADJ); and
$(EWW)_C$ for each condition using V_C (ADJ).

(4) Compute Holding Area #3 for Each Condition

HA (sq. ft.) = holding area #3 in square feet

$$= \frac{V_{D\ (ADJ)} \left[\frac{\text{Peds}}{\text{Min}}\right] \; 5 \left[\frac{\text{sq. ft.}}{\text{ped}}\right] \; \text{NGT} \quad \text{(sec)}}{60 \; \frac{\text{sec}}{\text{min}}}$$

$$= \left(\frac{1}{12}\right) \quad V_D \quad \text{(ADJ)} \quad \text{NGT}$$

Where NGT equals the nongreen time (or red time) faced by a pedestrian moving in the direction of the (V_D) vector.

(5) Compute Area Required for Condition 1

The area required for the present signal phase condition is given by -

AR (1) = area required for condition 1

= circulation area #1 + circulation area #2 + holding area #3

$$= (EWW)_A \quad (EWW)_B + (EWW)_A \quad (EWW)_C + HA$$

$$= (EWW)_A \; [(EWW)_B + (EWW)_C] + HA$$

(6) <u>Recycle for Condition 2</u>

For the area required for Condition 2, AR (2), recycle through steps (1) to (5).

(7) <u>Compute Available Area</u>

Refer to Figure 52 where the available intersection area can be read off for various combinations of intersecting sidewalk widths. The value of the curb radius (R) in Fig. 53 was assumed as follows:

R = 8 ft. for 8 ft. sidewalk widths
R = 10 ft. for 10 ft. sidewalk widths
R = 12 ft. for 12 ft. sidewalk widths
R = 15 ft. for 15 ft. and greater sidewalk widths

For two intersecting sidewalks of different widths, R is equal to the dimension of the lesser width.

The total width of sidewalk (X) and (Y) includes the effective width plus ancillary area.

For conditions not covered in Fig. 52, the area available can be computed using:

AA (sq. ft.) = available area in square feet

$$= 1.67\ XY - 0.215r^2$$

The effective width of sidewalk (A) or (B) at midblock is based upon peak hourly, two-directional volumes on each sidewalk (Vectors V_{AA} and V_{BB} in Fig. 53).

(8) <u>Compare Area Required (AR) with Area Available (AA)</u>

Condition 1 and Condition 2 will yield different total area requirements. For whichever is the greater, test;

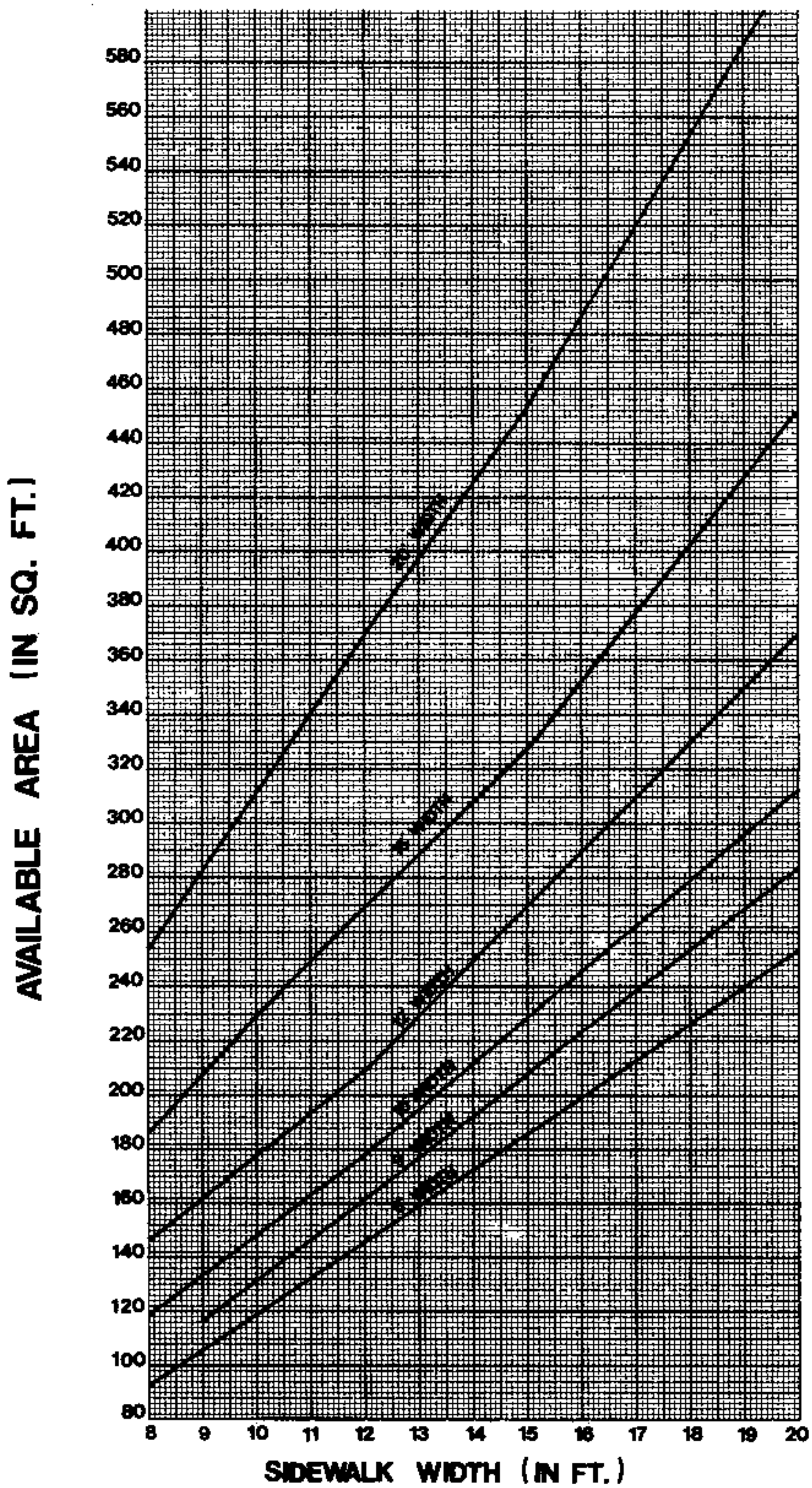
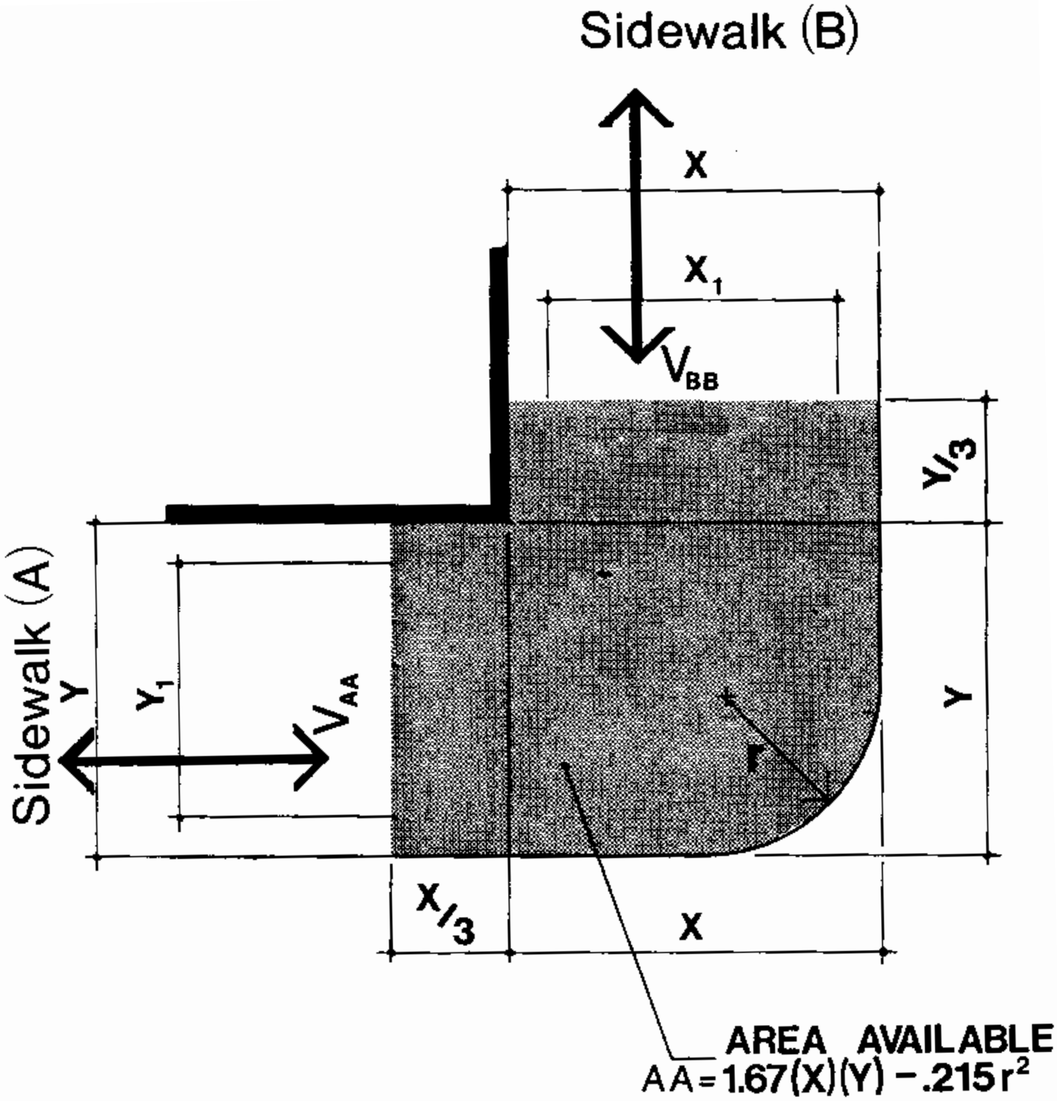
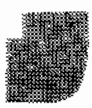


Figure 52
Available Intersection Area



AA = 

$\frac{X}{3}/\frac{Y}{3}$ = Auxiliary Area Available to Intersection

X = Total Sidewalk X Width

X_1 = Effective Sidewalk X Width

Y = Total Sidewalk Y Width

Y_1 = Effective Sidewalk Y Width

r = Radius of Curb where, $r \leq y$, $r \leq x$

Figure 53

Givens For Calculating Available Intersection Area

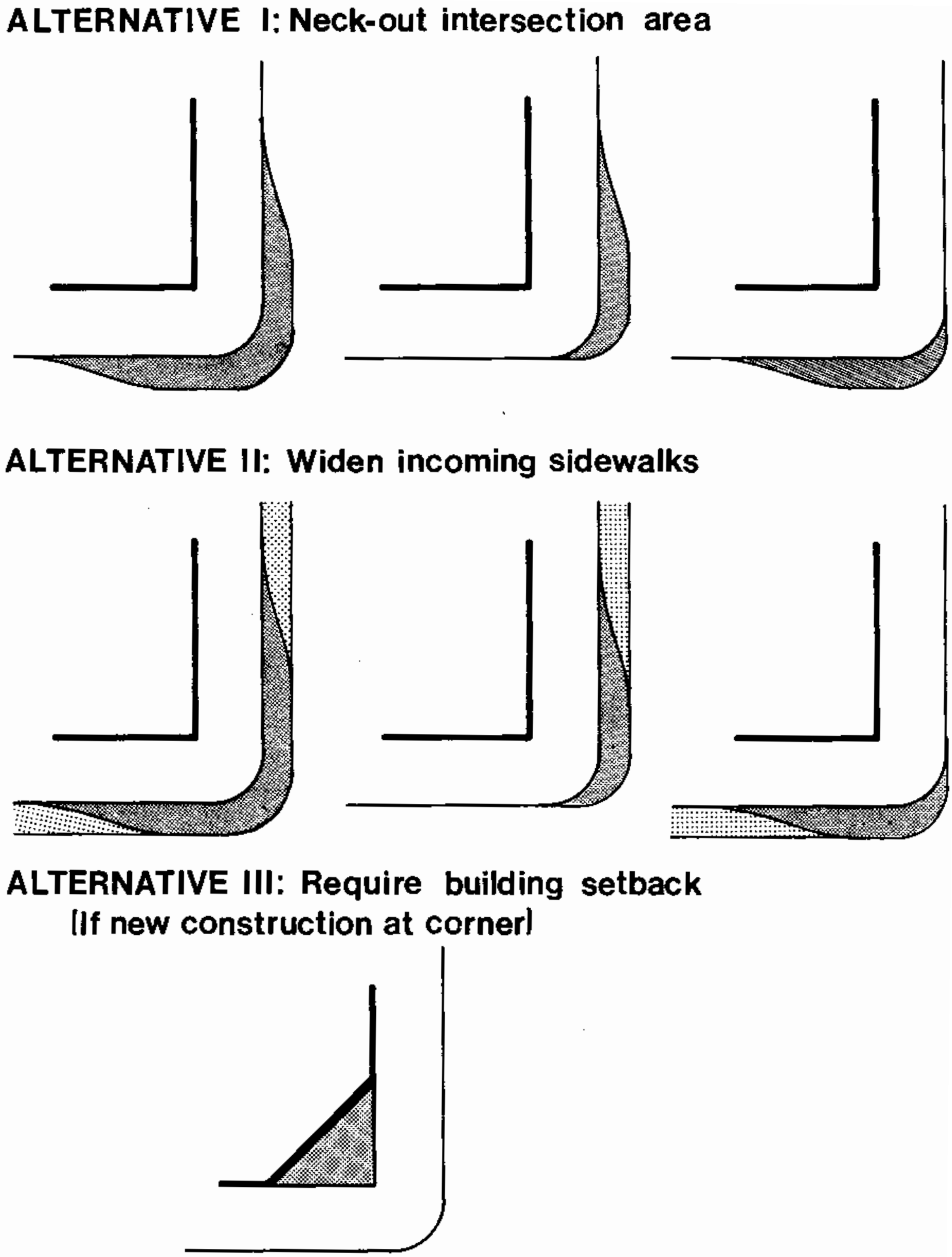


Figure 54

Alternative Methods Of Providing Additional Intersection Area

110% AA. . . intersection is adequate

If AR

110% AA. . . the intersection is deficient

That is, if the maximum of the two required areas is not greater than the available area by more than a 10% tolerance the intersection space is adequate; otherwise, it is deficient and additional space must be provided at the intersection to accommodate flow.

Some alternatives for treating intersections with deficient area are shown in Figure 54.

13.7.3 Crosswalk Width Requirements

To evaluate the crosswalk width requirements associated with Vector V_C and Vector V_D movements, the following procedures can be employed:

(1) Compute the Two-Directional Volumes

Let V_C (1) = 15 minute peak volume for movement Vector V_C during Condition 1.

Similarly, define $V_C(2)$, $V_D(1)$ and $V_D(2)$.

Then, the respective crosswalk 15-minute two-dimensional peak volumes can be defined as -

$V_1 = V_C(1) + V_D(2)$ and

$V_2 = V_C(2) + V_D(1)$.

The subscript for V_1 and V_2 indicate the crosswalk; subscript 1 refers to the vertical (north-south) crossing on Figures 49 and 50 and subscript 2 refers to the horizontal (east-west) crossing. Since the procedure is similar for both these crossings, the subscripts will be omitted in the following steps.

(2) Compute One-Minute+Adjusted Volume

$V(ADJ) \left[\frac{\text{Peds}}{\text{Min}}\right]$ = Peak one-minute two-dimensional pedestrian crosswalk volume

$$= \frac{V}{15} \left[\frac{\text{Peds}}{\text{Min}}\right] \quad \frac{TS}{TG - 3} \quad \left[\frac{\text{sec}}{\text{sec}}\right]$$

Where V is the 15-minute, two dimensional peak volume computed in (1) above, TS is the total signal cycle time and TG is the appropriate total green time, both expressed in seconds.

(3) Compute the Level of Service (PFM) of the Crosswalk

LS (PFW) = crosswalk level of service in peds per foor of width per minute.

$$= \frac{V \left[\frac{\text{peds}}{\text{min}}\right]}{EWW_S \text{ (ft)}}$$

Where V is the peak one-minute, two dimensional peak volume computed in (2) above, and EWW_S equals the effective walkway width of the incoming sidewalk; that is sidewalk A, or sidewalk B, in Figures 49 and 50.

(4) Evaluate the Level of Service

$$\text{If LS} \begin{cases} < 15 \text{ PFM. . . crosswalk is adequate} \\ > 15 \text{ PFM. . . crosswalk is deficient} \end{cases}$$

That is, if the crosswalk level of service computed in (3) above exceeds 15 PFM, the maximum allowable flow standard, then the crosswalk width should be increased to a minimum of -

EWW_C (ft) = minimum effective width of crosswalk

$$= \frac{V \left[\frac{\text{peds}}{\text{min}}\right]}{15 \left[\frac{\text{peds}}{\text{ft. min.}}\right]}$$

13.7.4 Stairway Width Requirements

Pedestrian traffic is more regulated on stairways than walkways. The pedestrian's perception of energy expenditure and safety is affected by the dimensional characteristics of the stair, i.e., its tread width, riser height and width between side railings. This, in turn, affects the flow capacity and width requirements of the stair to accommodate flow demand.

Stairway width requirements are determined similarly to walkway width requirements by applying a level of service standard to the projected peak flow demand volumes using the stair facility. Level of service standards for stairways have been described in Figure 13.1.2. The maximum practical flow capacity of a stairway is approximately 12 PFM. While flows above 12 PFM can be accommodated up to an absolute maximum of 19 PFM, the resulting quality of service is poor and should be avoided as a design standard for any stairway that is a part of the pedestrian network plan.

The dimensional characteristics of stairways are typically regulated by local building codes. Stairway width requirements are commonly specified in terms of unit widths of 22" and half-unit widths of 11". The maximum width between side railings is commonly set at 88". While the most efficient angle of incline for a stair in terms of traffic flow is 27°, an angle between 30°-35° is more commonly employed because of spatial and cost considerations. Arising out of an increased awareness to accommodate for the handicapped, a maximum riser height standard has generally been set at 7 inches.

This manual recommends a minimum stairway width of 4'-0" for any stairway that is a portion of the pedestrian network plan. This dimension has been established to allow two pedestrians to comfortably pass each other on the stairway. The recommended maximum flow rate standard to be applied to the projected peak 15 minute flow demand volume to determine stairway width requirements is 8 PFM. This flow standard should be used to size stairway widths where demand flow volumes require more than the 4'-0" minimum stairway width (i.e., hourly flow volumes above 2000 pedestrians/hour.) This standard has been set to avoid significant queuing at stairways and to accommodate one minute peak surges within the 12 PFM standard for maximum practical stairway flow capacity. Therefore, stairway width requirements can be determined as follows:

(1) Compute the peak pedestrian flow per minute by dividing the 15-minute peak volume by 15;

(2) Divide this resultant volume by 8 PFM, the level of service standard, to obtain the width requirement in feet;

(3) If the result is less than 4 feet, set the width to a <u>minimum of</u> 4 feet.

This procedure is summarized in the following:

SWR (ft) = stairway width requirement (in feet)

$$= \text{Max} \begin{cases} 4\ [\text{ft}] \\ \frac{V}{15} \left[\frac{\text{peds}}{\text{min}} \right] \qquad \frac{1}{8} \left[\frac{\text{ft. min.}}{\text{peds}} \right] \end{cases}$$

Where V = 15-minute peak pedestrian volume.

13.7.5 Escalator Design Capacity

Escalators are sometimes employed within the downtown pedestrian network plan to provide a mechanized ped-mover system for combined horizontal - vertical transfer of pedestrians. While escalators do not have higher flow capacities than stairways, they reduce the necessary energy expenditure by a pedestrian to change grade and, thus, can be used to induce greater pedestrian utilization of a particular pathway.

As part of the pedestrian network plan, an escalator should be viewed as complementary to, rather than a replacement of, necessary stairways, since adequate stairway facilities must be provided to accommodate pedestrian flows in the event of a breakdown in escalator service.

The physical attributes of escalators regulate their application and capacity. While escalator flow direction can be reversed, they provide only one directional service at any one time. Their angle of incline is typically 30°. Escalators operate almost exclusively at speeds of either 90 ft./minute (fpm) or 120 fpm. Capacity ratings provided by manufacturers are theoretical capacities. Practical or nominal capacity is about 75% of theoretical capacity. Table 36 displays typical escalator sizes and capacity characteristics. For design purposes those values entered under the "practical capacity" column should be used.

SIZE			SPEED	THEORETICAL CAPACTIY	PRACTICAL CAPACITY (ESC SERVICE RATE)	
STAIR WIDTH (")	RAILING WIDTH (")	OVERALL WIDTH (")	(FPM)	PEDS./HR.	PED./HR.	PED./MIN.
24	32	52	90	5,000	3,750	62.5
24	32	52	120	6,500	4,875	81.25
32	40	60	90	7,000	5,250	87.50
32	40	60	120	9,000	6,750	112.50
40	48	60	90	8,000	6,000	100.00
40	48	60	120	10,000	7,500	125.00

Source: J. Fruin, Pedestrian Planning and Design, 1971.

Table 36

Typical Escalator Speeds, Sizes And Capacities

13.7.6 Queuing Area Requirements

Queuing area is that area devoted to pedestrian activity that entails standing in a relatively stationary position for a period of time. A queue develops when the arrival rate to a particular point exceeds the capacity of the system to service pedestrians through that point. Queuing typically occurs within the pedestrian network at signalized intersections (as discussed earlier), bus stops, and theatre entrances as well as at stairway and escalator entry areas where the capacity of the stair or escalator is exceeded by the arrival rate of pedestrians on the pathway feeding the escalator or stair.

Queuing causes delay and inconvenience that is tolerable at varying degrees, depending upon trip purpose and available competing alternatives. Where queuing must occur, provision for sufficient holding area must be made to accommodate the queue and avoid creating an impedance to adjacent traffic flow as well as situations that would pose a risk to personal safety, i.e., confined situations where queues cannot be released at an adequate rate.

Queuing levels of services, as previously described in Figure 46 are based upon the human body dimension, psychological space preferences and the degree of personal mobility within the queue. The minimum queuing space module standard recommended in this manual is 5 sq. ft./person. The following procedures are used to determine the holding area required to accommodate various queues.

General Procedures:

1. Queuing areas for bus stops, theatres, etc: Bus stop waiting areas, theatre entrances, etc., are typically accommodated along the pedestrian walkway network. Since there are no competing alternatives for the above types of queues, the issue of tolerable waiting time and consequent diversion to alternatives does not apply. Adequate queuing area must be provided so that these queues do not become pathway impedances that constrict the necessary effective walkway width.

   Queuing areas for these types of facilities must be examined on a case by case basis to determine the extent of queuing that must be accommodated. Once the maximum number of persons accumulating in the area is estimated, a queuing level of service can be applied to determine the required area.

   The procedure for calculating the area required to accommodate for these types of queues is as follows:

$Q_{AR} = (P) \quad (M)$

Where,

Q_{AR} = maximum area required (sq. ft.)

P = maximum number of people accumulating in a given location, and

M = selected level of service space module (5 sq. ft. is the minimum recommended)

2. <u>Queuing areas at escalators</u>:

The following are required givens for the calculations:

1. (V) - Peak 15 min. volume in both directions.

2. (SR) - escalator service rate (peds/min) (given in Table 13.7.4.1).

3. (Wmax) - maximum tolerable waiting time before diverting to stairs or alternative facilities (in min).

   Research* has shown that the <u>maximum</u> tolerable waiting before diversion occurs is 60 sec. However, depending upon trip purpose, availability of alternatives, and perception of energy expenditure and risk associated with alternatives, this time interval can range between 30-60 sec. This value must be assessed and selected for each site specific condition.

Procedures:

1. Determine the arrival rate (AR) for the 1 min peak surge within the peak 15 min period.

$$AR = \frac{V}{15} \left[\frac{peds}{min}\right] \quad 1.33$$

where,

AR = arrival rate in (PPM)

V = 15 min peak volume in one direction and,

1.33 = surge rate adjustment factor for the 1 min peak within the 15 min peak period.

*J. Fruin, ibid.

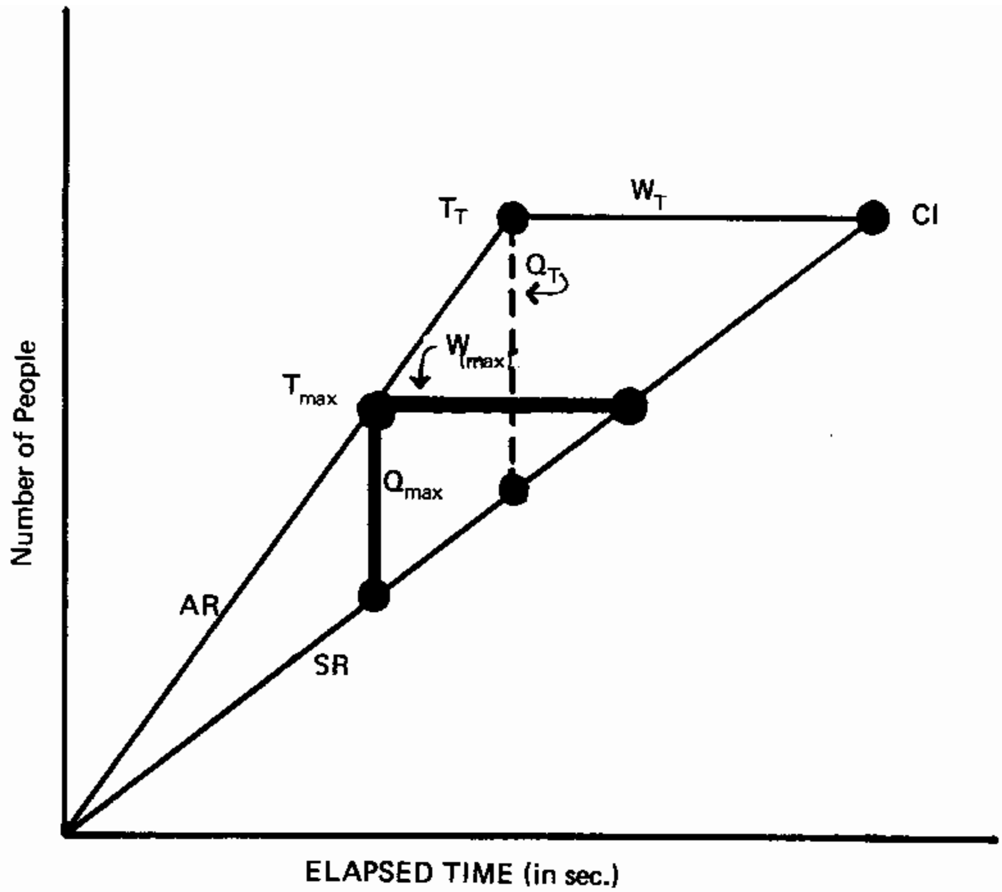


Figure 55

Relationship Between Escalator Queuing Variables

2. Select (Wmax).

3. Determine the maximum queue (Qmax) that will develop within the selected tolerable waiting time (Wmax) as follows: (See Fig. 55)

$$CI = \frac{AR \ (60)}{SR}, \text{ where}$$

CI = total elapsed time (in secs.) required for all arriving peds to move through the escalator.

W_T = CI - 60 where,

W_T = the total waiting time during the queue.

T_T = CI - W_T where

T_T = total elapsed time (in secs.) until queue begins.

$$T(max) = \frac{W\ (max) \ [^{T}T]}{W_T} \quad \text{where,}$$

T(max) = total elapsed time (in secs.) at which the maximum tolerable waiting time (Wmax) begins.

If Tmax $\leq$ Wmax then,
Q(max) = W(max)(SR) where,
W(max) = maximum number of people in the queue within the maximum tolerable waiting time (Wmax).

If Tmax $>$ Wmax then,

$$Q_T = \frac{(AR) \ (^{W}T)}{CI} \quad \text{where,}$$

Q_T = maximum number of people in the queue during the total waiting time (W_T)

Q_T = maximum number of people in the queue during the total waiting time (W_T)

then,

$$Qmax = \frac{Q_t \quad (Wmax)}{W_T}$$

4. Determine the minimum queuing area required at the escalator approach zone:

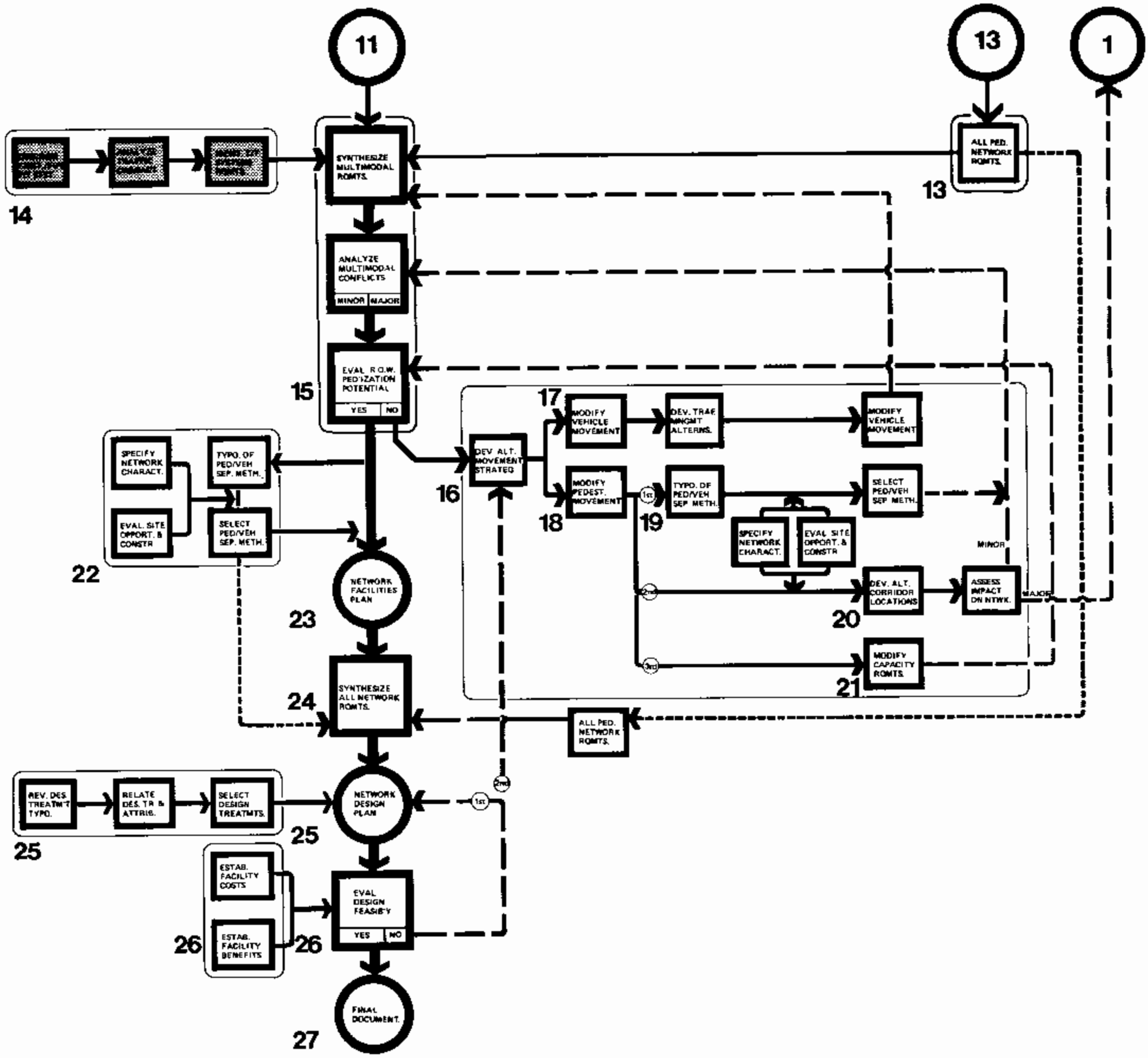
*A = Q(max) (M) where,

A = area required in sq. ft.,
(M) = queuing level of service space module (recommended at 5 sq. ft. per person).

*NOTE: Pedestrians in queuing at the approach zone to an escalator will tend to "bunch." In order to accommodate for this phenomenom (A) should approximate a square.

IDENTIFY TRAFFIC AND TRANSIT NETWORK REQUIREMENTS

14



TASK 14

IDENTIFY TRAFFIC AND TRANSIT NETWORK REQUIREMENTS

14.1 Task Description

Since the pedestrian network will for the most part utilize the available street rights-of-way, implementation in terms of the specific degree to which any particular network segment can be pedestrianized is a function of the specific R.O.W. requirements for accommodating other travel modes as well as pedestrian trip making.

If no increase beyond the existing sidewalk provision is required as a result of analyzing capacity requirements (Step 13.4) and if the physical/functional requirements yielded (Step 13.3) will not affect traffic or transit operations, then the investigation of other movement modes will be unnecessary and the PPP can be continued at Step 22.0.

In most cases, however, it can be expected that some aspects of the pedestrian network requirements will impact other movement modes. Therefore, a comparison between pedestrian network requirements and other modal requirements will have to be made (Task 15). Various aspects or characteristics of the vehicular access network service/delivery and transit systems thus must be initially examined. These include:

- operating characteristics
- areas of surplus capacity/deficiency
- systems dysfunctions
- the range of physical and functional constraints related to vehicular or transit usage and modal interface.

The above characteristics are examined specifically for the purpose of determining the amount of existing street R.O.W. which can be used to accommodate pedestrian circulation.

Figure 56 summarizes the concerns and relationship of Tasks 13 and 14.

14.2 References

The data sources related to identifying the traffic and transit characteristics mentioned in Step 14.0 are typically available from the following sources:

- Traffic studies (at the local, metropolitan or regional level)
- Transit studies
- Parking studies
- T.O.P.I.C.S. studies
- Transportation policy plans
- Traffic management plans
- Field observation

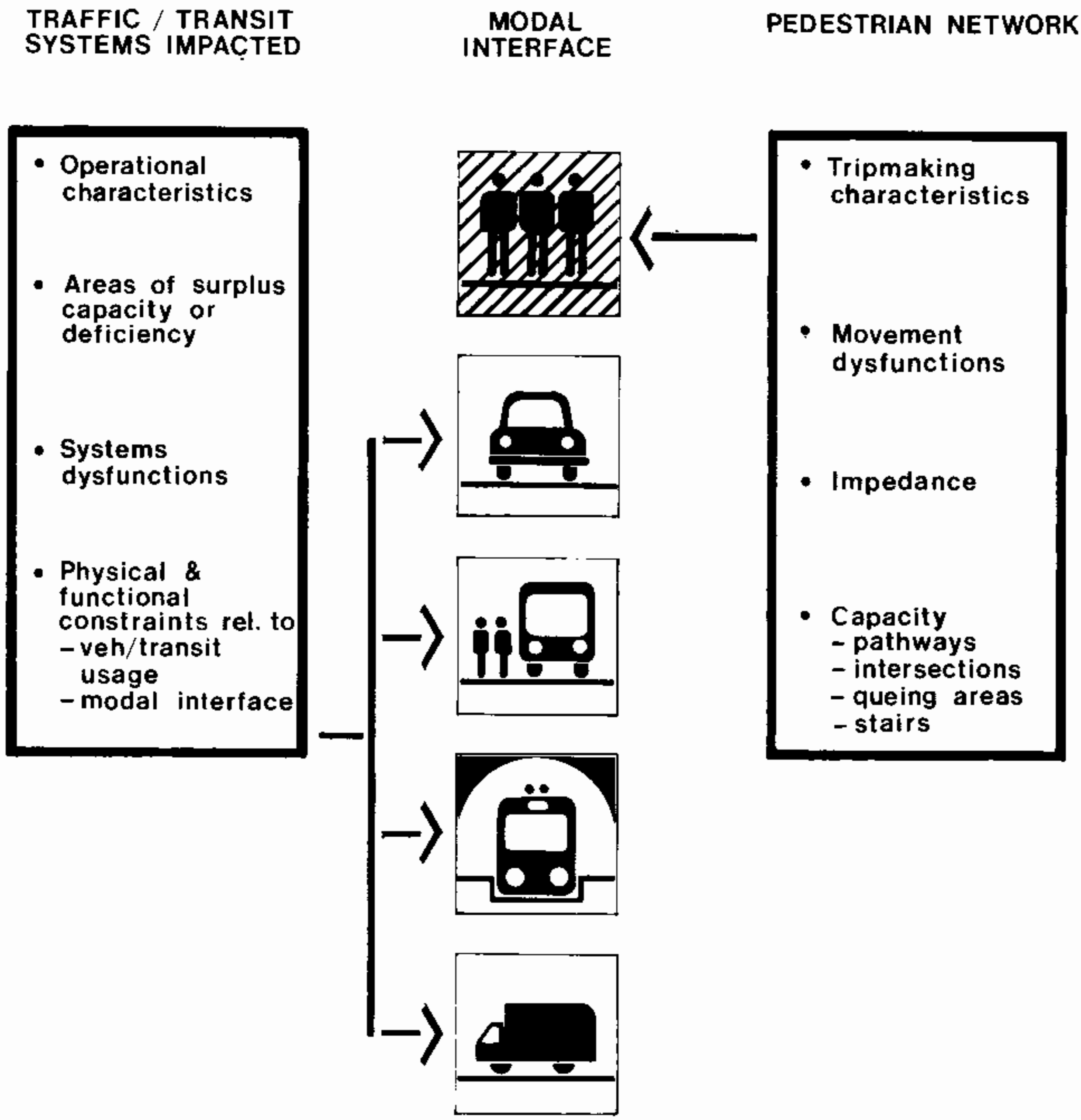


Figure 56

Interface Of Multimodal Requirements

Traffic and transit plans are normally developed within a prescribed or forecasted time frame. There may be considerable variation in time frame between such plans. The pedestrian network plan is also developed within the context of a specific time frame (e.g., 3 to 5 years, etc.). There is likely to be a difference between the time horizons of traffic and transit plans and that of the pedestrian network plan. The total requirements that all modes impose upon any specific R.O.W. must be evaluated within the same time frame as the pedestrian network plan. This will require that currently available traffic and transit plan proposals must be adjusted to correspond with the time frame of the pedestrian network. Depending upon the timeframe of such plans, this procedure may require the following reassessments:

- Updating or
- Projecting or
- Interpolation

14.3 Procedures

14.3.1 Describe Existing and Future Characteristics of Traffic and Transit Systems

1. Identify existing and future (for the planning time frame) modes which are potentially impacted by implementation of the pedestrian network, including:

   a. Vehicular access network
   b. Bus transit network
   c. Rapid transit network
   d. Service/delivery network
   e. Parking distribution

2. Map operating characteristics of the impacted modes.

   a. Vehicular access in terms of

      - traffic volume
      - directional flows (including turning movements, etc.)
      - travel patterns (O-Ds)
      - street functions (i.e., through traffic, arterials, collectors, distributors, etc.)

   b. Transit networks in terms of

      - existing routes
      - frequency
      - location of stops and access portals
      - current loading counts at points of discharge or entry (including access portal counts)

c. Service/Delivery Network

- existing routes
- frequency
- location of loading areas (on-street/off-street)

d. Parking

- distribution on-street (on-street and off-street)
- quantity (number of spaces)
- duration (long- or short-term occupancy)
- ownership (public/private)

14.3.2 Analyze Existing and Future Characteristics of T/T Systems

Table 37 provides a worksheet format for recording the relevant T/T characteristics by segment. These characteristics are elaborated in procedures 14.3.2.1 through 14.3.2.3.

14.3.2.1 Identify Areas of Surplus Capacity and Deficiency

1. Inventory streets which are coincident with pedestrian network corridors (illustrated by the network location plan in Task 11.0) in terms of:

- available R.O.W. width (including on-street parking)
- number of lanes
- direction of flow
- speed
- parking lane width

These data should be recorded in Table 38, Step 15.3.

2. Identify available capacity of specific street segments.

Employing the data from 1 above the available capacity for each street segment is determined by utilizing the procedures for capacity determination within the Federal Highway Capacity Manual*. The capacity available will identify the maximum number of vehicles that can be carried per hour, per lane for a given roadway under a specified set of environmental and traffic demand conditions.

3. Identify the actual levels of capacity for each street segment under examination.

*Highway Capacity Manual, Highway Research Board Special Report No. 87, Washington, D. C., 1965.

TRAFFIC AND TRANSIT SYSTEMS CHARACTERISTICS	STREET SEGMENT
A. LEVEL OF CAPACITY	
1 SURPLUS (+)	
2 DEFICIENCY (-)	
3 BALANCE (=)	
B. SYSTEMS DYSFUNCTIONS RELATIVE TO PEDESTRIAN TRIP MAKING	
4 PEDESTRIAN SAFETY DEFICIENCY	
5 PEDESTRIAN VEHICLE CONFLICT	
6 MODAL INCOMPATABILITY	
7 ACCESSIBILITY	
8 NEGATIVE ENVIRONMENTAL IMPACT	
SYSTEMS DISPLACEMENT	
9 Reduction of Net Parking Inventory	
10 Displacement of Parking	
11 Reduction of Service/Delivery Access	
12 Displacement/Reduction of Transit Interface (In Terms of Both Access & Availability)	
C. PHYSICAL/FUNCTIONAL CONSTRAINTS RELATIVE TO VEHICULAR/TRANSIT USAGE	
13 TURNING RADII FOR TRUCKS/BUSES/EMERGENCY VEHICLES	
14 SAFETY REGULATIONS AND COUNTERMEASURES	
15 TURNOUTS	
16 SERVICE DELIVERY ACCESS	
17 BUS STOP AREAS	
18 TAXI STANDS	
EVALUATION OF PEDESTRIANIZATION POTENTIAL	
MINOR POTENTIAL IMPACTS	
19 RESOLUTION THROUGH URBAN DESIGN TREATMENT	
MAJOR POTENTIAL IMPACTS	
20 RESOLUTION THROUGH THE DEVELOPMENT OF ALTERNATIVE MOVEMENT STRATEGIES	

Table 37

Worksheet Format - Traffic And Transit Characteristics

a. Compare the available capcity (from 2 above) with existing traffic volume requirements (i.e., existing volume per lane/per hour) for the purpose of determining:

(1) areas of surplus capacity (where available capacity exceeds actual traffic flow requirements)

(2) areas of deficient capacity (where available capacity is less than actual traffic flow requirements)

(3) areas where available capacity corresponds with actual traffic flow requirements

b. Calculate the specific level of capacity in the following manner:

(Req. Cap.) - (Avail. Cap.) = (Surplus or Deficient Cap.) measured in ft. width

Enter result under rows 1 through 3 in Table 37.

14.3.2.2 Identify Traffic and Transit Systems Dysfunctions Relative to Pedestrian Trip Making (movement)

Examine the relevant application of the following for all modes and segments and record results under rows 4 through 12 in Table 37.

a. Areas of deficient pedestrian safety - Accidents related to inadequate traffic controls and/or pedestrian countermeasures.

b. Areas of pedestrian/vehicular conflict - Where pedestrian trip making has negative impact upon the efficient operation of other modes (i.e., vehicular delay, congestion, etc.)

c. Areas of modal incompatibility - Where multi-modal requirements relative to a specific R.O.W. are in conflict (e.g., service loading, bus transit, vehicular flow, and parking share the available R.O.W.)

d. Systems displacement - Where implementation of the pedestrian network can result in a reduction and displacement of parking, a reduction of service/delivery and vehicular access and a reduction or displacement of transit interface in terms of access and availability.

14.3.2.3 Identify the Range of Physical and Functional Constraints Relative to Vehicular/Transit Usage and Modal Interface (for each mode).

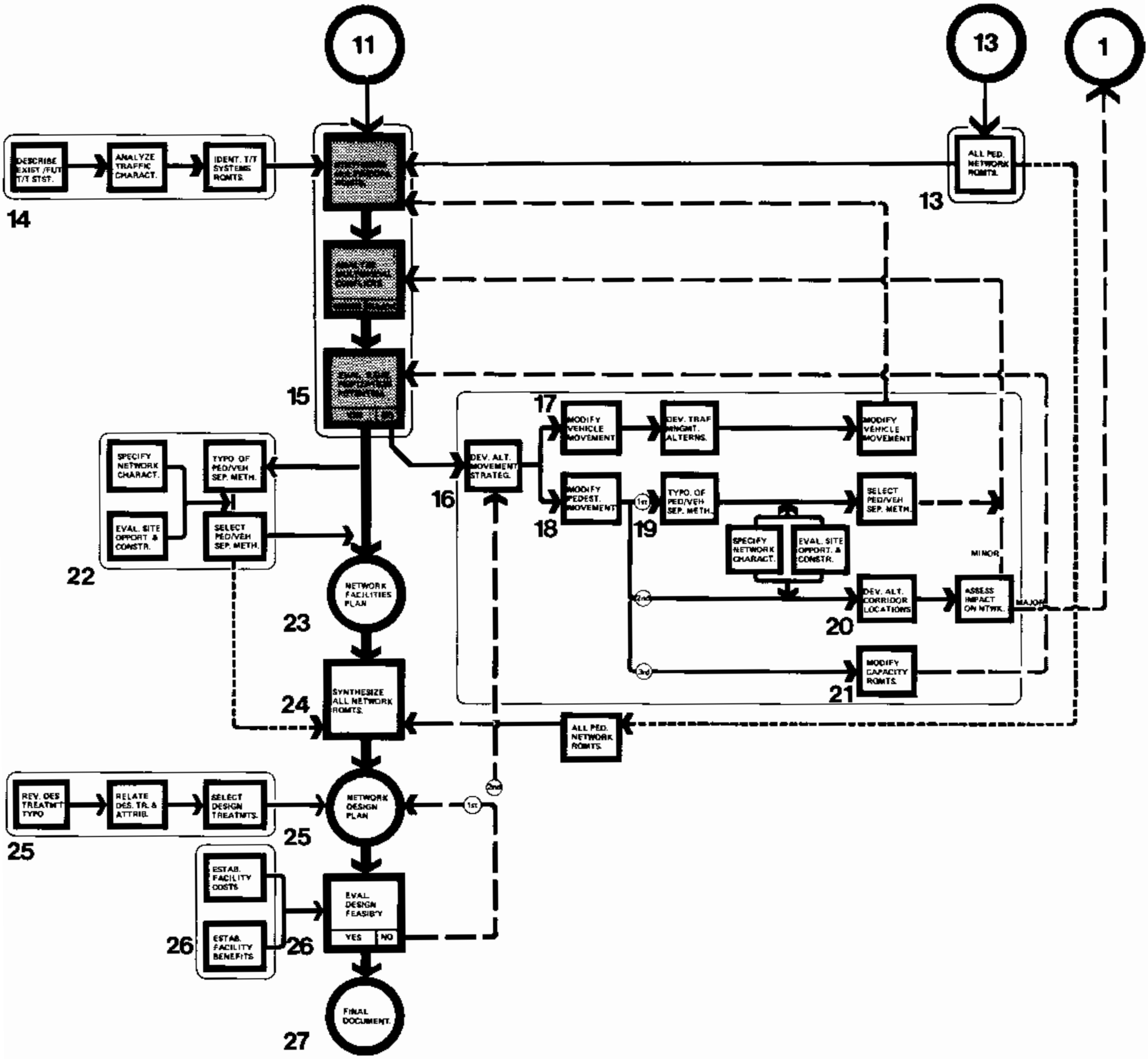
Examine the relevant application of the following for all modes and segments and record under rows 13 through 18 in Table 37.

- Turning radii (relative to trucks)
- Safety related regulations (i.e., signage, signalization, and other control measures)
- Turnouts/loading bays
- Access required for service/delivery and emergency vehicles
- Queuing areas for modal transfer
- Bus stop areas
- Taxi stands

The remaining two rows in Table 37, titled the "Evaluation of Pedestrianization Potential" are completed as part of Task 15.

SYNTHESIZE AND EVALUATE MULTI-MODAL REQUIREMENTS

15



TASK 15

SYNTHESIZE AND EVALUATE MULTIMODAL REQUIREMENTS

15.1 Task Description

The results of the first three model components (i.e., trip generation, trip distribution and exchange, and pathway choice) is the identification of those network corridors or segments which have the highest degree of potential utilization (in terms of pedestrian trip making) and consequently, the highest potential benefits.

The locational corridor plan addresses the question of what the network should be, both in terms of location of pathway as well as the priorities for pedestrianization. However, these priorities are for the most part dominated by pedestrian trip making considerations. Although the formulation of the locational network plan has taken into consideration a wide range of factors related to pedestrian movement as well as other circulation modes, the paramount objective of the plan is to accommodate pedestrian trip making.

The specific degree, however, to which any particular network segment can be pedestrianized is a function of the specific R.O.W. requirements for accommodating other travel modes.

The analysis of T/T systems characteristics (Step 14.3.2) was conducted without reference to the pedestrian network requirements. These characteristics must now be examined within the context of pedestrian network requirements. Therefore, the specific objectives of this step will be to assess the pedestrian network requirements for each street segment within the context of other modal requirements for the purpose of evaluating the potential for network implementation. This evaluation is two-fold:

A. To identify areas of conflict where implementation of the pedestrian network will result in negative impacts upon other travel modes, and

B. To evaluate the degree to which any specific street segment can be pedestrianized.

To work through the procedures that follow, the pedestrian requirements per segment (Table 33 Worksheets completed in Step 13.3.3) must be viewed together with the Traffic and Transit System's characteristics per segment (Table 37 - completed in Step 14.3.2) so that the requirements of all the various modes can be synthesized.

The initial phase of evaluation will be to identify areas of conflict where implementation of the pedestrian network will potentially result in negative impacts upon other travel modes. Each travel mode has specific requirements and objectives which are often conflicting and incompatible. The majority of these conflicts are related in particular to the interface of vehicular and pedestrian movement. These conflicts require both identification and resolution.

15.2 Inventory Of Considerations

These conflicts (negative impacts) relate to three specific areas:

1. Displacement

   - Reduction of net parking inventory
   - Displacement of parking
   - Reduction of service/delivery access
   - Displacement/reduction of transit interface (in terms of both access and availability)
   - Displacement/reduction of vehicular access to auto dependent facilities

2. Capacity

   - Reduction of level of service related to traffic or transit

3. Systems Dysfunctions

   - Pedestrian safety deficiency
   - Increased levels of pedestrian/vehicular conflict resulting in increased vehicular delay and travel time
   - Modal incompatibility
   - Negative environmental impacts (pollution, noise, etc.)

15.3 Procedures

15.3.1 Analysis of Multi-Modal Conflicts

1. Analyze (1) and (3) above for T/T systems characteristics relative to pedestrian network requirements. This analysis involves examining the functional interdependency between other modes and the pedestrian network requirements in terms of identifying:

a. Incompatibilities - areas where pedestrian network requirements and other modal requirements are in conflict and require resolution. In this instance, pedestrian network implementation will result in negatively impacting other modes.

b. Compatibilities - areas where pedestrian network requirements and other modal requirements are mutually supportive (no conflict) and pedestrian network implementation is beneficial to all modes.

2. The areas of conflict (incompatibilities) should be highlighted within the T/T characteristics worksheet (Table 37) which was initially developed in Step 14.3.2.

15.3.2 Evaluation of Pedestrianization Potential

1. Evaluation of Capacity Format

The second phase of evaluation will relate to assessing the degree to which a specific street segment can be pedestrianized from the standpoint of capacity. This evaluation is based upon a comparison of the capacity requirements for all modes utilizing the particular R.O.W. under examination. Table 38 provides a framework for conducting this evaluation. This framework is composed of the following components:

a. Inventory of T/T systems in terms of their spatial characteristics (columns 1 through 5)

b. Analysis of T/T systems in terms of their capacity characteristics (columns 6 though 8)

c. Inventory of existing pedestrian facilities in terms of their spatial characteristics (columns 9 and 10)

d. Analysis of existing pedestrian facilities in terms of their capacity (column 11)

e. Analysis of pedestrian network in terms of capacity requirements (columns 12, 13, 14, and 20)

f. Identification of total R.O.W. available for implementation of pedestrian network (columsn 15 through 19)

g. Assessment of pedestrianization potential (columns 21 and 22)

The data inventorying and analysis required for filling-in the matrix has all been done in previous steps. Instructions for the proper combination of the data for the purposes of calculation are entered at the bottom of columsn 14 through 22 in the matrix.

2. Procedures

a. The appropriate numerical value for each of the factors appearing in Table 38 (columns 1 through 22) must be recorded for each street segment under examination.

b. Evaluate capacity in terms of spatial requirements.

			EVALUATION OF SPATIAL CAPACITY	APPLICABILITY TO STREET SEGMENT
T/T SYSTEMS CHARACTERISTICS	INVENTORY	1	EXISTING R.O.W. (BUILDING LINE TO BUILDING LINE)	
		2	AVAILABLE R.O.W. (EFFECTIVE WIDTH FOR VEHICLE FLOW)	
			EXISTING PARKING LANES (WIDTH IN FEET) (NO. CARS ON STREET)	
		3	WIDTH	
		4	NUMBER	
		5	ANCILLARY AREAS (INCLUDING MEDIAN STRIPS EXCLUSIVE OF SIDEWALK AREAS)	
	CAPACITY	6	SURPLUS (NO. OF FEET WIDTH IN EXCESS)	
		7	DEFICIENCY (NO. OF FEET WIDTH NEEDED)	
		8	BALANCE (CAPACITY = AVAILABLE R.O.W.)	
PEDESTRIAN NETWORK REQUIREMENTS	INVENTORY	9	EXISTING PATHWAY (TOTAL WIDTH OF SIDEWALKS)	
		10	EXISTING EFFECTIVE WIDTH OF PATHWAY (IMPEDED AREA FOR PEDESTRIAN FLOW)	
	CAPACITY		EXISTING CAPACITY	
		11	AVAILABLE EFFECTIVE WIDTH OF PATHWAY (RESULTING FROM RELOCATION OF PATHWAY IMPEDANCE ELEMENTS)	
			REQUIRED CAPACITY	
		12	EFFECTIVE WIDTH REQUIRED (PEDESTRIAN VOLUME APPLIED TO LEVEL OF SERVICE STANDARDS)	
		13	ANCILLARY AREA REQUIRED (FOR WINDOW SHOPPING, ETC.)	
		13a	INTERSECTION AREA REQUIREMENT (EXCEEDS AVAILABLE AREAS)	
		(12 + 13) 14	TOTAL EFFECTIVE WIDTH REQUIRED	
R.O.W. AVAILABLE	FROM T/T SYSTEMS R.O.W.	(from 6) 15	EXCESS VEHICLE LANE WIDTH	
		(from 5) 16	ANCILLARY SPACE (MEDIANS, ETC.)	
		(5 + 6) 17	TOTAL AVAILABLE	
	FROM PED. R.O.W.	(from 11) 18	TOTAL EFFECTIVE	
	TOTAL AVAILABLE R.O.W.	(17 + 18) 19		
PEDESTRIAN R.O.W. REQUIRED	TOTAL WIDTH REQUIRED (EFFECTIVE & ANCILLARY)	(from 14) 20		
PEDESTRIANIZATION POTENTIAL	SURPLUS (IN FT.)	(19 - 20 = +) 21		
	DEFICIENCY (IN FT.)	(19 - 20 = -) 22		

Table 38

Worksheet Format - Evaluation Of Capacity

The evaluation of pedestrianization potential can result in two possible outcomes regarding the consequences of implementing specific pedestrian network segments:

- Entries made in the surplus column (21) indicate that there is adequate space available for implementation of the pedestrian network.

- Entries made in the deficiency column (22) indicate that there is not adequate space available for pedestrian network implementation. Under such circumstances implementation of the pedestrian network will result in negative impacts on other travel modes. In this case, it is probable that alternative movement strategies would have to be developed and evaluated. In some cases, however, depending on the degree and nature of the conflict and the significance of the pedestrian network element, tradeoffs might be considered.

c. Evaluation of Pedestrianization Potential (Results to be recorded on Table 37)

(1) Synthesize Capacity (space available) and identified Areas of Conflict

The specific degree to which any particular street segment can be pedestrianized is a function of both the evaluation of capacity (in terms of spatial availability) and the extent or degree of potential impacts (related to conflict between modal requirements).

This will require the synthesis of capacity (spatial availability) and identified negative impacts (resulting from conflicting multi-modal requirements) for each street segment.

(2) Determining initial implementation feasibility.

(a) The outcome of this synthesis is the identification of those conditions which affect the determinization of initial feasibility. Conditions for feasibility can be diagramatically depicted as follows:

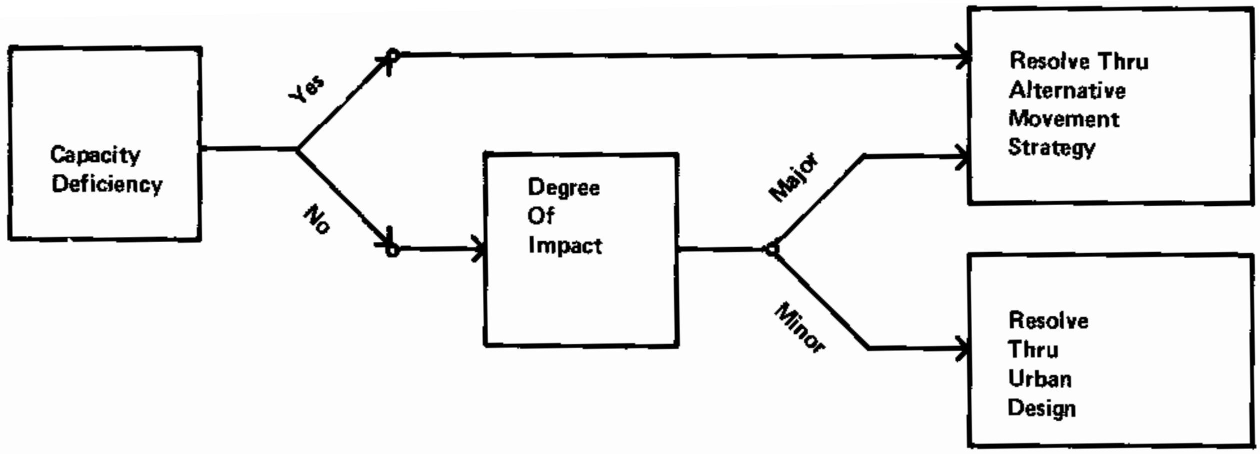


Fig. 57 - Outcomes of Initial Implementation Feasibility

In some instances, specific areas of conflict and potential impacts (either separately or in combination) can be resolved through specific urban design treatment (at the micro level) (e.g., a cul-de-sac vehicular R.O.W. can extend some distance into a pedestrian-dominant segment to provide access to a land use requiring automobile interface such as a hotel lobby, automobile showroom, etc.)

The specific degree of resolution, however, can only be identified during the Design Evaluation Procedures. Should this evaluation result in a pedestrian network plan which does not satisfy all conditions of feasibility in terms of potential impacts, conflict resolution and multi-modal requirements, the development of alternative movement strategies will be required.

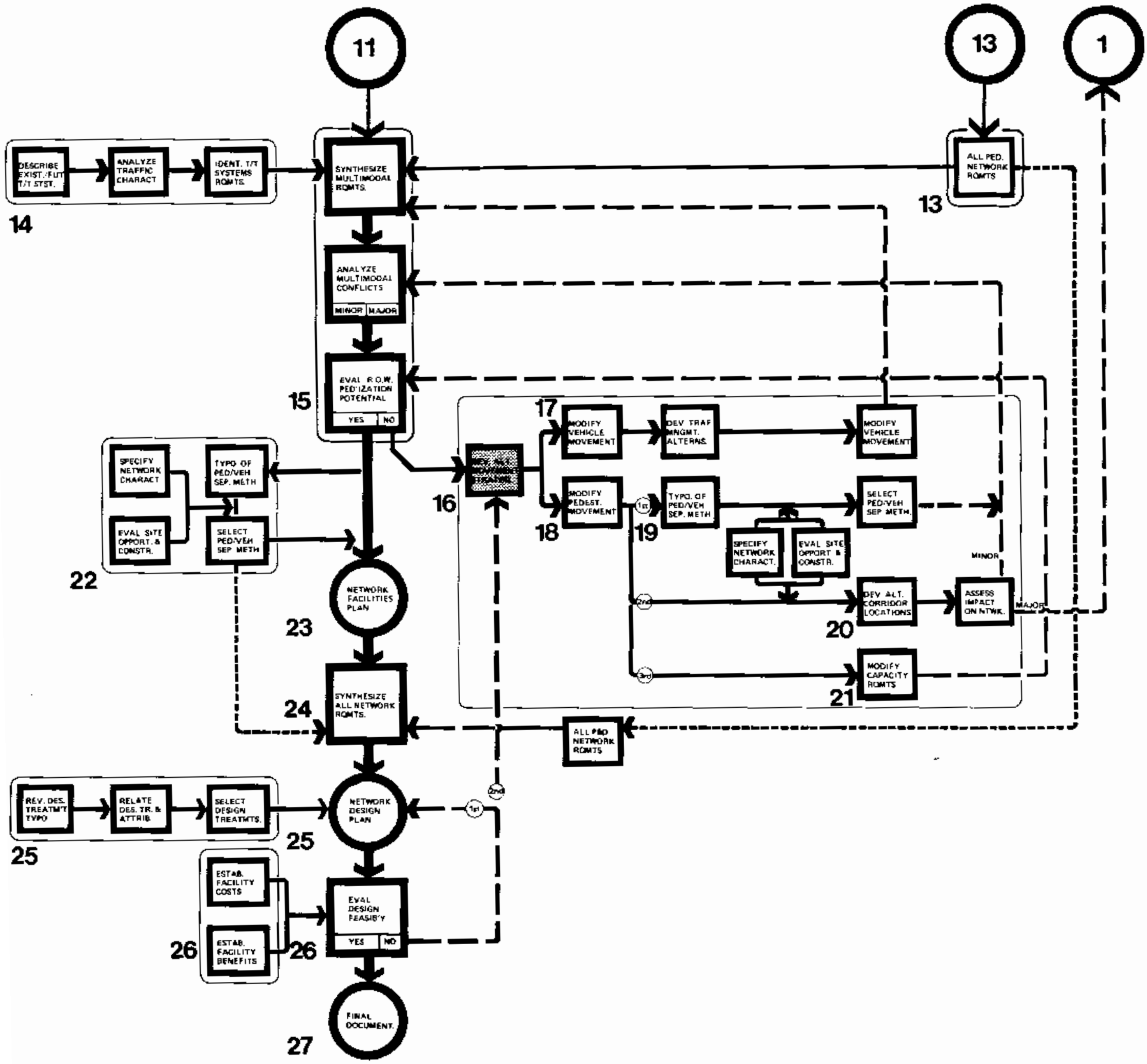
3. Recording Format

Based on the conditions of feasibility resulting from the previous step (15.3.2), Table 38 should be completed and the network location map should be annotated or coded for each street segment in terms of positive or negative implementation feasibility. Such coding should also describe the nature of the conflict, i.e., whether space is available or unavailable, whether the degree of potential impact is major or minor, and the various combinations of these conditions.

The development of alternative movement strategies which might be undertaken for certain segments will produce changes in the above annotations of the first approximation network in the direction of increasing feasibility and requiring the outstanding conflicts to be resolved through the application of urban design treatment rather than through the use of alternative movement strategies.

DEVELOP ALTERNATIVE MOVEMENT STRATEGIES

16



TASK 16

DEVELOP ALTERNATIVE MOVEMENT STRATEGIES

16.1 Overview of Tasks

Examination of the existing pedestrian, traffic and transit network characteristics and requirements will result (as pointed out in 15.3.2) in the identification of several pertinent conditions of feasibility which address the impact of implementing segments of the pedestrian network.

Where the conditions do not indicate initial feasibility, i.e., where the potential multi-modal conflicts (which include lack of available space and major negative impacts) are such that the desired pedestrianization cannot be realized within the existing situation, then such resolution will be achieved through the development of alternative movement strategies whose purpose will be to provide for the required pedestrian space and to reduce major negative multi-modal impacts.

For example, if the pedestrian locational network plan indicates that a specific street segment has a high potential for pedestrian utilization this would mean that this segment should receive a high degree of pedestrianization. The degree of pedestrianization can range from perhaps widening sidewalks to the development of a partial street mall (a mall which would accommodate vehicular or transit traffic as well as pedestrians) or the development of a full street mall (an auto-free zone).

On the other hand, examining the same street R.O.W. from the standpoint of other travel modes, it may be determined that the street is a major arterial in the vehicular network. This examination may also determine that the street is at full traffic handling capacity. If this were the case the impact of widening sidewalks (the most minimum improvement which will require taking existing vehicular R.O.W.) would serve to reduce traffic handling capacity and increase vehicular delay time.

There are two basic strategies for the resolution of these potential conflict:

1. Modification of the existing T/T network through traffic management planning

   and/or

2. Modification of the pedestrian network in terms of:

   a. The employment of various methods of ped/veh. separation and/or

b. The development of alternative locations for specific corridors of the network

and/or

c. The modificaton (reduction) of pedestrian level of service standards.

It is likely that several of these strategies and tactics will be applied to different parts of the network either separately or in combination.

Their employment will modify some of the earlier data inputs and results that have been generated in previous steps.

The decision to investigate vehicular movement modification before pedestrian movement modification or vice cersa for the resolution of a conflict will depend of course on the nature and magnitude of the given conflict and on the resultant judgement as to which strategy is likely to be the most relevant or effective in dealing with it.

Where there has been some prior policy-related determination of an intended pedestrian facility, such as the creation of a partial mall on a particular segment, then the movement strategy options to test the feasibility of implementing the facility would be narrowed to an investigation of traffic and transit management planning.

Generally traffic and transit management strategies are likely to be less costly to implement than the pedestrian movement strategies of vertical separation or corridor relocation. The third pedestrian movement alternative of reducing the level of service standards involves no implementation costs at all since it is merely a computational method for accepting reduced standards for pedestrians. Following this option will result in increased levels of congestion and thus decrease pathway amenity on pathway segments where levels of service are reduced - an outcome clearly at odds with the overall objective of the PPP - namely the facilitation of pedestrian movement. This particular strategy then must be viewed and used as a last resort in the resolution of spatial and other multi-modal conflicts.

If none of the other movement strategy options can remove conflicts and if this last resort would yield an unacceptable level of pedestrian congestion then the resolution of conflict or the required pedestrianization might be unattainable unless trade-offs are considered.

Following development of an alternative, it will be necessary to re-examine the effect that the proposed approach has upon earlier steps in the planning process. The specific conduct of this re-examination will depend on the extent and nature of the proposed alternative, and will be determined by the user to suit the objectives of a particular analysis. This judgement will be made within the consideration of several broad guidelines:

- All alternatives should be assessed against multi-modal requirements to ensure compliance, reduce conflicts and impacts and achieve basic objectives;

- Alternatives involving modification to vehicular/transit network elements only will require re-examination of multi-modal requirements at the points of critical pedestrian-vehicular interface affected by the changes;

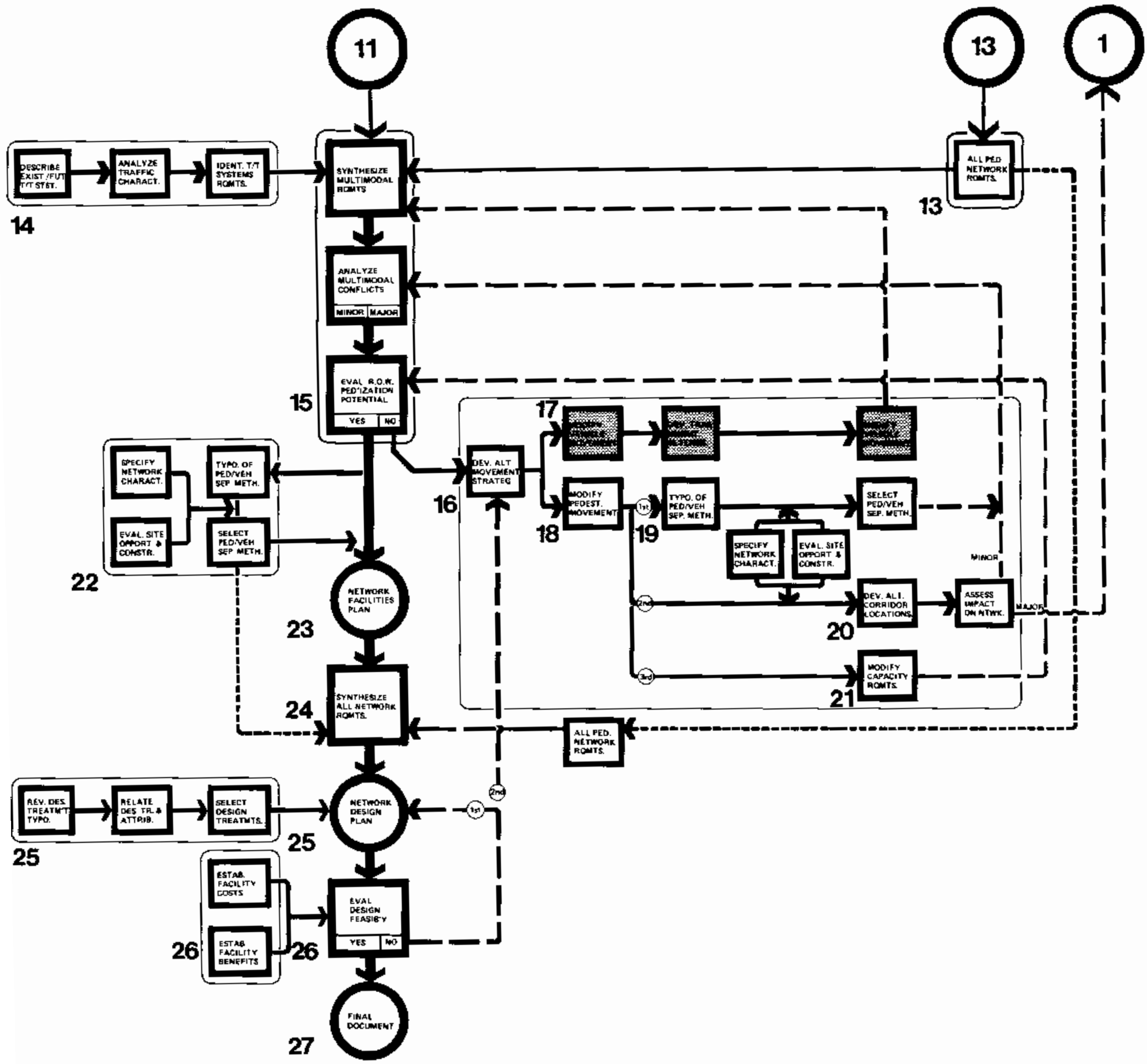
- Alternatives involving modification to pedestrian network elements only will usually require re-examination within the context of the potential utilizaton network and its associated gravity model analysis and

- Alternatives comprised of modifications to both the vehicular and the pedestrian networks will require a more comprehensive re-examination, possibly involving at a minimum a brief review of all prior steps in the planning process.

Regarding the re-examination of changes to the pedestrian network, the amount of effort expended to determine the impact of modifications should require only a fraction of that dedicated to the initial analysis. In most cases, the modifications will be localized, and will affect a small subset of the original network elements. The impact of these local network changes on outlying network elements will be small, due to the attenuation of pedestrian trip propensity with time or distance. The converse is also true; that is, outlying network elements will not greatly affect movement within a local area. Hence, in the re-examination of movement impacts of local modifications, the majority of the effect can be determined by looking at only a sub-network area.

MODIFY VEHICULAR MOVEMENT

17



TASK 17

MODIFY VEHICULAR MOVEMENT

17.1 Task Description

Implementation of various elements of the pedestrian network may have a significant impact upon the existing vehicular/transit network in terms of capacity, levels of accessibility, parking distribution and vehicular delay time. The areas of potential impact have been identified as a result of examining the existing T/T systems characteristics relative to the location of the primary pedestrian network corridors (segments) and the requirements associated with them.

On method of accommodating for pedestrian movement in areas where the needed R.O.W. is not currently available is to reconstitute and modify the existing T/T circulation network.

This can be accomplished through the employment of various Traffic Management techniques. Traffic management planning is for the most part oriented to satisfying very specific traffic operation and control objectives such as:

- improved safety
- reduction in vehicular volume
- reduction of vehicular speed
- mode shifting and
- others

For this purpose alternative traffic management plans will focus primarily upon modifications to the T/T networks which will allow the implementation of horizontal methods of pedestrian/vehicule separation (widened sidewalks, partial walls, transitways) in the pedestrian facilities network. These alternatives for the redistribution and rerouting of T/T will ultimately determine the specific degree to which specific street R.O.W.'s can be pedestrianized.

The objectives relative to the reuse of existing available street R.O.W. for pedestrian circulation are accomplished through the redistribution of traffic volumes as well as the modifications of both the direction and flow of vehicular and transit traffic. The alternatives for T/T redistribution must be coordinated so as to insure an equitable traffic operation for all modes affected. This means that changes and alterations to the T/T system should not result in a:

- reduction in overall mobility
- reduction of accessibility (to all modes impacted)
- reduction in traffic handling capacity
- increase in vehicular delay time and
- reduction in parking inventory through the removal or redistribution of on street parking.

The net impact of changes and alterations to the existing T/T networks required in order to accommodate the proposed pedestrian circulation plan should however result in

- increased safety through a reduction in pedestrian/vehicular conflict
- increased mobility
- increased levels of accessibility through a reduction in modal conflict
- increased capacity which will reduce vehicle delay time
- amelioration of negative environmental impacts (noise, pollution), and
- others (add objectives)

The alternative T/T plans must be developed and tested against specific T/T operational standards to insure that implementation of the pedestrian circulation system will not produce negative impacts.

17.2 Develop Alternative T/T Plans

Procedures

The following procedures outline a framework within which traffic and/or transit systems reorganization, planning and evaluation can take place.

17.2.1 Inventory Existing T/T Conditions

Each mode under examination should have been inventoried in Step 14.3.1 in terms of the following:

1. operational characteristics
2. physical and functional constraints relative to vehicle and/or transit usage
3. systems dysfunctions
4. R.O.W. availability

17.2.2 Evaluate Systems Current Operating Efficiency

Each mode under examination should have been analyzed in Step 14.3.2 in terms of:

1. adequacy (capacity)
2. deficiency and (capacity)
3. dysfunctions

17.2.3 Identify Objectives for Traffic and/or Transit Systems Reorganization Relative to Pedestrian Trip-Making and Systems Characteristics in terms of:

1. maintaining or increasing the current level of systems operational efficiency
2. increasing available R.O.W. for pedestrian trip-making
3. increasing pedestrian safety
4. decreasing pedestrian/vehicle conflict
5. decreasing vehicle delay
6. decreasing modal incompatibility
7. increasing accessibility
8. decreasing negative environmental impacts
9. accommodating for systems displacements (parking, service, etc.)
10. improving modal interface (in terms of location and accessibility)

These objectives are formulated by examining conflicts (potential impacts) between the current T/T systems characteristics in terms of capacity, dysfunction and usage constraints and pedestrian network requirements. The data inputs for this examination have previously been identified and synthesized within Table 33 and Table 37 of Step 15.1 "Multi-Modal Requirements."

17.2.4 Develop Alternative T/T Movement Strategies to Achieve Desired Objectives

The employment of various techniques identified in (1) and devices identified in (2) are a function of the specific objectives of the management plan for each specific street segment under consideration.

1. Movement Strategy Components

Depending upon the specified objectives as well as the specific nature and the magnitude of the potential impacts of the proposed pedestrian network upon other travel modes, the various alternative strategies will consist of the establishment (or modification on reconstitution) of:

- vehicle/transit travel patterns
- redirection of flows
- parking redistribution
- traffic rerouting (to create auto free areas or limited access areas)
- intersection modifications
- turning movement modifications
- signal timing modifications
- traffic channelization
- provision of countermeasures
- provision of other traffic control devices

2. Identify Traffic/Transit Management & Control Devices

The following (Table 39)is an abridged typology of devices that can be employed within the development of T/T management planning.

a. <u>Methods of slowing vehicles at points along a street</u>

Stop signs
Speed bumps and humps
Pavement undulations
Rumble strips
Traffic chokers
Off-set street alignments
Signalization

b. <u>Methods of slowing average vehicle speeds</u>

Speed limit signs and markings
Narrow streets
Bending street alignments
Channelization

c. <u>Methods of preventing access to or exit from certain streets at intersections</u>

Full and partial barriers
Turn prohibitions
Do Not Enter signs
One-way streets
Street closings

d. <u>Methods of forcing vehicles to turn</u>

Diverters and semi-diverters
Turn signs and pavement markings/traffic stars
Do Not Enter Signs
Oneway street terminals

e. <u>Methods of preventing or discouraging vehicles from turning</u>

Turn prohibition signs
Narrow entrances
Barriers
Median barriers

f. <u>Methods of slowing vehicles through intersections</u>

Stop signs
Traffic signals
Traffic circles

g. <u>Methods of limiting capacity</u>

Narrow streets
Reducing number of lanes
Increasing parking
Traffic chokers

h. <u>Related methods of improving safety</u>

Increasing sight distances
Limiting parking near intersections
Marking cross walks
Installing pedestrian signals
Installing pedestrian safety islands

i. <u>Methods of improving street environment</u>

Planting of trees and shrubs
Street maintenance
Litter removal
Better street lighting
Installation of parks

j. <u>Regulatory Methods</u>

Banning Ordinances (e.g., trucks)
Parking Ordinances
Enforcement Policies

Table 39 - Typology And Examples Of Traffic Management And Control Devices

17.3 Identify & Record Characteristics Of Alternative T/T Management Strategies in terms of:

1. operational characteristics
2. physical, functional constraints, relative to vehicle or transit usage
3. systems dysfunctions (as in Step 14.3.2.2)
4. capacity of R.O.W.

These data are to be reentered within the appropriate categories within the T/T Characteristics Table (as in Step 14.3.2).

17.3.1 Assess Alternative T/T Strategy/Strategies for the purpose of determining initial feasibility in terms of its/their impact upon the following:

a. operational efficiency (of reconstituted mode)
b. specified objectives
c. pedestrian network requirements
d. areas of conflict (impact potential)
e. pedestrianization R.O.W. potential

Evaluation procedures (a) operational efficiency, and (b) specified objectives of the alternative plans developed should be assessed in turn against current operating efficiency defined in Step 17.2.2, and systems objectives specified in Step 17.2.3 of these procedures.

Evaluation procedures are the same as Steps 15.3.1 and 15.3.2 within the Pedestrian Planning Process.

Using the evaluation procedures identified in Step 15.3 of the Pedestrian Planning Process, the reassessment of R.O.W. potential is performed as follows (ref. to Table 38).

1. compare "Total Effective Width Requirement" Col. 20 with "Total Available R.O.W." Col.19.

   - Col. 20 remains unchanged as this is the requirement for any selected alternative.
   - Col. 19 - enter in new value for available R.O.W. based upon selected separation method. (See Step 15.3 of the Pedestrian Planning Process procedure for performance of this exercise).

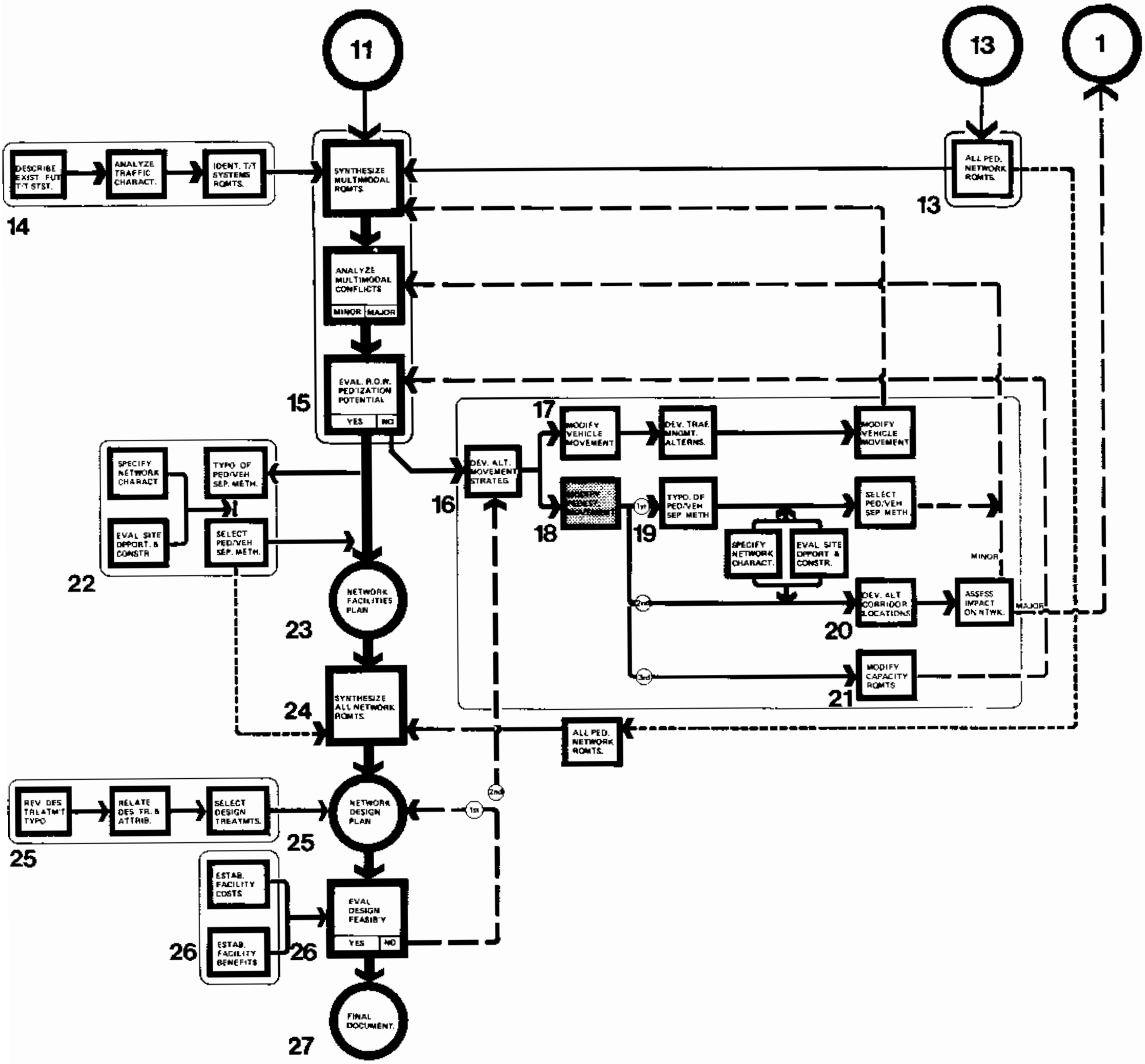
2. subtract Col. 19 from Col. 20. This will yield a new value for Col. 20 or 21 which will in turn identify the pedestrianization potential.

The evaluation of alternative T/T plans (in terms of 17.3.1.a. through e above) will result in either of the following two outcomes:

a. selection of T/T plan -- meets all conditions of feasibility (a through e) or
b. requirement to modify pedestrian movement -- no further reduction of the vehicular R.O.W. and/or reduction of potential impacts can be made. This could be attributed to a lack of reserve capacity on perimeter streets, parking and access requirements and other factors related to volumes, the direction of traffic flow and other preexisting traffic network characteristics.

MODIFY PEDESTRIAN MOVEMENT

18



TASK 18

MODIFY PEDESTRIAN MOVEMENT

18.1 Overview

There are three specific strategy alternatives in modifying the Pedestrian Movement Network:

1. alternative methods of pedestrian/vehicle separation
2. relocation of pedestrian movement corridors and
3. reduction of pedestrian trip making capacity standards (level of service)

The above strategy alternatives have been rank-ordered in terms of the sequence in which alternatives for modification to pedestrian movement should be undertaken. The determination of this order is based upon the degree to which each strategy impacts the pedestrian trip making network.

Alternative 1--Methods of Pedestrian/Vehicle Separation

Consideration of alternative methods of pedestrian/vehicle separation for any specific street segment will generally have an impact upon trip making at the sub-network level. These impacts for the most part are localized and relate primarily to issues of accessibility and continuity. These impacts can be addressed through specific design treatments.

Alternative 2--Relocation of Pedestrian Movement Corridors

Relocation of any particular pedestrian network segment (corridor) can have an impact upon pedestrian movement and trip making in network segments beyond the local or subnetwork scale. These impacts relate to pathway directness, accessibility and connectivity and may be non-localized in nature.

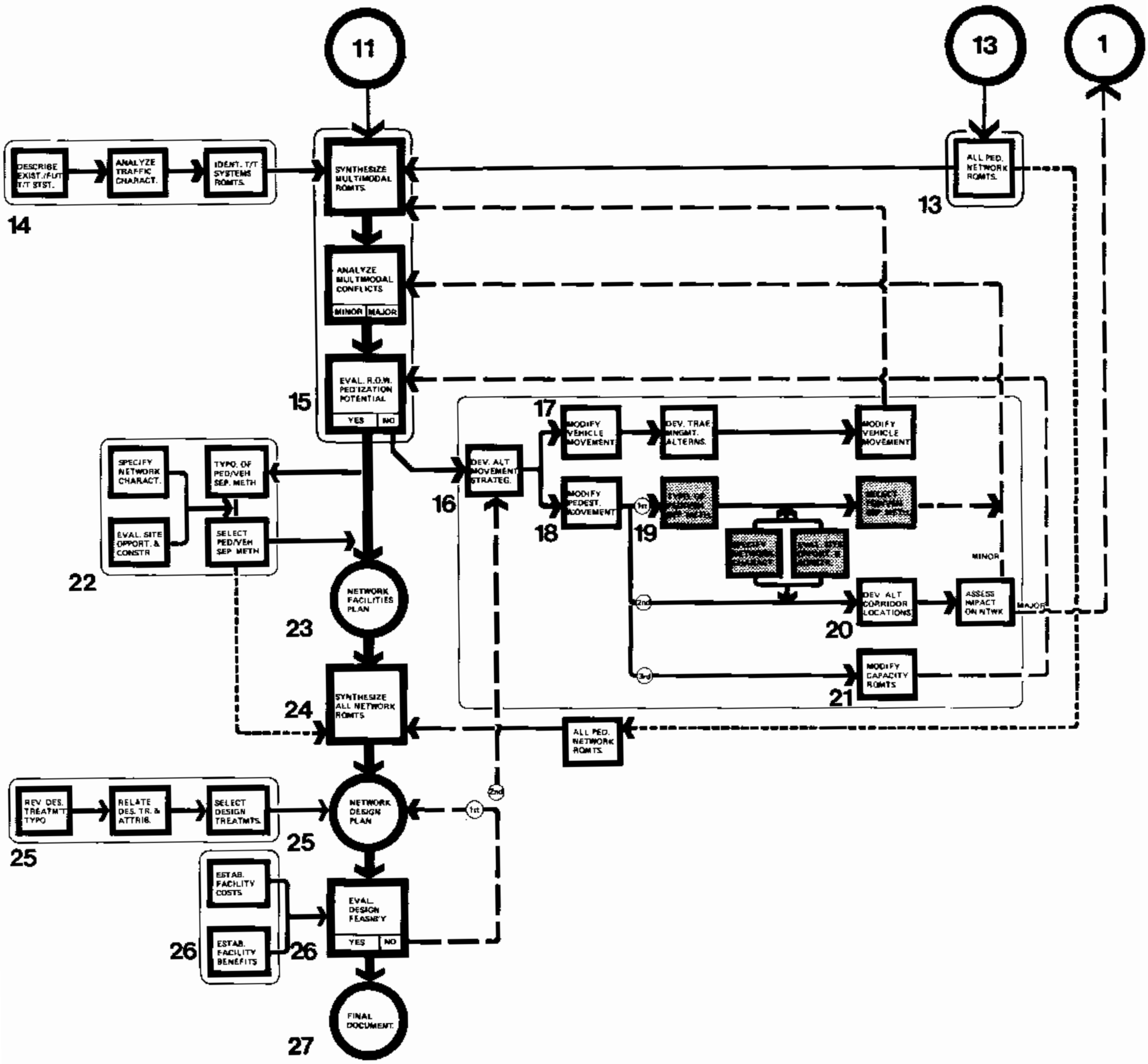
Since these impacts affect trip exchange as well as pathway choice, the relocation of corridors can result in producing a modified pedestrian utilization network. This would require a reiteration of the trip distribution model (Steps 6 thru 9).

Alternative 3--Reduction of Trip Making Capacity Standards

Reduction of the level of service will directly affect the amount of R.O.W. needed for the pedestrian pathway and thereby reduce the impact of the pedestrian network plan upon the available street R.O.W. This of course requires the acceptance of <u>less than optimal performance criteria for the movement of pedestrians</u> in terms of capacity walking speeds and queuing levels. In some cases, it may not be feasible to reduce level of service standards and pedestrian volumes relative to available pathway width may approach levels of "crowding" thereby making the link deficient. As the link itself becomes an impedance to the flow of pedestrian traffic--utilization is reduced and consequently potential benefits are impaired.

SELECT ALTERNATIVE METHODS OF PEDESTRIAN/ VEHICULAR SEPARATION

19



TASK 19

SELECT ALTERNATIVE METHODS OF PEDESTRIAN/VEHICULAR SEPARATION

19.1 Task Description

In the procedures that follow, a framework for the selection of an appropriate method of ped/veh separation will be provided. Within this framework, a given typology of separation methods will be reviewed in terms of those site specific conditions to which they apply (called "Conditions of Applicability"). After a judgement on the appropriate separation method has been made, an evaluation of its impact on conflict resolution and pedestrianization potential will be conducted.

19.2 References

- A typology of methods of ped/veh separation is presented and defined in Technical Supplement 12. Table 40 below, summarizes the elements of the typology.

- Supplement 13 contains definitions and discussions of each of the Conditions of Applicability.

19.3 Definition Of Conditions Of Applicability

The selection of any particular method of separation of P/V movement is dependent upon the following:

- Assessing network characteristics
- Assessing existing site opportunities and constraints

Taken together these are called the Conditions of Applicability (listed in Table 41) and represent technical criteria for selection. Contextually specific conditions (e.g., political, special needs or dysfunctions) can exist, however, which may in the final analysis override technical considerations.

19.4 Procedures

19.4.1 Identify Factors Which Influence the Selection of Methods of Pedestrian/Vehicular Separation

The selection of a particular method of P/V separation is contingent upon the degree to which the conditions of applicability prevail for any specific network segment under examination. Certain methods of P/V separation have a high degree of relevance to network characteristics, conflict resolution and existing site opportunities and constraints. A listing of these relevant characteristics and site opportunities/ constraints is provided below. Their definitions in Supplement 12 are to be read together with the Conditions of Applicability Matrix in Table 42. The supplement also contains a discussion of each condition which elabor-

HORIZONTAL SEPARATION

PARALLEL ELEMENTS

- Sidewalks
- Partial Malls (widened Sidewalks)
- Sidewalk Setbacks (arcades)

DISPLACED ELEMENTS

- Displaced Sidewalk Grids
- R.O.W. within Land Use Development Parcel or Building Structure
- Alleyways
- Full Malls
- Street Closings (including play streets)

VERTICAL SEPARATION

BELOW-GRADE ELEMENTS

- Tunnels, Subwalks, Subways

ABOVE-GRADE ELEMENTS

- Bridges (highway)
- Skywalks, Skyways, Elevated and Second-level Systems (CBD)
    - independent
    - flanking (independent/integral)
    - integral
    - interior

TIME DISPLACEMENT

- Crosswalks (intersection and midblock)
- Street Closings (temporary)

VERTICAL CONNECTIONS

- Stairs
- Ramps
- Escalators
- Elevators

Table 40

Typology Of Separated Pedestrian Systems And Facilities

I. Network Characteristics:

1. Pedestrian network requirements
2. Activity node
3. Function of network
4,5. Existing dysfunctions - needs and impacts
6. Degree of pedestrian/vehicle conflict
7. Safety
8. Security
9. Pathway directness
10,11. High volumes of pedestrians and/or vehicles
12. Imagibility
13. System phasing and implementation effort
14-16. Modal interface (at grade, and/or above or below grade.)
17. Costs of systems (capital, maintenance and operations)

II. Site Opportunities or Constraints

18,19. Climate protection through enclosure or shelter
20,21. Topography (flat or slope)
22-25. Activity abutting pathway (retail, office, ent./soc./rec., resid.)
26. Legal/jurisdictional
27. Infrastructure
28. Non-functional space
29. Existing land use interface
30-32. Future land use (at grade, and/or above grade or below grade)
33. No available right-of-way

Table 41

Factors Which Influence The Selection
Of Methods Of Pedestrian/Vehicle Separation

Methods of Pedestrian/Vehicle Separation			Conditions of Applicability: Network Characteristics																	Site Opportunities/Constraints																Assess. Index		
			PED NETWK REQMTS	ACTIVITY NODE	FUNCTION OF NTWK	EXIST. DYSFUNCTIONS NEEDS	EXIST. DYSFUNCTIONS IMPACTS	DEGREE OF PED/VEH CONFLICT	SAFETY	SECURITY	PATHWAY DIRECTNESS	HIGH PED VOLUMES	HIGH VEH VOLUMES	IMAGIBILITY	SYSTEMS PHASING/ IMPLEMENTATION	MODAL INTERFACE AT GRADE	MODAL INTERFACE ABOVE GRADE	MODAL INTERFACE BELOW GRADE	SYSTEMS COSTS	CLIMATE REQUIRES COVER	CLIMATE REQUIRES ENCLOSURE	FLAT TOPOGRAPHY	SLOPING TOPOGRAPHY	RETAIL USES ABUT PATHWAY	OFFICE USES ABUT PATHWAY	SOCIAL/CULTURAL USES ABUT PATH.	RESIDENTIAL USES ABUT PATHWAY	LEGAL/JURISDICTION ISSUES	INFRASTRUCTURE	USE OF NON-FUNCTIONAL SPACE	EXISTING LAND USE INTERFACE	FUTURE DEVELOPMT. AT GRADE	FUTURE DEVELOPMT. ABOVE GRADE	FUTURE DEVELOPMT. BELOW GRADE	NO AVAILABLE RIGHT-OF-WAY			
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	A	B	A+B
Horizontal Separation	Parallel Elements	Sidewalks		0	0	0	0	0	0	9	8	5	NA	2	10	20	0	0	20	0	6	10	4	2	4	2	10	10	10	0	20	8	0	0	20			
Horizontal Separation	Parallel Elements	Sidewalk Setback		0	0	0	5	6	7	5	10	8	8	9	9	20	0	0	18	0	10	10	4	7	8	6	0	8	9	0	0	14	0	0	20			
Horizontal Separation	Parallel Elements	Partial Malls		8	10	5	9	8	7	10	10	8	8	8	10	20	0	0	14	0	6	10	4	8	6	8	9	9	9	6	20	18	0	0	0			
Horizontal Separation	Displaced Elements	R.O.W. Within Land Parcel		10	10	NA	8	10	10	2	7	10	10	9	7	0	0	0	18	9	9	10	5	9	6	8	0	9	9	0	0	18	0	0	20			
Horizontal Separation	Displaced Elements	Alleyways		0	10	NA	8	10	10	2	7	10	0	4	5	0	0	0	20	0	6	10	5	7	6	8	3	8	8	4	14	18	0	0	0			
Horizontal Separation	Displaced Elements	Full Malls		10	10	10	10	10	10	8	10	10	1	10	9	0	0	0	8	0	8	10	7	10	2	9	1	5	6	10	20	20	0	0	0			
Vertical Separation	Below Grade	Tunnels, Highway Related		0	10	NA	10	10	10	0	9	10	10	0	6	0	0	20	0	10	10	7	10	NA	NA	NA	0	2	6	NA	NA	0	0	20	20			
Vertical Separation	Below Grade	Subways, Sub-walks (CBD)		0	2	NA	5	10	10	0	5	10	10	0	0	0	0	20	0	10	10	7	10	NA	NA	0	0	2	0	NA	0	0	0	20	20			
Vertical Separation	Above Grade Elements	Independent		3	8	NA	4	10	10	4	10	10	10	9	8	0	20	0	4	6	9	4	10	0	6	1	7	2	2	0	16	0	16	0	20			
Vertical Separation	Above Grade Elements	Integral Flanking		4	6	NA	7	10	10	6	6	10	10	8	0	0	20	0	14	8	9	4	2	2	4	2	0	1	3	0	8	0	20	0	20			
Vertical Separation	Above Grade Elements	Integral		5	6	NA	7	10	10	6	6	10	10	7	0	0	20	0	16	9	10	4	2	4	4	2	0	1	3	0	8	0	20	0	20			
Vertical Separation	Above Grade Elements	Interior		7	8	NA	10	10	10	8	10	10	10	5	0	0	20	0	18	10	10	5	NA	10	2	8	0	0	4	0	0	0	20	0	20			
Time Displacement	Cross-walks	Intersection		0	8	NA	8	7	9	10	10	10	8	0	10	10	NA	NA	20	0	2	10	NA	5	6	6	9	10	10	10	20	20	NA	NA	NA			
Time Displacement	Cross-walks	Midblock		0	10	NA	9	5	10	10	10	10	4	0	10	10	NA	NA	20	0	2	10	NA	7	7	7	10	8	10	NA	20	20	NA	NA	0			
Time Displacement		Street Closings (Temporary)		6	8	NA	10	10	10	10	NA	10	9	2	10	0	NA	NA	20	0	0	10	NA	7	NA	7	10	8	10	10	20	20	NA	NA	16			
Vertical Connectors		Stairs		NA	1	NA	1	NA	5	10	0	5	NA	0	10	NA	0	0	18	0	8	NA	4	1	5	4	6	10	9	NA	16	NA	0	0	2			
Vertical Connectors		Ramps			8	NA	8	NA	6	10	4	7	NA	2	10	NA	8	8	16	0	6	NA	10	3	3	7	8	10	9	NA	12	NA	8	8	0			
Vertical Connectors		Escalators			10	NA	10	NA	10	10	10	9	NA	10	10	NA	20	20	0	8	10	NA	8	9	9	9	NA	10	4	NA	4	NA	20	20	0			
Vertical Connectors		Elevators			5	NA	5	NA	10	0	7	6	NA	10	10	NA	14	14	4	10	10	NA	2	6	6	5	0	8	4	NA	0	NA	14	14	4			

SELECTION OF METHOD FOR PED./VEH. SEPARATION

Table 42

Conditions Of Applicability Matrix

ates its relationship to the various methods of separation and explains the logic behind the weightings in the Matrix Table 42.

19.4.2 Identification of Interdependencies Between Conditions of Application and Methods of Ped/Veh Separation

As previously stated, the selection of a particular method of ped/vehicle separation is a function of the degree to which the specific conditions (listed in 19.2) prevail for any particular network segment.

These conditions consist of Pedestrian Network Characteristics and existing site opportunities and constraints. Certain methods of separa tion are relevant to satisfying particular conditions to either a greater or lesser degree.

The relative interdependence between network characteristics and site opportunities/constraints and various methods of P/V separation is illustrated in Matrix 19.2.4.

The range of interdependence (expressed in weighted scores) is based on the study team's concencus on scores determined by the following:

A. Examination of state-of-the-art in pedestrian facilities systems planning design and implementation (in both the USA and Europe)

B. Examination of previous research relative to pedestrian facilities and systems in terms of

- systems characteristics
- resultant impacts
- costs
- reasons underlying implementation and
- environmental context.

C. Examination of case studies related to pedestrian facilities and systems currently in operation (nationwide - U.S.A.).

This examination* has provided a basis for determining the specific nature and degree of interdependence between methods of separation and conditions of applicability. This examination has resulted in classifying the specific nature of this interdependency according to the following categories:

*Relevant bibliographic material has been fully documented in an earlier part of this contract (DOT-FH-8816) under Phase 1, Interim Report, Appendix 2, Section B.

1. Generic

Those factors and/or conditions which have a dominant influence upon the selection of specific methods of P/V separation. A comparative evaluation of relevant data has provided evidence that the selection of various methods of separation is generally affected by similar factors which do not vary appreciably from site to site. These factors form a set of priority considerations in the selected process (e.g., provision of safety and security, etc.)

2. Site specific

Those factors and/or conditions which are locationally specific and consequently exhibit wide variation from site to site. Certain site specific conditions can dominate the selection of a particular method of P/V separation. Since there is considerable variation in these conditions, they cannot be utilized as general determinants within the selection process (e.g., provision of access, pedestrian movement contraints and barriers).

3. Design dependent

Those factors and/or conditions that can be satisfied through the employment of specific design treatments irrespective of either the method of separation on locationally specific issues. As there are a wide range of such treatments, they cannot be utilized as determinants within the selection process (e.g., provision of amenities, pathway interest, coherence, etc.).

Only those conditions which are generic in nature were considered in specifying the interdependencies. The purpose of Table 42 is to provide a general framework which will serve as a guide for determining the degree to which any particular method of separation is applicable under a specific set of circumstances.

The degree of applicability is based upon the following factors:

- The degree to which conflicts can be resolved through the employment of a specific separation method.
- The interdependency between network characteristics and various separation methods and,
- The relationship between existing site opportunities and constraints and various separation methods.

Table 42 illustrates the degree of interdependence between methods of separation and conditions of applicability in numerical terms. To this end, those conditions of roughly equal importance (columns 1 to 13, and 18 to 28) have been rated on a relevance scale ranging from 0 (conflicting) to 10 (very relevant).

In addition certain non-specifiable columns have been left open for entries to be made by the planner. For an explanation of these and their use, reference must be made to Supplement 13.

Within the list of applicable conditions, however, there are certain factors which predominate in the selection process as they may override other considerations. These factors include:

Column Number	Factor
Col. 17	Systems costs
14,15,16	Modal interface requirements
Col. 29	Disposition of existing land use
27,28,29	Disposition of future land uses
33	Availability of R.O.W.

Since these factors are both necessary and sufficient conditions upon which selection can be made, they are scored on the basis of 0 - 20, which takes into account their greater significance vis-a-vis the other conditions of applicability.

19.5 Select Pedestrian/Vehicular Separation Method

19.5.1 Identify Data Sources

The table provided below (Table 43) identifies the sources for the data which is necessary for determining conditions of applicability. These data may be retrieved from specific steps within the pedestrian planning process in which this data has been previously collected and recorded.

19.5.2 Synthesize Prevailing Conditions

Each street segment under consideration should be examined with respect to the list of factors provided in Table 42 in order to establish their specific relevance.

As these factors are general in nature and merely serve as guidelines for focusing attention upon those primary factors which influence the selection process, their particular relevance is a function of site specific conditions. Therefore, a statement describing the specific nature and magnitude to which the condition prevails should be recorded along with the Matrix for each segment.

This procedure should be repeated for each street segment under review. The result of this procedure is an individual matrix for each street segment within the network.

Factor Influencing the Selection of Methods of P/V Separation	DATA SOURCES				
	Eval. of Spatial Capacity	Pedestrian Network Reqmts.	T/T Systems Character.	Planning Policy	Data Base/ Manual
	See Step 15.3	Step 13.3	Step 14.3	Step 12.0	Step 2.0
NETWORK CHARACTERISTICS					
- Ped. Network Requirements		X			
- Function of Network					
- Exist. Dysfunctions (Needs, Impacts)		X	X		
- Degree of Ped/Veh. Conflict			X		
- Safety		X	X		
- Security		X			
- Systems Costs				X	X
- Systems Phasing/Implement.				X	
- Imagibility				X	
- Ped/Veh Volume		X	X		
- Directness		X			
- Modal Interface		X	X		
SITE OPPORTUNITIES/CONSTRAINTS					
- Climate					X
- Typography					X
- Existing Land Use Develop.					X
- Future Dev/Redevelopment (New Construction)					X
- Non-Functional Space		X	X		
- No available R.O.W.	X				
- Infrastructure					X
- Legal/Jurisdictional					X
- Activity Abutting Pathway					X

Table 43

Data Sources For Conditions Of Applicability

19.5.3 Evaluate the Applicability of Alternative Methods of P/V Separation

The previous procedure (19.5.2) identified the relevant and prevailing conditions for each segment. To assess the degree of applicability of various alternative methods of separation, the score values within each column of the relevant network characteristics and site opportunities/constraints should be added. (All columns excluding column 17, Systems Costs.)

The summation of these scores should be entered in Column A of the Assessment Index. In a similar fashion the score value for Column 17 should be summed and entered in Column B within the Assessment Index.

The score values entered in Column A allow an assessment of alternative methods of P/V separation exclusive of cost issues. Excluding systems costs, these score values indicate the most applicable methods of separation. However, to assess final feasibility of facilities implementation the modifying effects of systems costs must be taken into consideration. Where alternative methods of separation are seemingly comparable in their level of applicability - systems cost can be utilized to differentiate between alternatives.*

The summation of columns A and B should now be entered in the appropriate column within the Assessment Index. These final scores will identify the relative degree to which each method of separation is applicable.

19.5.4 Selection of Method of P/V Separation

Based upon the evaluation performed in 19.5.3, the appropriate method of separation for each street segment can be selected. It should be noted with regard to horizontal methods of separation that the "displaced elements" of "alleyways" and "R.O.W.s within in land parcels and/or buildings", when considered as options under alternative methods of separation, imply that the location of the movement corridors of the first network approximation is basically respected. Any minor deviation from the basic corridor, if in the direction of what is known to be the movement desire line, does not constitute a corridor relocation. The selection of an alleyway or R.O.W. within a parcel which deviates substantially from the first network approximations corridor location for the same trip making, particularly if this deviation is not in the direction of the movement's desire line (i.e., the straight line connecting the origin and destination), must be considered an alternative corridor location and the appropriate requirements and procedures for this alternative must be followed under Step 20.0.

*More specific facility costs may be determined, if desired, at this point by reference to Step 26.0.

It should furthermore be noted that included within the typology of methods of separation are vertical connectors (stairs, ramps, escalators and elevators). These are contingent upon the employment of various methods of grade separation and as such cannot be considered categorically as alternative methods of P/V separation. However, the relative score values for these elements should be taken into consideration during the design phase of the PPP as they are considered elements of the pathway.

19.5.5 Identify Specific Physical and Functional Requirements of the Selected Method of Ped/Veh Separation

For each street segment, the physical and functional properties of the selected separation method must be identified in terms of:

1. dimensional properties

   - effective horizontal width requirement

2. General pathway configuration

   - horizontal disposition
   - vertical disposition

3. Location of vertical connectors (if applicable)

4. Systems extent

5. Systems phasing requirements

19.6 Assess Impact On Conflict Resolution

Those multi-modal conflicts that were identifed on the ped network in Steps 15.3.1 and 15.3.2 must now be reviewed for those segments that have been examined for the application of methods of separation in order to assess the degree to which conflicts have been resolved or alleviated.

19.6.1 Re-Examination of Requirements

Formerly determined physical/functional requirements related to the ped network (Table 33) should be reexamined in light of the specific method of separation which has been selected for each network segment in terms of:

1. Modification, elemination or retention of specific requirements.

2. Provision of new requirements based on site specific conditions.

19.6.2 Review Conflicting Multi-Modal Requirements

The relationship of the modified ped network requirements to T/T systems characteristics must now be reviewed in terms of their impact on former conflicts regarding Displacement and Systems Dysfunctions as defined in Step 15.2.

19.7 Assess Impact Upon Available R.O.W.

The selected separation method must be evaluated in terms of its impact upon available street R.O.W. in order to assess the degree to which a specific street segment can be pedestrianized. Methods of separation can directly affect the level of both pedestrian and vehicular capacity as they potentially create additional R.O.W. (in the case of vertical methods) or require various amounts of horizontal R.O.W. (in the case of horizontal and time displaced methods).

The physical and functional properties identified in Step 19.5.5 above provide the data for determining the spatial requirements for the selected separation method. These dimensional requirements should be entered in the matrix entitled "Evaluation of Spatial Capacity" for the purpose of reassessing the potential for pedestrianization procedures.

Using the evaluation procedures identified in Step 15.3, the reassessment of R.O.W. potential is performed as follows. (Ref. to Table 38)

1. Compare "Total Effective Width Requirements" Col. 20 with "Total Available R.O.W." Col. 19.

2. Col. 20 - remains unchanged as this is the requirement for any selected alternative.

3. Col. 19 - enter in new value for available R.O.W. based upon selected separation method. (See Step 6 PPP procedure for performance of this exercise.)

4. Subtract Col. 19 from Col. 20. This will yield a new value for Col. 20 or 21 which will in turn identify the pedestrianization potential.

The resultant increase in compatibility must be noted on the annotated first network approximation map (see Step 15.3.2) and any such modifications which change major impacts to minor impacts to be addressed through design treatments must also be noted in Table 37, Column 19.

RELOCATE PEDESTRIAN CORRIDORS

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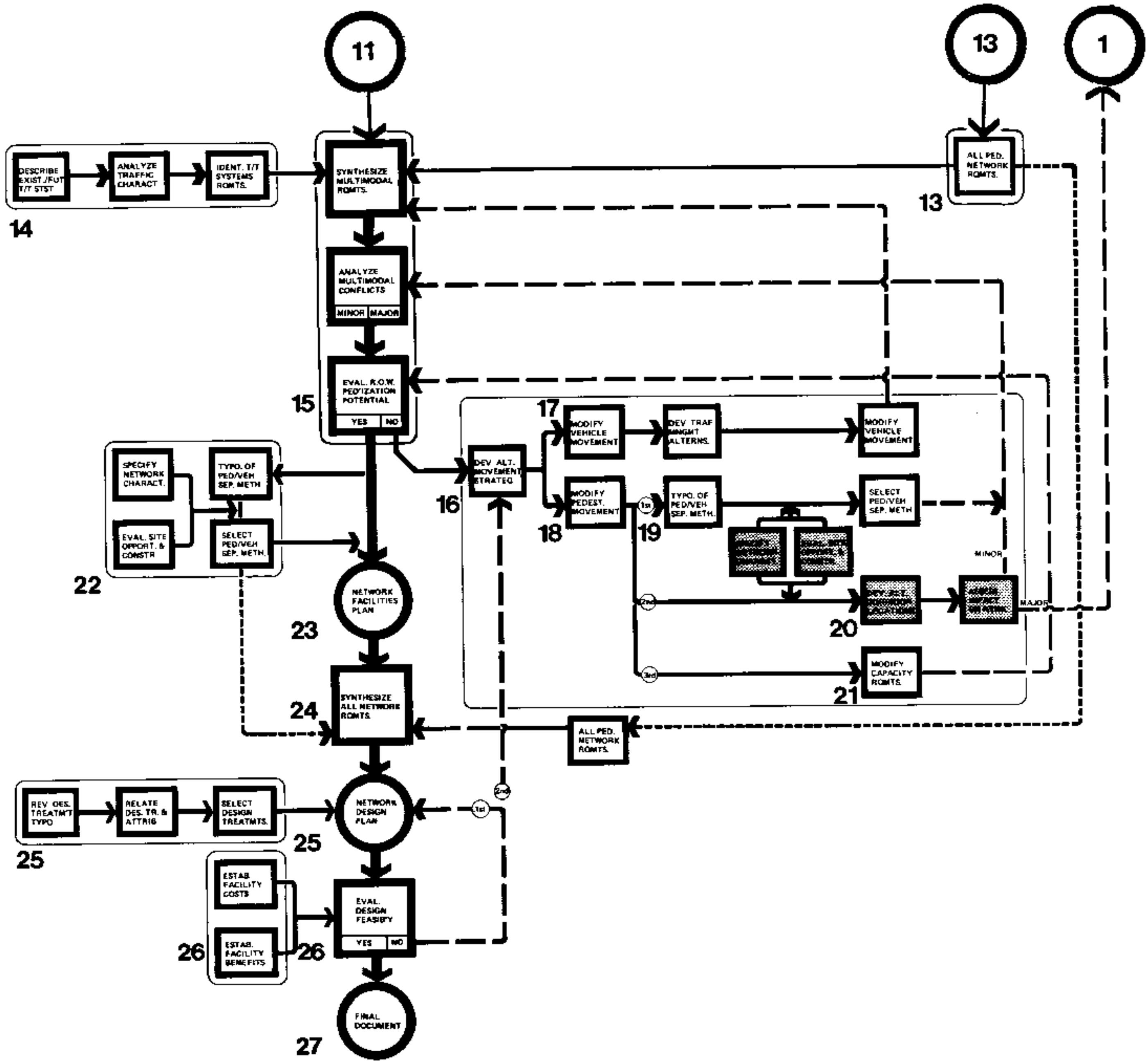


TASK 20
RELOCATE PEDESTRIAN CORRIDORS

20.1 Task Overview

The second alternative in modifying the pedestrian movement network is to consider alternative corridor locations.

The corridors located by the future network location plan indicate those links which have the highest potential for pedestrian utilization based upon a comprehensive set of tripmaking characteristics. The factors which influenced trip-making were for the most part based upon:

- The location of trip generators (land use activity)
- The pathway by which those trips were distributed and exchanged
- The conditions which affect pathway choice

Consequently, these corridors warrant the highest degree of pedestrianization in order to accommodate for anticipated pedestrian flow and for the other segment requirements which will facilitate trip-making.

As has previously been noted, since the majority of these pedestrian corridors are located within the available street R.O.W., specific determinations must be made regarding the amount of the existing street R.O.W. which can be used for pedestrian circulation and the impacts of satisfying other network requirements. These determinations are made as follows using specific procedures discussed in detail within the process to date:

1. Examination of the existing traffic/transit systems in order to identify systems characteristics and existing capacity requirements as well as areas of conflict and surplus capacity and/or deficiency

2. Examination of alternatives in redistributing T/T movement through the use of traffic management or other traffic planning techniques

3. Examination of alternative methods of separating pedestrian/vehicular traffic in order to reduce conflict and reduce the impact of pedestrian network requirements upon the existing street R.O.W.

Should these avenues of investigation prove unsuccessful - that is to say, if based upon the technical requirements of pedestrian circulation and other modal requirements the pedestrian segment component cannot be accommodated or implemented within the parameters of the existing street R.O.W. - then alternative pedestrian corridor locations must be examined.

20.2 Identify Alternative Corridor Locations

The objective of such a reexamination is to determine whether or not the specific network links affected can be accommodated in other areas adjacent to or in the vicinity of the initial corridor location without jeopardizing the intent of the overall circulation plan in terms of utiliza tion. This reexamination may take into consideration:

1. The use of parallel alleys

2. The use of horizontally displaced pathways which are mid-block or penetrate through interior or exterior public space of adjacent development parcels and other alternatives which foster linkage between major building generators

3. The use of alternative street R.O.W's

Since, however, the intitial corridor locations were based upon a comprehensive set of pedestrian trip-making factors, they indicate the most direct and desirable routes. Alteration of these routes through relocation may result in a less desirable location and, in many cases, locations which are not feasible as they are less direct and will therefore be less util-ized. In other cases, due to the location of existing land use activities and due to the lack of opportunity to create an alternative paralledl pedestrian R.O.W., corridor relocation will net be feasible.

The potential utilization of the modified or relocated pathways is contingent upon the ability to modify pedestrian movement behavior, that is, to change and redirect movement to the provided pathway. In certain instances this is possible; specific conditions, however, are required in order to provide benefits to the user (the pedestrian), thus achieving behavior modification and ensuring a high degree of utilization.

20.2.1 Develop requirements for achieving the desired level of pedestrian utilization.

These requirements are based upon the following criteria:

1. Activities which have the ability to generate pedestrian trips.

2. Activities which have the ability to attract pedestrian trips.

3. Provision of pathway attributes which induce increased utilization and maximize perceived benefits to trip makers.

4. Introduction of pedestrian movement contraints which will reduce the utilization of alternative pathways.

As the criteria suggest, a significant level of intervention in the network might be required to achieve the utilization that can satisfy corridor relocation. The level of intervention is comparable to that which would have been required if, for planning policy reasons, certain corridors of thefirst approximation were relocated in Steps 12.2 and 12.3 of the PPP.

If all the criteria listed above (1-4) can be met in the development of alternative corridors, then the probability of modifying movement as desired is high. If, however, only (3) and (4) can be achieved, the probability of movement modification will be lower.

The only conclusive way in which movement modification can be tested, particularly where the corridor link is a significant one in the network, is by re-executing the distribution model using the new input data generated in (1) through (4) and inspecting the resultant new volume assignments to the corridor under examination and those on other links impacted by the movement shift.

20.3 Assess Impact Level On Network

Relocation of any particular pedestrian network segment (corridor) can potentially have an impact upon pedestrian movement and tripmaking in segments beyond the local subnetwork scale. These impacts would relate to pathway directness, accessibility, and connectivity and would be networkwide or non-localized in nature.

Since these kinds of impacts affect overall trip exchange as well as pathway choice, the relocation of corridors can result in producing a modified pedestrian utilization network. This may require a reiteration of the trip distribution model.

1. Determine the nature of the impact on

   - trip generation
   - pathway choice

   Based upon the selected requirements for modification, new inputs to both the calibration of trip generation as well as those factors which effect pathway choice will be identified.

2. Determine the level of impact:

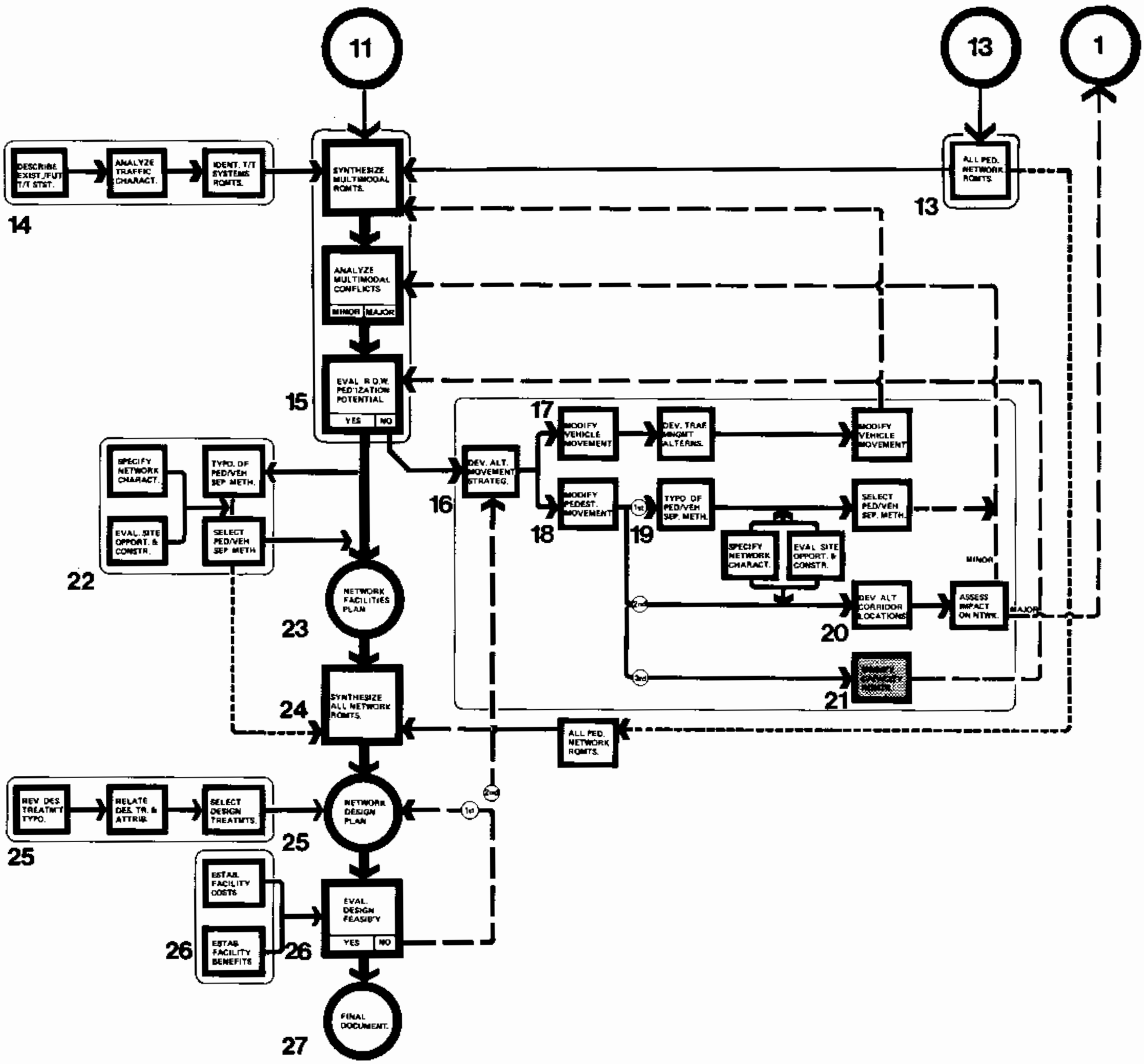
   - sub-network
   - network

   Since both trip generation and pathway choice affect trip distribution, the specific nature and level of the impacts (resulting from required network modifications) will determine the extent to which the exchange model must be recalibrated. This iteration will result in establishing a new potential utilization network.

If only sub-network volumes are affected then the procedures under Steps 19.6, 15.2 and 15.3 must be followed to assess the relocated corridor's impacts on conflict reduction and pedestrianization potential on that segment. If, however, network volumes within a wide radius are impacted, then Step 11.0 of the PPP onwards must be reviewed in terms of the new first network approximation that will have been generated as a result of corridor relocation.

MODIFY CAPACITY REQUIREMENTS

21



TASK 21

MODIFY CAPACITY REQUIREMENTS

21.1 Task Description

Pedestrian network capacity requirements are predicated upon prescribed level of service standards as well as other initially established pedestrian trip-making criteria. Therefore a less drastic physical method of accommodating pedestrian movement (should previous alternatives prove unsuccessful) is to modify the level of service standards which were initially employed to determine pedestrian network capacity requirements (effective width) on various network links.

Reduction of the level of service standards will directly affect the amount of R.O.W. needed for the pedestrian pathway and thereby reduce the impact of the pedestrian network plan upon the available street R.O.W. This, of course, requires the acceptance of less than optimum criteria for the movement of pedestrians in terms of capacity walking speeds and queuing levels. In some cases it may not be feasible to reduce level of service standards for pedestrian volumes relative to available pathway width which may approach levels of congestion, thereby making the link deficient. As the link itself becomes an impedance to the flow of pedestrian traffic, utilization is reduced and consequently potential benefits are impaired.

21.2 Procedures

In modifying level of service standards the following guidelines should be followed:

1. Effective width requirements of walkways and stairways in the pedestrian network plan should not be reduced further than standards which would result in a 3 PFM increase over the PFM value of the optimum width to hourly design volume relationship defined in Figure 47.

2. In no case should the adjusted effective width requirement fall below 5.0 ft. for walkways and 4.0 ft. for stairways that are part of the pedestrian network plan.

3. No queuing level of service standard should fall below 5 sq. ft./person.

4. Segments used mainly for shopping trips might be modified first since this activity generally has a higher tolerance of crowding.

Sample Procedure

Given:

A walkway has a peak hourly design volume of 5000 pedestrian whose recommended effective width requirement is 12.5 ft. (from Figure 13.1.4). However, the optimum width required is not available within the street right-ofway because of vehicular circulation requirements. What is the minimum acceptable effective width that the walkway could be?

Solution:

1. Calculate the PFM value of the recommended (optimum) effective width to hourly design volume relationship:

$$\text{Flow (optimum)} = \frac{5000}{60\ (12.5)} = 6.66 \text{ PFM}$$

2. Determine the maximum acceptable PFM for the walkway:

$$\text{Flow (maximum)} = 6.66 + 3.0 = 9.66 \text{ PFM}$$

3. Determine the minimum acceptable effective walkway width for the given hourly design volume:

$$\text{EWW (min)} = \frac{5000}{60\ (9.66)} = 8.6 \text{ ft.}$$

4. Check that the resulting minimum acceptable width requirement calculated in Step 3 is not below the absolute minimum effective walkway requirement standard (5 ft.):

   5.0' is less than 8.66'

   Therefore: 8.7 ft. is the minimum acceptable effective walkway width.

Once the above guidelines have been met, the new width requirements are to be entered in Table 38 and the appropriate calculations in Procedure 15.3 followed.

SELECT ALTERNATIVE METHODS OF PEDESTRIAN / VEHICULAR SEPARATION

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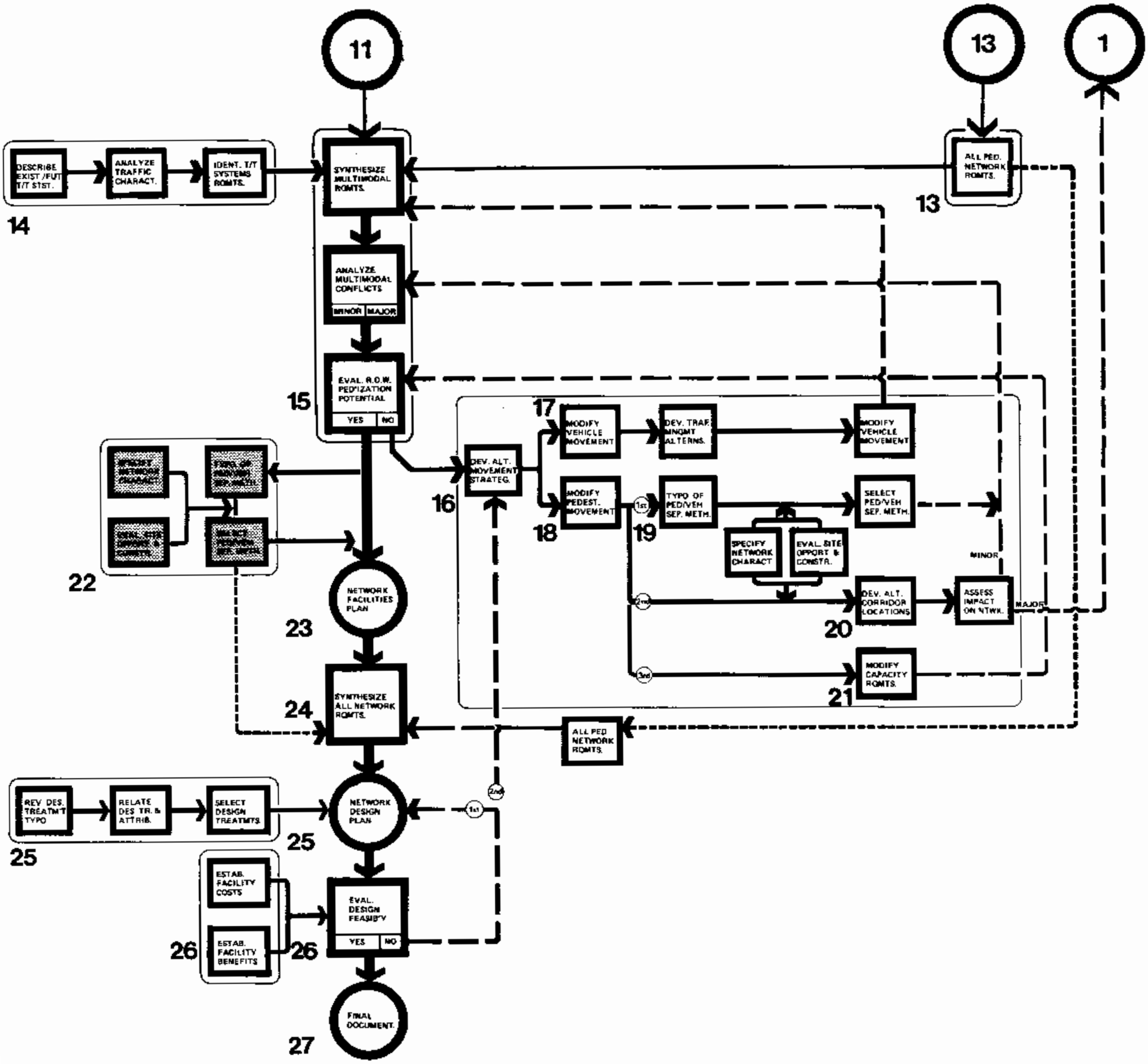

TASK 22
SELECT ALTERNATIVE METHODS OF PEDESTRIAN/VEHICULAR SEPARATION

22.1 Task Description

If the outcome of the evaluation of multimodal requirements was such that:

1. pedestrianization potential (in terms of R.O.W. availability) is sufficient and
2. multimodal conflicts and impacts are minimal,

then the investigation of alternative movement strategies would not be undertaken. Even under such circumstances, however, the creation of specialized pedestrian facilities might be undertaken. For example, in a given situation existing sidewalks, while adequate may be used at their maximum capacity during peak hours. Vehicular traffic alongside might underutilize its r.o.w. Under such circumstances and depending upon the adjacent land uses and planning policy intentions, it may be desirable to widen the sidewalks and install various landscaping amenities. Alternatively, while no problems may result from the sidewalk capacity analysis and other network requirements, significant opportunities might exist to develop pedestrian facilities (e.g., extensive redevelopment, hilly topography). Irrespective of the results of the multimodal evaluation, then, an assessment of the methods of pedestrian/vehicle separation must be made so that the nature of the pedestrian corridors can be specified.

The procedural outline for selection of methods of pedestrian/vehicle separation is as follows:

Introductory Steps 22.1 through 22.3 parallel Steps 19.1 through 19.3.

Step 22.4.1 Identify factors which influence the selection of Methods of Pedestrian/Vehicular Separation (As in 19.4.1).

Step 22.4.2 Identification of Interdependencies Between Condition of Applicability and Methods of Ped/Vehicular Separation (As in 19.4.2)

Step 22.5.1 Identify Data Sources (As in 19.5.1)

Step 22.5.2 Synthesize Prevailing Conditions (As in 19.5.2)

Step 22.5.3 Evaluate the Applicability of Alternative Methods of P/V Separation (As in 19.5.3)

Step 22.5.4 Selection of Method of P/V Separation (As in 19.5.4)

Step 22.5.5 Identify Specific Physical and Functional Requirements of the Selected Method of Ped/Veh Separation (As in 19.5.5)

It should be noted that those procedures which refer to the assessment of the separation method's impact on available r.o.w. and conflict resolution (as in Step 19.4) are omitted in the latter parts of the above sequence. Any new physical or functional requirements which result from the selection of a method of separation will be resolved in the selection of design treatments.

PRODUCE NETWORK FACILITIES PLAN

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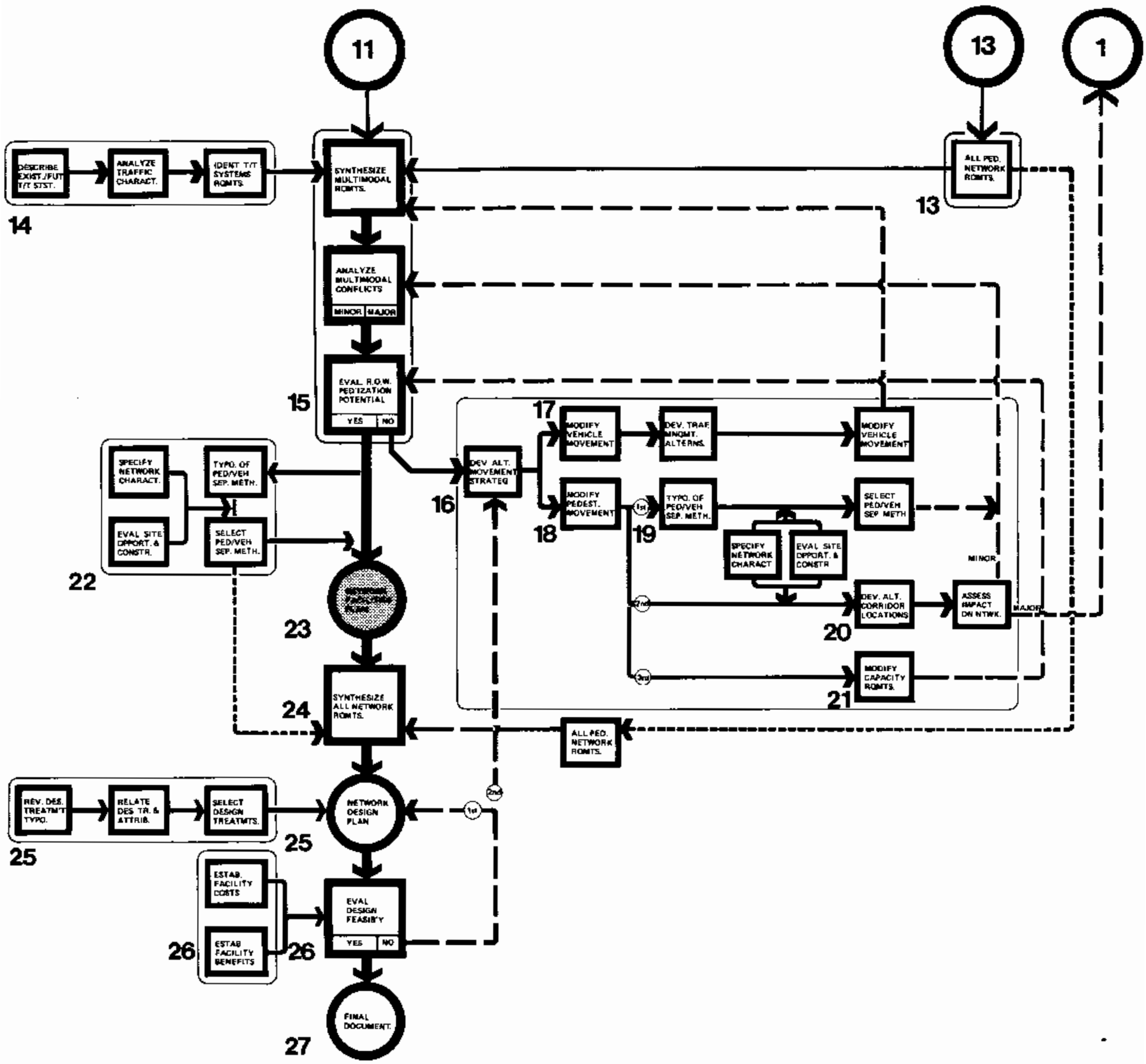


TASK 23
PRODUCE NETWORK FACILITIES PLAN

23.1 Task Description

The selection of specific methods of pedestrian/vehicle separation determines the final disposition of each segment of the network. The Network Facilities Plan graphic should include the following information:

1. The nature of network segments in terms of methods of separation/vehicle separation

2. The location of vertical connectors

Fig. 58 is an example of a Network Facilities Plan.

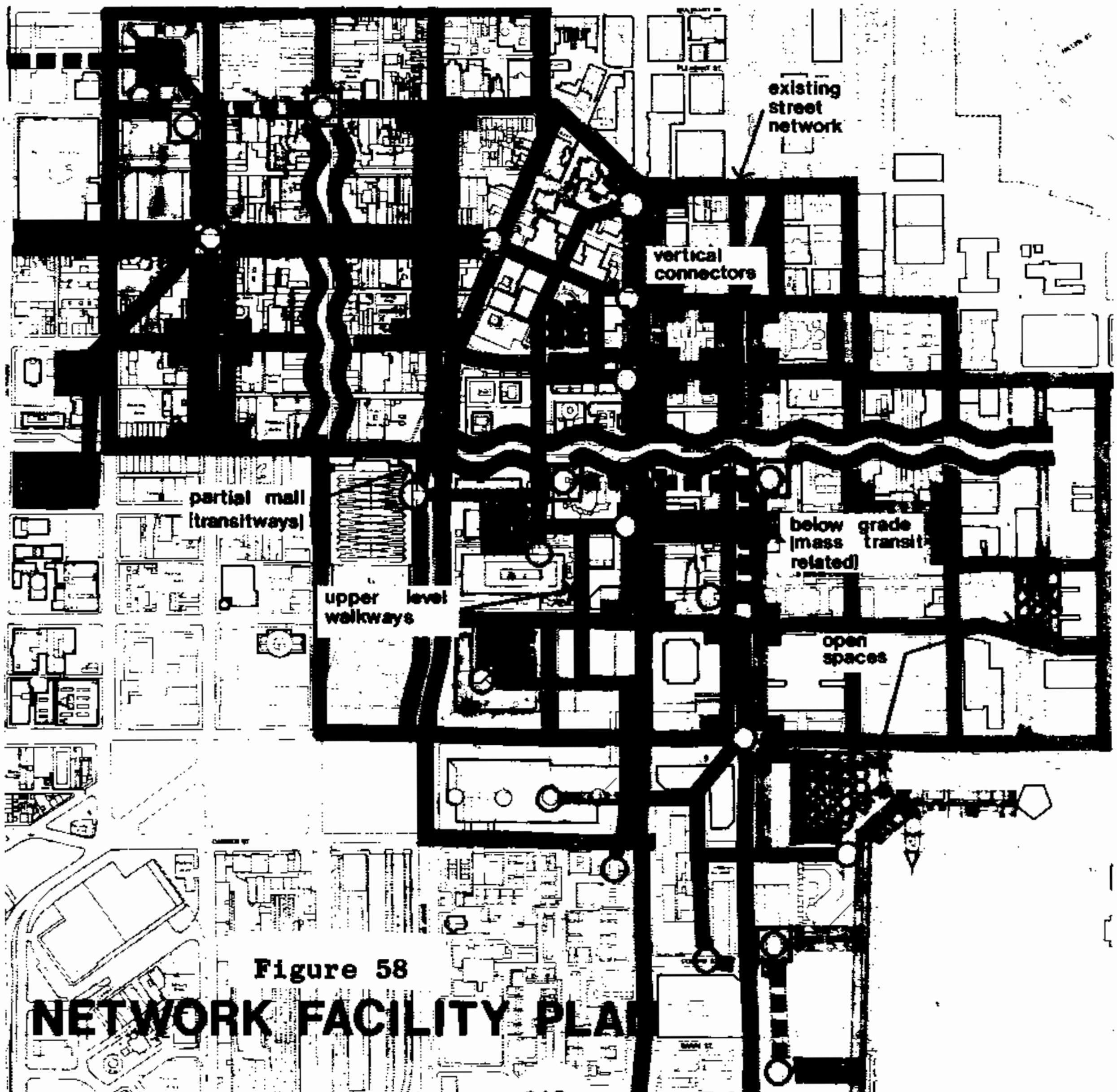
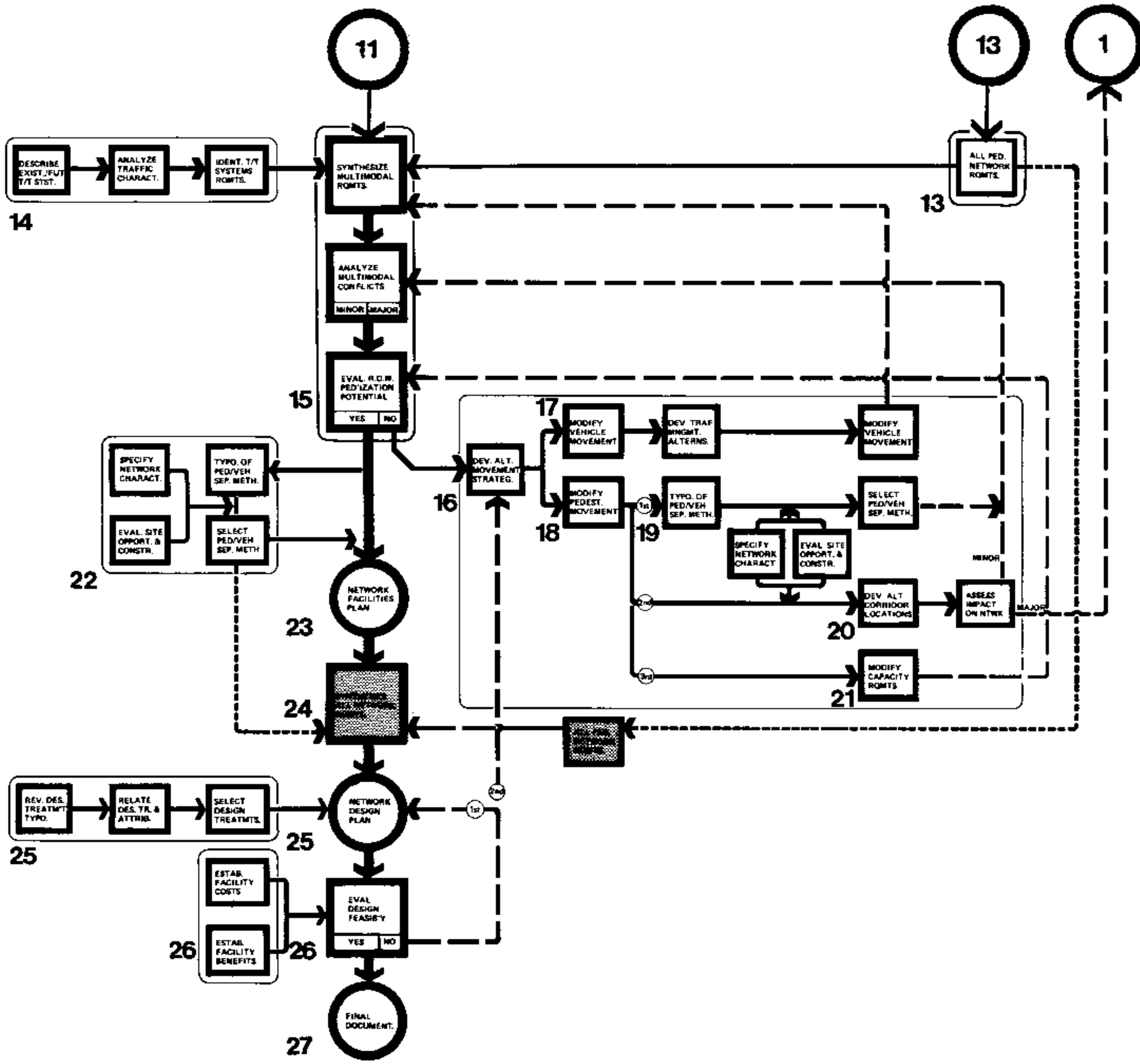


Figure 58
NETWORK FACILITY PLAN

SYNTHESIZE ALL SUBNETWORK REQUIREMENTS

24



TASK 24
SYNETHESIZE ALL SUBNETWORK REQUIREMENTS

24.1 Task Description

By this phase, all issues having implications that are network-wide have been resolved. The general disposition of the network is now a given. Design treatments will affect discrete network segments and, at most, localized subnetworks.

The design program consists of all the requirements or performance specifications that will govern the selection and application of design treatments. Figure 59 indicates diagramatically the relationship between the program elements and the design treatments selection phase which follows.

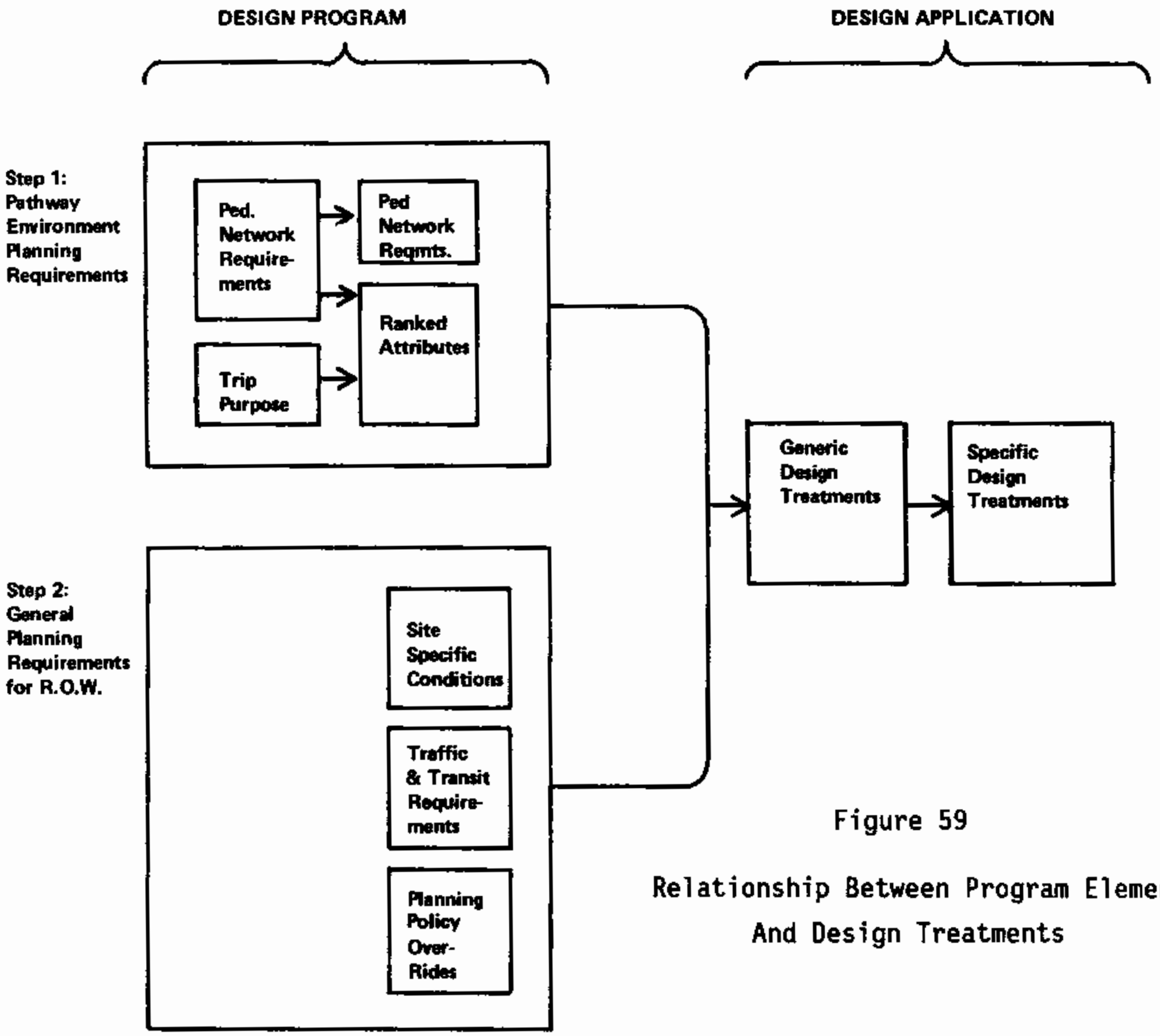


Figure 59

Relationship Between Program Elements And Design Treatments

The program is organized into two categories which correspond with a classification of the street environment into two zones as portrayed in Figure 60. The requirements of one zone, that of the pathway environment itself, was analyzed in Step 13.0, where special attention was paid to the need for various attributes. The other refers to more general planning requirements that relate to the overall R.O.W. and its interface with the pathway environment. These requirements have been accumulated at various points in the procedures as indicated in Table 44.

Taken together, the requirements related to the two zones constitute a comprehensive program for design.

	Program Element	Source
1.	Specific physical & functional ped. network requirements by segment as augmented by requirement arising from the consideration of methods of P/V separation.	Generated in Step 13.3.3 on worksheets 33
2.	Pathway attributes ranked by related network requirements and trip purposes.	Generated in Step 13.3.3 on worksheets 33 and 34
3.	Requirements related to see site specific conditions.	Based on initial data inventory, site observation and survey responses.
4.	Requirements related to traffic traffic and transit system characteristics.	Generated in Step 14.3.2 on Matrix Table 37
5.	Requirements related to planning policy.*	Generated in Step 12.0

Table 44
Design Program Elements and Sources

For ease of reference in the subsequent design treatment procedures, the program data for each segment of the network should be consolidated as much as possible.

*Examples of such policy objectives might be: the exploitation of an adjacent land use as an opportunity to enhance activity; the creation of a design treatment theme to link a subnetwork together visually; a considerable increase in security personnel; a policy to preserve the setting of a particular building adjacent to the pathway, etc. The impact of policy considerations can potentially override, reinforce or eliminate the consideration of certain design treatments.

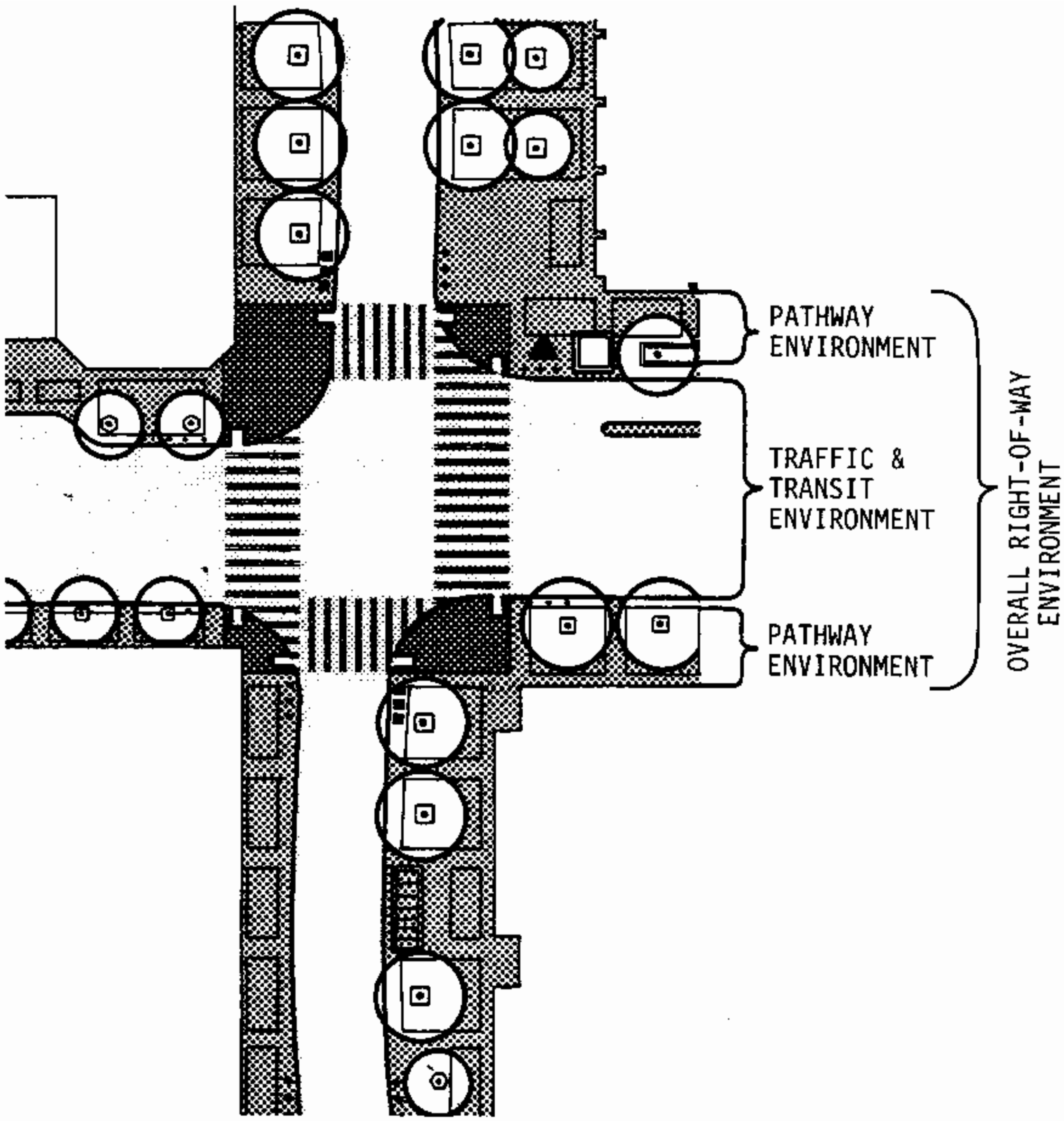
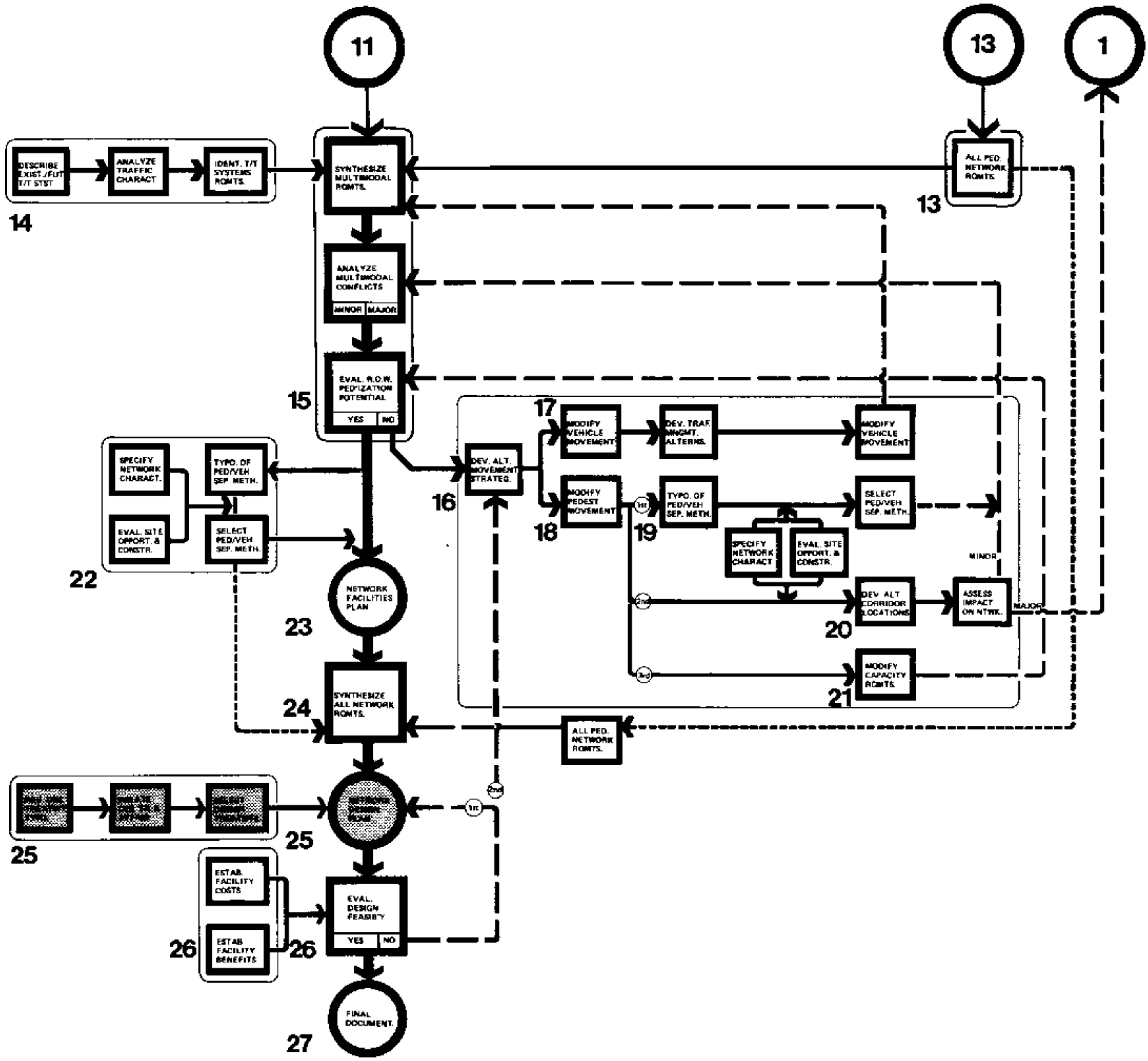


Figure 60

Pedestrian Systems Interface Element

SELECT DESIGN TREATMENTS

25



TASK 25

SELECT DESIGN TREATMENTS

The intent of the procedures in this phase is to provide guidelines for the selection of appropriate generic types of design treatments and the avoidance of inappropriate ones. No attempt will be made to specify the great variety of available design treatments nor the infinite number of site-specific conditions or combinations of conditions which might suggest a particular treatment as the solution. This is the domain of the designer where sensibility and judgement come into play. These procedures seek only to usefully structure for the designer the necessary programmatic information and selection criteria.

In this section, programmatic requirements will be related to a typology of design treatments. Only in the case of pathway attribute requirements will the relationship with the design treatment typology be structured. (See Step 25.2) For the rest, the intent of the typology is to provide a useful and efficient framework in considering the suitability of various treatments for specific pathway conditions.

25.1 Identification Of Design Treatments

The fundamental function of streetscape treatments is to support, or where necessary modify, trip making for the purpose of increased pedestrian system utilization and increased perception of benefit by the trip makers. Specific pathway elements can be aggregated into basic types. The method employed to group these pathway treatments and structure the typology of this section is based upon the combination of generic functions which design treatments perform and their generic physical characteristics. Collectively the categories represent the full range of state-of-the-art treatments used by planning/design professionals to support pedestrian systems:

I. Traffic Control Devices

a) Traffic signalization/phasing
b) Regulatory signs
c) Control devices
d) Right-of-way controls

II. Pedestrian Movement Constaints

a) Marked crosswalks
b) Demand-actuated signals
c) Right-of-way controls
d) Pedestrian control devices

III. Vertical Connectors

a) Stairs
b) Ramps
c) Escalators
d) Elevators

IV. Signage

a) Wayfinding/overhead
b) Wayfinding/freestanding
c) Announcements/overhead
d) Announcements/freestanding

V. Lighting

a) Pedestrian-related
b) Vehicular-related

VI. Street Furniture

a) Pedestrian convenience
b) Pedestrian amenities

VII. Landscaping

a) Large trees
b) Low plants
c) Non-grade plantings

Table 45

Design Treatment Typology

Appendix P contains definitions of the above major treatment categories and their subcategories.

25.2 <u>Identification of Interdependence Between Pathway Attributes and Design Treatments</u>

As Figure 59 indicated, the ranked pathway attributes developed in Step 13.3.3 are to be interfaced with the design treatment typology. For each network segment matrix Table 46 depicts these relationships in graphic form. The matrix is based on a review of current literature and other material related to design treatments and represents a synthesis of current state-of-the-art thinking.

A positive value indicates that the relevant treatments in that category can contribute to the development of the related pathway attribute. A negative correlation value on the matrix flags those treatments which can potentially counteract the achievement of a desired pathway

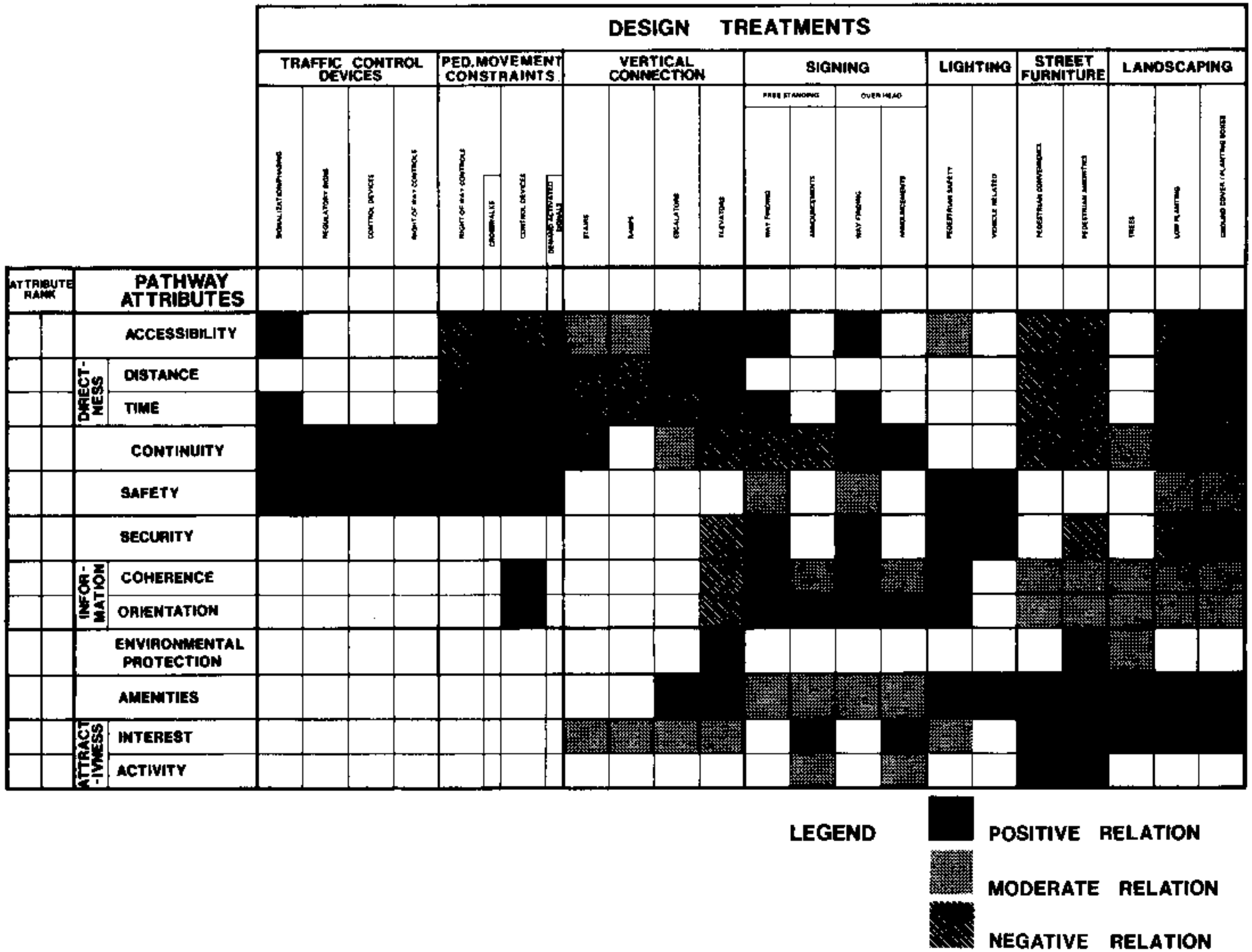


Table 46

Relationship Between Design Treatments And Pathway Attributes attribute. The treatments/attributes matrix, representing functional interdependencies, is used to determine those treatments that are necessary and suitable for the achievement of desired conditions, as well as those that should be avoided. Used in conjunction with the treatment evaluation tables (which are provided in Step 25.3), gross mistakes in treatment application can be avoided.

Two rankings for the attributes will have been entered in the matrix, one deriving from all network requirements except trip purpose, the other from trip purpose alone.

The two rankings in Table 46, viewed together, provide a general guide to the priorities of the various attributes required. Where both rankings coincide, the priority of the attribute is reinforced. Where there is some difference, judgement must be used to ascribe a priority. The attributes clearly differ in nature and are not interchangeable. The desirable attribute ranking yielded by the trip purpose analysis must be viewed against and modified by the preexistence of the same attributes in the context under examination.

It can readily be observed from Table 46 that particular treatment categories which aid in the achievement of some attributes, potentially conflict with others. The proper placement of such treatments can avoid or minimize conflicts in some cases. In others, tradeoff judgements between treatments will have to be made once all the data relevant to design treatments has been synthesized.*

The Table is further interpreted in terms of advantages and disadvantages related to each design treatment category in the following section, where locational criteria are added for each category as well.

25.3 Select Specific Design Treatments

25.3.1 Identification of Guidelines and Conditions Relative to Location of Pathway Elements

Specific treatments or design elements within any design treatment category will be examined either because of their relationship to a relevant attribute or because of their appropriateness in meeting a particular requirement or site-specific condition, irrespective of the attribute involved. In some cases, the type and location of a design element will be wholly determined by the nature of the requirement itself (e.g., a pedestrian-activated crosswalk signal); in others there will be wide freedom in choosing between elements and in locating them on the pathway.

Where some latitude exists, the location of elements must be related to the usage characteristics of pathways.

*An exception to the tradeoff notion is the attribute of pedestrian safety. Irrespective of its attribute ranking, where a safety deficiency exists, the hazard must clearly be rectified.

25.3.2 Classification of Pathway Usage Characteristics

Pathways under use were subdivided as follows in the discussion on capacity requirements.

1. Circulation areas: Those parts of the pathway used for continuous movement (effective width).

2. Ancillary areas: Those parts of the pathway not used for continuous movement by tripmakers, but adjacent to or associated with the pathway.

3. Specialized conditions or functions (queuing areas, vertical connectors, etc.).

In certain cases the configuration of the pathway or the nature of abutting land uses will determine which part of the pathway will be used as the circulation area and which will become ancillary. In other cases, the design, through the placement of design elements, will indicate the pathway differentiation into circulation or ancillary areas. The need for such differentiation is contingent upon trip purpose.

For work trips, circulation areas must be clearly defined and be free of impedances. The most significant attributes related to work trips are directness (measured in time, distance, or accessibility), attractiveness, and low impedance. These attributes suggest that for work trips, circulation areas should preferably not contain

- Street furniture that is obstructive

- Vertical connectors (except escalators)

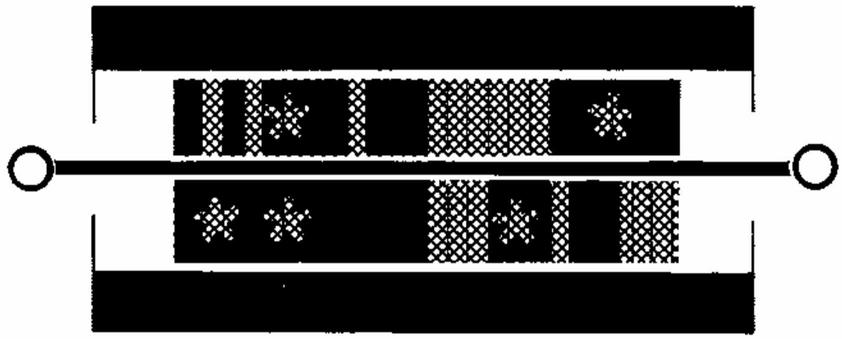
- Pedestrian movement constraints (other than crosswalks or demand-activated signals) except insofar as they aid in providing pathway continuity

- Freestanding signage

Schematically the desirable relationship between circulation areas and ancillary areas for the work trip can be represented as shown in Figure 61.

For shopping trips, circulation areas must also be differentiated from ancillary areas since directness is a required pathway attribute. Other attributes to be provided include amenities, information and attractiveness. This suggests that shopping trip-making exhibits a higher level of tolerance to discontinuous circulation areas than, say, the work trip.

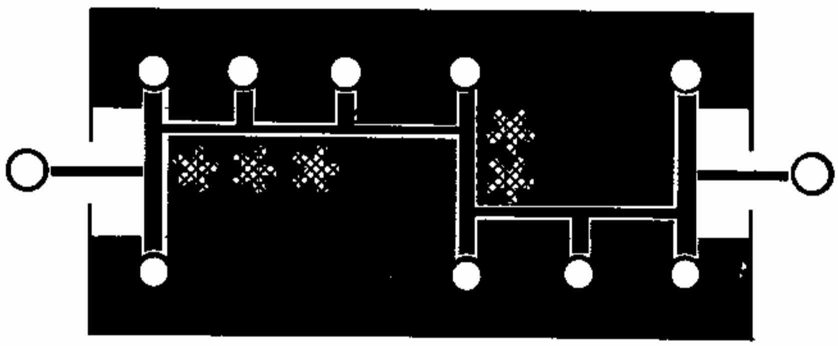
Schematically the possible relationships between circulation areas and ancillary areas are represented on Figure 62.



EMPHASIZING DIRECT PATHWAY

Figure 61

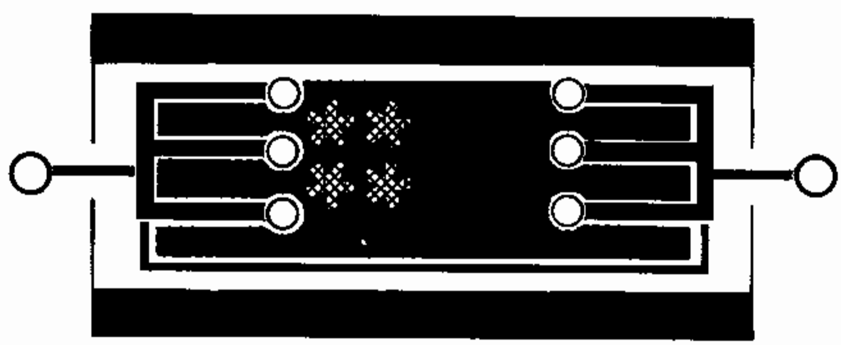
Schematic Design Treatment Placement - Work Trip



EMPHASIZING ACCESS TO ABUTTING ACTIVITY

Figure 62

Schematic Design Treatment Placement - Shopping Trip



EMPHASIZING ACTIVITY WITHIN THE PATHWAY

Figure 63

Schematic Design Treatment Placement - Soical/Recreational Trip

Design elements for ancillary areas, while they may be chosen with some freedom to provide attributes of information, amenities and attractivenss, must not impede accessibility to abutting retail land uses.

In the case of social/recreational trips there can be a considerable integration of circulation and ancillary areas since directness and accessibility are less important attributes than the provision of amenities and attractiveness. Schematically the relationship between circulation areas and ancillary areas, which in this case can themselves become points of attraction, can be represented as shown on Figure 63.

25.3.3 Locational Guidelines

The design treatment categories are described in Section 25.3.4 in terms of their positive and negative capacities for achieving the various pathway attributes. These descriptions of advantages and disadvantages are based on Table 46. The locational guidelines that are also provided for each treatment category note the following kinds of considerations:

1. Any relationship to the relevant trip purpose requirements as they affect the pathway's physical/functional characteristics.

2. A dependency on the site-specific conditions.

3. The minimization of the treatment categories' potential negative impacts.

4. General guidelines for the appropriate location of a design treatment category based on the nature of the category (irrespective of trip purpose).

Reference to Section 25.3.4 will ensure that the placement of the various design elements reinforces pedestrian tripmaking and movement.

Supplement 15 deals with recommended design treatments for intersections of various kinds.

25.3.4 Summary of Advantages, Disadvantages and Locational Considerations for Design Treatments

TRAFFIC CONTROL DEVICES

ADVANTAGES

- Potential to have positive effect on issues of pedestrian vehicular conflict and reduction of impedance to pedestrian movement.

DISADVANTAGES

- Due to the nature in which control devices are located they may negatively impact desired safety by creating a sense of disorientation or confusion.

LOCATIONAL CONSIDERATIONS

- For the most part, these elements are dependent upon site specific conditions and regulated by local state and federal laws.

- Standardization should be maintained with respect to the overall vehicular system so that the location of control devices can be anticipated and appropriate responses can be safely made by the motorist.

- For the purpose of increased safety and the reduction of disorientation and confusion, components should be coordinated in terms of locational and physical interrelationship to provide a disciplined presentation of information to the motorist.

- Where appropriate the structural support of control devices should be located in buffer or collector strips. At intersections, the support should be located outside the pedestrian holding apron.

PEDESTRIAN MOVEMENT CONSTRAINTS

ADVANTAGES

- Through an increase in pedestrian awareness and control of pedestrian movement positive impacts occur to pedestrian safety and impedance to movement.

- May also provide unity and a level of pathway coherence.

- Crosswalks and pedestrian signals have a positive impact on directness of movement and increased accessibility.

DISADVANTAGES

- Due to the nature of countermeasures, they in general tend to impair accessibility and thereby increase effective trip time and trip distance.

LOCATIONAL CONSIDERATIONS

- For the most part they are dependent upon site specific conditions.

- Should be located to minimize excessive displacement of dominant pathway desire lines and maintain pathway continuity.

VERTICAL CONNECTORS

ADVANTAGES

- Provides for increased accessibility.
- In special cases (escalators, etc.) they potentially through their specific design treatment can be pathway amenities.
- Escalators and elevators have a positive impact on distance.
- Elevators by their physical characteristics provide environmental protection.

DISADVANTAGES

- All forms of vertical connection have a negative impact on effective time and in some cases distance.
- From the standpoint of (1) energy expenditure in the case of stairs and ramps and, (2) time delay for queuing in the case of escalators and elevators, there can potentially be an impact on pathway directiveness, coherence, and orientation.
- Elevators can negatively impact security.

LOCATIONAL CONSIDERATIONS

- Considerations to great extent are based upon site specific conditions along pedestrian network.
- Provide at those locations that minimize effective pathway distance and time along dominant pedestrian desire lines.
- Provide at those locations that are obvious and highly visible to enhance use.
- Locate at extreme points of upper level pedestrian systems and at major activity generators.
- Location of escalators and elevators should take into account the associated queuing, apron areas and respect effect width requirements along the unimpeded pathway.
- Avoid locating elevators in areas where security is a problem.

SIGNALS

ADVANTAGES

- Possesses predominant advantages across most all attributes. Has positive effect on way finding.

DISADVANTAGES

- Potential of freestanding elements to impede pedestrian movement.
- Due to the manner in which they are located, they may create a visual sense of clutter thus negatively impacting attractiveness.

LOCATIONAL CONSIDERATIONS

- The nature of support (overhead freestanding) and the location of signage with respect to the unimpeded pathway is dependent upon the predominant trip purpose and associated physical and functional characteristics.
- Provide at those key locations where alternative routes are available to the pedestrian and a pathway choice must be made.
- At those locations where pedestrian egress to and from transportation facilities into the pedestrian network.
- At points where the signing element is readily visible and accessible, yet not in the stream of pedestrian movement so as to cause an impedance.
- At locations where changes of level are necessary and/or the visibility of activities further along the pathway is blocked.
- At places where there is an expectation of substantial numbers of people unfamiliar with the downtown area.
- Should be coordinated with the lighting system.
- Locate in manner to avoid the sense of clutter.

LIGHTING

ADVANTAGES

- Lighting provides for pedestrian safety and security.
- Provides for pathway amenity coherence and orientation.

DISADVANTAGES

- No negative impacts.

LOCATIONAL CONSIDERATIONS

- For the provision of coherence and orientation locate lighting to: (1) define the organization and hierarchial structure of street and pedestrian pathway circulation and (2) provide accenting to special features and activity areas.

- Locate to provide essential information about the immediate area to all users of the public right-of-way, especially at points of pedestrian/vehicular conflict and where a pathway choice must be made.

- Special locational consideration should be given to (1) locations where security, safety and vandals are a problem and (2) where night visibility is essential to the support of other treatment categories related to safety and security.

- Where appropriate the structural support for lighting should be located in buffer and collector strips, and at intersections located outside the pedestrian holding apron.

STREET FURNITURE

ADVANTAGES

- Provides for pathway amenity, interest, and activity.

- In special cases may provide a level of environmental protection.

- Can contribute to pathway coherence and orientation.

DISADVANTAGES

- As a function of location they can potentially impede tripmaking and impair accessibility.

- As a function of their physical properties they can potentially create security problems related to vandalism.

LOCATIONAL CONSIDERATIONS

- Locational considerations are dependent upon the predominate trip purpose and associated physical and functional characteristics as well as site specific conditions.

- Locate elements in manner that avoids sense of clutter.
- Locate where surveillance is available and vandalism is not a significant problem.
- Locate to define the pedestrian pathway and where appropriate, provide at points of orientation.
- Convenience treatments such as mail boxes, drinking fountains, etc. can be clustered in buffer zones, or passive activity areas.
- The location of treatments related to convenience is dependent upon the service provided and should be easily accessible yet out of areas of major pedestrian/vehicular conflict.
- Amenity treatments may be clustered at strategic points to create or enhance an activity node.

LANDSCAPE

ADVANTAGES

- Ability to provide amenity and pathway interest.
- Can become a device to unify pathway corridors and provide an additional level of pathway coherence and cohesion.
- Low landscaping can be used to form a buffer zone to reduce pedestrian/vehicular conflict and thereby enhance safety.
- Large trees can provide a level of environmental protection.

DISADVANTAGES

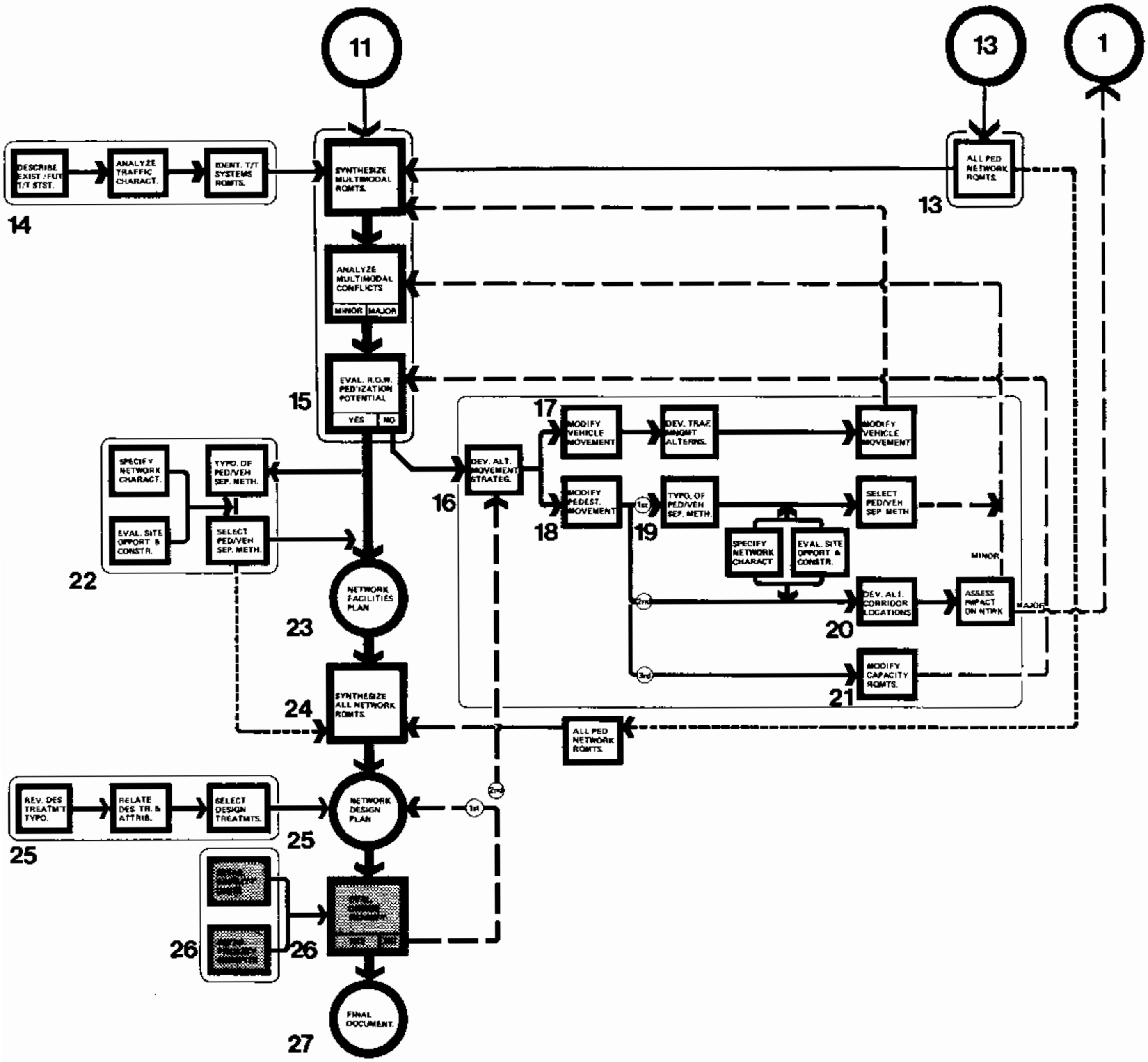
- Low planting and planting boxes can, due to location potentially impede trip movement.
- Can create a security problem in that it may provide low hidden areas.

LOCATIONAL CONSIDERATIONS

- Locational considerations are dependent upon the predominate trip purpose along pathway and associated physical/functional characteristics, as well as site specific conditions.
- Locate in those areas where lighting and surveillance is sufficient to avoid vandalism.

PERFORM NETWORK IMPACT ASSESSMENT

26



TASK 26

PERFORM NETWORK IMPACT ASSESSMENT

26.1 Task Description

Impact assessment includes:

(1) an evaluation of implementation feasibility in terms of the location, type and design of pedestrian facilities

(2) an assessment of the level of effectiveness that will be achieved through systems implementation in terms of benefit, utilization and cost impacts.

The feasibility evaluation considers mainly technical criteria and is conducted as an integral part of most planning procedures in the Manual. The assessment of effectiveness considers a broad range of impacts, and for the most part addresses the final system design.

Each facility or segment of the overall pedestrian network should be assessed independently. Certain network segments, however, may be functionally interdependent and will require a more comprehensive assessment.

Each facility or segment of the overall pedestrian network should be assessed independently. Certain network segments, however, may be functionally interdependent and will require a more comprehensive assessment.

26.2 Evaluation of Implementation Feasibility

Evaluation procedures have been developed within the respective methodologies and technical procedures of several critical steps within the Pedestrian Planning Process. The performance, as well as the outcome of these procedures required that a specific evaluation be made within the context of the developmental procedure.

Evaluation procedures which are "built into" the Planning Process are identified in Table 47.

Prior to finalizing the Pedestrian Network Plan, the Network Design Plan (which is the result of Step 25.0) must be evaluated. This evaluation includes consideration of the degree to which the Design Plan satisfies all Subnetwork Requirements.

The requirements, which were synthesized in Step 24.0 and constitute the design program, are also used here as criteria for design evaluation. These were:

Task	Item	Description of Evaluation
4.	Trip Generation	Assessment of generic trip generation against actual counts.
6.	Intercentroid Separation	Assessment of forecasted exchange patterns against actual travel patterns. (Relative distribution or proportion not actual quantification)
7.	Trip Exchange	Assessment of actual attitudes and perceptions of trip makers against generic data.
9.	Calibration	Assessment of modelled volume assignments against actual counts
12.	Planning Policy	Assessment of the impact of potential network upon current planning policy decisions
13.	Identification of Pedestrian Network Requirements	Assessment of current deficiencies and impacts relative to the walking environment
15.	Identification of Impacts and Conflicts	Assessment of pedestrian network requirements against multi-modal requirements. (Implementation feasibility)
15.	Evaluation of R.O.W. Potential For Pedestrianization	Assessment of pedestrian network requirements (spatial) against available street R.O.W. (implementation feasibility)
17.	Traffic/Transit Characteristics	Assessment of existing traffic/transit systems deficiencies and dysfunctions
16-21.	Development of Alternative Movement Strategies:	
-	Traffic Management	Assessment of traffic/transit alternatives against current traffic/transit systems operational efficiency
-	Selection of Methods of P/V Separation	Assessment of various separation methods against network characteristics, site opportunities, constraints and cost
-	Relocation of Movement Corridors	Assessment of impact of corridor relocation upon network utilization in terms of trip making and trip exchange
-	Modification of Level of Service Standards	Assessment of impact upon network utilization in terms of trip making
23.	Development of Network Facilities Plan	Assessment of plan refinements in terms of separation methods with municipality
25.	Pathway Attributes	Assessment of the impact of pathway attributes related to trip making by specific trip purpose.
25.	Design Treatments	Assessment of the relationship between pathway attributes and design treatment categories

Table 47

Evaluation Procedures Within The PPP

a. Physical and function pedestrian network requirements.
b. Requirements related to methods of P/V separation.
c. Attribute-related requirements.
d. Requirements related to site specific conditions.
e. Requirements related to Traffic and Transit Systems characteristics.
f. Requirements deriving from survey responses.
g. Requirements related to general planning policy.

All of the evaluation procedures described above have been directed towards establishing feasibility of implementation in three critical areas:

- facility location and extent
- facility type (method of pedestrian/vehicle separation)
- facility design

At various points within the pedestrian planning process competing planning or design alternatives will have been generated and evaluated so that the resulting final plan network will illustrate the single most valid alternative of those considered in terms of facility location, extent and nature. The procedures, however, do not preclude the examination of several competing alternatives in terms of type (method of ped/veh separation) and design treatments if the user so desires and has the resources.

26.3 Assessment of Level of Effectiveness

The assessment of the level of effectiveness that will be achieved through network facility implementation invokes the interrelated concepts of systems benefits and systems utilization. The level of effectiveness is a function of both the benefits to be derived as well as the utilization attained.

The process of planning and designing separate facilities for pedestrian circulation focused upon the concept of utilization. To this end the process enumerated all of the factors and impact which should be taken into consideration in establishing the need for a facility as well as determining the location and configuration of elements of the pedestrian network. The central issue in determining the potential effectiveness of a given or proposed system is the degree of utilization - for without utilization no benefits can be derived. User demand is fundamental to the concept of systems utilization, which has been found in prior research studies to be the basic source of potential benefits to be derived through systems implementation. User demand is both a necessary and sufficient condition upon which the process is invoked and feasibility can be defined. This is to say that without substantial utilization no benefits can be derived by either the user or the non-user (abutting property occupants and the motorist). Pedestrian facilities, therefore, should be planned and designed based upon their propensity to be utilized. The extent to which they might be utilized is dependent on two basic factors:

1. Facility pathways must serve points of significant pedestrian trip generation or attraction.

2. Facility pathways must provide the pedestrian with benefits not found on alternative paths.

The level of effectiveness will be measured in terms of the net change in benefit as well as utilization between the proposed facility and the existing environment. The possible results of such an assessment are illustrated as follows (Figure 64).

UTILIZATION	BENEFIT: Proposed Greater Than Existing	BENEFIT: Proposed Less than or Equal To Existing
Proposed Greater Than or Equal to Existing	Select Proposed (1)	Existing Preferable (2)
Proposed Less Than Existing	Requires Further Analysis (4)	Existing Preferable (3)

Figure 64

Possible Outcomes Of Level Of Effectiveness Assessment

- Condition 1 - If the proposed system exhibits potential levels of both utilization and benefit which are clearly greater than those of the existing environment, then the proposed system, subject to cost issues, is preferred;

- Condition 2 - If the proposed system exhibits a potential level of utilization which is greater than that of the existing environment, but the potential benefit of the proposed is less than the existing, then implementation of the proposed system should not proceed; the expense involved in implementing the proposed system simply would not be justified by a decrease in overall benefit. A condition like this might occur when the proposed system aggregates movement, thereby resulting in a higher utilization. However, it is possible that the impact on abutting land uses or vehicular traffic, for example, may be negative, and therefore, the proposed system would not be justified.

- Condition 3 - This is the reverse of Condition 1. If both utilization and benefit are greater for the existing situation than for the proposed system, then the proposed system is clearly not justified, regardless of cost issues.

- Condition 4 - When comparing the proposed system with an existing situation, it is possible that the proposed system might result in reduced utilization, but increased benefit. In this case, the issue of system justification, coupled with cost issues, is less clear, and further judgement or analysis may be necessary. This condition might arise, for example, when a pedestrian overcrossing is proposed to alleviate a severe and hazardous pedestrian/ vehicular conflict. The inconvenience of using the facility may reduce overall utilization of the affected network segment, due to the perceived disincentive of moving up to the crossing level. However, for those pedestrians who continue to traverse the affected segment, the trip will be made at less risk, which results in increased benefit despite reduced utilization. To evaluate this condition, it may be necessary to examine additional considerations, external to the straightforward assessment. Another situation arises when a given segment is so congested that the crowding represents a disbenefit to pedestrians. A proposed system that offers alternative pathways could reduce utilization on the congested segment, and result in an elimination of the disbenefit. Again, external considerations related to the impact on the alternative pathways should be examined.

A sequence of procedures that may be used in assessing level of effectiveness is provided in the following sections.

26.4 Procedures

26.4.1 Identify Potential Impacts

Table 48 identifies and classifies various potential areas of impact or benefit that are associated with the assessment of pedestrian facilities. The list represents a synthesis of variables from several sources and is meant to illustrate the most significant benefit or impact variables, rather than be exhaustive. Certain of the variables, as the

COST	BENEFIT	QUANT. IN $	IMPACTS
			PRIMARY IMPACTS UPON PEDESTRIAN
	o	x	- Pedestrian Safety (From Vehicular Conflict)
	o	x	- Trip Times and Distances
			- Accessibility (To Desired Activities)
			- Environmental Protection (Including Noise and Air)
			- Capacity (Crowding, Queueing)
			- Security (From Threat of Crime)
			- Ease of Walking (Uniform Surface, etc.)
			- Continuity
			- Provision For Special Groups (Handicapped, Aged, etc.)
			- Coherence (Way-Finding, Signing)
			- Amenity and Comfort
			- Interest
			- Health (Exercise, Fatigue)
			- Social Interaction
			SECONDARY IMPACTS UPON VEHICLES AND ABUTTING PROPERTY
			<u>Motor Vehicle</u>
*	o	x	- Operating Costs
			- Congestion (Air, Noise, etc.)
			- Accessibility (To Desired Activities)
			- Usage (Pedestrian/Vehicular Modal Choice)
			- Motorist Frustration
	o	x	- Accidents (Pedestrian/Vehicular Conflict)
			- Diversion During Construction
*	o	x	- Vehicular Delay
			<u>Abutting Activities</u>
	o	x	- Property Values
	o	x	- Retail Sales
	o	x	- Occupancy Rates
			- Land Utilization Intensity
			- Servicing (of Adjacent Activities)/Deliveries
			- Employee Accessibility
			- Clientele, Shopping Habits
			- Attitudes (Workers, Shoppers, Merchants)
			- Connectivity of Compatible Land Uses
			- Greater Use of Sidewalk
*		x	- Displacement or Dislocation
*	o	x	- Renovation
			INDIRECT AND GENERALIZED HIGHER ORDER IMPACTS
			<u>Financial</u>
	o	x	- Net Increased Tax Revenue From Existing Sources
	o	x	- Stabilization of a Declining Tax Base
	o	x	- Net Additions to the Tax Base
*		x	- Change in Cost of Providing Community Services
	o	x	- Increased Employment From Increased Land Utilization
			<u>Environmental</u>
			- Improved Air Quality
			- Reduced (or Relocation of) Noise
			- Increased and Improved Open Space
			<u>Perceptual</u>
			- Enhanced Civic Image
			- Improved Visual Attractiveness
			- Increased Public Optimism and Enthusiasm
			<u>Social</u>
			- Less Littering
			- Connectivity of Neighborhoods and Other Land Uses
			- Less Crime and Vandalism
			- Enhanced "Place-to-Be" Image
			- Increased Hours of Activity
			- More Public Events
			- Attraction of Outside Conventions, Expositions
			- Residential Dislocation
			- Public Participation in the Planning Process
*		x	COST OF CONSTRUCTING, OPERATING & MAINTAINING FACILITIES

Table 48

Impacts Of Pedestrian System Implementation table indicates, are quantifiable in dollar terms using various methods that have been developed in prior research. (See Supplement 16.)

26.4.2 Determine Change in Level of Benefit

The methodology that is recommended for determining the level of benefit is that developed by the Stanford Research Institute in a study entitled Quantifying the Benefits of Separating Pedestrians and Vehicles.*

While this methodology was developed primarily to select from amongst several alternative proposals, it can validly be used to compare a single proposal with the existing situation as is proposed in this section. Figure 65 illustrates the general flow of steps within the methodology and Figure 66 shows a sample worksheet produced at the end of this evaluation exercise. Supplement 16 contains selected chapters from the above study which explains the methodology and provides techniques for the measurement of benefits. The list of facility evaluation variables suggested in the above study has been selectively abridged to include only those considered to be most relevant to the issues that have typically influenced decisions to create pedestrian facilities. Accordingly, only those techniques for evaluating or 'scoring' the selected variables have been included in the Appendix. Also, modifications to the variable weighting system have been made and are explained within the preamble to Supplement 16. The study explicitly invites modifications of the above kind and these in no way invalidate its basic methodology.

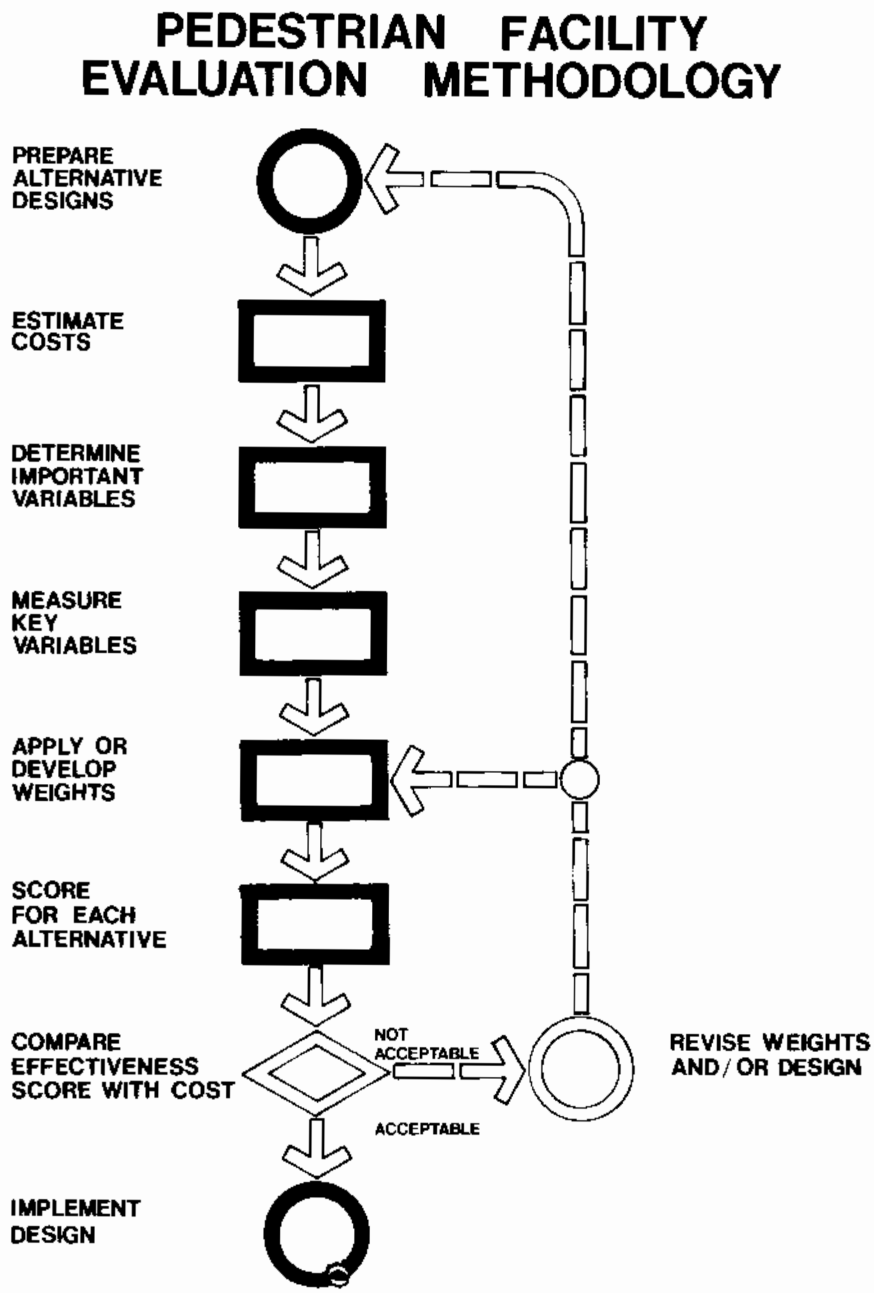
Once the change in benefits has been determined, reference to Figure 64 may be made. If benefits of the proposed system exceed those of the existing or "do nothing" situation, the proposal is unsound in terms of either facility location, extent, or nature. It is conceivable, however, that for a given particular situation, no benefits can accrue through the provision of a pedestrian oriented facility and that, by implication, the issues or problems that were to be addressed and remedied might require other kinds of solutions, or in fact, might be insoluble.

If proposed benefits exceed those of the existing situation, the proposal must next be tested to determine the change in level of utilization.

26.4.3 Determine Change in Level of Utilization

The method for determining change in utilization between the existing and proposed environments consists of recycling the final network plan through the relevant trip distribution procedures exercised earlier to produce the potential utilization network.

*NCHRP Report Number 189, Transportation Research Board, Washington, D.C. to be published in September, 1978.



CAN BE USED TO DETERMINE CHANGES IN LEVEL OF UTILIZATION & BENEFIT BETWEEN:

1. **TWO ALTERNATIVE FACILITIES**

2. **A PROPOSED FACILITY AND THE EXISTING ENVIRONMENT**

Figure 65

Methodology For Determining Change In Level Of Benefit

NAME OF PROJECT	MIDDLETOWN MALL	INITIAL COST	$10,500,000	TOTAL SCORE	+293
		ANNUAL COST	$ 350,000		

EVALUATION CATEGORIES	VARIABLES FOR EVALUATION	VARIABLE SCORE	VARIABLE WEIGHTING	WEIGHTED SCORE
PEDESTRIAN/ TRANSPORTATION	TRAVEL TIME	+ 2	5%	10.1
	EASE OF WALKING	+ 8	5%	40.0
	CONVENIENCE (ACCESS AND AVAILABILITY)	+ 9	10%	90.0
OTHER COMMUNITY TRANSPORTATION	ADAPTABILITY TO FUTURE TRANSPORTATION DEVELOPMENT PLANS	0	3.3%	3.3
	IMPACT ON USE OF EXISTING TRANSPORTATION SYSTEMS	+ 6	6.7%	40.2
SAFETY	SOCIETAL COST OF ACCIDENTS	+ 6	1.2%	7.2
	ACCIDENT THREAT CONCERN	+ 8	4.4%	35.2
	CRIME CONCERN	+ 4	4.4%	17.6
ATTRACTIVENESS OF SURROUNDINGS	PEDESTRIAN ORIENTED ENVIRONMENT	+ 3	5.5%	16.5
	CLIMATE CONTROL AND ENVIRONMENT	- 8	3.3%	-26.4
ENVIRONMENT/ HEALTH	CONSERVATION OF RESOURCES	+ 5	1.2%	6.0
RESIDENTIAL NEIGHBORHOODS	COMMUNITY PRIDE, COHESIVENESS, AND SOCIAL INTERACTION	+ 1	5 %	5.0
	AESTHETIC IMPACT, AND COMPATIBILITY WITH NEIGHBORHOOD	0	5 %	0
COMMERCIAL/ INDUSTRIAL DISTRICTS	GROSS RETAIL SALES	+ 3	10%	30.0
	EASE OF DELIVERIES AND EMPLOYEE COMMUTING	+ 5	1.7%	8.5
	ATTRACTIVENESS OF AREA TO BUSI-BUSINESS	- 2	8.3%	-16.6
PLANNING PROCESS	PUBLIC PARTICIPATION IN THE PLANNING PROCESS	+ 4	4 %	16.0
ECONOMIC IMPACTS	NET CHANGE IN TAX RECEIPTS AND OTHER REVENUE	0	8 %	0
COMMUNITY IMPACTS	COMMUNITY ACTIVITIES	0	2 %	0
	ADAPTABILITY TO FUTURE URBAN DEVELOPMENT PLANS	+10	6%	60.0

WORKSHEET FOR FACILITY EVALUATION

Figure 66

Sample Facility Evaluation Worksheet

The extent of recycling or reiteration will depend on the amount and nature of the changes proposed in the final network. Where changes are localized at a subnetwork level and the impacts of such changes are clearly confined to the same subnetwork area, only that section of the network need be recycled through the gravity model. Where changes are extensive and occur throughout the entire network, it may be necessary to recalculate utilization over the entire network to properly capture the effects of the proposal.

A major part of the reiteration exercise will be the reassessment of the new pathway attributes (Task 6.3.5). These new ratings, which must be established by simulating the pedestrian 'walking through' the proposed facility, will substiture for the earlier ratings of the existing situation and thus modify the former intercentroid separation factors, and in turn affect potential utilization.

Once the new potential utilization volumes have been established and the difference between these and the earlier volumes determined these results must be associated with either conditions 1 or 4 within Figure 64.

Whichever condition applies, the final determination of the relative effectiveness of the proposed facility must be influenced by reviewing the <u>cost impacts</u> associated with facilities' implementation. The next section provides information and a framework for assessing facility costs.

26.5 Facility Costs

26.5.1 The General Facility Cost Approach

The intent of this section is to provide data and costing tools for various types of pedestrian facilities. It is not intended to substitute for the detailed analysis of costs that would necessarily precede any large capital investment, but rather to provide an estimating framework for the following purposes:

- As a means to isolate those elements which contribute to the overall cost of a particular class of pedestrian facility for the purposes of cross-comparison and identification of those specific elements which represent either a cost savings or added expenditures.

- As a cost estimating framework in which a pedestrian system can be defined, its individual sub-elements and associated impacts assigned a dollar value, and the total facilities cost computed.

Figure 67 graphically illustrates the basic structure of the approach. Through use of the approach basic facility characteristics and unit cost factors are input into a series of computational procedures to develop the capital cost of construction, the time stream of future operating and maintenance costs, and finally the overall facility investment cost.

As illustrated in Figure 67 the cost approach consists of five major steps. These steps are described below and are intended to provide an overview of the approach.

Step 1

Facility type, dimensional properties and similar system characteristics are used to isolate specific construction cost elements. These costs are then combined to obtain a base facility construction cost or "base cost". The base cost is related only to the cost of constructing the facility and does not reflect costs which are contingent upon the actual or proposed con - struction site. Cost elements provided in Step 26.5.3 are based on actual data and have been adjusted to correspond to U.S. average costs in 1976 dollars.[1]

[1]When compling data on costs incurred at different points in time and location for the purpose of comparison or preliminary estimating it is necessary to make adjustments to account for the temporal and geographical differences of known inflationary effects. The adjustment of raw data to get comparable costs in 1976 dollars was computed by using Table 17-3 in Supplement 17, ENR Building Cost Index History, 1913-1976. In Table 17-3, 1967 is used as the Base Year for calibrating known inflationary factors. The procedures for cost adjustment are described in Section 26.5.4.

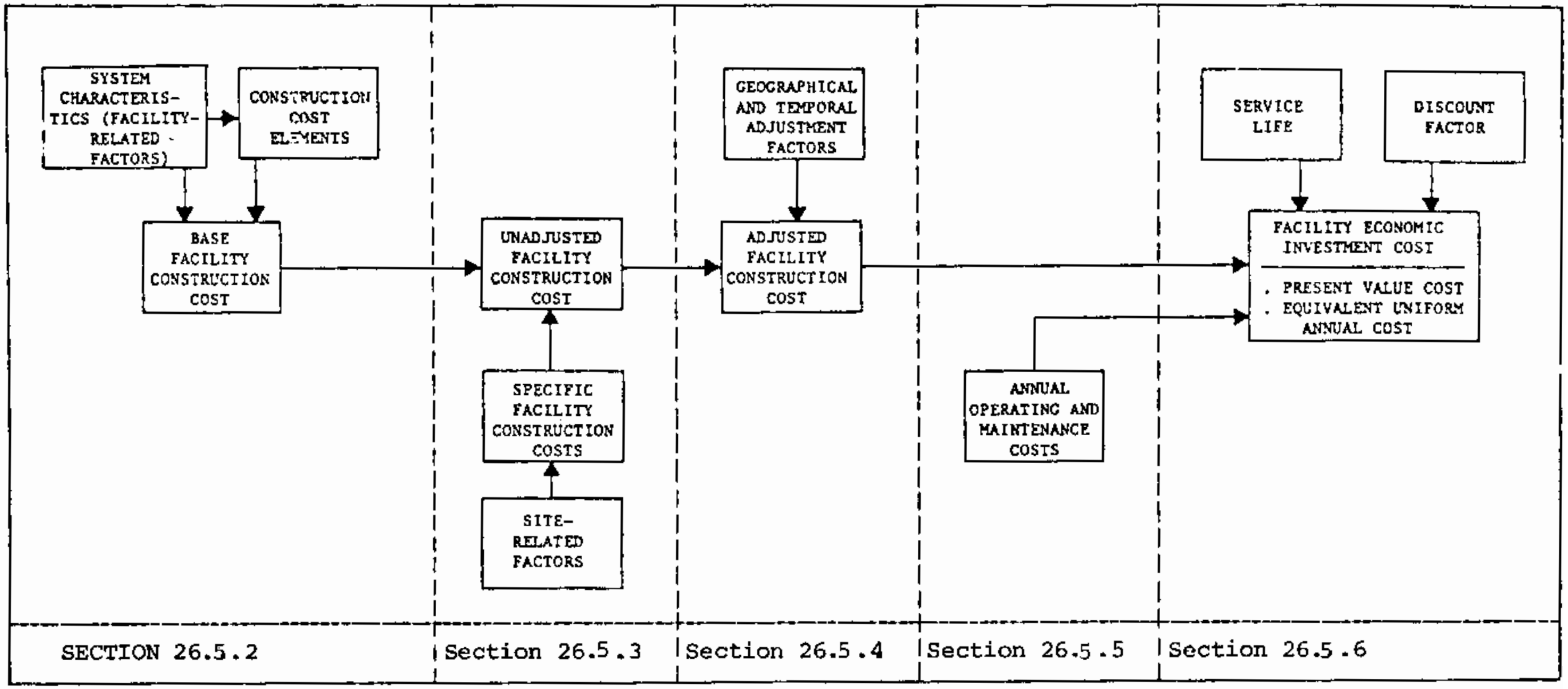


Figure 67

Facility Costing Approach

Step 2

Characteristics of the facility site, such as foundation conditions and traffic delays due to construction are used to develop a set of site-specific facility construction costs. The specific costs are then added to the base cost computed in Step 1 to obtain the unadjusted facility construction cost.

Step 3

As required, the unadjusted facility construction cost will be modified using the appropriate factors to account for geographical and temporal differences in the data or to facilitate comparison with similar costs from other times or locations. The resultant cost will be called the adjusted facility construction cost. If annual operation and maintenance costs are minimal or can otherwise be ignored, then the adjusted cost will suffice for purposes of estimation and comparison. If this is not the case, Steps 4 and 5 are accomplished.

Step 4

The annual cost of facility operation and maintenance is computed. Due to the wide range of conditions and variability in the available data, only very rough guidelines are presented. The actual (estimated) costs are best computed using specific information for each proposed facility.

Step 5

Two basic and equivalent methods are presented for reducing current investment costs of construction and the future costs streams for facility operation and maintenance to a single value so that comparisons can be made. This final figure is called the facility economic investment cost.

Each step in the procedure introduces additional cost elements that contribute to overall facility cost. In general, comparisons between alternative systems or between costs and benefits are valid only after Step 5 using methods similar to those described in Step 26.5.6. In too many cases, engineering estimates take into account only those elements related to the facility and ignore site contingent costs, temporal effects or continuing operating and maintenance costs. This is equivalent to using the output of Step 1 which may result in the acceptance of invalid conclusions. Particular care has to be exercised when using average costs since they often exclude the effects of those site-specific costs introduced in Step 2 of the above approach. At a minimum, the procedure should be carried through Step 2 before any comparisons are made, and then only if it is clear that the other cost elements can be disregarded without prejudicing the study results.

The following sections will delineate the method for carrying out each of the five steps.

26.5.2 The Basic Facility Construction Cost

1. Factors Influencing Base Cost

The facility construction cost, unadjusted for any effects of time or geographical location and disregarding any costs specifically related to the site or site preparation, will be called the basic facility construction cost or more briefly the base cost. The base cost can be computed as the product of two elements:

- The unit cost of construction, i.e., the cost per square foot, the cost per lineal foot or similar measure, and
- The number of construction units (square feet, lineal feet) consistent with the unit cost figure.

Both the unit cost and the number of units are functions of several other factors as shown in Table 49 and discussed in the sections that follow.

- FACILITY TYPE
- DIMENSIONAL PROPERTIES
- STRUCTURAL PROPERTIES
- MATERIAL AND CONSTRUCTION METHOD
- ENCLOSURE SYSTEM
- SUB-ELEMENTS

Table 49

Facility-Related Factors That Influence Base Cost Of Construction

Structural Properties

The important structural properties to be addressed are:

- Length of clear span
- Method of facility support

The per unit construction cost of a section of facility will increase as a function of the length of clear span. For purposes of cost analysis, spans of 40, 80 and 120 feet are considered. Various span lengths require systems of support that occur at different spatial intervals, or continuously, depending on the facility type. Hence, the length of clear span together with the method of support are factors that influence the base cost.

Material and Construction Method

Probably the most dominant factors that influence the base cost of construction for a given facility type are those related to material and construction method used. The first four combina-tions described below are used to develop cost factors in subsection 3 of Step 26.5.2. The others are included for completeness, but are not used to develop costs due to difficulties in generalizing their application.

a. Steel - Prefabricated steel truss members, assembled off site, delivered to the site and subsequently erected. This would include by definition vierendeel (vertical and horizontal members only) or conventional triangulation systems; see subsection 3a of Step 26.5.2 on skyway costs.

b. Steel - Standard steel construction, steel rolled and shop fabricated, all connections and joinings are erected in place, on site.

c. Concrete - Cast-in-place - using conventional reinforced framing, the concrete is cast-in-place on site. This would include beam and slab, one way joists, or waffle construction systems.

d. Concrete - Pre-cast - pre-stressed members and piers are prefabricated off site, then delivered to the site for erection. This would include by definition single or double "T" sections up to 65 feet in length by 8 feet in width.

e. Concrete - Cast-in-place - post-tensioned. High strength strands are used which are stressed to place the concrete in compression prior to the application of service loads.

f. Composite construction - The use of steel and concrete together. This construction is normally performed in place, on site.

There are also other methods of construction which involve the use of concrete or steel arches, and systems involving the use of suspension cables. However, from an economic standpoint these systems are considered to be impractical.

The cost factors given in this step are based on the ready availability of both material and construction expertise related to each of the options defined above. A secondary level of cost-influencing factors may have to be considered if either of these resources is constrained. The following factors may be present and could impact on the unit cost of construction:

- Geographical or regional material supply characteristics

- Scarcity of supply resulting in long delivery times and possible delays

2. Facility Construction Cost Elements

In this section, cost elements are provided for various facility types. An attempt has been made to cover a wide range of alternative possibilities. It has been necessary, however, to make basic assumptions on dimensions, spans and other variables in order to reduce the unlimited number of combinations to a reasonable subset for presentation. These assumptions are specified for each facility type in the sections following the summary Table 26.

3. Facility-Related Factors

Facility Type

Base construction costs will obviously vary by the type of facility since it affects the unit cost of construction, and will also affect the dimensions used to determine the number of construction units. Specific facilities are discussed in detail in Step 19.1. For the purpose of costing, the following generic facility types will be con sidered:

- Elevated skyways
- Street and highway underpasses (pedestrian tunnels)
- Vertical connections
- Street overpasses (pedestrian bridges)
- Full and partial at-grade malls

Dimensional Properties

The height, width and length dimensions of a specific facility will determine the number of construction units, and will also impact on facility support costs and several of the specific site-related costs discussed in Step 26.5.3.

Unless otherwise noted, the costs represent surface costs only and do not include such costs as those associated with utility relocation, enclosure or climate control.

		1976 COST RANGE		UNIT COST	AVERAGE 1976 COST
		LOW	HIGH		
a. ELEVATED SKYWAYS	Walkway Only	300	500	$/LF	402
	Covered Walkway			$/LF	486
	Covered Walkway with Heating			$/LF	1,276
	Covered Walkway with HV/AC			$/LF	1,438
	Each Pier			$/Unit	5,569
b. UNDER-PASSES	Cut/Cover (New)			$/LF	1,100
	Cut/Cover (Existing)			$/LF	1,650
	Tunnel (Existing)			$/LF	2,876
c. VERTICAL CONNECTIONS	Stairs			$/Unit	13,564
	Ramp			$/Unit	18,570
	Elevator			$/Unit	53,580
	Escalator			$/Unit	169,200
d. STREET OVERPASSES	Conventional Steel Work	1,022	1,205	$/LF	1,113
	Cast-In-Place Concrete	832	1,021	$/LF	926
	Precast Concrete	855	1,065	$/LF	960
e. AT-GRADE MALLS	Full Malls	1.39	41.28	$/Ft ^{2}	14.50-18.50
		83.40	2477.00	$/LF	870 - 1,110
	Semi Malls	1.40	12.05	$/Ft^2	6.50-8.00
		84.00	723.00	$/LF	390-480
	Transit Malls	6.84	13.95	$/Ft^2	9.60
		410	837.00	$/LF	576.00

Table 50

Summary Of Total Cost By Facility Type

All costs are based upon actual component costs[2], cost estimating experience, and data collected from existing literature which provides a cost breakdown on specific facilities.[3] These costs were adjusted for temporal and geographical inflationary effects to correspond with average U.S. costs in 1976 constant dollars. The method by which the data was adjusted is described in Supplement 17.

In Table 50 unit cost figures for selected facilities, including malls, have been summarized to provide a rough estimate for comparing base construction costs. Disregarding locational contingencies if it is assumed that the alternatives are equally effective, the unit cost comparison provides a valid means to evaluate the facilities. Some examples are provided in Appendix Q.1.

The necessary assumptions used to develop the rough cost estimates for elevated skyways, underpasses, and vertical connectors, and street overpasses are the same as those outlined in Figures 68 through 71, except for elevated skyways.

Additional elevated skyway assumptions include:

1. Material/construction considerations for superstructures reflect an average for conventional steel and conventional concrete/cast-in-place.
2. Span = 80'.

<u>Facility Types</u>

a. Elevated Skyways

Elevated skyways are similar to highway overpasses in terms of their method of costing. The unit cost is dependent on material, construction and span. Enclosure costs are also functions of facility length. The cost of piers must be added to the base cost of the skyway structure. Cost elements for conventional steel and concrete skyways are given in Table 51 and related assumptions are given in Figure 68. Skyways of trussed steel construction are a special case of skyways; costs per square foot for spans of 80 feet or less are given in Table 52.

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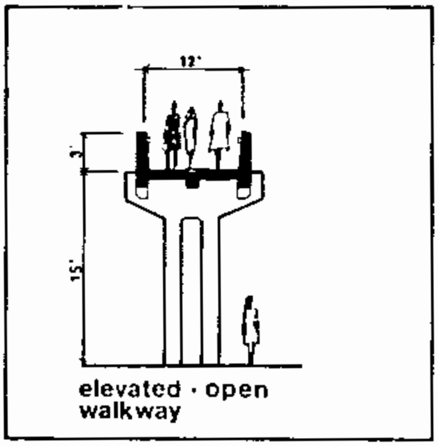
[2]Previous unit costs were developed by RTKL Associates Inc., and M.D.A. Associates, Washington, D.C., for use in the following sources: Reference 7 and 8.

[3]Major sources of literature are: Reference 1 and 2.



SECTION

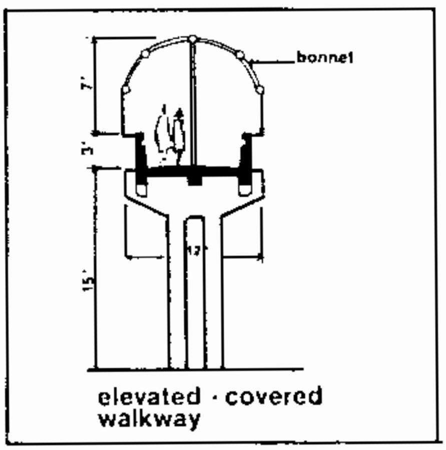
DIMENSIONAL PROPERTIES FOR OPEN SKYWAYS

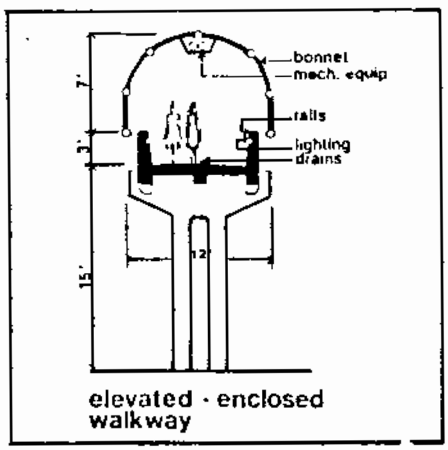
Assumptions

(1) Aerial Structure
- Cost varies by material/construction and span
- Includes costs of lighting, drainage, and handrails
- Spans are 0' - 40' and 40' - 80'

(2) Superstructure (Pier)
- Concrete, cast-in-place, includes footing
- 15 feet high, with 2foot wide section
- Applies to all enclosure types

(3) Enclosures
- Sectional dimensional properties





covered
- . Bonnet is aluminum tubing frame with 1/4" tinted plexiglass

enclosed
- . heated only
- . heated and air conditioned

Figure 68

Assumptions Regarding Elevated Skyway Systems

(1) SKYWAY ONLY				
Material/ Construction	Conventional Steel (cased)		Conventional Concrete/Cast-in-place	
Length of Clear Span (feet)	40	80	40	80
Cost per Lineal Foot ($)	451	502	268	303
(2) ENCLOSURE SYSTEM				
(a) Enclosed, heated only	Add $84.60 per lineal foot to (1)			
(b) Enclosed, heated only	Add $874 per lineal foot to (1)			
(c) Enclosed, heated and air conditioned	Add $1,030 per lineal foot to (1)			
(3) PIER	Add $5,570 for each pier			

Table 51

Elemental Construction Cost For Elevated Skyway Systems

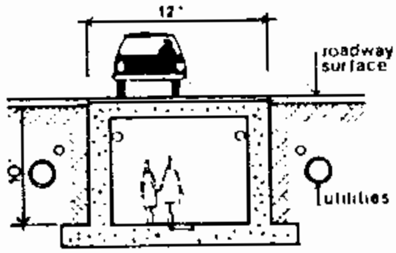
CONDITION	$ PER SQUARE FOOT
(1) Structure only including decking	$138.18
(2) Totally enclosed and air conditioned	$239.70

Table 52

Unit Costs For Steel Trussed Constructed Skyways (Spans Of 80 Feet Or Less)

b. Street and Highway Underpasses

The unit costs for street and highway underpasses (pedestrian tunnels) are given in Table 53. Assumptions are given in Figure 69. Note that condition (1) is applicable to underpasses constructed during roadway construction; the other two conditions are for existing roads or streets.



highway - underpass crossing

SECTION

DIMENSIONAL PROPERTIES

ASSUMPTIONS

(1) Condition 1 - Built In Conjunction With New Roadway Construction
- Concrete, continuously supported
- 12-15 feet wide by 10 feet high, minimum length of 80 feet
- Natural ventilation (for lengths less than 200 feet)
- Lighting and drainage cost included
- Normal cut and fill excavation (rock and other foundation problems will incur extra cost as detailed in Step 26.2.3.

(2) Condition 2 - Built Under Existing Roadway
- Same as condition 1 except that added costs are incurred to remove road (street) surface and provide decking to maintain traffic flow

(3) Condition 3 - Tunnel Under Existing Roadway
- Same as condition 1, except costs reflect tunnel excavation including normal shoring and cast-in-place concrete
- Traffic flow is unimpeded

Figure 69

Assumptions Regarding Street And Highway Underpasses

CONDITION	$ PER LINEAL FOOT
(1) Cut and Cover Construction, No Restriction	$1,100
(2) Cut and Cover Construction With Street Decking to Maintain Traffic Flow	$1,650
(3) Tunnelled Underpass, Cast-in-Place Concrete	$2,876

Table 53

Unit Construction Costs For Highway Underpasses

c. Vertical Connections

Each grade-separated system requires one or more terminal connections for the purpose of linking the system to the at-grade pedestrian access network. A variety of frequently used terminal connections have been identified in Figure 70, including stairs, ramps, elevators and escalators. The selection and use of any or all of these connectors is contingent upon several factors:

1. The total vertical difference between the elevation of the system at the point of desired accessibility

2. Pedestrian volumes at the access and egress portals

3. Type of node in terms of activity linkage

4. The capacity characteristics in terms of volumes of pedestrians through an area in a given period of time

5. Population characteristics considering proportion of elderly, handicapped.

The net addition to the base cost of any particular system is determined by adding the cost resulting from the use of particular terminal or intermediate connectors.

Representative assumptions and related costs for the four types of connections are given in Figure 70.

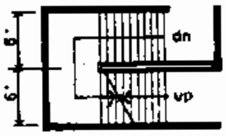
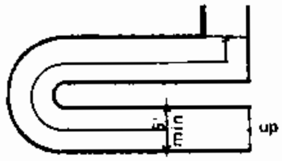
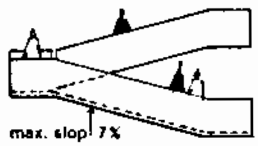
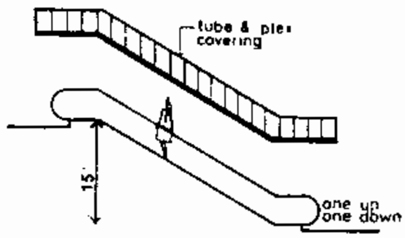
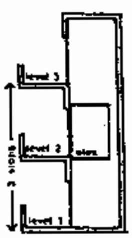
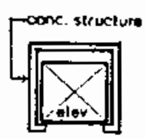
CONNECTION	DESCRIPTION	TOTAL COST
Stair	  PLAN SECTION Width of run is 6 feet; connect grade to 15 feet minimum; costs of concrete structure enclosure walls, rails and lighting included.	$13,560
Ramp	  PLAN SECTION Width of run is 6 feet; connect from grade to 15 feet minimum; maximum slope is 7%; costs of concrete structure, enclosure walls, rails and 1 lighting included.	$18,570
Escalator	 SECTION One pair (up/down) from grade to 15 feet; cost includes units, enclosure structure and covering.	$169,200
Elevator	 SECTION  PLAN One cab (capacity 3000 lbs.) to stop at three levels; cost includes elevator and housing structure.	$53,580

Figure 70

Typical Terminal Connection
Assumptions and Costs

d. Street Overpasses

Table 54 contains the elemental cost information necessary to estimate the base cost of construction for street overcrossings (pedestrian bridges). Basic assumptions relating to the street crossing are detailed in Figure 71.

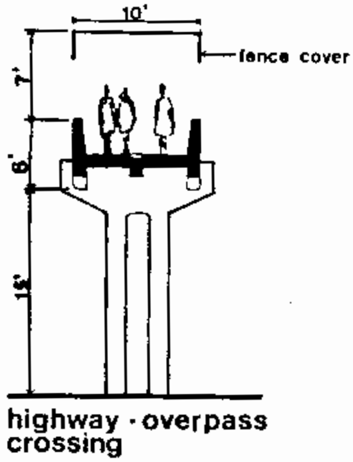
The unit cost per lineal foot as a function of material, construction and span is first determined for each bridge section. The costs of lighting and drainage are added accordingly. These costs are then multiplied by the appropriate lineal feet of construction and summed to obtain the base cost of the aerial structure. The cost of piers and median strips are then added using the cost-per-unit figures given.

(1) UNIT COST OF AERIAL STRUCTURE									
Material/ Construction	Conventional Steelwork (cased)			Conventional Concrete/Cast in Place			Concrete/Precast		
Length of Clear Span (feet)	40	80	120	40	80	120	40	80	120
Cost per Lineal Foot ($)	486	536	564	303	345	381	317	366	395

(2) OTHER COSTS	
Drainage	Add $22.50 per lineal foot
Lighting	Add $39.50 per lineal foot
Pier	Add $3,412 for each pier
Median Strip (30'x8')	Add $1,692 for each median

Table 54

Elemental Construction Cost For
Highway Overpasses
(Twelve Feet Wide Overall)



SECTION

DIMENSIONAL PROPERTIES

Assumptions

(1) Aerial Structure
- 12-15 foot width overall
- Varying depth edge beams/side walls depending on span
- Protective screening (fencing cover) provided to serve as safety covering
- Lighting and drainage are costed separately
- Cost varies with finishing materials, construction and span

(2) Piers
- 15 foot high cast-in-place concrete
- 2 foot wide at terminal of overpass
- Median strip, if required, costed separately

(3) Median Strip
- 30 x 8 foot median
- Concrete with curbing and guard rails

Figure 71

Assumptions Regarding Costs Of Street Overpasses

e. At-Grade Malls

For the purpose of developing unit cost guidelines, data was collected for three basic types of malls from existing literature on 37 specific projects built between 1960 and 1976*. The three basic types of malls are:

- Full Malls - which provide for complete pedestrian and vehicular separation.

- Transit Malls - accommodate both pedestrian and vehicular usage. In this instance vehicular usage is limited to buses and taxicabs only.

- Semi-Malls - accommodate both pedestrian and vehicular usage. In this case no restrictions are placed upon the type of vehicular usage.

The adjusted 1976 unit cost ranges and averages for the three types of malls in Table 50 represent information collected from prior research on 37 malls throughout the U.S. The unit costs provide for surface improvements only and do not include such costs as utility relocation, street canopies and arcades. Data was available in sufficient detail to include the cost figures of 20 facilities in the determination of the unit cost range and average for full malls; six facilities for semi-malls; and four facilities for transit malls.

The resulting unit cost ranges for the three types of malls are useful in identifying gross estimates for base construction cost. The average unit cost provides a useful guide relative to expenditures for surface treatment improvements.

The costs for surface treatments is primarily a function of the type of paving materials and the number of mall facilities provided. As can be noted from the unit cost ranges in Table 50, the degree of improvement varies substantially. Full malls, for example, range from as little as $\$1.39/ft.^2$ to as much as $\$41.28/ft.^2$

*Information concerning physical factors and costs of 37 malls is based upon prior contact with redevelopment agencies, planning departments, and downtown associations throughout the country, and the following sources: Reference 1, 2, 7, and 8.

While such improvements as subsurface utility systems and site preparation work are not included in the above costs, it should be noted that the proportion of the overall budget expenditure for this type of improvement varies substantially from project to project, depending upon the scale of the specific plan and the problems attendant to it. Pomona, California, for example, reported spending as much as 80% of its budget on these costs while Monroe, N.C., reportedly spent only 9% of its total mall budget for this type of site dependent improvement.

Allocation of Unit Costs for At-Grade Malls

While the mall figures in Table 50 serve as a means to identify what has been spent by cities on surface improvements, they do not necessarily provide an insight into what is required to accommodate an adequate level of surface design treatment. For example, within the cost ranges of each mall type, some unit costs obviously provide more than an adequate level of design treatments while others clearly do not.

Table 55 provides a more reliable guideline with respect to the adequacy of treatment accommodation for full malls and partial malls (partial malls include both transit malls and semi-malls). In Table 55 those factors that contribute to the overall mall construction costs have been categorized and actual component costs, including installation costs, have been developed for specific treatment elements. Based upon a prior review of fifteen malls that were considered to provide an adequate and substantial level of design treatments, average quantities of each treatment element were determined. These average quantities were developed on a per block basis encompassing an area approximately 60' x 350'. Using the cost accumulation approach, each of the average quantities were multiplied by their unit cost. The resulting total cost for each treatment category was then summed to determine an overall construction cost. The overall unit cost per $ft.^2$ was determined by dividing the overall cost by the total mall area per block.

While the procedure provides useful guidelines values, care should be taken in using the final unit costs as malls exhibit a wide degree of latitude in the quantity of landscaping and street furniture. In addition the quality of amenities vary significantly.

Cost breakdowns, relative to total cost, for full and partial malls have been provided in Tables 56 and 57. The percentages derived from the distribution of costs in Table 55 and represent a rough approximation of how the budget

		Unit * Cost	PARTIAL MALL		FULL MALL	
			Ave.** Quan.	Total Cost	Ave.** Quan.	Total Cost
Site Preparation	Removal of Sidewalk	$ 6.30/sy	450 sy	$ 2,835	800 sy	$ 5,040
	Removal of Curbing	3.00/lf	800 lf	2,400	800 lf	2,400
	Removal of Street Paving	6.82/sy	700 sy	4,774	1,500 sy	10,230
	Utilities Relocation	12.97/cy	85 cy	1,102	170 cy	2,205
				$ 11,111		$ 19,875
NEW CONSTRUCTION	Concrete Stairs	31.93/lf	100 lf	3,193	200 lf	6,385
	Concrete Curb	13.39/lf	950 lf	12,720	1,400 lf	18,746
	Concrete Sidewalk	2.96/sf	11,000 sf	32,560	19,000 sf	56,240
	Textured Sidewalk	3.45/sf				
	Brick Paved Sidewalk	6.56/sf				
	Concrete Street Paving	3.23/sf				
	Planter Wall 8" x 2'-6"	26.08/lf	200 lf	5,216	800 lf	20,864
	18' Retaining Wall	8.58/sf				
	10' Retaining Wall	7.07/sf				
	Structural Sidewalk	7.17/sf				
	Street Lighting	810./fix.	10 fix	8,100	10 fix	8,100
	Accent Lighting	21.85/lf	100 lf	2,185	500 lf	10,925
				$63,974		$121,260

Table 55

Allocation Of Unit Costs For At Grade Malls

		Unit* Cost	PARTIAL MALL		FULL MALL	
			Ave.** Quan.	Total Cost	Ave.** Quan.	Total Cost
LANDSCAPING	Large Trees - 6" Caliper	$ 444.40 ea.	45	$19,998	45	$ 19,998
	Small Trees - 2" - 2½" Caliper	145.44 ea.	25	3,636	40	5,817.60
	Deciduous Shrubs	21.20 ea				
	Evergreen Shrubs	36.36 ea.				
	Ground Cover	15.15/sy.	500 sy.	7,575	1000 sy.	15,150
	Sod	2.02/sy.				
				$31,209		$ 40,965
STREET FURNITURE	Concrete Bench	62.00/sf.	300 sf.	18,612	900 sf.	55,836
	Wood Bench	303.00 ea.				
	Bollards & Chain	141.00 ea.	12	1,692	25	3,525
	Trash Recepticals, etc.	151.50 ea.	10	1,515	10	1,515
	OUtside Table & Chairs	1,410.00 ea.				
	Fountains/Water Pools	101.52/sf.	100 sf.	10,152	500 sf.	50,760
	Canvas Awning	11.61/sy.				
	Tubular Awning Frame	8.08/sf.				
	Kiosks - Wood & Canvas	1,410.00 ea.	2	2,820	5	7,050
	Tree Gratings	282.00 ea.	20	5,640	40	11,280
				$40,431		$129,966

Table 55

Allocation Of Unit Costs For At Grade Malls (Cont'd)

		Unit * Cost	PARTIAL MALL		FULL MALL			
			Ave.** Quan.	Total Cost	Ave.** Quan.	Total Cost	Ave. Quan.	Total Cost
SIGNING	Sign, Post & Frame	$520.50 ea.	6	$ 3,123	12	$ 6,245		
				$3,123		$ 6,245		
SHELTERS	Bus Shelters or							
	Covering for Arcades	176.25/lf.	130 lf.	26,437	400 lf.	70,500		
				$26,437		$70,500		
COST	TOTAL MALL CONST. COST		$176,285.00		$388,811.00			
	COST PER FOOT^2		7.90/ft.^{2}		18.51/ft.^{2}			

*Source: Previous unit costs were developed by RTKL Associates and MDA Associates for use in Reference (7) and (8).

**Quantities are for 1 block (60' wide and 350" long) and are based upon averages for malls actually completed in 15 cities.

Table 55

Allocation Of Unit Costs For At Grade Malls (Cont'd)

COST CONTRIBUTING CATEGORY	PARTIAL MALL % OF TOTAL COST	FULL MALL% OF TOTAL COST
Site Preparation	6.3	5.1
General Construction	36.3	31.3
Landscaping	17.7	10.5
Street Furniture	23.1	33.4
Signing	1.7	1.6
Bus Shelters	14.9	18.1
TOTAL	100.0	100.0

Table 56

Categorical Percentage Cost Breakdown
Relative To Total Cost For Partial Mall

COST CONTRIBUTING CATEGORY	PARTIAL MALL % OF TOTAL COST	FULL MALL % OF TOTAL COST
Site Preparation	7.4	6.2
General Construction	42.7	38.2
Landscaping	20.8	12.8
Street Furniture	27.0	40.8
Signing	2.1	2.0
TOTAL	100.0	100.0

Table 57

Categorical Percentage Cost Breakdown
Relative To Total Cost For Full Mall

dollar is distributed to provide an adequate level of design treatments. In Table 56 the percentages include the costs of bus shelters and arcade coverings while those in Table 57 do not.

Given a preliminary overall budget, either Table 56 or 57 can be used to provide a rough initial allocation of the budget by category. This can be obtained by multiplying the budget by the percentage factor for each cost category. The rough cost breakdown can be employed as a general guide for developing preliminary plans and estimates when using the format provided in Table 55. It can also be used to check the overall distribution of costs resulting from the use of Table 55. If the distribution of costs deriving from Table 55 varies significantly from distribution patterns of Table 56 or 57, it may indicate that either too little or too much of the budget has been allocated to a specific category and a refinement of the allocation of treatments may be desirable.

26.5.3 Site-Specific Facility Construction Costs

The construction cost of a facility will often depend on a great number of variables that are related to the specific site at which the facility is to be constructed. These variables were purposely eliminated in the previous section where the intent was to derive a base construction cost that was dependent upon factors associated with the facility itself, but independent of the cost contingencies related to the facility site. In this section several of the site-related factors that influence cost are discussed. No attempt has been made to delineate every site-specific cost contingency, but rather to detail those that tend to dominate or greatly influence total construction cost, or those such as the cost of traffic delays during construction which are often overlooked in economic analyses of proposed facilities. Also, it would not be practical in all instances to provide point estimates of various site-related costs due to their associated variance, and hence, some values are given instead as reasonable ranges. The following factors are discussed in subsequent sections:

- Foundation conditions
- Utilities relocation
- Structural considerations
- Traffic delays during construction.

1. Foundation Conditions

An important site-related factor is the condition of the soil and the requirements necessary to prepare the soil to receive the facility's substructure. A substantial range of additional facilities costs are the direct result of the poor supporting characteristic of soils, the elevation of the water table, the existence of rock, and the necessity to excavate in proximity to existing superstructure. Each of these conditions is site-specific and results in additional costs due to unusual construction requirements; Table 58 estimated cost impacts of various conditions in most cases. Where these conditions exist, below-grade facilities are not always feasible.

CONDITION	CONSTRUCTION REQUIREMENTS	ADDED COSTS
Rock	Special Excavation Equipment	$14-28/cu.yd.
Elevation of Water Table	Dewatering or Pumping	$6.25-8.25/cu.yd.
Poor Supporting Characteristics of Soil	Installation Of Piles or Employment of Mat Foundations	$310/pile
Close Proximity of Existing Buildings	Underpinning (Excavating Sheeting)	$140-185/cu.yd.

Table 58

Examples Of Added Construction Costs
Resulting From Site Foundation Conditions

2. Utilities Relocation

Careful consideration must be given to the existence of various below-grade utility lines and conduits that may be affected by the path of the facility's construction in CBD areas. These utilities (water, gas, electric, telephone, etc.) may require relocation, replacement and upgrading depending upon both their location and their condition. In addition to physical relocation, existing utility lines may need to be supported and protected from new construction; these lines may have to be encased and/or shored throughout the course of construction to guard against possible breakage even though they are not directly in the way of the facility.

The range of costs associated with utilities relocation is extreme. Cost allowances per cubic yard of excavation due to utilities can range from $48.75/cu.yd. to $15.00/cu.yd. This cost can contribute an additional 30 to 200 percent to base construction costs. In Toronto, under-street crossings for a 20-foot right-of-way are estimated to cost between $1600 per lineal foot where utility problems are minimal to $4500 per lineal foot where utility problems are severe. (See Reference 8) The possibility of routing below-grade walkways to avoid utilities should be considered. In Winnipeg, a below-grade system was estimated to cost $7 million due to severe conflict with existing underground utilities, but by a unique configuration of the system, walkways were re-routed to avoid utilities with a resulting $4.5 million savings - thereby making the below-grade system cost comparable with a proposed $2.5 million above-grade alternative.

3. Structural Considerations

Several structural considerations, namely spanning distance and method of support, were addressed in the development of base facility costs in Step 26.5.2. The consideration and selection of a structural system is also contingent upon several locational factors, such as the following:

- Length to be spanned unsupported
- Whether or not it is feasible to locate intermediate pier supports in medians within the road right-of-way
- The compatibility of the structure with ambient environmental and architectural characteristics.

In the case of skyway and elevated walkway construction, there are added costs associated with increasing unsupported span lengths which must be weighed against additional costs associated with superstructure (cost of providing supporting piers at varying intervals), as well as the cost of median construction which may in turn result in construction impedance to traffic flow and operations. The location of elevated systems relative to buildings is also an important determinant in the selection of a structure; whether the system ties into existing or new buildings, or is free standing and has no direct connection to abutting properties, largely determines the span and support acter istics of the structure, and hence, the cost of constructing the system.

4. Traffic Delays During Construction

The construction of any pedestrian facility built either within, above or below a vehicular right-of-way will normally require alteration or modification to the flow of vehicular traffic either permanently, or temporarily during the period of the facility's construction. The costs of permanent street or lane closings must be determined in terms of changes in the overall traffic network and movement caused by the proposed facility. Temporary street closings, lane blockage, detours and rerouting, on the other hand, caused by construction of other types of pedestrian facilities generally result in vehicular delays during construction. The costs of these delays to vehicles represents a cost that is attributable to the facility construction, but one that is often overlooked.

The actual cost of delay will depend on factors such as:*

a. Number of vehicles and traffic lanes affected by the construction per unit time

b. Average delay time per vehicle

c. Excess cost of vehicle operation due to speed reduction and idling per delayed vehicle

d. Value of vehicle time per unit time

e. Duration of construction

These factors can be used to compute the increased cost of vehicle operation and vehicle delay resulting from the con - struction.

The last factor listed above, the total time over which construction delays vehicles, can be controlled to reduce the impact of delay. The use of precast or prefabricated members, for example, results in longer allowable spans, reduced depth of structure and increased speed of erection. Hence, while prefabrication is being done at a location off-site, on-site preparation can be accomplished concurrently since they are independent of each other. The net result is a considerable time sabings in the overall construction process, as well as in the on-site erection.

In other situations, it may be impractical (i.e., in active and dense urban areas) to store construction materials and equipment necessary for on-site construction in the immediate proximity of the facility location. When this happens, the storage or movement of materials and equipment can cause measurable traffic delays during the construction period which should be considered. Again, use of off-site prefabrication may help to alleviate this problem.

Table 59 provides a simple relationship between material/ construction types and time required to erect on-site. The actual extent of construction delays will depend on numerous other factors, but all things being equal, the impact of the construction technique employed will be as shown.

A more detailed estimate of construction time for individual unit items would be possible, but it would not give an accurate reflection of a construction schedule based upon a project using

*Reference 8, Section 6.1, presents data for calculating these factors.

a varied number of different units. Timing is best assessed after a project has been put together, and it will be dependent upon a number of variable factors such as location, complexity of design, availability of services and construction technology. Construction time is also dependent upon the size of the project in terms of construction dollars, and the size of the contractor performing the construction, both of which vary from project to project. Therefore, no more specific guidelines construction timetable can be provided.

TYPE OF CONSTRUCTION TECHNIQUE	TIME REQUIRED TO ERECT FACILITY ON-SITE			
	LESS TIME		MORE TIME	
	1	2	3	4
1. Prefabricated Steel Truss	X			
2. Standard Steel Construction		X		
3. Cast-in-Place, Concrete		X		
4. Cast-in-Place, Concrete, Pre-tensioned			X	
5. Precast Concrete	X			
6. Composite Steel and Concrete			X	
7. Concrete or Steel Arches, etc.				X

Table 59

Comparative Time To Erect Facilities
On-Site Versus Construction Technique

5. The Unadjusted Facility Construction Cost

The unadjusted facility construction cost is the base cost of construction (Step 26.5.2) plus the costs of site contingencies. If comparison is being made of alternative facilities on the basis of capital investment using cost data relative to a special locale and uniform with regards to time, then the unadjusted construction costs will suffice. In subsequent sections the unadjusted construction cost, as indicated in Figure 72, will be called the Facility Construction Cost, or simply Construction Cost.

C	=	THE UNADJUSTED FACILITY CONSTRUCTION COST (OR "CONSTRUCTION COST")		
	=	THE BASE COST OF FACILITY CONSTRUCTION See Step 26.5.2	+	THE SPECIFIC COSTS OF SITE CONTINGENCIES See Step 26.2.3

Figure 72

Definition Of Facility Construction Cost

26.5.4 Geographical and Temporal Adjustments

When compiling facility cost data for comparison or as preliminary estimates, it may be necessary to make certain adjustments to cost elements in order to account for geographical or temporal differences. When the unadjusted construction cost computed as shown in Figure 72 is adjusted for geographical and/or temporal differences, it will be referred to as the adjusted construction cost.

1. Geographical Differences

   Construction costs vary from region to region throughout the United States due to material supply characteristics, available labor and available construction technology. Therefore, in order to compare the cost of two similar types of facilities that are located in different regions, an adjustment factor must be applied to make the cost compatible. Likewise, in utilizing construction costs from one region to estimate costs in another, an adjustment is necessary.

2. Temporal Differences

   Inflation causes the price of commodities, including construction material and labor costs for pedestrian facilities to rise over time. In an economic analysis comparing capital invest ment for proposed alternatives, it is preferred practice to omit any consideration of inflationary effects. However, when comparing specific costs previously incurred at different points in time, it is useful to apply known inflation factors to get comparable costs.

   A tabulation of building cost indices using 1967 as the base year along with application method, is provided in Supplement 17. The unadjusted construction cost computed in the previous sections and which represent average U.S. costs in 1976 dollars can be both temporally and geographically adjusted by use of these indices.

26.5.5 Operation and Maintenance Costs

Most pedestrian facilities require some expenditures related to operation and maintenance (O&M). The importance of these costs varies considerably. The level of O&M cost is principally a function of:

- The facility's physical design properties
- User group characteristics (e.g., shoppers, commuters)
- The degree of direct accessibility by maintenance crews

- The proximity of the facility to other publicly maintained areas (whether the facility can be maintained as part of a large maintenance area)

- The ownership of the facility (public or private)

- Degree of enclosure of the system

Furthermore, operating costs are dependent on additional factors such as:

- Level of comfort provided
- Type of security required
- Availability of service

Facilities such as pedestrian highway overpasses incur minimal O&M costs, primarily lighting and some annual maintenance. Large-scale systems, on the other hand, may incur substantial costs; where figures are available, they range from $150/sq. ft./year for enclosed pedestrian skyways to $2.25/ sq.ft./year for open street malls.

A percentage breakdown of O&M costs based on at-grade walkway systems in several major urban centers is given in Table 60.

O&M CATEGORY	PERCENTAGE ALLOCATION
Taxes	25
Maintenance	26
Repairs	15
Utilities	14
Security	14
Miscellaneous	6
	100%

Table 60

Percentage Allocation Of O&M Costs - CBD Systems

Source: RTKL Associates Inc. estimates

The maintenance cost curve begins to rise sharply with the age of the structure especially during the last quarter of its projected life span, until such a time as repair costs cannot be justified. This is mainly attributed not the the structure of the facility, but to the deterioration of the mechanical systems operating within the facility. Most public facilities (such as walkways, overpasses, etc.), however, do not contain major mechanical systems, and therefore do not represent an accelerated maintenance cost curve. Maintenance costs remain relatively constant; increases reflect only the rising cost of labor and materials attributed to normal inflation. Therefore, maintenance cost curves will not be examined for these types of facilities.

26.5.6 The Facility Economic Investment Cost

In the preceding sections, the primary focus has been on the construction cost which can be expressed in current dollars. Although the cost of constructing large-scale pedestrian systems may involve capital investment over several years, very few problems are encountered in comparing the investment cost requirements of alternatives if only the costs of construction are considered. Unlike the costs of construction, however, the cost streams of expenditures for system operation and maintenance occur over the future years in which the facility is in service. Money has a time-dependent value that makes an amount now on-hand worth more than the promise of an equivalent amount at some future time. Hence, in terms of their "present value", future expenditures are of lower value (cost less) than current expenditures.

There are situations where the tradeoff between a low capital investment for construction combined with a high annual operating and maintenance expense may be directly competitive on the basis of present value to another alternative having a higher construction cost and lower annual upkeep. The more interesting comparison, however, is between the total economic cost of the facility and the total economic benefit derived from it. Given that a monetary value can be assigned to the benefit stream, the problem remains to express compatibly costs and benefits occurring at different times and in different time-phased patterns. Several methods for accomplishing this will be examined in this section.

Two equivalent methods for examining and comparing investment costs and annual expenses and/or benefits for different alternatives are:

- Present value of costs (benefits) method
- Equivalent uniform annual cost (benefit) method

1. Present Value Method

In the present value method, all costs both present and future are represented as a single sum which expresses the amount of capital required now (or at the start of the project) to finance facility construction and subsequent annual operating and maintenance expenses. This is accomplsihed by computing the present value of the O&M cost stream and adding it to the construction cost (assumed to be at its present value). The required computation is shown in Figure 73.

(PVC)	=	PRESENT VALUE OF FACILITY COSTS				
	=	ADJUSTED FACILITY CONSTRUCTION COST	+			PRESENT VALUE OF O&M COSTS
	=	ADJUSTED FACILITY CONSTRUCTION COST	+	(PVF)	X	ANNUAL UNIFORM O&M COSTS

Where: (PVF) = PRESENT VALUE FACTOR

$$= \frac{(1 + i)^N - 1}{i(1 + i)^N}$$

And: N = The Facility Service Life (in Years)

i = Discount Factor (Interest Rate)

Figure 73

Computation Of The Present Value Of Facility Costs

The present value computation in Figure 73 is expressed in its simplest form and assumes that the facility has zero salvage value at the end of its service life, and that annual O&M costs are uniform over the entire service life of the facility. The present value factors (PVF) have been tabulated for a wide range of i and N values, and are readily available.

In a similar manner, given that annual benefits are expressed in dollars, the present value of the benefit stream can be computed by summing over all years of service as shown in Figure 74.

(PVB)	=	PRESENT VALUE OF ANNUAL FACILITY BENEFITS		
	=	(PVF)	X	ANNUAL UNIFORM VALUE OF BENEFITS

Where (PVF) is as defined in Figure 73.

Figure 74

Computation Of The Present Value Of Facility Benefits

The present values of cost and benefit can then be compared in one of several ways. Figure 75 shows the computations for the benefits to cost ratio method and the net present value method. When comparing alternatives, all other considerations being equal, the alternative with the greatest benefit to cost ratio or net present value is preferred. Only alternatives for which benefits exceed costs would be considered economically feasible.

2. The Equivalent Uniform Annual Cost Method

This method will yield results which are identical to those obtained using the present value method. In this case, the methods combine the cost of facility construction and the annual O&M expenses into an annual sum which represents a uniform value required in each year to repay the facility construction loan with interest, plus operate and maintain the facility. Note that the loan repayment is a conceptual representation and is not necessarily related to the actual or proposed financing scheme. The equivalent uniform annual cost method is often preferred by highway planners and the basic computation is shown in Figure 76.

The benefit to cost ratio and net present value computed as shown in Figure 77 will yield the same result at that obtained using present value measures in Figure 75.

(B/C) = BENEFIT TO COST RATIO

= (PVB)/(PVC)

Or (NPV) = NET PRESENT VALUE OF BENEFITS OVER COSTS

= [(PVB) - (PVC)]

Where: (PVC) is as computed in Figure 73 and
(PVB) is as computed in Figure 74

Figure 75

Computation Of Benefit/Cost Ratios And Net Present Values Of Alternatives

(AC) = EQUIVALENT UNIFORM ANNUAL FACILITY COST

= EQUIVALENT UNIFORM ANNUAL COST OF FACILITY CONSTRUCTION + ANNUAL UNIFORM O&M COSTS

Where: (CRF) = CAPITAL RECOVERY FACTOR

$$= \frac{i(1 + i)^N}{(1 + i)^N \quad 1}$$

Figure 76

Computation Of The Equivalent Annual
Facility Cost

(B/C) = BENEFIT TO COST RATIO

= EQUIVALENT UNIFORM ANNUAL FACILITY COST ANNUAL VALUE OF FACILITY BENEFITS

= (AC) / (AB)

Or (NPV) = NET PRESENT VALUE OF BENEFITS OVER COSTS

= [(AB) - (AC)] (PVF)

Where: PVF = The Present Value Factor Defined in Figure 73.

Figure 77

Alternative Computation Of Benefit/Cost Ratios
And Net Present Value Of Alternative

3. Sensitivity of Factors

In the computations described above, the interest rate and service life are usually chosen by judgement. Since the analysis is sensitive to these factors, it is often advantageous to determine their impact on solutions. This can be done by making a series of solutions for different i and different N.

The interest rate is probably the most critical factor since a change of several percent in the interest rate can change the results of the comparative analysis. Values between 5 and 12 percent are often used.* The impact is most significant when alternatives being compared have significantly different initial investment or annual O&M costs.

An analysis tends to be most sensitive to values of N, on the other hand, at the low range. This usually is not important for pedestrian facilities, which are apt to have a long potential service life. In general, the service life should be specifid at the low end of its possible range for added conservatism, even though the analysis will be slightly more sensitive to service life at this value.

Service life, especially for extensive CBD systems, will often be difficult to estimate to any reasonable degree of accuracy. The consideration of longevity in this instance relates closely to the amortization period, interest rates, depreciation curves and equity and tax considerations. The developer/owner is usually concerned about realizing a financial return on his investment. Many public facilities, however, are implemented within different financial frameworks where the object is not one of realizing a financial return. Most often they have an initial one-time cost (for construction, etc.) which is not related to any considerations that could be utilized in determining the economic life of the facility. A possible method for determining the useful life of these facilities might lie in an examination of the physical and economic characteristics of the properties abutting the facility, is, to examine the probability of significant change and redevelopment occurring in those areas that abut and directly affect the facility in terms of age, depreciation and revenue. This would require the difficult task of examining in detail abutting property conditions prior to determining a life cycle of each respective facility.

The format in Table 61 is intended to provide a comprehensive accounting procedure for computing the total economic investment cost of:

- Street overpasses
- Street underpasses
- Elevated skyways

The format for at-grade Malls is provided in Table 62.

*A useful guideline value is provided by the Federal Office of Management and Budget. The value is time dependent, consequently, a specific value has not been provided in this Section.

26.5.7 Procedures for Computing Costs for Grade Separated Facilities

Reading from left to right, the columns in Table 61 follow the facility costing process diagrammed in Figure 67 and introduce, in successive order, cost considerations that contribute to the overall facility cost. The rows are ordered to permit the user to efficiently and systematically calculate the contribution of each relevant column factor to the overall cost.

To use the format, the first procedural step is to check (x) in Row A (System Characteristics) those column factors that apply to the particular facility being costed. With respect to the checked columns, enter in Row B (Facility Requirements) the overall facility requirements, such as the overall length of the facility, etc.

Based upon factors checked in Row A and requirements in Row B, enter in Row C (Unit Costs) appropriate unit cost estimates. It should be noted that all unit costs used in the accounting procedures must derive from the same geographic and temporal considerations. That is to say, unit cost developed in New York 1970 should not be mixed in the accounting procedure with unit cost developed in 1975 for Chicago. If the unit costs are not geographically and temporally the same they should be adjusted by means of the methods described in Step 26.5.4. The unit costs provided in this step have been adjusted to reflect U.S. average costs in 1976 dollars and can be located in Tables 50 through 55.

The total cost for each column factor is determined by multiplying the unit cost entered in Row C by the requirements in Row B. The unit of measure ($ft.^2$, l.f., c.y., etc.) must, of course, be the same for both Row B and Row C of each column factor. The result is entered in Row D.

The process described above is completed for each of the relevant system variables in Column 1 through 29. The resulting total factor costs entered in Row D are then added together to determine the basic facility construction cost and summation is entered in the box of Column 31.

The same procedure is repeated for the site related variables in Columns 32 through 52 and the summation of the factor costs is entered in Column 53. (Total specific facility construction cost).

The total facility construction costs (Column 54) is the summation of costs entered in Rows 31 and 53.

The next procedure in Columns 55 and 56 adjusts the total construction costs of Column 54 geographically and temporarily with respect to the specific location of the facility site. If the unit cost factors used in the preceding steps were developed for the region or city in which the facility is located and the figures represent current unit cost estimates, then the procedures in Columns 55 and 56 can be by-passed and the total cost in Column 54 can be entered without adjustment in Column (Adjusted Facility Construction Cost). The procedures outlined in Columns 55 and 56 are intended to be used in conjunction with the unit cost estimates provided in the preceeding parts of this step. Using these unit costs, the index value for I_{us} is valid and the index value for I_x can be found in Table 17.1 of Supplement 17. The adjustment factor, A_x, is calculated using the formula that is provided and multiplied by the cost figure in Column 54. The resulting adjusted facility construction cost is entered in Column 56.

In columns 57 through 64 the total present value of costs for O&M is determined. General guidelines for estimating the O&M costs in Columns 57 to 62 is provided in Step 26.5.5. Once those costs have been determined, the cost of capital (i) established and the facility services life (N) estimated, the present value factor (PVF) can be calculated by using the formula that is provided or by simply extracting the appropriate value from precalculated reference tables which are readily available. The present value of O&M costs is then computed by multiplying the sum of O&M costs in Column 63 by (PVF) and entering the result in Column 65.

Various methods for calculating the total economic investment cost of a facility are discussed in Step 26.5.6. The user should select from the alternatives the method he (or she) considers the most suitable or appropriate. The method used in Table 26.5.12, present Value of Facility Costs, was provided simply to complete the costing process. By including the process in the table, it was not intended to infer that this specific method is the best of the alternatives available.

The present value of facility costs is determined by summing the cost entered in Column 56 with the cost entered in Column 65.

(The format for at-grade malls is provided in Table 26.5.13.)

26.5.8 Procedures for Computing Costs for At-Grade Malls

The format for at-grade malls is provided in Table 62. To develop preliminary estimates for specific plans, Table 26.5.13 can be used as an accounting sheet. A variety of design treatment unit costs have been provided in the Table for this purpose. The first procedural step is to develop average quantities for each design treatment as represented by the plan on a per block basis. Enter these quantities in the average quantity column of Table 62. In entering quantities care should be taken to make sure the unit of measure ($ft.^2$, LF, etc.) corresponds with that of the unit cost of the design treatment. Then multiply the unit cost by the average quantity to determine the per block cost to accommodate the design treatment. Sum the costs of each design treatment to determine the total per block cost.

If quantities vary from block to block, this procedure should be repeated for each block. To determine the overall estimate of the specific plan, sum the totals of each block. The overall cost per $foot^2$ is determined by dividing the above estimate by the total square feet encompassed by the mall. For a prototypical full mall this total square footage would be approximately (21,000 $ft.^2$) x (number of blocks in plan).

TYPE OF FACILITY AND LOCATION

D Unit Cost	C Unit Cost	B Overall Requirements	A System Characteristics	No.	Item	Category	
				1	Width	Dimensional	SYSTEMS VARIABLES
				2	Height	Dimensional	
				3	Required Length	Dimensional	
				4	Steel	Materials / Construction Technique	
				5	Concrete, Poured-In-Place	Materials / Construction Technique	
				6	Concrete, Precast	Materials / Construction Technique	
				7	0-50′	Structural – Span	
				8	50′-100′	Structural – Span	
				9	100′	Structural – Span	
				10	Support at Terminals (clear span)	Structural – Support	
				11	Multi-Span	Structural – Support	
				12	Continuous Support	Structural – Support	
				13	SUBTOTAL		
				14	Stairs	Terminal Connection	
				15	Ramps	Terminal Connection	
				16	Escalators	Terminal Connection	
				17	Elevators	Terminal Connection	
				18	SUBTOTAL		
				19	Site Preparation	Elements	
				20	New Construction	Elements	
				21	Landscaping	Elements	
				22	Street Furniture	Elements	
				23	Signing	Elements	
				24	SUBTOTAL		
				25	Open	Enclosure Systems	
				26	Covered	Enclosure Systems	
				27	Ventilation	Enclosure Systems – Enclosed	
				28	Heating	Enclosure Systems – Enclosed	
				29	Air Conditioning	Enclosure Systems – Enclosed	
				30	SUBTOTAL		
				31	FACILITY CONSTRUCTION COST (SUM TOTALS 13, 19 and 25)		

Table 61

Accounting Framework For
Computing Total Investment Cost
For Grade-Separated Facilities

				No.	Item		Category	Section
				32	Poor Soil Material Foundation Piles		Foundation Conditions	SPECIFIC (SITE RELATED) COST IMPACT VARIABLES
				33	Water Pumping Dewatering			
				34	Excavation (Rocks, etc.)			
				35	Underpinning			
				36	SUBTOTAL			
				37	High	PHYSICAL RELOCATION	Utilities Relocation	
				38	Medium			
				39	Low			
				40	High	SUPPORT AND PROTECTION		
				41	Medium			
				42	Low			
				43	SUBTOTAL			
				44	0'-50' Short Span		Structural	
				45	50'-100' Long Span			
				46	100'			
				47	SUBTOTAL			
				48	Rerouting		Traffic Delay	
				49	Street Closing			
				50	Construction Impedance			
				51	Other & Locational Contingencies			
				52	SUBTOTAL			
				53	TOTAL SPECIFIC FACILITY CONSTRUCTION COST			
				54	TOTAL UNADJUSTED FACILITY CONSTRUCTION COST (SUM TOTALS 32 and 54)			
				55	$A_x = \frac{I_x}{I_{us}} = \frac{\quad}{223}$ *			Geo. & Temp. Adjustment
				56				
				57				Operating & Maintenance (O & M)
				58				
				59				
				60				
				61				
				62				
				63	SUBTOTAL			
				64	$PVF = \frac{(I+:)^{N-1}}{(I+i)^N}$ **			
				65				
				66			Total Facility Economic Investment Cost	

* Where: I_x = Index for City, I_{us} = 223 = U.S. Average Index (for 1976)
A_x = Adjustment Factor

**Where: N = Facility Service Life (Yrs.), i = Discount Factors (Cost of Capital).
PVF = Present Value Factor

Table 61 (Cont'd)

		Unit * Cost	PARTIAL MALL		FULL MALL			
			Ave.** Quan.	Total Cost	Ave.** Quan.	Total Cost	Ave. Quan.	Total Cost
Site Preparation	Removal of Sidewalk	$ 6.30/sy	450 sy	$ 2,835	800 sy	$ 5,040		
	Removal of Curbing	3.00/lf	800 lf	2,400	800 lf	2,400		
	Removal of Street Paving	6.82/sy	700 sy	4,774	1,500 sy	10,230		
	Utilities Relocation	12.97/cy	85 cy	1,102	170 cy	2,205		
				$ 11,111		$ 19,875		
NEW CONSTRUCTION	Concrete Stairs	31.93/lf	100 lf	3,193	200 lf	6,385		
	Concrete Curb	13.39/lf	950 lf	12,720	1,400 lf	18,746		
	Concrete Sidewalk	2.96/sf	11,000 sf	32,560	19,000 sf	56,240		
	Textured Sidewalk	3.45/sf						
	Brick Paved Sidewalk	6.56/sf						
	Concrete Street Paving	3.23/sf						
	Planter Wall 8" x 2'-6"	26.08/lf	200 lf	5,216	800 lf	20,864		
	18' Retaining Wall	8.58/sf						
	10' Retaining Wall	7.07/sf						
	Structural Sidewalk	7.17/sf						
	Street Lighting	810./fix.	10 fix	8,100	10 fix	8,100		
	Accent Lighting	21.85/lf	100 lf	2,185	500 lf	10,925		
				$63,974		$121,260		

Table 62

Allocation Of Unit Costs For At
At Grade Malls

		Unit* Cost	PARTIAL MALL		FULL MALL			
			Ave.** Quan.	Total Cost	Ave.** Quan.	Total Cost	Ave. Quan.	Total Cost
LANDSCAPING	Large Trees - 6" Caliper	$ 444.40 ea.	45	$19,998	45	$ 19,998		
	Small Trees - 2" - 2½" Caliper	145.44 ea.	25	3,636	40	5,817.60		
	Deciduous Shrubs	21.20 ea						
	Evergreen Shrubs	38.36 ea.						
	Ground Cover	15.15/sy.	500 sy.	7,675	1000 sy.	15,150		
	Sod	2.02/sy.						
				$31,209		$ 40,965		
STREET FURNITURE	Concrete Bench	62.00/sf.	300 sf.	18,612	900 sf.	55,836		
	Wood Bench	303.00 ea.						
	Bollards & Chain	141.00 ea.	12	1,692	25	3,525		
	Trash Recepticals, etc.	151.50 ea.	10	1,515	10	1,515		
	OUtside Table & Chairs	1,410.00 ea.						
	Fountains/Water Pools	101.52/sf.	100 sf.	10,152	500 sf.	50,760		
	Canvas Awning	11.61/sy.						
	Tubular Awning Frame	8.08/sf.						
	Kiosks - Wood & Canvas	1,410.00 ea.	2	2,820	5	7,050		
	Tree Gratings	282.00 ea.	20	5,640	40	11,280		
				$40,431		$129,966		

Table 62 (Cont'd)

		Unit * Cost	PARTIAL MALL		FULL MALL			
			Ave.** Quan.	Total Cost	Ave.** Quan.	Total Cost	Ave. Quan.	Total Cost
SIGNING	Sign, Post & Frame	$520.50 ea.	6	$ 3,123	12	$ 6,245		
				$3,123		$ 6,245		
SHELTERS	Bus Shelters or Covering for Arcades	176.25/lf.	130 lf.	26,437	400 lf.	70,500		
				$26,437		$70,500		
COST	TOTAL MALL CONST. COST		$176,285.00		$388,811.00			
	COST PER FOOT^2		7.90/ft.^{2}		18.51/ft.^{2}			

*Source: Previous unit costs were developed by RTKL Associates and MDA Associates for use in Reference (7) and (8).

**Quantities are for 1 block (60' wide and 360" long) and are based upon averages for malls actually completed in 15 cities.

Table 62 (Cont'd)

For more general estimating purposes the distribution of cost breakdowns, relative to total cost, for full and partial malls have been provided in Tables 56 and 57.

STEP 26 REFERENCES

1. Laurence A. Alexander, Downtown Malls: Feasibility and Development, Downtown Research and Development Center, New York, New York, 1974.

2. Laurence A. Alexander, Downtown Malls, An Annual Review, Vol. 1 & 2, Downtown Research and Development Center, New York, New York, 1975

3. Dodge Manual for Building, Construction, Pricing and Scheduling, 1976; Dodge Building Cost Service - McGraw Hill Information Systems.

4. ENR Building Code Index History 1913 to 1976.

5. Interview with V. Ponte, October 31, 1973.

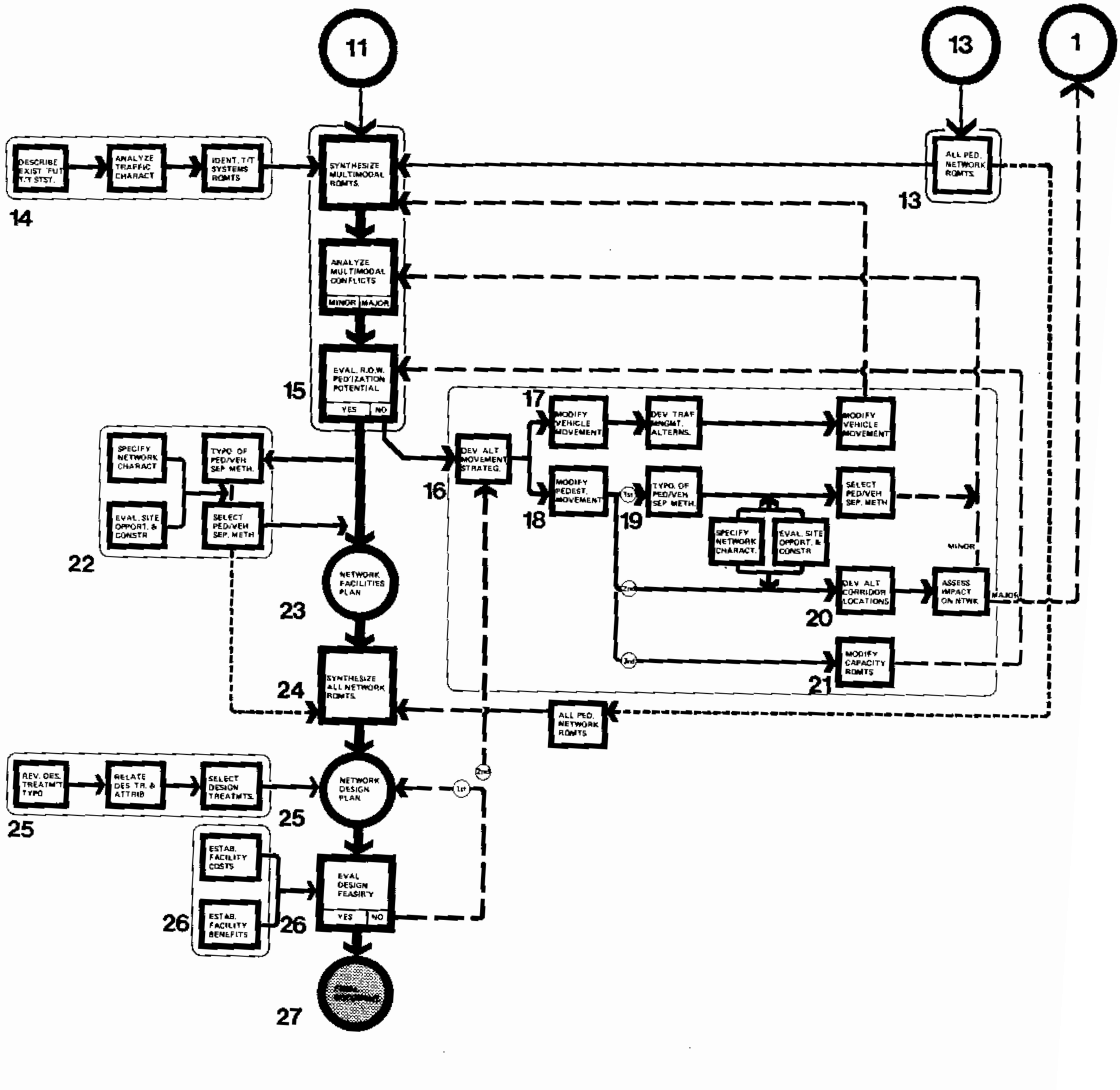
6. On Foot Downtown, Joint Report by the Toronto Planning Department (Toronto).

7. RTKL Associates Inc., Pedestrian Circulation Study for Downtown Baltimore, September 1975.

8. William G. Scott and Leonard S. Kagan, Comparison of Cost and Benefits of Facilities for Pedestrians, Report No. FHWA-Rd-75-7, Department of Transportation, Federal Highway Administration, Office of Research and Development, Washington, D.C., December 1973.

PRODUCE NETWORK DESIGN PLAN

27



TASK 27

PRODUCE NETWORK DESIGN PLAN

27.1 Task Description

Once any revisions to the design based on impact assessment are completed, final graphic presentations are prepared. Figures 78, 79, 80 and 81 are typical products of this final task.

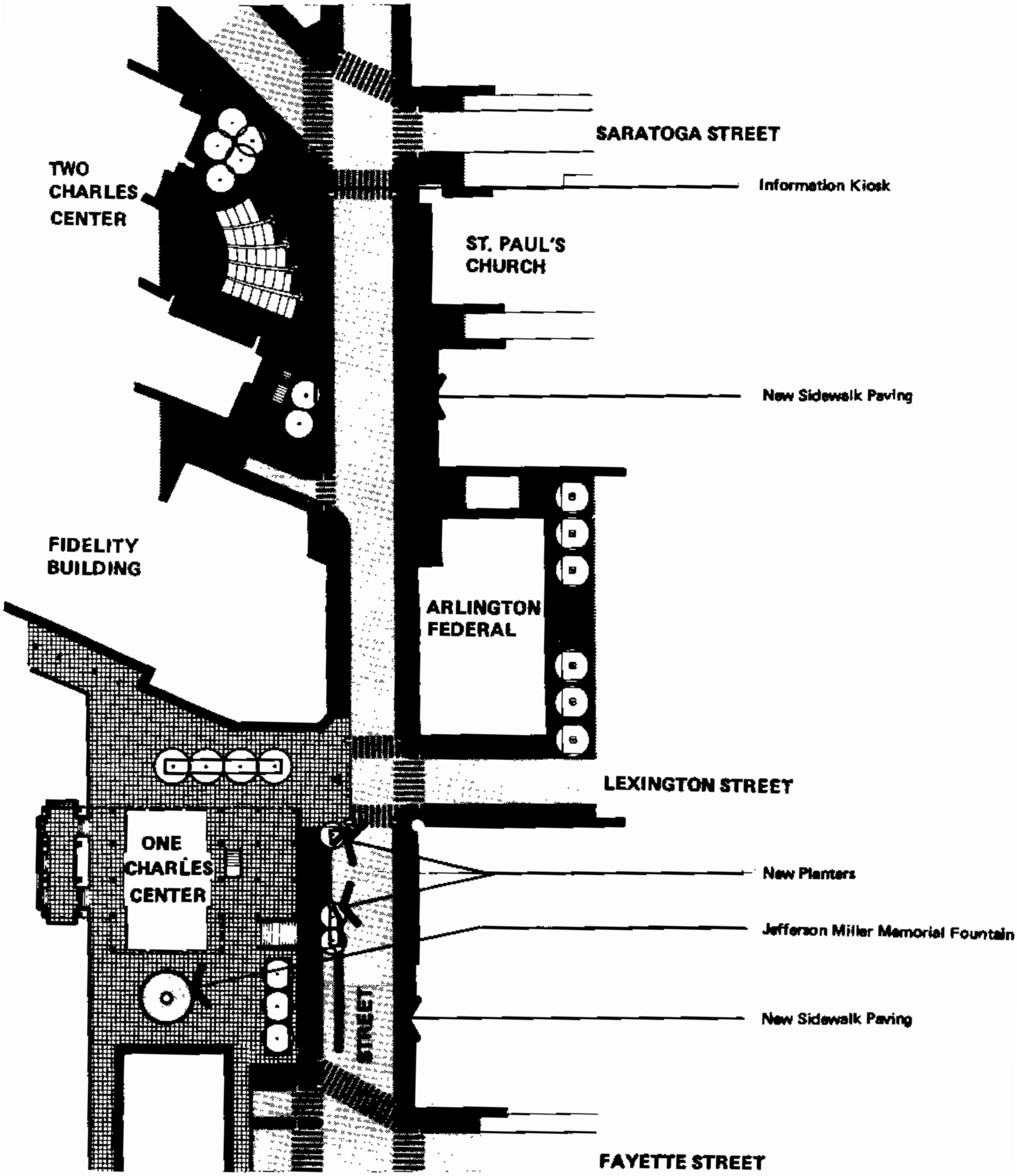


Figure 78

Design Plan Documentation - Widened Sidewalks

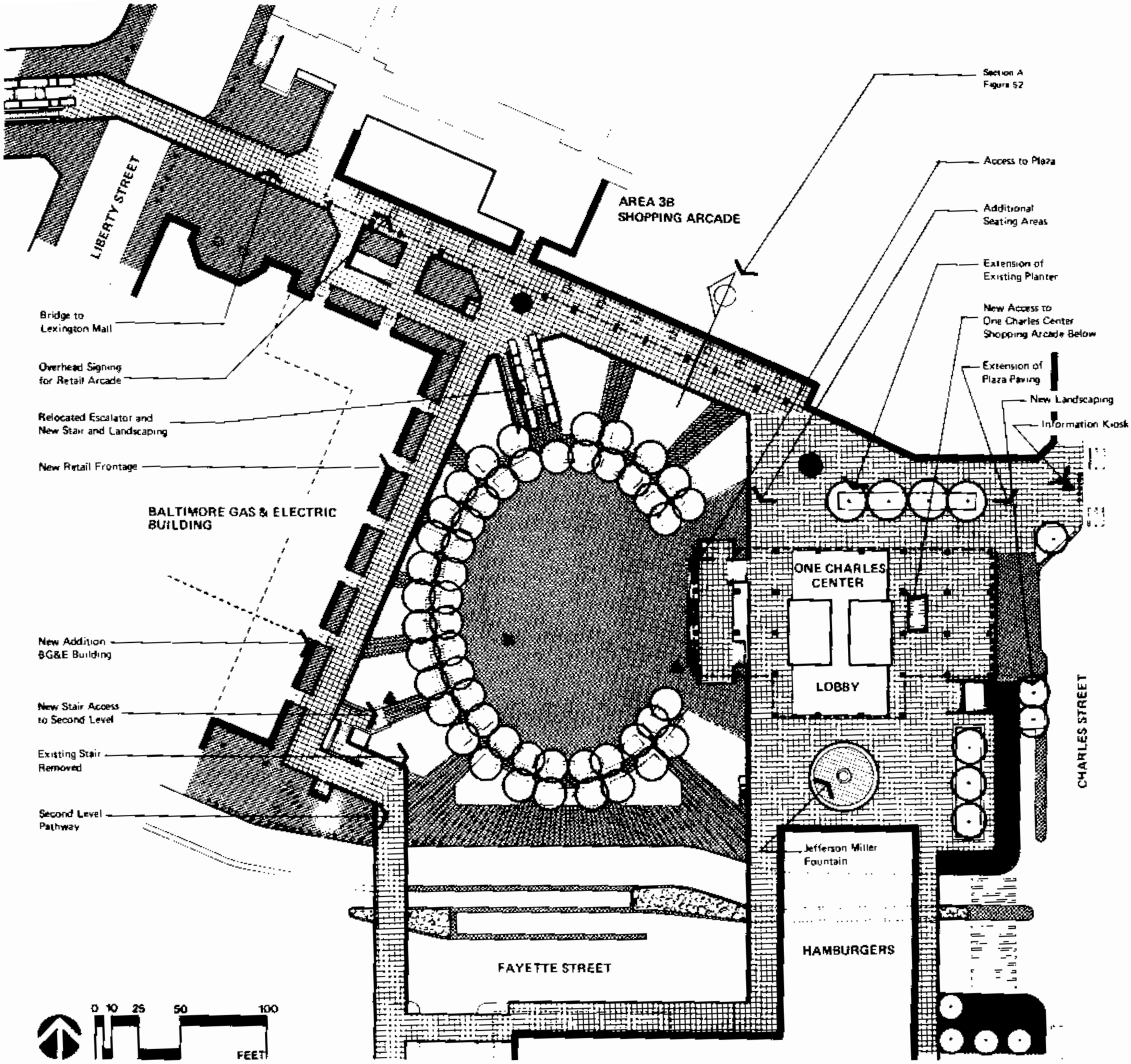
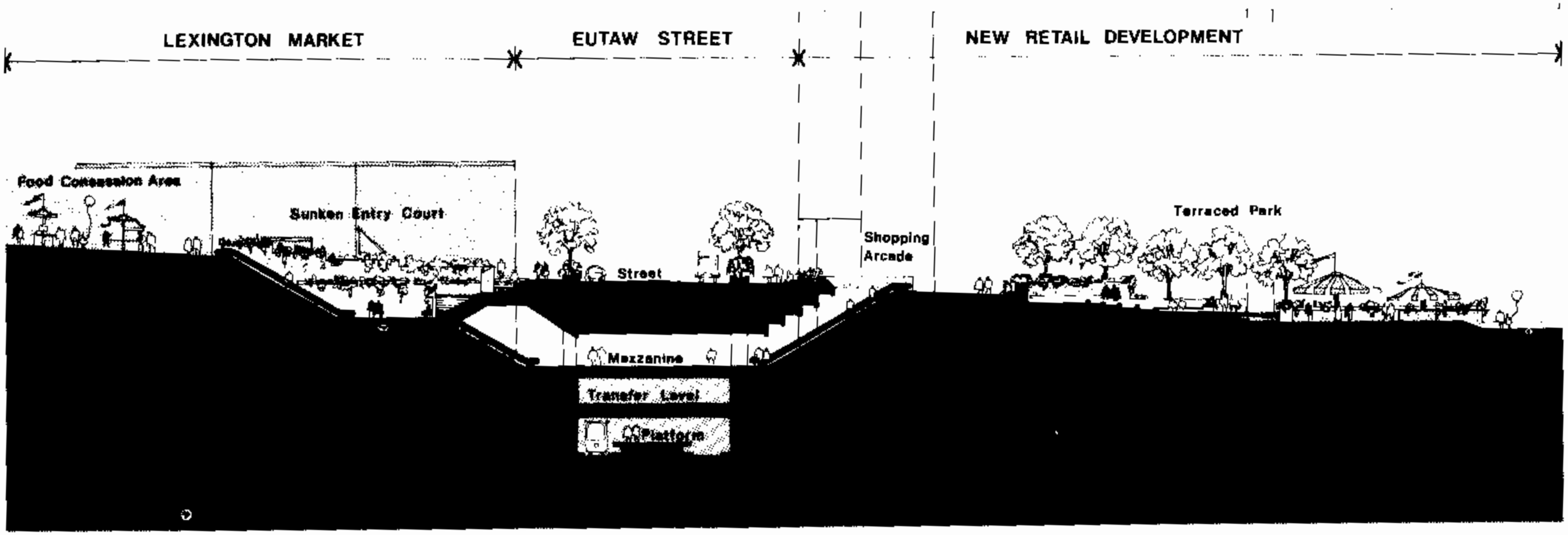
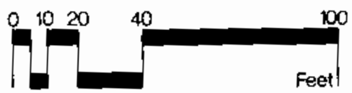


Figure 79

Design Plan Documentation - Plaza Treatment





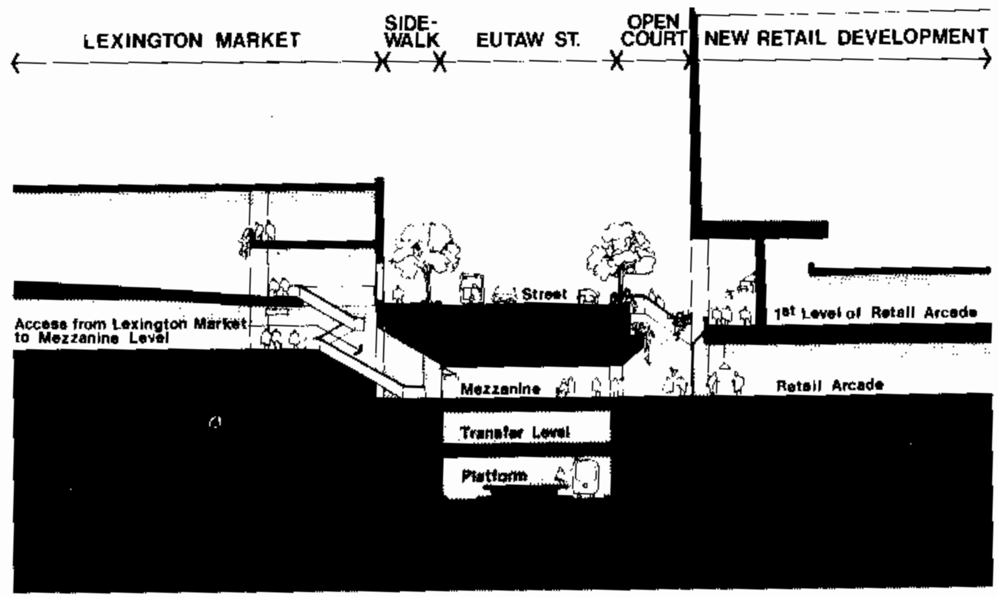


Figure 80

Design Plan Documentation - Sections

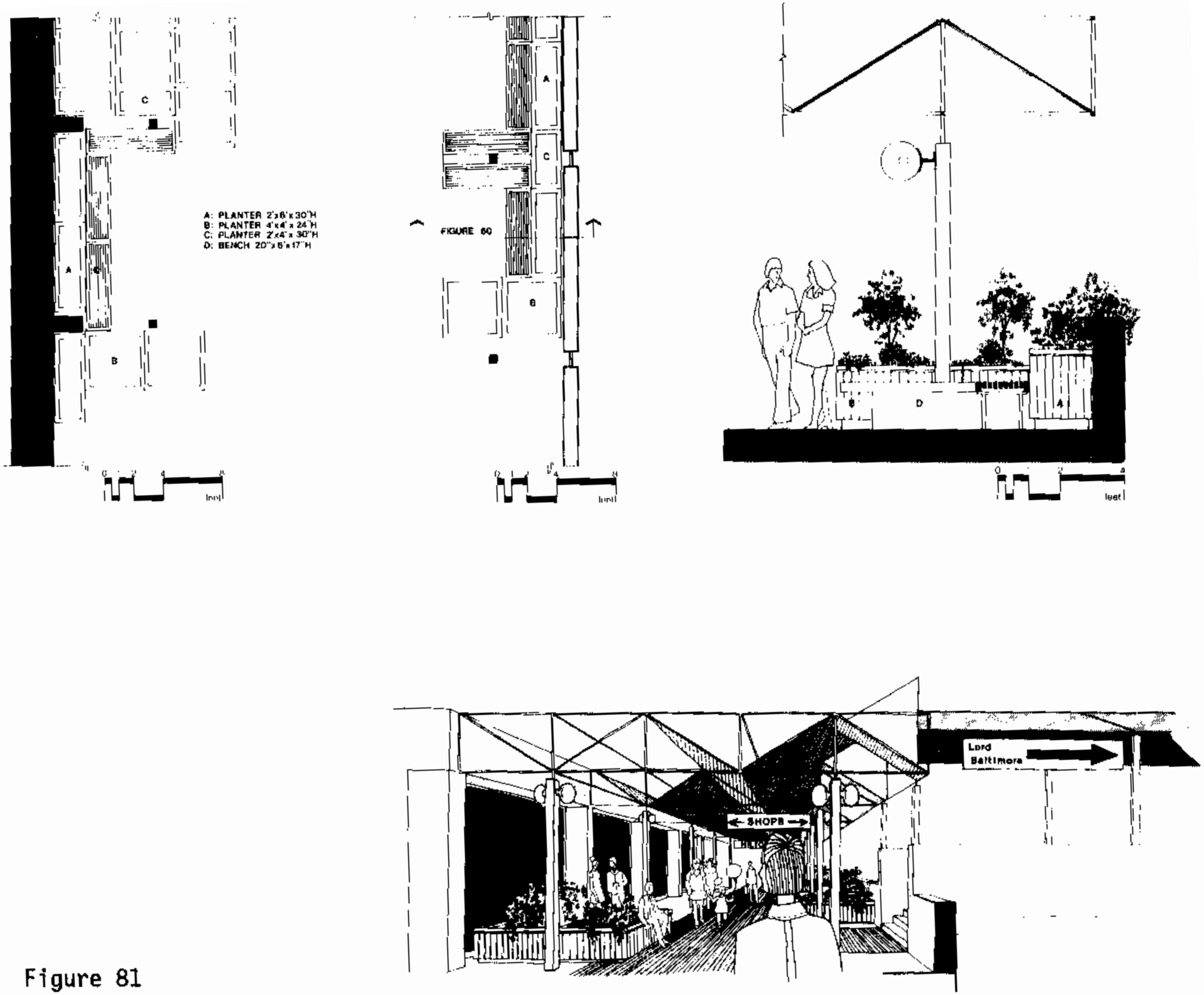


Figure 81

Design Plan Documentation - Design Details

* U.S.G.P.O. 628-433/1302-2631

FEDERALLY COORDINATED PROGRAM OF HIGHWAY RESEARCH AND DEVELOPMENT (FCP)

The Offices of Research and Development of the Federal Highway Administration are responsible for a broad program of research with resources including its own staff, contract programs, and a Federal-Aid program which is conducted by or through the State highway departments and which also finances the National Cooperative Highway Research Program managed by the Transportation Research Board. The Federally Coordinated Program of Highway Research and Development (FCP) is a carefully selected group of projects aimed at urgent, national problems, which concentrates these resources on these problems to obtain timely solutions. Virtually all of the available funds and staff resources are a part of the FCP, together with as much of the Federal-aid research funds of the States and the NCHRP resources as the States agree to devote to these projects.*

FCP Category Descriptions

1. Improved Highway Design and Operation for Safety

Safety R&D addresses problems connected with the responsibilities of the Federal Highway Administration under the Highway Safety Act and includes investigation of appropriate design standards, roadside hardware, signing, and physical and scientific data for the formulation of improved safety regulations.

2. Reduction of Traffic Congestion and Improved Operational Efficiency

Traffic R&D is concerned with increasing the operational efficiency of existing highways by advancing technology, by improving designs for existing as well as new facilities, and by keeping the demand-capacity relationship in better balance through traffic management techniques such as bus and carpool preferential treatment, motorist information, and rerouting of traffic.

* The complete 7-volume official statement of the FCP is available from the National Technical Information Service (NTIS), Springfield, Virginia 22161 (Order No. PB 242057, price $45 postpaid). Single copies of the introductory volume are obtainable without charge from Program Analysis (HRD-2), Offices of Research and Development, Federal Highway Administration, Washington, D.C. 20590.

3. Environmental Considerations in Highway Design, Location, Construction, and Operation

Environmental R&D is directed toward identifying and evaluating highway elements which affect the quality of the human environment. The ultimate goals are reduction of adverse highway and traffic impacts, and protection and enhancement of the environment.

4. Improved Materials Utilization and Durability

Materials R&D is concerned with expanding the knowledge of materials properties and technology to fully utilize available naturally occurring materials, to develop extender or substitute materials for materials in short supply, and to devise procedures for converting industrial and other wastes into useful highway products. These activities are all directed toward the common goals of lowering the cost of highway construction and extending the period of maintenance-free operation.

5. Improved Design to Reduce Costs, Extend Life Expectancy, and Insure Structural Safety

Structural R&D is concerned with furthering the latest technological advances in structural designs, fabrication processes, and construction techniques, to provide safe, efficient highways at reasonable cost.

6. Prototype Development and Implementation of Research

This category is concerned with developing and transferring research and technology into practice, or, as it has been commonly identified, "technology transfer."

7. Improved Technology for Highway Maintenance

Maintenance R&D objectives include the development and application of new technology to improve management, to augment the utilization of resources, and to increase operational efficiency and safety in the maintenance of highway facilities.