

DOT TSC FAA 80-18
REPORT NO. FAA-EM-80-9

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AIRPORT GROUND ACCESS PLANNING GUIDE

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JULY 1980

FINAL REPORT

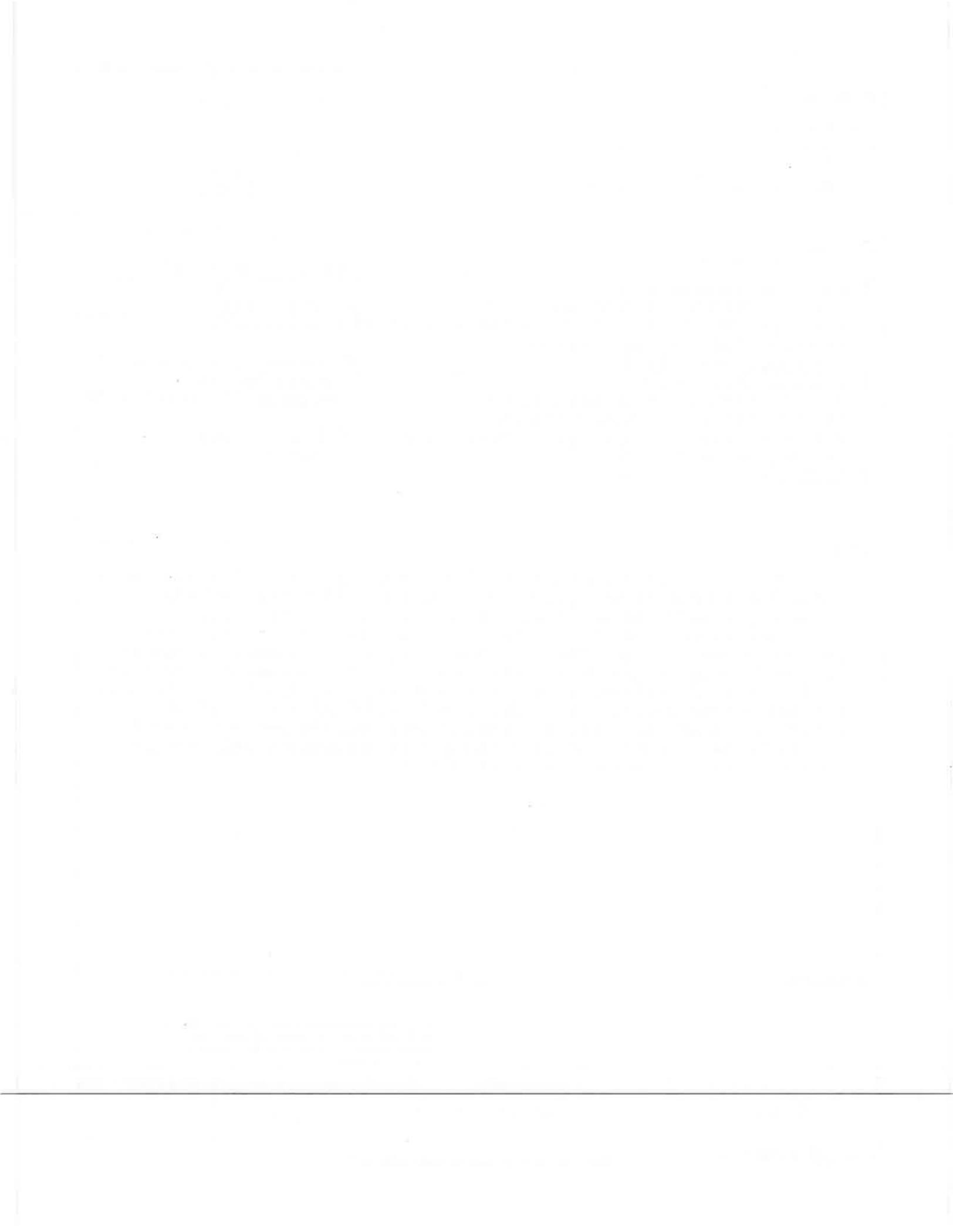
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VIRGINIA 22161

Prepared for

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Office of Systems Engineering Management
Washington DC 20591



1. Report No. FAA-EM-80-9	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle AIRPORT GROUND ACCESS PLANNING GUIDE		5. Report Date July 1980	
		6. Performing Organization Code 522	
7. Author(s) Mark Gorstein		8. Performing Organization Report No. DOT-TSC-FAA-80-18	
9. Performing Organization Name and Address U.S. DEPARTMENT OF TRANSPORTATION RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION Transportation Systems Center Cambridge MA 02142		10. Work Unit No. (TRAIS) FA-032/R0108	
		11. Contract or Grant No.	
12. Sponsoring Agency Name and Address U.S. DEPARTMENT OF TRANSPORTATION FEDERAL AVIATION ADMINISTRATION Office of Systems Engineering Management Washington D C 20591		13. Type of Report and Period Covered Final Report October '78-October '80	
		14. Sponsoring Agency Code AEM-200	
15. Supplementary Notes			
16. Abstract <p>Airport access has been identified by some airport authorities as a potential threat to the growth of aviation. In order to help airport planners and local authorities define the critical elements of an access problem and identify improvement projects for their consideration, TSC and FAA/OSEM have prepared a planning document designed to guide and direct the process. This document describes methods for identifying access constraints, step-by-step techniques for collecting needed access data, and useful ways to evaluate potential solutions. These solutions may include not only major construction projects but also changes in management and service that can lead to improved airport access.</p>			
17. Key Words		18. Distribution Statement DOCUMENT IS AVAILABLE TO THE PUBLIC THROUGH THE NATIONAL TECHNICAL INFORMATION SERVICE, SPRINGFIELD, VIRGINIA 22161	
19. Security Classif. (of this report) unclassified	20. Security Classif. (of this page) unclassified	21. No. of Pages 150	22. Price



PREFACE

As a mode of transportation, air travel in the United States has increased steadily over recent decades and is expected to continue growing. Consequently, employment of the most effective airport ground access plans is essential not only for passengers and airport employees but for businesses serving the airport trade. This report is organized to aid local authorities in the evaluation of the existing access situations and introduces alternative solutions; alternative solutions take into consideration economic, environmental, and political constraints.

Appreciation is expressed to Dr. Steven Gordon of Simat, Helliesen & Eichner, Inc. and to Richard Tilles and Robert Lepore of Tippetts-Abbett-McCarthy-Stratton for contributing text and graphs.

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		
sq in	square inches	6.5	square centimeters	cm ²
sq ft	square feet	0.09	square meters	m ²
sq yd	square yards	0.8	square meters	m ²
sq mi	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		
teaspoon	teaspoons	5	milliliters	ml
fluid ounce	fluid ounces	30	milliliters	ml
cup	cup	0.24	liters	l
quart	quarts	0.95	liters	l
gallon	gallons	3.8	liters	l
cu ft	cubic feet	0.03	cubic meters	m ³
cu yd	cubic yards	0.76	cubic meters	m ³
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

Approximate Conversions from Metric Measures

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

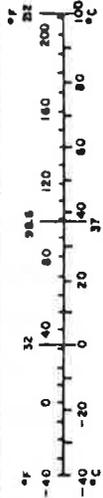


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EXECUTIVE SUMMARY

Purpose

The purpose of this report is to present advice on planning ground access to airports. It is part of the FAA's continuing effort to provide to the planning community the latest available techniques relative to planning all aspects of the airport system. This document is intended to help the Federal Aviation Administration (FAA) and local authorities participate in planning for airport access and in evaluating the adequacy of existing access facilities. It is also intended to familiarize local planners with the terminology, techniques, and requirements of airport access planning.

Specific areas addressed are data collection, identification of access constraints, and identification and evaluation of solutions.

The Planning Process

The basic process of airport access planning is shown graphically in Figure ES-1. The first phase involves collection of data on the roadways to the airport, roadways within the airport, and on the people who use these roads. The data are used to identify roadways which constrain air passenger travel by operating at a poor level of service. The method deals with highways because they provide the principal means of airport access. Rail access is considered for its potential to divert automobile trips and therefore improve highway service levels.

Next, solutions to these constraints are identified. These solutions, ranging from low cost transportation systems management (TSM) actions to construction of new highways or fixed guideway transit systems, are then evaluated by comparing economic and other factors. At this stage the analysis of benefits and costs of a given solution may point the way to others not previously considered. Those solutions eventually recommended

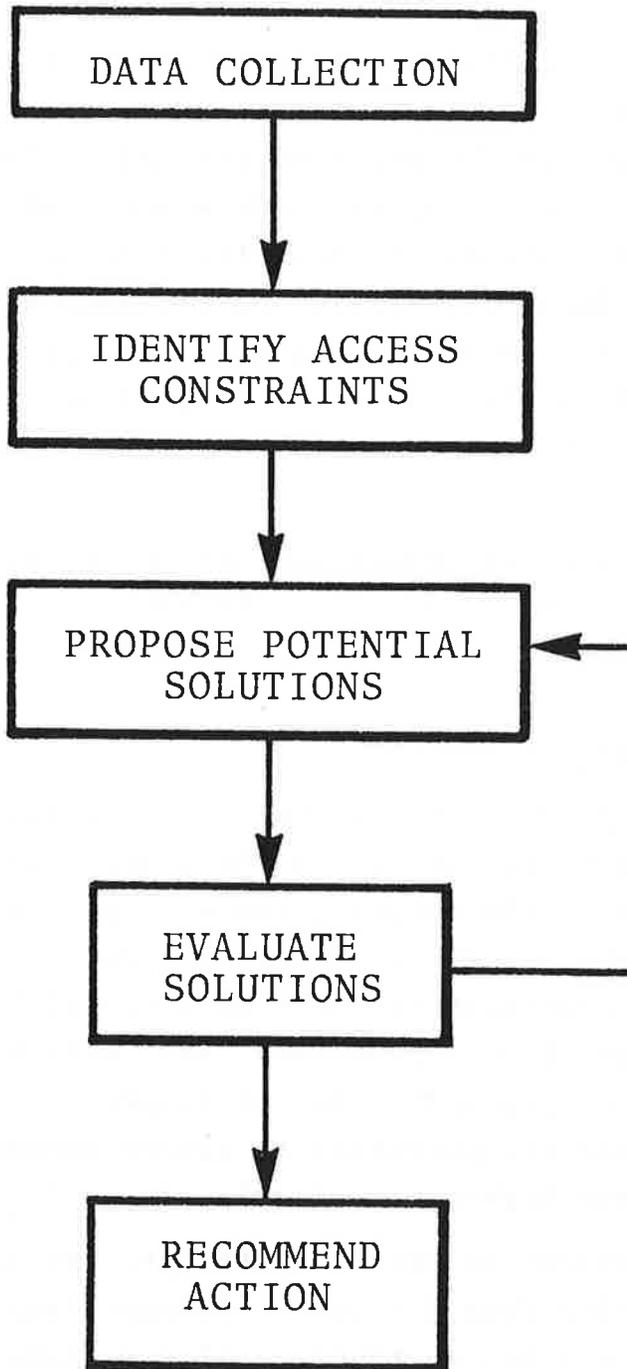


FIGURE ES-1. THE AIRPORT ACCESS PLANNING PROCESS

will incorporate environmental, community and political factors in addition to economic considerations.

Each element of the planning process is described in the remainder of the summary.

Collect Data

Table ES-1 shows the types of data required in four categories: demand, facilities and services, economic and planning. Demand data are used to determine the capacity required of airport access roadways. Facility data are required to determine the capacities of these roadways and to identify any capacity constraints that may exist on the airport itself (access or airside). Economic data are used to compare alternatives for improving ground access, and to assess the impact of inadequate ground access relative to some "idealized alternative." Finally, planning data are needed to coordinate ground access with the planned or programmed changes.

Identify Constraints

Figure ES-2 illustrates the process used to identify the location of access constraints. Airport vehicles are first distributed upon the roadway system. Then on each roadway, the non-airport vehicles are added to estimate the total demand. Finally, demand is compared to capacity, which is a function of roadway geometry and the minimum "acceptable" level of service. If demand exceeds capacity, an "access constraint" is said to exist because an acceptable level of service cannot be achieved during peak periods.

Identify Alternative Solutions

Although a new or upgraded access highway generally provides the most straightforward solution to capacity deficiencies, it is becoming more and more difficult to plan highways that are environmentally acceptable and will win community support. Thus, it is important that the planner be familiar with other alternatives which might relieve part or all of the access constraints.

TABLE ES-1. TYPES OF DATA REQUIRED FOR AIRPORT ACCESS PLANNING

<u>Demand</u>
Number of Users
Air Passengers
Airport Vehicles
Employees
Local Origin & Destination
Mode of Access
Non-Airport User Trips
Peaking
<u>Facilities and Services</u>
On-Airport Facilities
Off-Airport Facilities
Airport Access Services
<u>Economic</u>
Employment
Vehicle Fuel Use and Cost
Value of Time
Multiplier
Elasticities
<u>Planning</u>
Aviation Plans
Ground Transport Plans
Land Use Plans

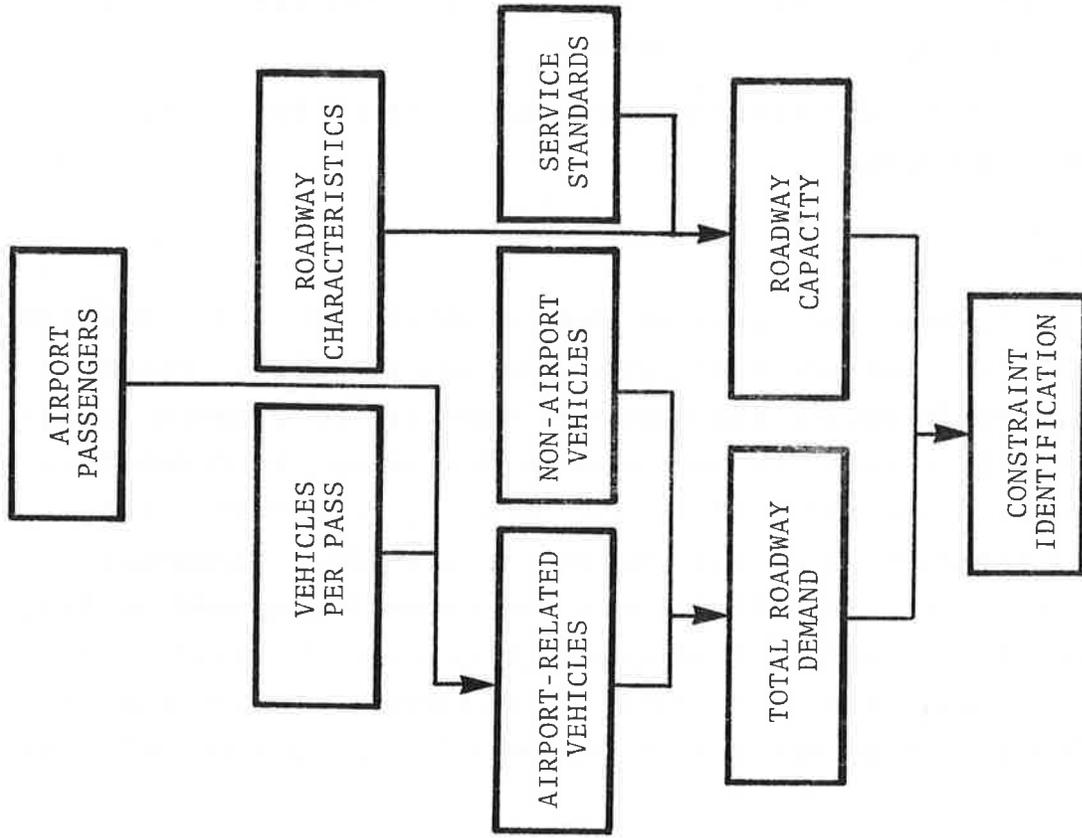


FIGURE ES-2. IDENTIFICATION OF ROADWAY CAPACITY RESTRAINTS

Alternative solutions are discussed in this circular under two major headings, construction and transportation systems management (TSM). Construction alternatives provide direct and large scale capacity increases, but have associated high costs and often significant adverse environmental impacts. TSC alternatives normally provide lesser relief to congestion, but are far easier to implement because of lower cost and lesser adverse impacts. Those solutions tested may include a combination of improvements (particularly with TSM) that form a logical "program package."

Table ES-2 lists the various types of solutions within the categories discussed above. Potential solutions tested in the subsequent analysis phase should be carefully selected on the basis of appropriateness to the particular airport and urban situation.

Evaluate Solutions

Figures ES-3 and ES-4 illustrate the procedures used to evaluate solutions. Figure ES-3 illustrates the computation of roadway delay in the access trip. Generally, roadway delay is best alleviated by changes in roadway characteristics (associated with construction alternatives) which increase capacity. However, changes in mode split, use of access roadways by non-airport vehicles, and the peaking of airport traffic may all be affected by alternatives being considered, and thus will have an impact on the level of access delay.

Figure ES-4 illustrates how the net benefit of alternatives can be estimated and compared. Alternative benefits include changes in mode split (affecting fuel use), changes in access delay (affecting airport and non-airport user travel time), and changes in airport use (improving services and generating employment). In addition, the cost and revenue generated directly by the alternative will affect its net economic value. The net effect may be quantified by assigning dollar values to the various impacts and combining them over time to derive measures of economic benefit, such as net present value.

TABLE ES-2. SOLUTIONS TO AIRPORT ACCESS PROBLEMS

Construction Solutions

Highway System
Rail Service

Transportation Systems Management
(TSM) Solutions

Traffic Operations
Signalization
Channelization
Reversible Lanes

Preferential Treatment of High-
Occupancy Vehicles
Freeway Lanes and Access Ramps
Arterial Lanes
Park-and-Ride Facilities

Improved Transit Service
Transit Service
Marketing

Reduced Vehicle Use
Carpooling
Pricing

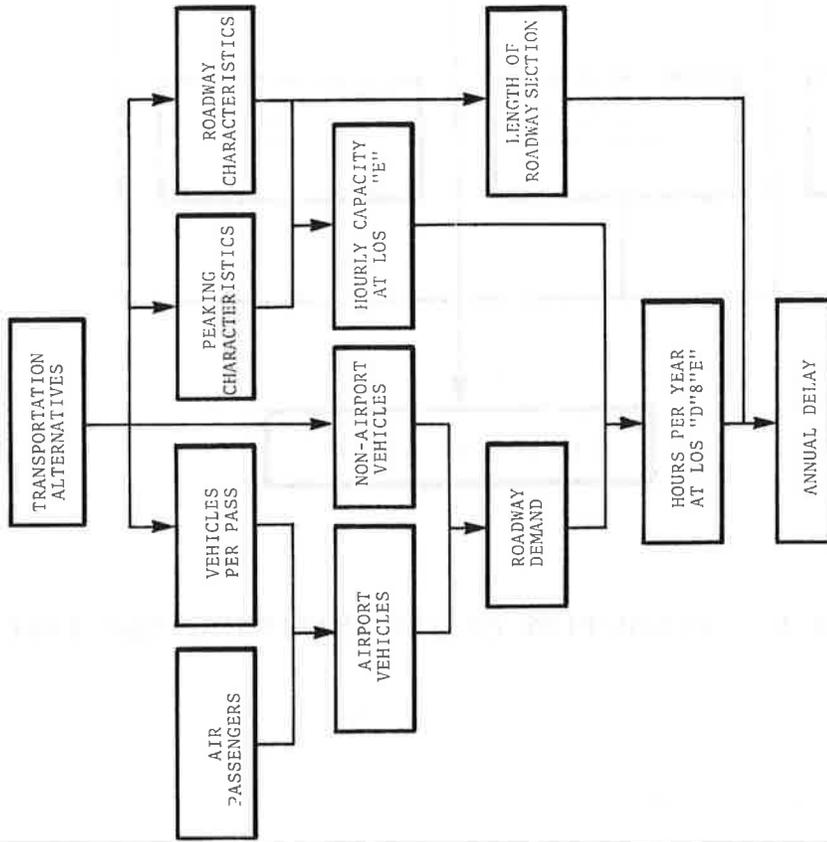


FIGURE ES-3. METHOD FOR ESTIMATING ACCESS DELAY

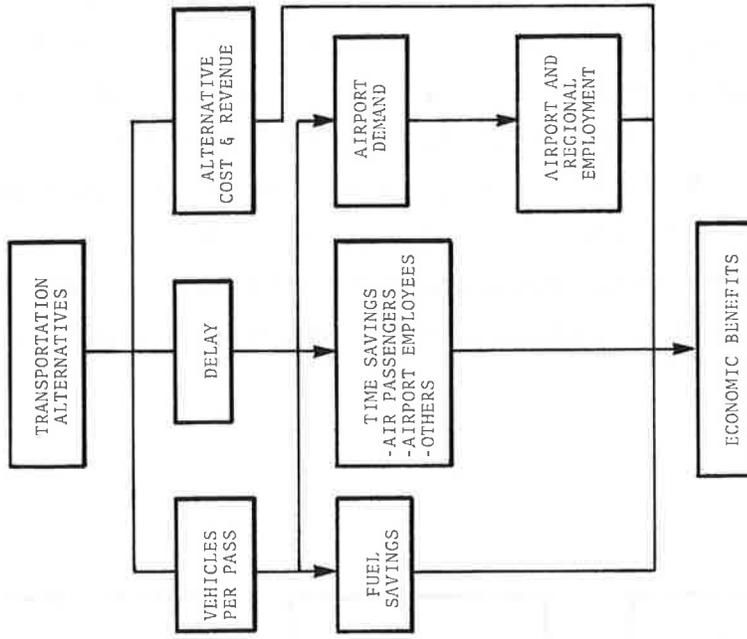


FIGURE ES-4. ESTIMATING NET ECONOMIC BENEFIT OF ACCESS ALTERNATIVES

Recommend Action

The recommended action results from synthesizing the various factors shown in Figure ES-5. Each alternative must be graded upon how great an economic benefit it brings, how it fits into environmental and community concerns, and how available funding meets investment needs. Political constraints may also eliminate some of the proposed solutions. The process of identifying community preferences and assessing environmental impacts is beyond the scope of this circular, but is addressed in other FAA publications.

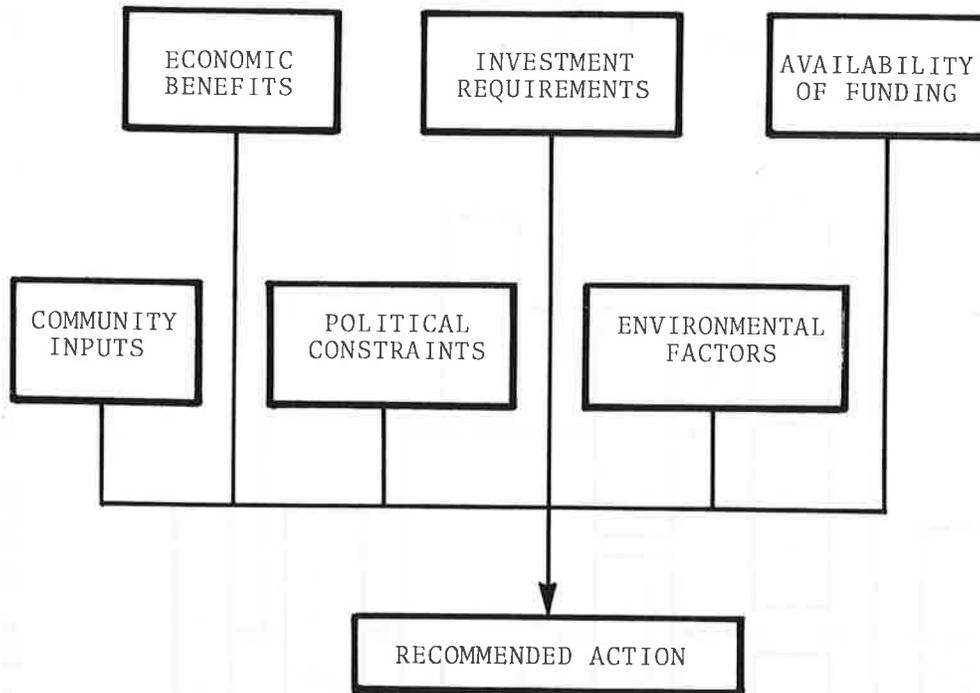


FIGURE ES-5. EVALUATION OF ALTERNATIVE ACCESS IMPROVEMENTS

1. INTRODUCTION

1.1 PURPOSE

The purpose of this circular is to present advice on planning ground access to airports. It is intended to help the Federal Aviation Administration (FAA) and local authorities participate in planning for airport access and in evaluating the adequacy of existing access facilities. It is also intended to familiarize local planners with the terminology, techniques, and requirements of airport access planning. Specific areas addressed are data collection, identification of access constraints, and identification and evaluation of solutions.

This circular is one of a series developed by the FAA to provide the planning community with the latest available techniques for planning all aspects of the airport system. Other circulars in this series are Airport Master Planning, Planning the State Airport System, and Regional/Metropolitan Airport Planning.

1.2 THE NEED FOR AIRPORT GROUND ACCESS PLANNING

1.2.1 Air Traveler Benefits

As shown in Figure 1-1, the ground trip to and from airports is often longer than the air trip between them. Currently, ground access delays at many of the heavily used airports negate the time savings of high speed air travel. In many cases, improvement of ground access may be the single most effective means of improving the overall journey of the air passenger. Planning is necessary to help decide among alternative access improvements and to quantify what benefits can be expected from their implementation.

1.2.2 Public Benefits

Long delays in airport access contribute to fuel wastage and air pollution by automobiles. In addition, delays in ground access are likely to reduce the attractiveness and use of the air-

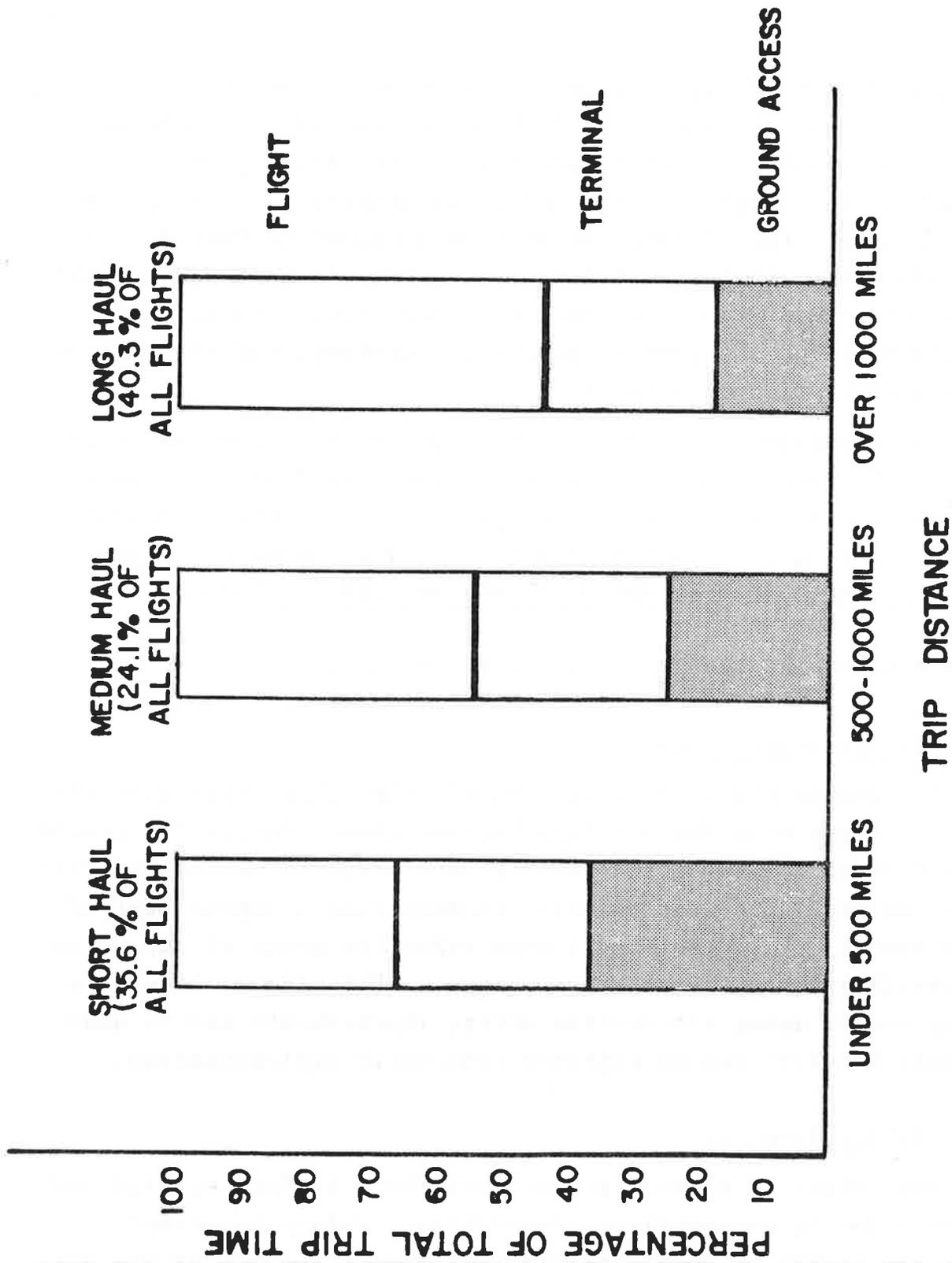


FIGURE 1-1. DISTRIBUTION OF AIR-TRIP TRAVEL TIME BY FLIGHT DISTANCE

port. As a result, it may become more difficult to attract industry to a particular area, and some businesses requiring frequent air transport may be forced to relocate. In addition, service industries, such as gas stations motels and hotels, and restaurants, may be directly affected by reductions in air travel. Proper planning for airport access may eliminate or reduce these problems.

1.2.3 Intermodal Coordination

Airports, as intermodal facilities, are affected by several agencies that view problems from different perspectives. For instance, air mode planners often consider ground access decisions to be beyond their realm of responsibility and control; additionally, ground access planning requires a different set of skills and techniques from those used in planning for air travel. Furthermore, ground transportation planners often treat airports no differently from other major traffic generators, such as shopping centers or ballparks. As a result, ground mode planners may not take into account vital decisions made by air transportation planners. The purpose of airport ground access planning is to coordinate the perspectives of the various planning authorities so that all factors are considered.

1.2.4 Local/Federal Coordination

Airport ground access planning fulfills the essential function of coordinating local and Federal planning. At present, ground transportation priorities are established predominantly at the local level, and air transportation priorities at the Federal level. Ground access planning can help integrate local and Federal intent, resolving conflicts and preventing problems.

1.3 THE PLANNING PROCESS

The basic process of airport access planning is shown graphically in Figure 1-2. Each step of the process is part of a coordinated program leading to the identification and recommenda-

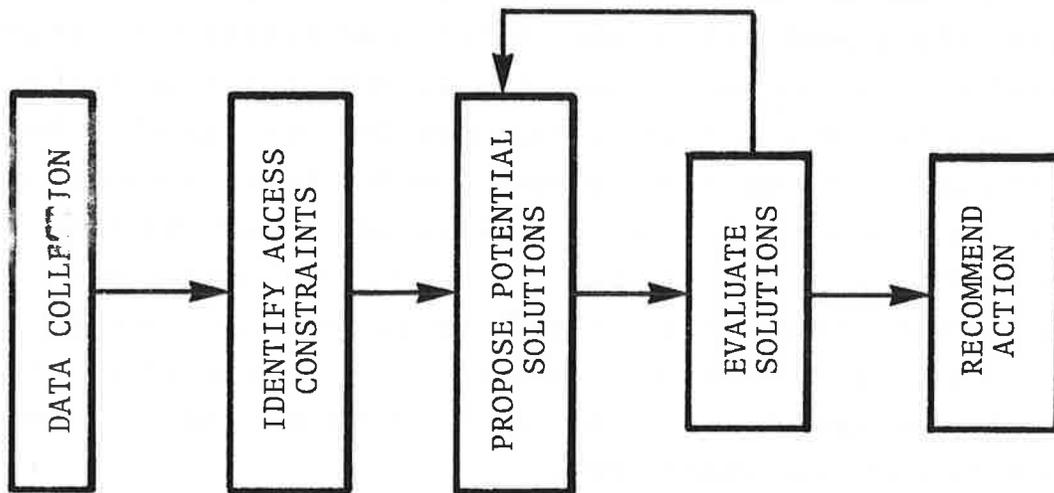


FIGURE 1-2. THE AIRPORT ACCESS PLANNING PROCESS

tion of needed airport access improvements. As such, airport access planning is goal-oriented, leading to specific alternative solutions to existing or forecasted deficiencies.

The first step of the planning process is the collection of data. The airport planner must initially describe the existing access system. Generally, data on the roadways to and within the airport, estimates of the use of current airport access modes, and forecasts of future airport activity are required. Often, these data can be obtained from existing airport planning documents and from other transportation sources within the region. Sometimes, however, new data must be collected to ensure valid information on existing conditions.

The second step is to identify access constraints. This usually requires identifying roadways which provide a significant proportion of airport user access (demand) and which are operating at a poor level of service (capacity). Often, these constraints can be identified visually and confirmed by analysis of traffic flows. Subsequently, the analysis measures these constraints in terms of airport user delay and then the magnitude of the access problem can be determined. With the identification of problem areas, alternative improvements may now be considered.

Step three identifies various solutions to the problem. Solutions may run the gamut from low cost transportation systems management (TSM) actions which make better use of the existing transportation facilities to high cost construction projects (new highways or rail extensions) which expand or alter the existing transportation network. The suitability of the various systems depends, of course, on conditions peculiar to the airport in question.

The fourth step is to evaluate the various solutions by comparing economic and other factors. The process described in this report concentrates on specific procedures to be used in comparing the economic benefits of alternative access systems. This includes estimation of such factors as cost, fuel savings, airport user and non-user travel time savings, and generation of new employment. Steps three (propose solution) and four (evaluate solution) are

somewhat iterative in that an analysis of benefits and costs of a given solution may point the way to other solutions not previously considered.

The final step of the planning process is to recommend action based on the previous evaluation of alternatives. These recommendations would include documentation and support for the preferred alternatives and would incorporate environmental, community, and political factors in addition to economic considerations.

2. COLLECT DATA

2.1 GENERAL

Table 2-1 shows the types of data that are required for airport access analyses. These data requirements are discussed in more detail below.

<u>TYPE OF DATA</u>	<u>WHY REQUIRED</u>
Demand	To determine the capacity required of airport access roadways
Facility	To determine the capacity supplied by airport access roadways
Economic	To compare alternatives for improving ground access
Planning	To coordinate proposals for improving ground access with other planned or programmed changes

2.2 DEMAND DATA

Required demand data fall into the following five categories:

- o number of users (by type)
- o local origin and destination
- o modes of travel
- o characteristics of non-airport travelers also using the access system
- o peaking characteristics of demand.

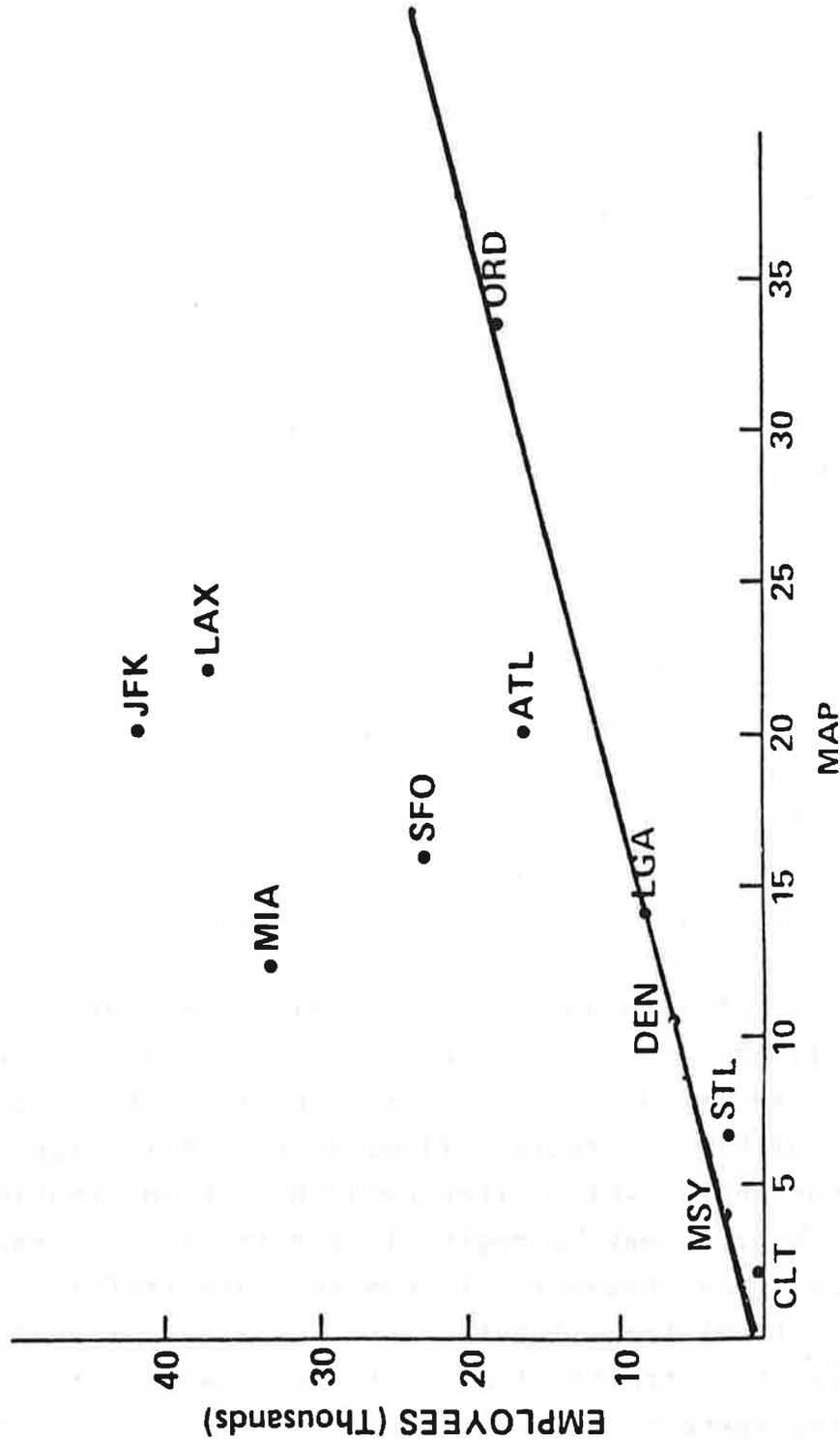
2.2.1 Number of Users

Data are needed on the number of airport-related vehicles and the number of airport users. Vehicle counts can be obtained by using automatic counters at all entrances and exists of the airport. Such counters may be used advantageously to record the peaking of flows, their distribution among various airport entrances and exists, and the destination of flows inside the airport. Passenger volumes are reported in airport master plans and FAA publications [1]. Employee population data are generally available from the airport, or may be estimated as a function of enplaned passengers. Figure 2-1 depicts an employee/passenger ratio for the number of employees required to operate the airport and its associated activities. Those airports well above the line contain large amounts of activities only indirectly related to airport operations.

2.2.2 Local Origination and Destination

This type of data is usually collected by survey (see Section 2.6.1) and may be reported by such secondary sources as airport Master Plans or comprehensive transportation plans. Because of the expense of survey administration, local origin and destination (O&D) data are usually collected only as part of a major planning effort and, as a result, tend to be fairly old. A recent study of ground access at 16 airports [3] found that the data had an average age of six years and were as old as 9.5 years at some airports. However, these data may be brought up to date or projected with consideration given to adjunct surveys of relevant socioeconomic variables [4]. The raw surveys most commonly identify the location of local origins and destinations by address, zip code, or point on a map. When the data are reported, however, they are usually aggregated to zones of various sizes. In the above-mentioned case studies [3] the number of zones used to identify the O&D data range from 8 to 34, with the average city having 14 identifiable zones. It is important to obtain separate O&D data for air travelers and employees, since employees tend to live

RELATIONSHIP BETWEEN DIRECT AIRPORT/AIRLINE
EMPLOYMENT AND MILLION ANNUAL PASSENGERS (MAP)



SOURCE: THE AIR TRANSPORT ASSOCIATION

FIGURE 2.1 ECONOMIC IMPACTS METHODOLOGY

closer to the airport.

2.2.3 Mode Split

Mode split is the term applied to the percentages of passengers using (or vehicles composing) the various modes of transport. The most common modal distinction for access planning purposes is among private auto, rented car, taxi, limousine, bus, and rapid transit. A finer breakout of the private auto mode--drive-and-park, drop-off, and remote-park--is desirable because the drop-off mode requires twice as many vehicle trips per passenger as the drive-and-park mode. Mode split information is usually collected by surveying passengers and employees. The data are often found in Airport Master Plans, but may also be available from other transportation projects. Table 2-2 gives mode split data at some representative major U.S. airports.

2.2.4 Non-Airport Trips

Trips to the airport typically account for only about 2 percent of all traffic in an urban area [5]. Although the proportion reaches much higher levels on roadways near the airport, non-airport trips generally remain in the large majority on the access system. Consequently, the characteristics of non-airport travel are a major concern in planning for airport access. Generally, traffic volume data are available for all trips, rather than just non-airport trips. Volumes for non-airport trips must be estimated by subtracting data on airport trips from the total. The major source of highway traffic flows is the State Highway Divisions or Departments, which often publish such information annually. Other sources may be regional or metropolitan transportation agencies, local Chambers of Commerce, and traffic safety departments. Local transit authorities usually maintain statistics on public mode traffic flows. In many metropolitan regions, local planning agencies maintain computerized Urban Transportation Planning Systems which are driven by interzonal origin-destination demand estimates. The interzonal O&D data are useful for deriving

TABLE 2-2. AIR PASSENGER ACCESS MODE TO AIRPORT¹

<u>Airport</u>	<u>Automobile</u> ²	<u>Taxi</u>	<u>Public Bus/ Rapid Transit</u> ³	<u>Private Bus/ Limousine</u> ⁴
Baltimore-Washington Int. (1974)	84%	8%	2%	6%
Boston-Logan Int. (1972)	69	18	7	6
Chicago-O'Hare Int. (1976)	70	11	2	17
Cleveland-Hopkins Int. (1970)	67	9	15	10
Dallas-Ft. Worth Airport (1975)	74	9	11	6
Denver-Stapleton Int.	68	25	2	5
Los Angeles Int. (1977)	80	4	2	14
Miami Int. (1978)	55	24	1	20
Minneapolis-St. Paul Int. (1970)	71	15	3	11
New York JFK (1972)	54	22	4	20
LaGuardia (1972)	43	38	3	16
Newark (1977)	74	10	4	12
Pittsburgh Int. (1968)	74	10	-	16
Phoenix (1969)	87	5	1	7
Washington Dulles Int. (1978)	71	12	3	14
National (1974)	56	39	2	3

¹Excludes Transfer Passengers

²Includes Rental Car

³Includes Helicopter at Los Angeles (2%), New York JFK (2%) and Newark (1%)

⁴Includes Hotel/Motel Bus and Courtesy Shuttle Bus

estimates of how traffic flows will change when highway or transit facilities are improved or become congested. In most compilations of vehicular flow, data are provided on an average daily and peak hour basis. In addition, flows are often available by direction of travel and by time of day.

2.2.5 Peaking

The peaking of airport demand, and more specifically, the degree to which on-airport and off-airport peaks are coincident, is an important input. To the extent that airport volumes are low during the hours of peak roadway use by others, daily airport volume may be increased without running up against roadway capacity constraints. Conversely, when airport and non-airport roadway peaks coincide, access capacity for airport use is minimized.

Table 2-3 displays the peaking of passenger enplanements plus deplanements at airports of various sizes and locations. Although these data may not coincide exactly with airport vehicle traffic, they do illustrate that peak periods of airport and non-airport travel are not necessarily coincident. In particular, except for the Pacific time zone, the morning airport traffic is relatively light compared to the evening peak, often falling below noontime and early afternoon volumes. It is also noteworthy that the severity of peaking is more pronounced the smaller the airport. For specific airports, more accurate data on vehicle flows can be obtained by manual or automatic counting, as discussed in Section 2.6.4.

2.3 INVENTORY OF FACILITIES AND SERVICES

2.3.1 On-Airport Facilities

The adequacy of on-airport facilities affects a very important portion of the access trip, that portion within airport boundaries. Of particular interest are the circulation roadways, parking facilities, and enplaning and deplaning curbsides. Data collection should include maps of the airport property showing number of lanes

TABLE 2-3. SUMMARY OF PEAKING CHARACTERISTICS OF PASSENGERS AT THE AVERAGE AIRPORT

Hub-Site (1)	Time Zone (2)	Peak Hour as Percent of Total (3)	Top 4 Hours in Rank Order			
			1 (4)	2 (5)	3 (6)	4 _____
Large	Eastern	10.5%	4-5 PM	5-6 PM	7-8 PM	12-1 PM
	Central	10.4	5-6 PM	4-5 PM	6-7 PM	1-2 PM
	Mountain	10.4	6-7 PM	11-12 AM	1-2 PM	12-1 PM
	Pacific	9.0	8-9 AM	1-2 PM	12-1 PM	5-6 PM
Medium	Eastern	12.5	5-7 PM	4-5 PM	1-2 PM	6-7 PM
	Central	10.7	3-4 PM	9-10 AM	6-7 PM	10-11 PM
	Mountain	11.9	2-3 PM	12-1 PM	1-2 PM	6-7 PM
	Pacific	9.1	7-8 AM	12-1 PM	5-6 PM	6-7 PM
Small	Eastern	12.6	3-4 PM	4-5 PM	5-6 PM	10-11 AM
	Central	13.6	7-8 PM	8-9 AM	4-5 PM	8-9 AM
	Mountain	16.2	10-11 AM	11-12 AM	4-5 PM	12-1 PM
	Pacific	11.8	7-8 AM	10-11 AM	2-3 PM	4-5 PM

Source: Profiles of Scheduled Air Carrier Passenger Traffic for Top 100 U.S. Airports [2], August 5, 1977.

of all roadways (or their capacity, if available), number of parking positions in all lots, length of passenger drop-off and pick-up curbs, the location of traffic signals (and their timing), and other impediments to traffic flow (such as railroad crossings).

2.3.2 Off-Airport Facilities

Relevant off-airport facilities include toll roads, bridges, tunnels, interchanges, intersections and transit links and terminals included in the "Airport Access System" (see Section 3.1). If available, roadway capacity is of particular interest; if unavailable, factors affecting capacity, such as number of lanes, speed limits, location of exit and entrance ramps, and traffic signals, should be obtained. There are several sources for these data. State and local highway departments (for their internal planning) generally maintain data on the layout of the physical systems, and often they maintain capacity data as well. Also, in many urban areas, metropolitan planning staffs maintain a computerized urban transportation planning (UTP) system which includes a coded layout of the transportation network (both highway and transit) and estimates of the capacity of the highway links.

2.3.3 Airport Access Services

Airport access services include airport bus, limousine, taxi, rapid rail, commuter rail, and many mode combinations (e.g., remote park/express bus). The quality of airport services affects the mode split of airport users. Of particular interest are the fares, routes, and frequency of the various services, although such factors as cleanliness and repair of vehicles, promotional activity, on-time performance, and safety do affect the use of the public modes.

2.4 ECONOMIC DATA

Economic data are used for two purposes, forecasting and evaluating alternative proposed access improvements. The types of economic data required are

- o socioeconomic and demographic
- o fuel cost and usage
- o employment
- o other data.

2.4.1 Socioeconomic and Demographic Data

Socioeconomic and demographic data are useful in understanding long-range trends in the trip-making characteristics of the population located within zones of a metropolitan area. These data are generally available from State Economic Planning and Development offices, State Census departments, the U.S. Bureau of the Census, and the Bureau of Economic Analysis.

2.4.2 Fuel

Data needed include the price of automobile gasoline (regional average) and the fuel use/vehicle hour at idle, for the average vehicle on the road. These data may be obtained from the U.S. Department of Energy.

2.4.3 Employment

Employment data, by type at the county level, are desirable. These data are generally available from State and local planning offices. They are needed to estimate increases in regional employment which are attributable to increased airport use as a result of improved airport access.

2.4.4 Other Data

The following additional data should be acquired or estimated to put a dollar value on the relative benefits of improved airport access (see Chapter 5).

- regional economic multiplier
- value of time
- value of a job created

- elasticity of air travel with respect to trip time
- economic discount rate

2.5 INVENTORY OF PLANS

To assure intermodal and interagency planning coordination, the latest versions of the following planning documents should be obtained:

- o Master Plans of affected airports
- o Regional/Metropolitan Airport Systems Plan, if one exists
- o State Airport Plan
- o Comprehensive Metropolitan Land Use and Transportation Plan
- o Multi-Year Overall Planning Work Program (formerly the Unified Work Program) submitted by urbanized areas for DOT operating administration funds.

2.6 SURVEYS

One important method for acquiring current ground access data is the use of surveys. A variety of survey techniques is available. A detailed account of these techniques is given in the Airport Travel Survey Manual, U.S. DOT, Federal Highway Administration, Washington, DC, July, 1973. Prior to selecting a data collection survey technique, the airport planner should know clearly the specific data requirements to be obtained by the survey, characteristics of the ground transportation facilities and services provided the airport.

Following the selection of a survey strategy (single or combination of survey types), the next step toward preparation of survey specifications is to select the data collection techniques that will be employed for the survey to be conducted. Survey techniques may be grouped into four general categories:

- o personal interview

- o self-administered questionnaires, collected by survey personnel
- o self-administered questionnaires, mail-back
- o counts or observations

These techniques are discussed below.

2.6.1 Personal Interview Technique

The personal interview technique is most appropriate where activity levels are low, or where the trip makers to be surveyed are concentrated at a small number of points. Therefore, it is most suitable to small and possibly medium hub airports. The personal interview affords the most accurate survey technique, since the interviewer is able to assist the respondent in interpretation of questions; it also achieves high response rates. The personal interview, however, has several disadvantages requiring careful consideration.

First, the average interview takes approximately three to five minutes, with seven to nine interviews completed per hour by each surveyor. For a given sample size (normally 10 percent to 15 percent), it is the most costly of all survey techniques. A typical total cost of at least \$5.00 per usable sample can be expected--almost double the cost of other survey techniques.

Secondly, extensive logistical preparation is essential. Survey staff must be recruited well in advance for one or more training sessions. Supervisory staff must be adequately trained to administer the survey and monitor and improve survey staff performance. Work shifts, meal breaks and survey staff rotations must be planned and scheduled.

Thirdly, and most importantly, the interviews will likely disrupt the passenger's schedule. Since most air passengers (particularly those traveling on business) are in a hurry, a definite potential for sample bias toward the "unhurried" passenger is created.

2.6.2 Questionnaire Collected by Survey Personnel

The self-administered, collected questionnaire technique is limited to samples where the respondents are captive between the time of questionnaire distribution and collection. This survey technique is particularly well suited to airline passengers on board their flight ("inflight survey"), to airport employees for whom questionnaires may be distributed and collected at their place of work, and to users of regularly scheduled bus or rapid transit services.

The collected questionnaire provides the least costly survey technique for gathering detailed travel data and normally achieves high response rates. In addition, the collected questionnaire provides the respondent ample time to answer questions without causing travel disruption, assuming in the case of fixed-route transit respondents that ample travel time is provided between the airport and the nearest boarding or departure point.

Two disadvantages of the collected questionnaire are that it permits little opportunity for assistance in explaining survey questions to the respondent, and it requires considerable airline or ground transportation carrier cooperation and assistance in implementation.

2.6.3 Mailback Questionnaire

The use of mailback questionnaires is most appropriate when respondents would not know the answers to certain questions until leaving the airport or when activity levels make the use of the personal interviewing technique unfeasible.

The mailback questionnaire is the easiest survey technique to implement, requiring the least surveyor and supervisory training. In addition, it requires little airline or ground transportation carrier assistance and results in no respondent travel delay.

However, since completion and return of questionnaires is dependent upon voluntary action on the part of respondents, the

sample is more difficult to control than with personal interviewing or collected questionnaire techniques. With normal return rates on the order of 25 percent, a high potential for bias exists. Mailback questionnaire usage should be limited, in most instances, to mode specific surveys of taxis, rental cars, limousines, and shuttle services.

2.6.4 Counts Observations

Manual and machine counts are conducted to determine traffic volumes by direction and vehicle type on the various roads to the airport. These data primarily provide the basis for expanding, factoring or checking data acquired through personal interview or questionnaire surveys to represent the entire population of vehicles entering or leaving the airport. In some cases they may be used to determine fairly coarse origin and destination information. The technique is very valuable in determining characteristics such as vehicle occupancy, vehicle dwell time at the curb, and parking lot occupancy and turnover.

The technique is normally inexpensive. For example a one-day, 18-hour manual count of turning movements, vehicle types, occupancy rates, and related types of data will typically cost \$300 to \$400 for each location observed. This estimate includes the cost for surveyors, supervision, and data tabulation.

For machine traffic counts at the airport entrance, parking lots, or access roadways, costs are even less. Assuming the machine counters are available for loan or rental, a one-week count of as many as ten locations would cost approximately \$300.

Table 2-4 provides a brief summary of the relative advantages, disadvantages, costs, and typical response rates associated with each survey technique. These elements basically suggest that for larger airports (medium hub or larger) the collected questionnaire survey is preferred. This technique should be supplemented by direct observations such as vehicle counts to factor and check questionnaire results.

TABLE 2-4. TYPES OF AIRPORT GROUND ACCESS SURVEYS

	<u>Personal Interview</u>	<u>Collected Questionnaire</u>	<u>Mailback</u>	<u>Direct Observation</u>	<u>(Traffic Counts, Visual Observation)</u>
<u>Cost/Usable Sample</u>	\$5.00	\$2.50	\$3.00	Varies	
<u>Response Rate</u>	80%	75%	25%	N/A	
<u>Advantages</u>	Interviewer can assist passenger	Passenger has time to answer questions	Can pick up departing passenger characteristics	Short turnaround	
	High response rate	Low cost, high response	Does not delay passenger	Usually low cost	
	Respondent may become reluctant to reveal socio-economic data	No schedule disruption	Minimal airline assistance required	No problems with passenger misinterpretation or lapse of memory	
<u>Disadvantages</u>	High potential for bias in favor of early arriver	Requires airline assistance in logistics	Postage adds cost	Narrow range of data type possible	
	Can disrupt passenger's schedule	No assistance available for passenger	Low response rate; high potential for bias	Difficult to correlate data	
	High cost	No assistance available for passenger			

A more detailed explanation of the collected questionnaire survey procedures and a sample selection is provided in Appendix B.

3. IDENTIFY CONSTRAINTS

3.1 OVERVIEW

Figure 3-1 illustrates the method described below for identifying airport access constraints. On each roadway of interest, the unconstrained demand--composed of airport and non-airport users--is first estimated as a function of time. The demand is then compared to the available capacity at a prescribed level of service. Demand cannot exceed this capacity without violating the level of service constraint.

It should be noted that there is no physical or mathematical force to keep the level of service constraint from being violated. When demand exceeds capacity, as it does by 1982 in the example of Figure 3-1, the level of service constraint will be violated unless capacity can be increased, demand reduced, or demand peaks are spread out. These alternatives form the bases for the solutions discussed in Section 4.

3.2 SELECTION OF ROADWAYS FOR ANALYSIS

As a practical matter, it is necessary to focus attention on a small subset of the road network providing access to the airport. Many of the roads in a region, although heavily congested, may be used by only a small fraction of the passengers destined for or leaving the airport. As a result, improving such roadways will have little impact on the access trip of most airport users, and cannot be considered central to the goal of improved airport access.

At what point a roadway has a significant bearing on airport access is a matter of judgment. A suggested rule of thumb is to include any road which can reasonably be expected to be used by 25 percent or more of the airport bound passengers. Reducing the cutoff adds to the number of roadways included in the access system, and therefore adds to the cost and complexity of further analysis while only marginally decreasing the likelihood of over-

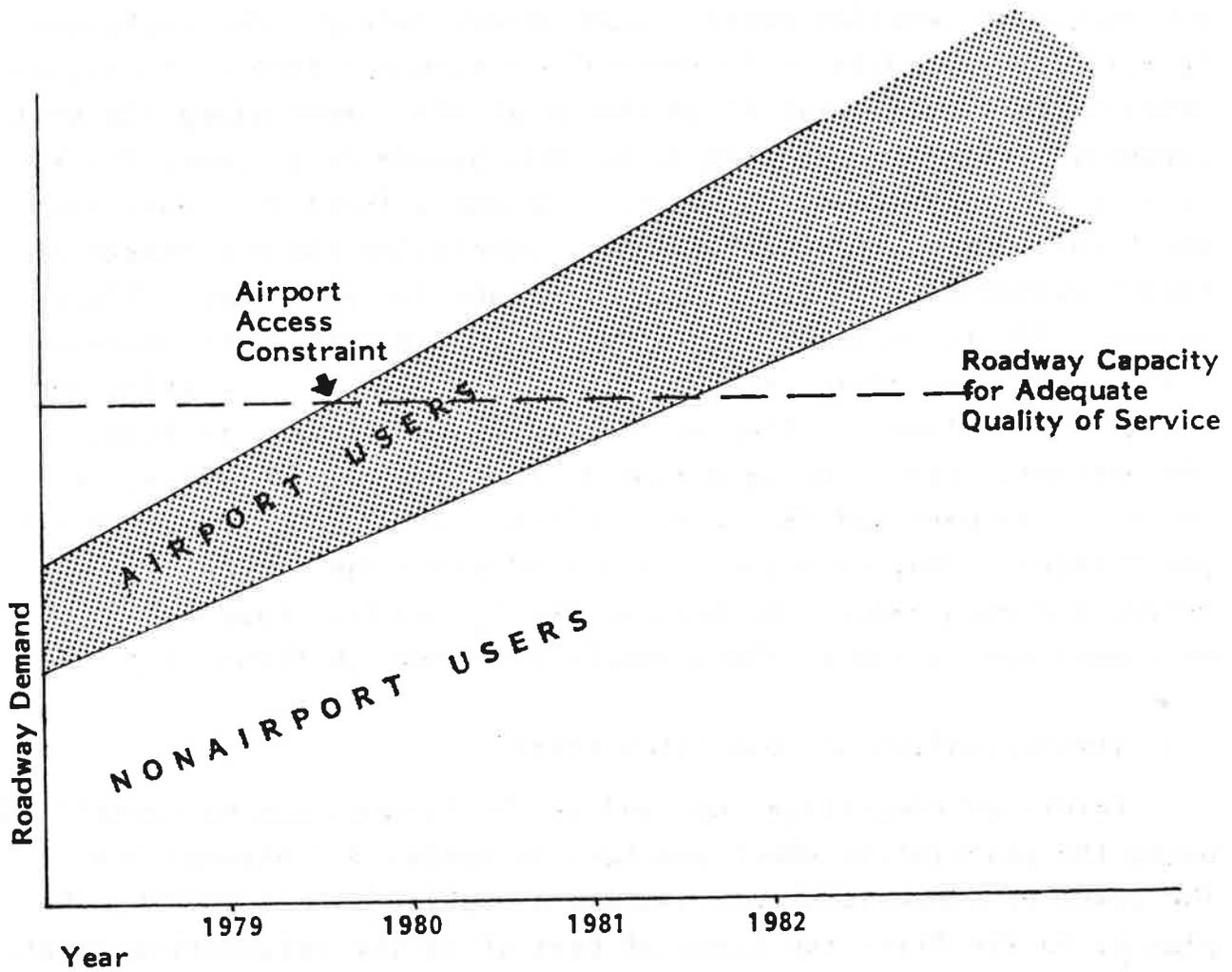


FIGURE 3-1. OVERVIEW OF CONSTRAINT IDENTIFICATION METHOD

looking a major access problem. Nevertheless, if access to the airport from a major section of the city is constrained to a single arterial, that arterial should be considered a part of the access system, even if the percentage of airport bound passengers using it falls below the cutoff.

Generally, few data exist on the percentage of airport bound passengers or vehicles using a particular roadway. One technique to estimate such data is to route the passengers from each origin-destination zone identified in the local O&D survey along the most conducive route(s). An example of this procedure is shown for the city of Reno, Nevada in Table 3-1. Column 1 lists the zones from which data were collected. Column 2 identifies the percentage of survey respondents originating or destined for each zone. Since Column 2 figures usually do not add to 100 percent (often because some survey respondents give no answer, or specify a location not included in Column 1), they are scaled up in Column 3 to total 100 percent. Each line in Column 4 gives a possible routing between the airport and the zone. Column 5 shows how the passengers percentages in Column 3 are distributed among the alternative routes for each zone. The airport traffic on each road may then be summed upon a map as shown (again for Reno) in Figure 3-2.

3.3 IDENTIFICATION OF CONGESTION POINTS

Points of congestion, now and in the future, can be identified using the calculation sheet provided in Tables 3-2 through 3-5. The level of congestion constituting a problem is selected by the planner in the first two lines of Part IV of the calculation sheet. It is suggested that roadways experiencing level of service E for over 200 hours/year be considered as problem areas; however, other criteria may be used.

Level of Service (LOS) E is selected as the recommended criterion for problem evaluation because it is about the worst "tolerable" level of service, and that level at which maximum flow occurs. It is defined by the Highway Capacity Manual as a condition approaching:

TABLE 3-1. ROUTING OF AIRPORT ACCESS TRIPS
BY LOCAL ORIGIN/DESTINATION ZONE

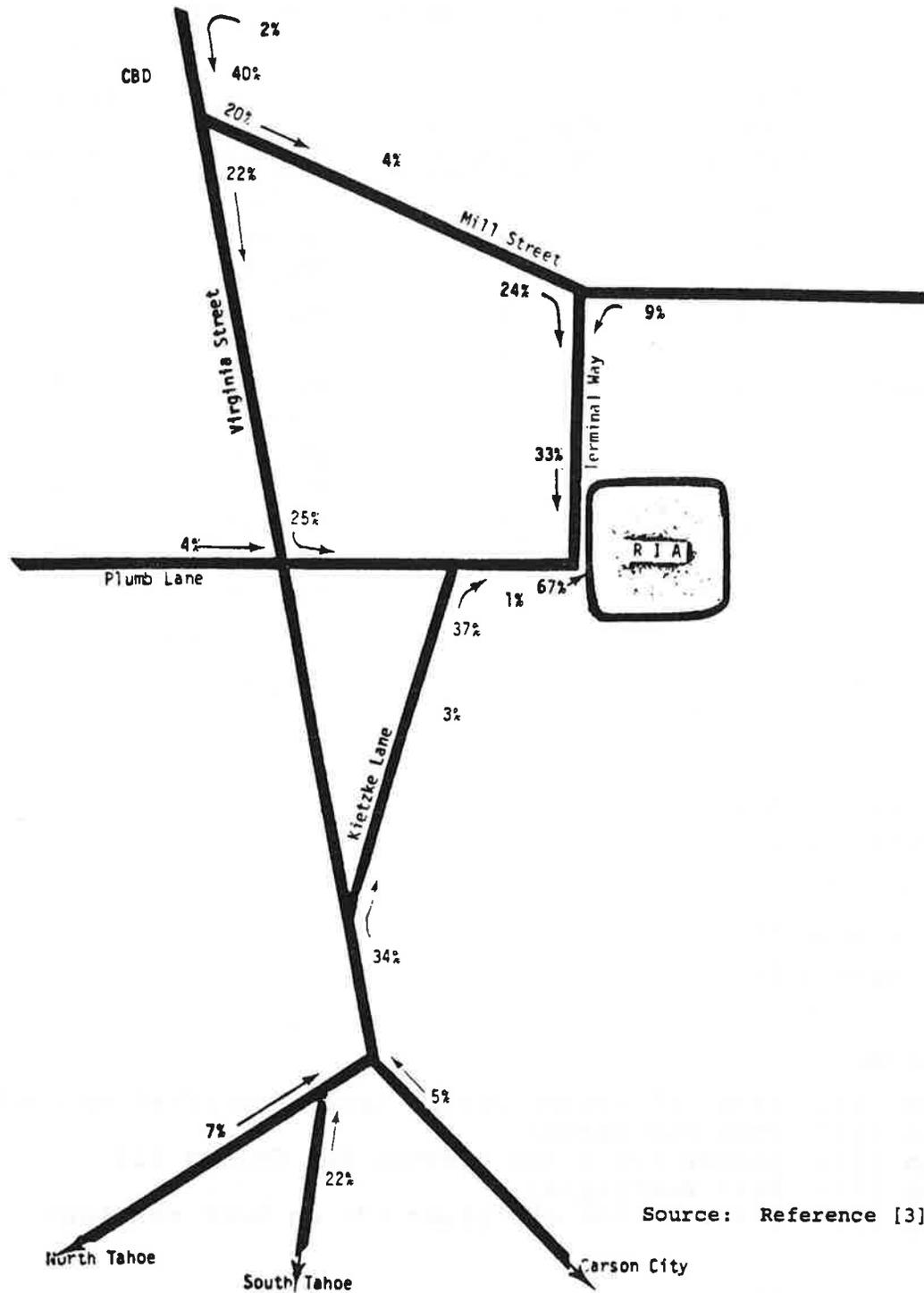
<u>Zone</u>	<u>Percent Per Survey</u>	<u>Percent as Distributed</u>	<u>Routing</u>	<u>Percent by Route</u>
(1)	(2)	(3)	(4)	(5)
Reno CBD	36	40	MS, TW VS, PL	20 20
North Reno	5	6	MS, TW VS, PL	4 2
Southwest Reno	6	7	PL VS, PL	4 3
Southeast Reno	4	4	KL, PL PL	3 1
South Tahoe	20	22	VS, KL, PL	22
Sparks	8	9	MS, TW	9
North Tahoe	6	7	VS, KL, PL	7
Carson City	4	5	VS, KL, PL	5

Key: KL Kietzke Lane
MS Mill Street
PL Plumb Lane
TW Terminal Way
VS Virginia St.

Notes to Columns:

Column (1): From O&D Survey except zone identified as "other"
Column (2): From O&D Survey
Column (3): $\text{Column (2)} \times 100 \div \text{Total for Column (2)}$
Column (4): Best Routing(s)
Column (5): Distribution of Column (3) on best routings

Source: Reference [3].



Source: Reference [3].

FIGURE 3-2. DISTRIBUTION OF APPROACH TRAFFIC RENO INTERNATIONAL AIRPORT

TABLE 3-2. CALCULATION SHEET FOR IDENTIFICATION OF ACCESS CONSTRAINTS

Part I: Location of Constraints

Roadway: I-95

Year: 1990

1. Complete Parts II and III.
2. Enter annual airport passenger unconstrained demand (enplaned and deplaned)..... _____
3. Enter airport passenger capacity (Part III, Line 5)..... _____
4. Compute annual passenger volume (minumum of 2 and 3)..... _____
5. Estimate annual passengers/daily two-way vehicles (default: Part II, Line 3)..... _____
6. Compute daily two-way airport vehicles (Line 4 ÷ Line 5)..... _____
7. Estimate fraction of Line 6 that uses roadway under analysis (default: Use current year figure from Part II, Line 5)..... _____
8. Compute two-way airport vehicles using roadway (line 6 x Line 7)..... _____
9. Estimate growth rate for non-airport traffic (this line may be omitted if data for Line 10 can be obtained from planning documents).... _____
10. Estimate non-airport vehicles using roadway (two-way) (from planning documents, or apply the growth rate of Line 9, above, to the base volume of Part II, Line 7)..... _____
11. Compute two-way roadway volume (Line 8 + Line 10)..... _____
12. Complete Part IV.
13. Enter two-way roadway capacity (Part IV, Line 8)..... _____
14. Is there an access constraint? Answer YES if and only if Line 11 is greater than Line 13)

TABLE 3-3. CALCULATION SHEET FOR IDENTIFICATION OF ACCESS CONSTRAINTS

Part II: Base Year Data

Roadway: I-95

1. Annual passengers, enplaning and deplaning (MAP).. _____
2. Daily vehicles entering airport (two-way)^{1/}..... _____
3. Annual passengers/daily vehicles ([1] ÷ [2]) ^{1/}..... _____
4. Average daily traffic (ADT) (two-way)..... _____
5. Fraction of airport-destined vehicles that use roadway..... _____
6. Airport-destined vehicles using roadway ([2] x [5]) _____
7. Non-airport vehicles using roadway ([4] - [6]).... _____

^{1/} If line 2 is unknown, it may be estimated from Figure 3-4, or Line 3 may be estimated from Table 3-6 and Line 2 computed as [1] ÷ [3].

TABLE 3-4. CALCULATION SHEET FOR IDENTIFICATION OF ACCESS CONSTRAINTS

Part III: Airside Constrained Passenger Capacity

Year: 1990

1. Enter airside capacity in operations/year^{1/} ... _____
2. Enter maximum percent by air carrier..... _____
3. Estimate seats/departure (average aircraft capacity) ^{2/}..... _____
4. Estimate enplaned load factor at airport capacity (the ratio of enplaned passengers to departing seats) ^{3/}..... _____
5. Compute maximum annual passengers (Line 1 x Line 2 x Line 3 x Line 4).....

^{1/} Sources: Airport Capacity Manual, FAA models, airport master plans.

^{2/} Table 3-7 provides some historical and forecasted data at selected airports.

^{3/} Table 3-7 provides some historical data at selected airports. Table 3 8 provides estimates of passengers/operation at selected airports; enplaned load factors may be estimated from this and Line [2].

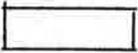
TABLE 3-5. CALCULATION SHEET FOR IDENTIFICATION OF ACCESS CONSTRAINTS

Part IV: Roadway Capacity

Roadway: I-95

Year: 1990

1. Enter required quality of service
 - a. Level of service..... _____
 - b. Number of hours/year not to be exceeded. _____
2. Estimate two-way hourly capacity at LOS of Line 1.a., per Highway Capacity Manual..... _____
3. Estimate the ratio of daily traffic flow to hourly capacity (at traffic levels resulting in the quality of service of Line 1). This is a function of the peaking characteristics of roadway volumes (default: Use nomograph of Figure 3.5)..... _____
4. Compute daily two-way capacity if airport and roadway volumes peak at the same time (Line 2 x Line 3)..... _____
5. Estimate coincident peaking factor (Airport vehicles in peak roadway hour ÷ airport vehicles in peak airport hour) (Default: 0.9) _____
6. Compute fraction of roadway vehicles that are airport-related (Part I, Line 8 ÷ Part I, Line 11)..... _____
7. Compute adjustment to capacity due to non-coincident peaking (1 + (Line 5 x Line 6) - Line 6)..... _____
8. Compute adjusted two-way capacity (line 4 ÷ Line 7)..... _____



...unstable flow, with tolerable operating speeds being maintained although considerably affected by changes in operating conditions. Fluctuations in volume and temporary restrictions to flow may cause substantial drops in operating speeds. Drivers have little freedom to maneuver and comfort and convenience are low, but conditions may be tolerated for short periods of time.

Level of Service F is not recommended for planning purposes because capacity at LOS F is less than that at LOS E due to slow speeds and frequent stops of long duration. Level of Service D is also not recommended, as it is generally not considered poor enough to require corrective action. Figure 3-3 illustrates highway conditions at Levels of Service A through F.

The criterion of 200 hrs/yr. translates into the weekday peak hour. Generally, poor levels of service, if they occur less often than once per weekday, may be tolerated. Alternative criteria are 30 hrs/yr. (corresponds to holiday travel) or 1,000 hrs/yr. (corresponds to four to five peak hours per day).

The logic behind the calculation sheets is depicted in Figure 3-4. First, the daily capacity of the roadway is calculated as a function of user-supplier service standards and roadway characteristics. Then, the volume of airport related traffic is computed from the airport demand (constrained by airside capacity), the ratio of airport demand (enplanements and deplanements to airport-related vehicles), and the percentage of airport-related vehicles that use the road of interest. Non-airport traffic on the roadway is added to compute the total roadway demand, and this is compared to the roadway capacity. An access constraint is said to exist if demand exceeds capacity. Typical factors relating airport vehicles to air passengers are shown in Table 3-6 (which includes transfer passengers) and Figure 3-5 (which excludes transfer passengers).

When an access constraint exists, the roadway in question will experience a level of service worse than that stipulated on the calculation sheet. Section 5.1 describes how the impacts of such poorer levels of service may be quantified.

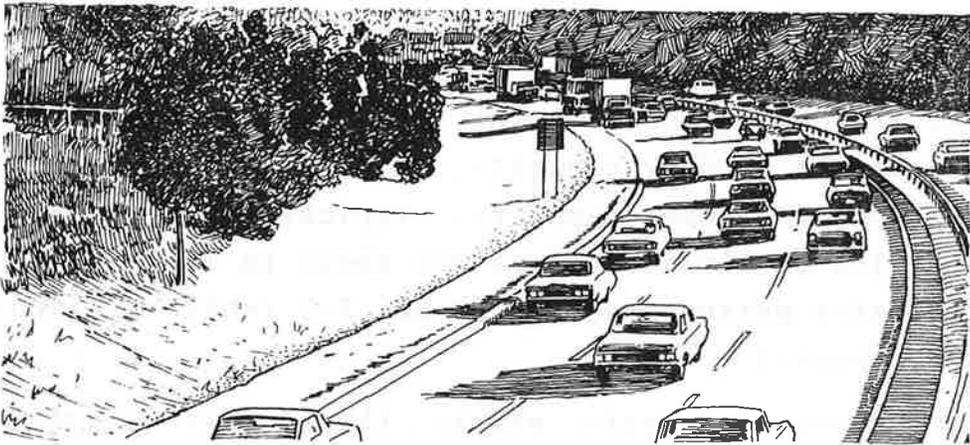
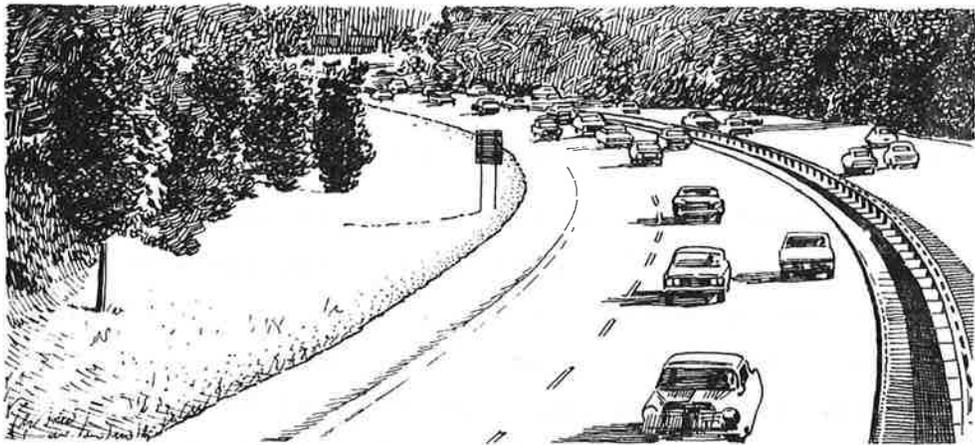
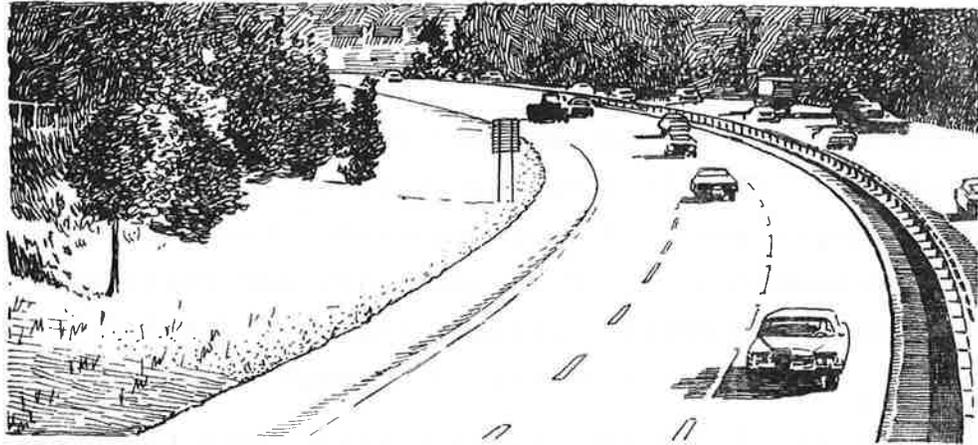


FIGURE 3-3. LEVELS OF SERVICE A, B, C

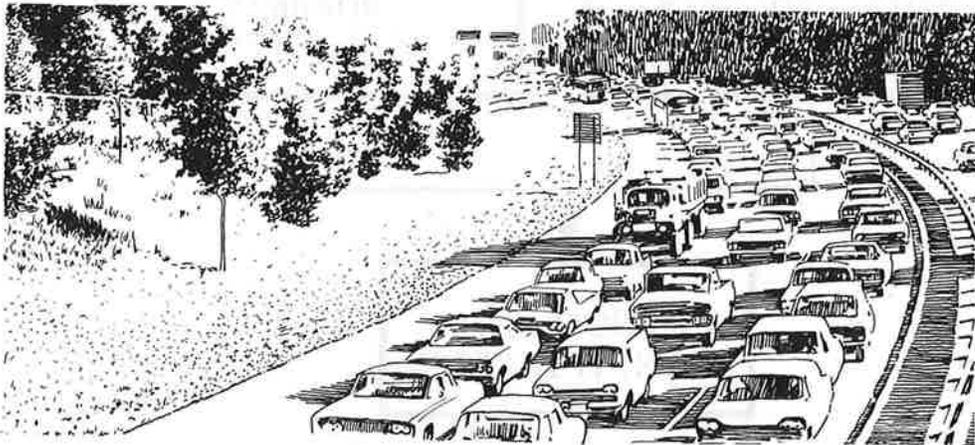
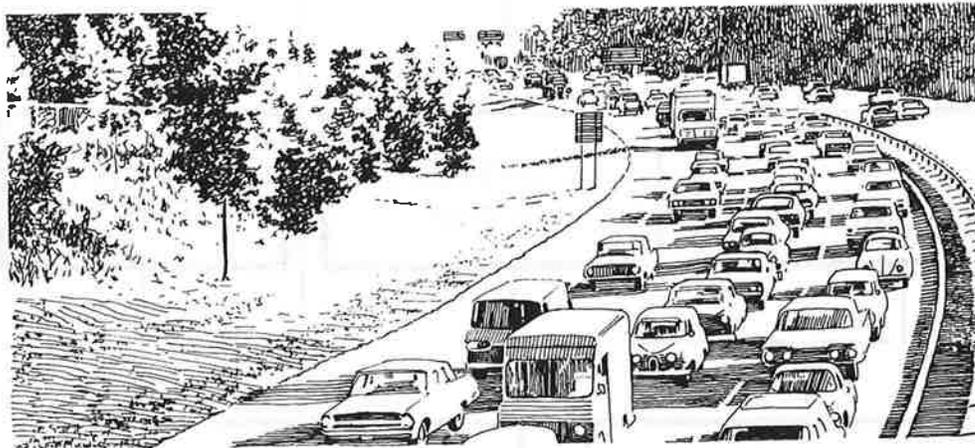
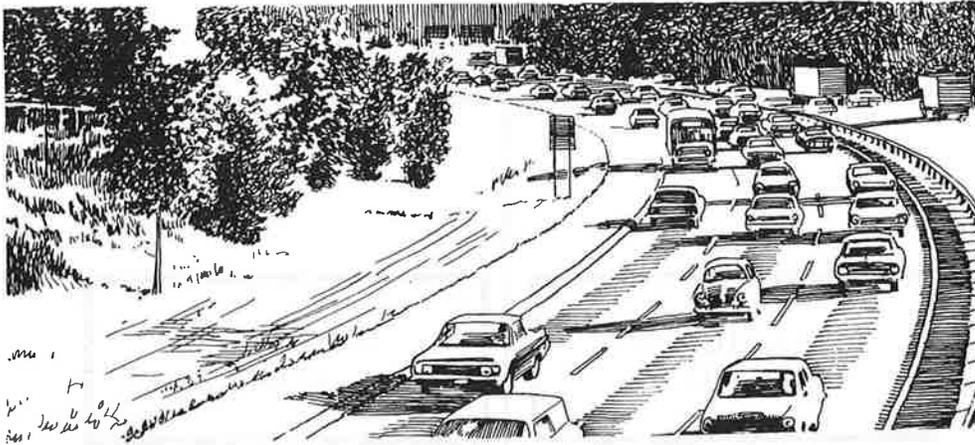


FIGURE 3-3. LEVELS OF SERVICE D, E, F (cont'd)

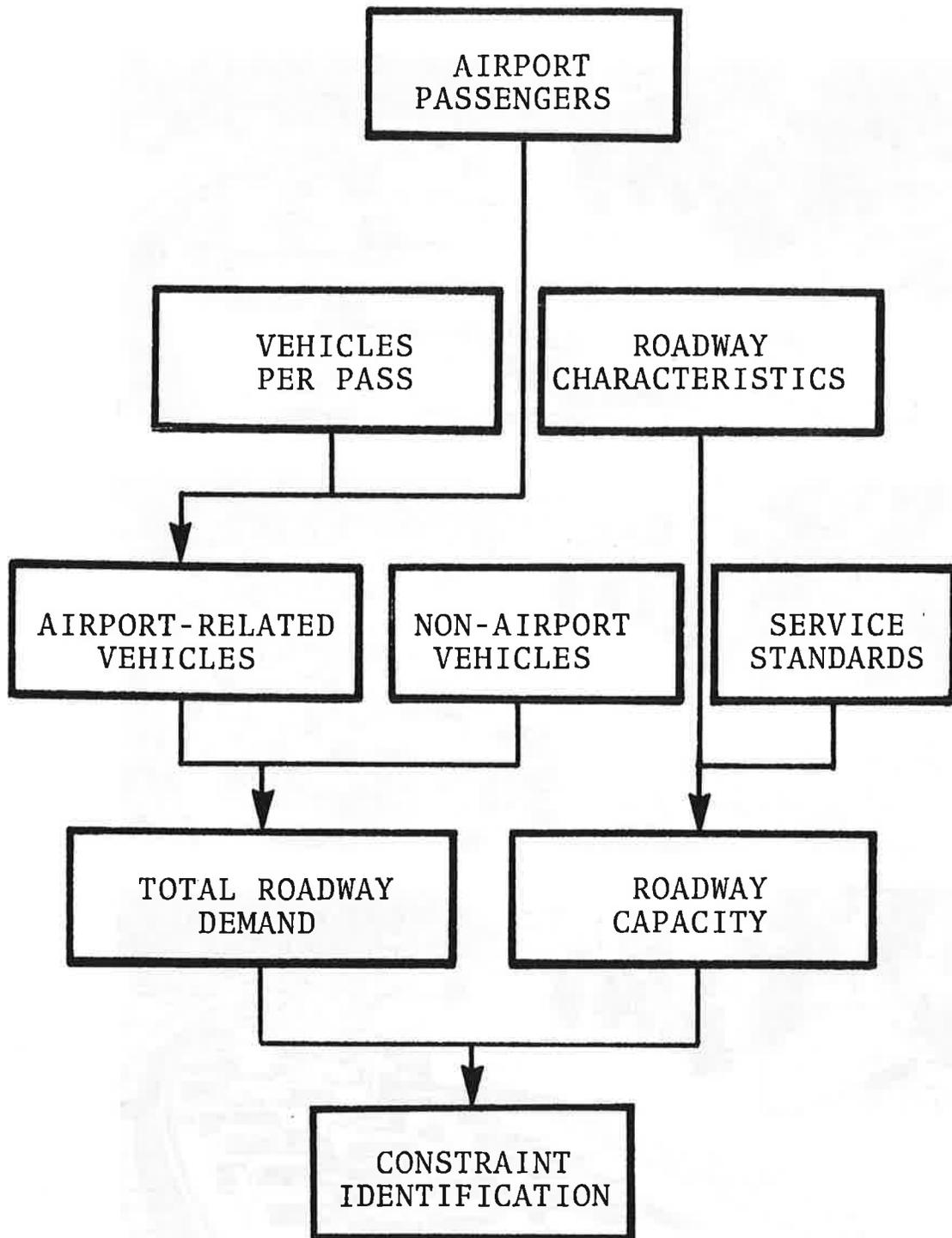


FIGURE 3-4. IDENTIFICATION OF ROADWAY CAPACITY CONSTRAINTS

TABLE 3-6. ANNUAL PASSENGERS/DAILY VEHICLES: A
 REPRESENTATIVE SAMPLE OF AIRPORTS

<u>Rank</u>	<u>Airport/Location</u>	<u>Annual Passengers/ Daily Vehicles</u>
(1)	(2)	(3)
1	Chicago, O'Hare International	660
2	Los Angeles International	348
3	Miami International	300
4	Baton Rouge, Ryan Field	300
5	Denver, Stapleton Airport	293
6	Newark International	280
7	New York, John F. Kennedy International	277
8	Boston, Logan International	275
9	New York, LaGuardia	252
10	Greater Pittsburgh International	242
11	Cleveland, Hopkins International	193
12	Fort Lauderdale-Hollywood International	168
13	Portland (OR) International	166
14	Louisville, Standiford Field	148
15	Reno International	127

Median:	275
Mean:	269
Standard Deviation:	127

Source: U.S. Department of Transportation, Federal Aviation Administration, Airport Ground Access, Report FAA-UM-79-4, (NTIS, Springfield, VA), October 1978.

TABLE 3-7. AIRPORT LOAD FACTORS AND AIRCRAFT CAPACITY PROJECTIONS

<u>Airport</u>	1975 Enplaned <u>Load Factors</u> ^{1/}	<u>Seats/Air Carrier Operation</u>				
		<u>1975</u>	<u>1980</u>	<u>1985</u>	<u>1990</u>	<u>1995</u>
Boston - Logan Int.	.53	93.1	113.3	137.8	167.7	204.0
Cleveland - Hopkins Int.	.48	110.0	122.0	132.0	142.0	---
Denver - Stapleton Int.	.46	122.5	148.0	166.5	185.0	209.5
Louisville - Standiford Field	.32	96.0	115.0	135.0	146.0	163.0
Miami Int.	.49	130.0	161.0	183.0	209.0	238.0
Ft. Lauderdale - Hollywood Int.	.42	124.0	135.0	146.0	157.0	168.0
Greater Pittsburg Int.	.45	100.0	109.0	121.0	132.0	143.0

1/ Enplaning passengers/departing seats.

Source: Reference [3].

TABLE 3-8. PASSENGERS PER AIR CARRIER OPERATION

<u>Airport</u>	<u>Passenger/Operation</u>				
	<u>1975</u>	<u>1980</u>	<u>1985</u>	<u>1990</u>	<u>1995</u>
Baton Rouge - Ryan	22.2	28.3	33.3	38.8	44.2
New York - LaGuardia	44.1	48.7	53.8	59.4	65.5
New York - JFK Int.	64.7	71.4	78.9	87.1	96.1
New York - Newark Int.	37.7	45.9	55.8	67.9	82.6
Reno Int.	49.5	57.4	67.0	74.5	82.3

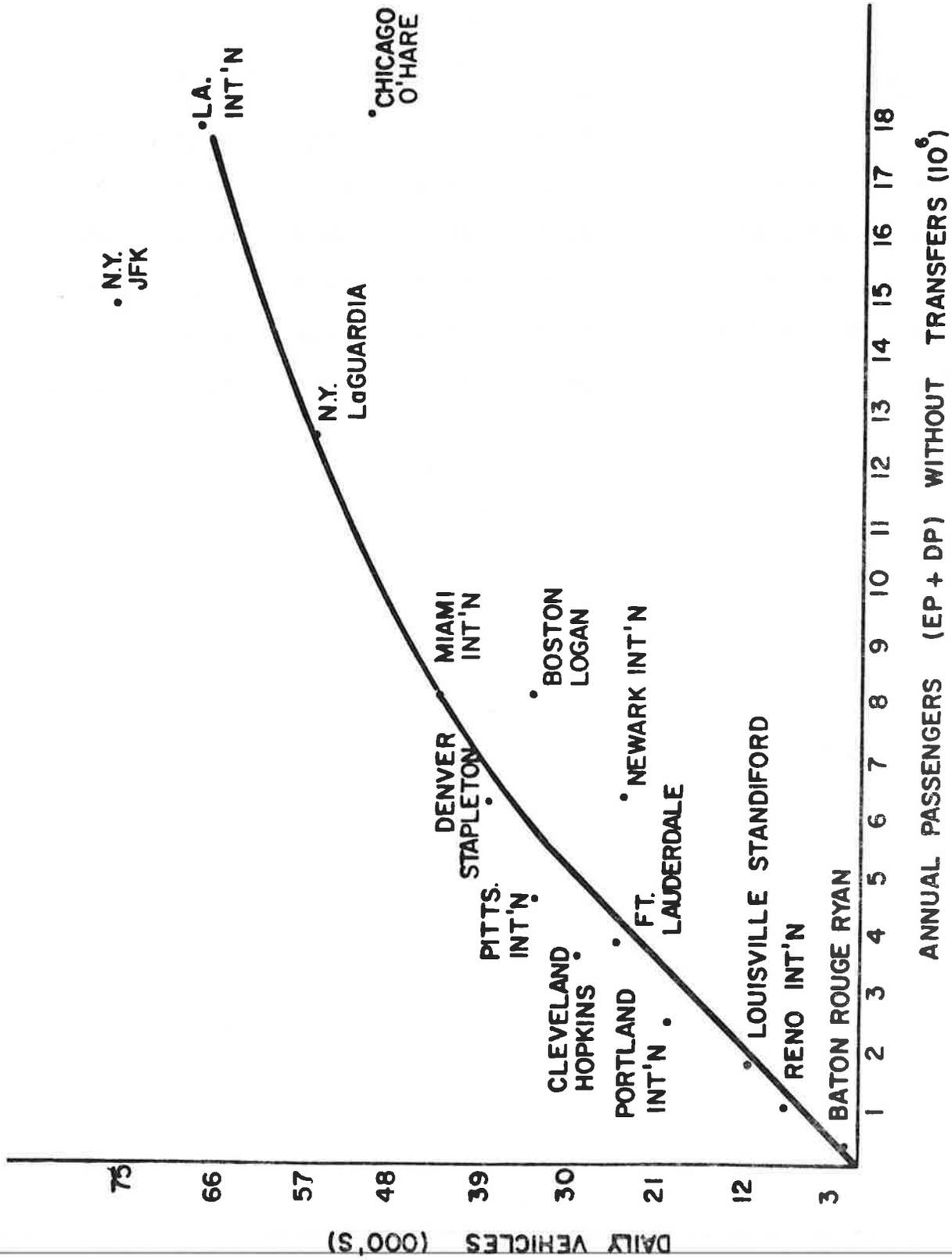
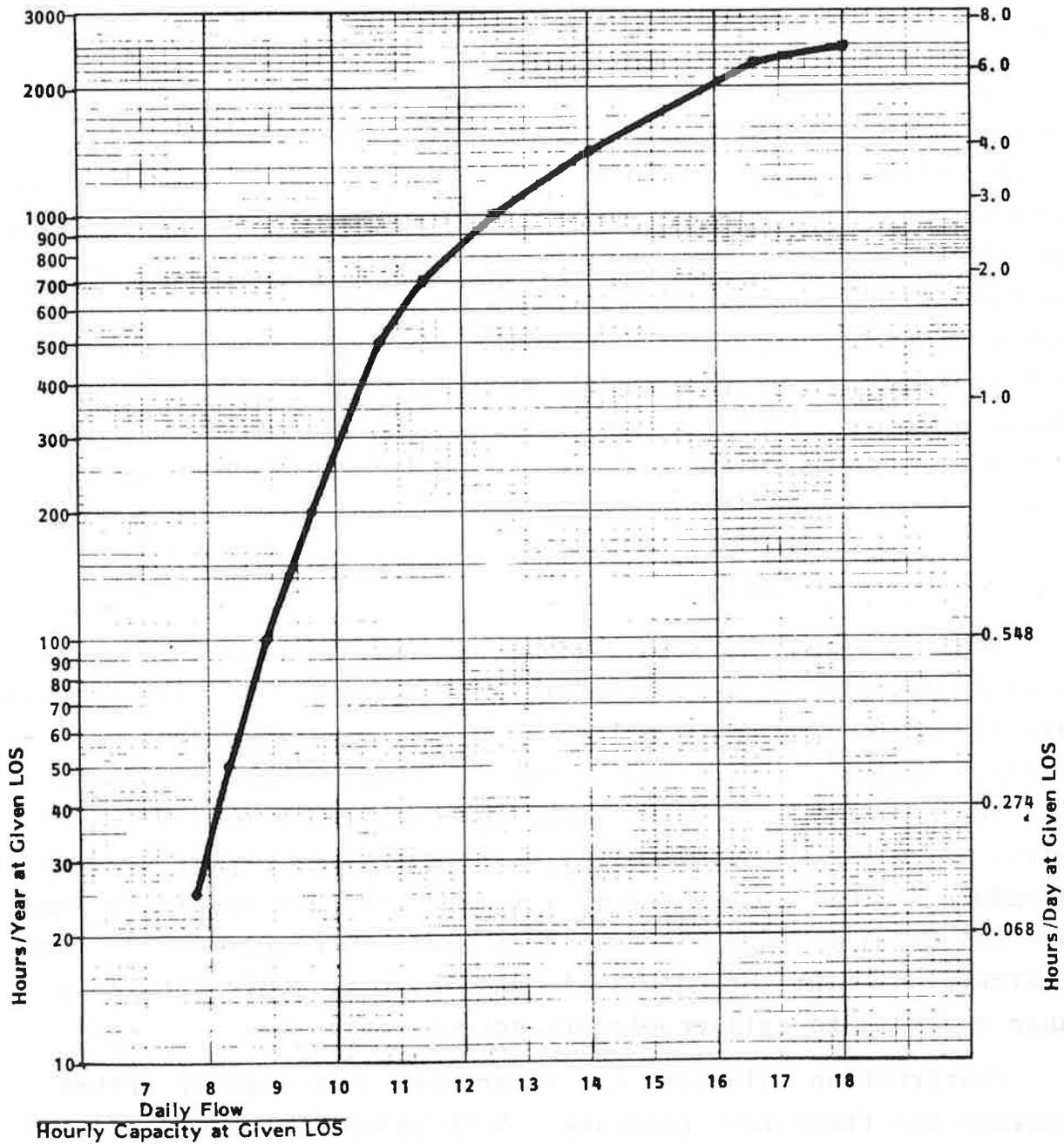


FIGURE 3-5. RATIO OF DAILY AIRPORT TRAFFIC VOLUMES TO ANNUAL AIR PASSENGERS



Source: Highway Capacity Manual, Figure 3.15, p. 38 (curve for 2-direction Urban).

FIGURE 3-6. TYPICAL RELATIONSHIP BETWEEN THE FREQUENCY OF OCCURRENCE OF A GIVEN LOS AND THE RATIO OF ADT TO CAPACITY AT THAT LOS

4. IDENTIFY ALTERNATIVE SOLUTIONS

4.1 GENERAL

The preceding chapter showed how to identify airport access congestion areas. This chapter describes various means of relieving the congestion. Basically, solutions fall into two categories, those that are capital intensive (construction) requiring considerable effort and time to build, and those that are non-capital intensive (transportation systems management) requiring modest effort to implement. Those improvements falling within each category are summarized in Table 4-1. The table also includes typical sources of major funding, normal implementation period, and average expected costs associated with each improvement listed.

4.2 CONSTRUCTION SOLUTIONS

Construction solutions to airport access congestion involve major programs to expand or substantially alter the existing transportation facilities serving the airport. The primary objective of these programs is to improve the carrying capacity of the airport access facilities while reducing the airport user's travel delay. Such programs normally provide the best methods available to reduce airport access congestion, but they are costly to implement and usually require a number of years to complete. As such, construction solutions should be considered as medium- to long-range programs to relieve airport access congestion.

Construction solutions can be grouped into highway system programs and fixed-rail programs. Both categories are discussed in this section in terms of how they may be applicable for improving airport access.

4.2.1 Highway System

The term "roadway" is normally applied to several functional

TABLE 4-1 SOLUTIONS TO AIRPORT ACCESS PROBLEMS

<u>SOLUTIONS</u>	<u>FUNDING</u>	<u>IMPLEMENTATION</u> (years)	<u>COST</u> (\$ Millions)
<u>Construction</u>			
Highway System	FHWA-Federal Aid Urban	5-10	1-4/Lane
Rail Service	UMTA-Section 3, or Interstate Transfer	5-10	20-30/Mile Surface
<u>Transportation System</u> <u>Management</u>			
Improved Use of Existing Roadspace	FHWA-Urban Systems	1-3	Up to 0.1/Intersection
Traffic Operations: Signalization Channelization Reversible Lanes			Up to 0.1/Intersection Up to 0.5/Intersection 0.1/Mile
Preferential Treatment of High-Occupancy Vehicles Freeway Lanes and Access Ramps	FHWA-Section 146, or UMTA-Section 3	2-4	0.1-0.5/Mile
Arterial Lanes Park-and-Ride Facilities	UMTA-Section 3 FAA-ADAP	1-3	0.5/400-500 Space Lot 2.0/400-500 Space Gar.
Improved Transit Service Transit Services Marketing	Private: Local-State	1-2	N.A.
Reduced Vehicle Use Carpooling Pricing Parking Rates Access Tolls	Airport Revenue	1-2	N.A.

types of highway:

- o Arterial highway - a highway primarily for through traffic, characterized by intersections at grade and direct access to abutting property.
- o Expressway - a divided arterial highway for through traffic with full or partial control of access and generally with grade separations at major intersections.
- o Freeway - an expressway with full control of access.

The primary objective of roadway construction is to improve the carrying capacity of the facility, capacity defined as the maximum number of vehicles which have a reasonable expectation of passing over a given section of a lane or a roadway during a given period at a given level of service. The capacity of a roadway is dependent on many prevailing conditions or factors, including the functional type of roadway, location of the roadway (CBD*, fringe of the urban area, other), composition of traffic (percentage of trucks and buses), and roadway alignment of geometrics.

Table 4-2 provides a summary of capacity on various roadways per lane at levels of service "C" and "E". Level of service "C" is commonly used as the design standard for highway construction projects. Level of service "E" provides the maximum hourly throughput of vehicles.

Many highway construction projects to improve airport access have been built or proposed throughout the United States. Table 4-3 provides a list of projects which have been built or proposed to directly or indirectly provide improved access (level of service) to the area's airport. The table lists projects according to the type of construction program, i.e., new roadway, reconstruction, or roadway widening, and lists the status of each project dimensions (width, length, costs) were included when available.

* CBD, used hereafter, refers to the Central Business District of a city.

TABLE 4.2. TRAFFIC CAPACITIES OF VARIOUS ROADWAY FOR TYPICAL CONDITIONS

FACILITY TYPE	LOCATION	ASSUMPTIONS	LEVEL OF SERVICE*	
			C	E
Freeway	All locations	Uninterrupted flow, 5% truck mix on rolling terrain, 6 lanes	1250	1750
Expressway	CBD	3 lanes each direction	600	800
		11 foot lane width 5% trucks and buses 10% turns 2 traffic signals/mile		
Arterials (two-way with parking)	Outside CBD	Same factors as above, except 1 traffic signal/mile	800	1000
	CBD	22 foot approach width, 5% trucks, 10% turns, 5 signals/mile	350	400
Arterial (two-way without parking)	Outside CBD	Same as above, except 2-3 signals/mile	450	550
	CBD	22 foot approach width, 5 signals/mile	500	600
Arterial (one-way)	Outside CBD	Same as above, except 3 signals/mile	650	800
	CBD	44 foot approach width, no parking, 5 signals/mile	650	700
	Outside CBD	40 foot approach width, parking one side, 3 signals/mile	500	600

*volumes shown represent vehicles per hour, per lane

TABLE 4-3. HIGHWAY PLANS AND PROJECTS TO IMPROVE AIRPORT ACCESS

<u>New Highways</u>	<u>Status</u>	
Baton Rouge, LA	I-110 (4 lanes, 2 miles, \$32.5 million)	Final Design
Boston, MA.	Third Harbor Tunnel (6 lanes \$500 million)	Proposed
Cleveland, OH.	I-480 (6 lanes, 20 miles)	Construction
Los Angeles, CA.	Century Freeway (10 lanes, 17 mi, \$481 million)	Courts
Ft. Lauderdale, FL.	A1A (6 lanes, 2 miles, \$11 million)	Final Design
Newark, NJ.	U.S. 21 & I-78 Connector (6 lanes, \$77 million)	Under Study
San Francisco, CA.	I-380 (6 lane, east-west connector)	Complete
Washington, DC.	Dulles Airport Access Road	Complete
<u>Roadway Reconstruction</u>		
Denver, CO.	Quebec Street (6 lane arterial, 1 mile, \$10 million)	Proposed
Honolulu, HA.	Kamehameha Highway (6 lane expressway, 2 miles)	Complete
Pittsburgh, PA.	Airport Parkway (4 lane expressway, 3 miles, \$24 million)	Plans Dropped
<u>Roadway Widening</u>		
Ft. Lauderdale, FL.	U.S. 1 (1 mile, 1 lane, \$6 million)	Final Design
Miami, FL.	N.W. 57th Street (arterial)	Programmed
	East-West Expressway	Proposed
	Airport Expressway	Proposed
Louisville, KY.	Watterson Expressway	Proposed
Los Angeles, CA.	Airport Boulevard (arterial)	Design
	96th Street (arterial)	Design
	Arbor Vitae (arterial)	Design

The construction costs associated with new or rebuilt roadways vary considerably, based on such factors as land costs, relocation required and design type (e.g., at grade, elevated, or depressed). Generally, the construction costs for a new roadway (including land) will range from \$1.5 million per arterial lane-mile to \$3.0 to \$4.0 million per freeway/expressway lane-mile. For a roadway reconstruction or widening, costs will normally range from \$1.0 million per arterial lane-mile to \$2.0 million per freeway/expressway lane-mile. However, costs can easily exceed these estimates within particularly congested areas, or for very complicated design projects. For example, Boston's proposed Third Harbor Tunnel project is estimated to cost over \$30 million per lane-mile to construct.

Construction programs to provide new or rebuilt highways within a region can result in vastly improved access to the airport. However, in most instances, the major disadvantage of such programs involves the time span from initial conception to final implementation. The typical highway project will require from five to ten years to complete, relegating such programs as long-term solutions to existing ground access problems. For example, the Century Freeway (I-105) project in Los Angeles (a ten-lane freeway terminating at the southern boundary of LAX) was first conceived in 1963. The required draft environmental impact statement for the project was not completed until January 1975, with construction still not underway. In Denver, proposals to upgrade Quebec Street (used by nearly three-quarters of all passengers at Stapleton) to reduce severe congestion problems have met opposition, and it is unclear when or if those plans will ever be implemented.

Federal assistance for the construction costs associated with new or rebuilt highway programs is provided by the Federal Highway Administration's Federal-Aid Urban Program. Funds available provide from 70 percent to 90 percent of the total construction-design costs of the project. The actual amount of federal funds available is largely determined by the classification of the roadway project, i.e., Interstate, Urban Primary, Primary, or Urban Systems.

4.2.2 Rail Service to Airports

As highways become more crowded and energy costs increase, more and more airports have been linked to downtown areas via rail transit. Most examples (Table 4-4) are in Europe, but more U.S. cities are using the service where conditions make such service feasible.

Conditions promoting the feasibility of airport rail service include:

- o Existing rail transit in city
- o Poor highway access
- o High proportion of trips from CBD
- o Proximity of airport to working rail line or available right-of-way.

Rail transport is probably not worth considering unless it provides a convenient alternative to highway travel. For example, the new service at London Heathrow provides 40-minute service direct from Hyde Park Corner to the airport and has been averaging 30,000 daily passengers. On the other hand, express train/bus service to New York's JFK Airport averaged about 1,000 passengers/day in its first five months. The principal reason for the major difference is the inconvenient rail-bus transfer required to get to JFK.

The potential impact of rail transit on choice of mode to the airport can be seen through experience at Cleveland's Hopkins Airport. Cleveland's rail system runs directly to the airport from the CBD and the airport station is located near the entrance to the Main Terminal Building. The frequency of service from the airport is every 10 to 12 minutes with less frequent trains during the late evening hours. The 12-mile trip to downtown Cleveland takes approximately 22 minutes compared to 30 minutes by Freeway during rush hours.

As Table 4-5 shows, 14.5 percent of all passengers and 35.7 percent of passengers coming from the Cleveland CBD use the new transit system. Only 11.2 percent of employees use the system,

TABLE 4-4. EXAMPLES OF RAIL USE AT AIRPORTS

<u>Airport</u>	<u>Percent Use by Air Passenger</u>	<u>Remarks</u>
<u>United States</u>		
Boston	6%	Requires shuttle bus; poor downtown transfers
Cleveland	14%	Good CBD service; parallel freeway also good
Chicago O'Hare	-	Approved for funding
Philadelphia	-	Under construction
Washington Nat'l	15%	Walk or shuttle bus to terminals; will have better CBD connections in future
<u>Foreign</u>		
London Heathrow	25%	Frequent service; highways often congested
London Gatwick	40%	Train faster than auto in rush hours
Tokyo Haneda	15%	Monorail; poor downtown connection
Brussels	20%	Downtown baggage check-in
Frankfurt	-	Recently connected to CBD

TABLE 4-5. MODE SPLIT AT CLEVELAND HOPKINS BEFORE AND AFTER RAIL TRANSIT

Percent Traveling by Mode to Airport

<u>MODE</u>	<u>ALL AIR PASSENGERS</u>		<u>AIR PASSENGERS: CBD</u>		<u>ALL AIRPORT EMPLOYEES</u>	
	Before	After	Before	After	Before	After
Private Auto	61.9	56.8	21.1	17.1	90.5	86.9
Rental Car	9.2	10.2	8.8	7.1	--	--
Taxi	11.5	8.5	27.4	17.6	1.1	0.1
Public Bus	1.5	--	4.2	--	8.4	0.5
Airport Limousine	13.3	7.1	36.8	20.3	--	--
Other	2.6	2.9	1.7	2.2	0	1.2
Rapid Transit	--	14.5	--	35.7	--	11.2
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0

Source: Cleveland-Hopkins Airport Access Study, June 1970

primarily because employees tend to locate within convenient driving distance of the airport. In all three categories, trips to private auto decreased by about 4 to 5 percentage points with the remainder of the mode shift coming from other modes.

The cost of rail transit service varies widely depending upon the circumstances. Construction completely at grade would cost \$20 to \$30 million/mile. Constructing tunnel sections, on the other hand would cost between \$60 and \$110 million/mile, depending on the type of construction.

The principal source of Federal funding for rail transit construction is an UMTA Section 3 grant, which provides an 80 percent share of the total cost of the project.

4.3 TRANSPORTATION SYSTEMS MANAGEMENT (TSM)

Transportation Systems Management encompasses programs and policies set up jointly by FHWA and UMTA in 1975. The TSM requirement calls upon urbanized areas to consider a wide range of actions with low-capital investment requirements that can improve transportation service in the short-term. A major objective of the TSM concept is to make more efficient use of the highways and transit systems already in place, thus reducing the need for major new capital investments and for operating assistance.

The TSM regulations require that the TSM projects selected for implementation by urbanized areas be included as the short-range element of the Transportation Improvement Program (TIP). In the case of UMTA, the development of the TSM projects in the annual element of the TIP are made a condition of future UMTA program approvals for all urbanized areas with populations over 200,000.

TSM programs can basically be grouped into three categories:

- o Actions to improve the efficiency of existing roadspace
- o Actions to improve transit service
- o Actions to reduce vehicle use

All three categories are discussed in this section with emphasis on how they may be used to improve airport access.

4.3.1. Actions to Improve the Efficiency of Existing Roadspace

A major goal of all TSM actions is to improve the efficiency of existing roadways by implementing low-cost measures. Such measures include:

- o Traffic operations to improve vehicular flow
- o Preferential treatment of high-occupancy vehicles
- o Park-and-ride facilities

Traffic Operations to Improve Vehicular Flow- Traffic operational improvements would include such items as improved signalization, traffic channelization and reversible lanes.

Traffic Signals- Improving the operation of traffic signals can improve traffic flow where arterial roads carry large proportions of airport traffic.

Signal coordination through progressive interconnection of traffic signals or a computerized traffic-responsive control system has been demonstrated by numerous projects to provide improved traffic capacity and operating speeds by reducing the number and length of signal stops in an urban trip.

Funding to improve signals and control strategies is provided by the Federal Highway Administration's (FHWA) Urban Systems program. Construction funds are available on a 70 percent Federal, 30 percent Local basis. Planning and design are locally funded.

Traffic Channelization- Channelization requires using islands, pavement markings, or other suitable means of facilitating traffic flow to separate potential areas of conflict. Channelization may also include providing additional lanes or approaches to the intersection where sufficient right of way exists to allow for maximum utilization of available space. Where turning move-

ments are heavy, specially designated turning lanes can promote smooth vehicular flow by removing turning movements from through lanes. At the Greater Pittsburgh International Airport, traffic capacity into the airport from the principal passenger entrance at the Airport Parkway (State Route 60) was greatly increased with the construction of a two-lane road turnout ("jughandle") at the intersection, accompanied by a separate signal phase.

Construction funds for channelization projects are provided by the Urban Systems program also on a 70 percent-Federal, 30 percent-Local basis. Project planning and design is locally funded.

Reversible Lanes - On roadways where directional flow is unbalanced, e.g., at least a 65-35 directional split during peak periods, reversible lanes can be used to increase the capacity of the roadway in the peak direction of flow. Since airport traffic is usually balanced, this technique would be applicable only to highways carrying a high percentage of commuter traffic. Reversible lanes usually refer to roadways not separated by a median strip; thus, reversible lane operations are an effective and inexpensive way of increasing the efficiency of existing facilities without roadway expansion.

Atlanta, Los Angeles, Chicago, Milwaukee, and Arlington, Virginia are among the cities in which reversible lanes have been successfully implemented. Atlanta converted a 3.5-mile, three lane section of Memorial Drive from a traffic configuration of two outbound lanes and one inbound lane to one lane in each direction and a center reversible lane. Peak period travel time has been reduced by 25 percent in the direction of heavy flow, while opposing, light-flow directional traffic has experienced no change in travel time.

Funding for reversible lane projects is provided by the Urban Systems program of the FHWA on a 70 percent-Federal, 30 percent-Local basis. Alternative funding may also be available through Section 146 of the 1973 Highway Act or Section 3 of the UMTA Act of 1964 where a demonstration of high-occupancy vehicle usage of

the reversible lane project is included.

Preferential Treatment of High-Occupancy Vehicles- The following TSM actions improve the flow of high-occupancy vehicles during peak travel periods:

- o Freeway bus and carpool lanes and access ramps
- o Bus and carpool lanes on city streets and urban arterials

The travel time savings and improved transit service levels resulting from these actions enhance the attractiveness of high occupancy modes. Ultimately, shifts away from the use of low-occupancy autos and an overall improvement in vehicular flow can be expected. This type of improvement is applicable to airport traffic with respect to airport buses and limousines.

Freeway Bus and Carpool Lanes and Access Ramps- Dedicating freeway lanes and access ramps for the exclusive use of buses and/or carpools during peak travel periods permits these vehicles to bypass congested sections of roadway and substantially decreases the passenger's travel time.

Basically, the techniques used to give low-cost preferential treatment to high occupancy vehicles on freeways and expressways involve instituting:

- o A reserved with-flow lane
- o A reserved contra-flow lane
- o Exclusive bus access ramps

The capital and operating costs associated with giving preferential treatment to high-occupancy vehicles differ considerably among projects, depending on the priority technique used, the prevailing costs at the time of implementation, the differences in existing roadway design, and other site-specific conditions (Table 4-6).

Capital funding is provided by Section 3 (UMTA) which provides an 80 percent-Federal share. Alternative funding may be available through Section 146 of the 1973 Highway Act.

TABLE 4-6. CAPITAL AND OPERATING COSTS OF FREEWAY BUS LANES AND ACCESS RAMPS (1976)

EXAMPLE	PRIORITY TREATMENT	PROJECT DISTANCE (Miles)	CAPITAL COSTS		OPERATING COSTS
			Construction	Other	
Marin County Greenbrae to San Francisco, CA	With-flow and Contra-flow lanes (B) ¹	3.9 con-tra-flow; 7.5 with-flow	\$46,154/contra-flow mile; \$426,667/with-flow mile ²	\$30,000 traffic signing	\$5,000/month to operate lane re-versal system plus \$4,200 for traffic enforcement
Interstate 35W Minneapolis, MN	9 freeway ramps (B)	15	Average = \$83,333/ramp	None	None
Approach to Lincoln Tunnel NJ to New York City	Contra-flow lane (B)	2.5	Access to bus lane \$53,600/mile	\$556,000 traffic controls	Approximately \$11,000/month for crew to change lane directions each morning
Long Island Expressway New York City	Contra-flow lane (B)	2.2	\$25,000/mile	None	Approximately \$11,000/month
Southeast Expressway Boston, MA	Contra-flow lane (B)	8.4	\$4,700/mile	None	Approximately \$12,000/month
San Francisco-Oakland Bay Bridge San Francisco, CA	With-flow lanes (B&C) ¹	1	\$58,000/mile	\$3,000 carpool matching (12-71) plus \$350,000 installation of a metering system (3-74)	\$2,000/month road-way-related costs plus \$300/month metering expense

¹(B) = bus only; (B&C) = bus and carpool.

²Includes construction of 7.5 miles of with-flow bus lane.

Bus and Carpool Lanes on City Streets and Urban Arterials -

Like their freeway counterparts, reserved lanes on city streets and urban arterials expedite the movement of high-occupancy vehicles through congested areas. Reserved lanes on urban roadways have been successful in improving travel time, increasing the utilization of existing facilities, and reducing stop-and-go-driving.

The major source of federal capital assistance (80 percent) is provided by Section 3 of the UMTA Act of 1964.

Park-and-Ride Facilities

Park-and-ride centers serve as relatively uncongested collection points where users are subsequently shuttled to their destinations on express transit buses. Coupling fringe parking facilities with inexpensive transit service to activity centers can contribute significantly to reduce the number of low-occupancy vehicles, assuming the services provided are competitive with low-occupancy vehicles in terms of trip time and costs.

In recent years, park-and-ride facilities have been developed to serve the access needs of the air passenger. In Los Angeles, several perimeter lots (12,500 spaces) have been implemented to discourage long-term parking in the airport's central terminal area. The perimeter lots are provided with free transit service to and from the terminals. In addition, a remote park-and-ride facility (1,377 spaces) at Van Nuys Airport, located 25 miles from LAX, is used as a parking facility for LAX. High frequency bus transportation is provided between the facility and the airport, subsidized by the Los Angeles Department of Airports.

Fringe parking facilities constructed as part of a larger transit plan, to be used by CBD commuters as well as the airport user, are eligible for Section 3 funds (UMTA Act of 1964).

4.3.2 Actions to Improve Transit Service

Transit Service

Virtually all airports have some form of public transporta-

tion service. This service usually consists of taxi and limousine, and, less frequently, public bus or rail transit.

Major factors influencing the usage of airport transit service include:

- o The services available and type of service provided
- o The origin or destination of the traveler
- o Resident versus non-resident travel
- o Amount of baggage.

As airport roadway congestion becomes more acute, more emphasis is being given to improve the attractiveness of alternative modes and services to the airport. Clearly, transit service to the central business district remains dominant, due to its concentration of trips. However, a number of new transit techniques have been implemented or proposed to serve the market in other parts of the region. Table 4-7 provides examples of transit techniques employed by airports to improve the attractiveness of public transportation.

Express bus/limousine service to the central business district is normally provided by private carrier, although in several cities, such as Pittsburgh and Philadelphia, express service to downtown is also provided by the regional transit authority. Private carrier fares are higher than those of the public carrier, but are usually offset by more convenient equipment and more frequent service.

In recent years, regularly scheduled express bus/limousine service from outside the CBD have been gaining popularity. In Miami, express bus service to Miami International from the Golden Glades Park-and-Ride Lot was implemented as part of a larger, regional concept to improve public transportation service. The 12-mile trip to the airport via the bus priority lane on I-95 takes approximately 25 minutes compared to 30 minutes by automobile during peak travel periods. Although specific ridership data are not available, patronage and the amount of service provided has been steadily increasing since the service was imple-

TABLE 4-7. TYPES OF AIRPORT TRANSIT SERVICES

<u>Airport</u>	<u>Service</u>	<u>Remarks</u>
Boston	Massport Shuttle	Connects with Subway Station, carries 6% of air passengers,
	Share-A-Cab	Service to suburbs increases occupancy of taxi, reduces fares
Los Angeles	Non-CBD Express Bus	Service to Fly Away park-and-ride lot, Van Nuys Airport carries 550 passengers/day
	Remote Lot Shuttles	Free Shuttle service from perimeter lots to terminals, contract to private carrier
Miami	Non-CBD Express Bus	I-95 preferential bus lane service from park-and-ride facility; public authority
	Shuttle Bus to Subway	Proposed high frequency service to new rapid transit line, public carrier
Philadelphia	Express Bus to CBD	High frequency express service to CBD, public carrier
Portland	Suburban Limousine	Scheduled limousine service from outlying communities, private carrier
Reno	Mini-Bus to CBD	High frequency mini-bus service to downtown.

mented in March 1976. Service is provided by the public transit authority for an average fare of \$0.65.

In Los Angeles, the Department of Airports initiated express bus services to LAX from its parking lot facility at Van Nuys Airport. The service is intended to reduce congestion at the airport by encouraging long-term parking at remote locations. High frequency service (every 30 minutes) is provided to LAX by private carrier under subsidy contract to the Department. Ridership has increased to a present daily average of 550 air passengers. In addition, to further reduce congestion within the terminal area, the Department of Airports has recently purchased twenty medium-size buses to provide, under private contract, free shuttle service to several perimeter lots at LAX.

Shuttle services to existing public transportation services can also play an important role in improving transit usage. Normally, shuttle services are used to connect with existing rail services. In Boston, modified buses are used to connect all major airlines with the Airport subway station approximately one-mile from the central terminal. Service is provided every five minutes during peak hours at a \$0.25 fare. The service carries nearly 7 percent of all air passengers. In Newark, high frequency bus service ("Airlink") is provided between the airport and rail connections at Penn Station-Newark. Similar bus shuttles are planned for LaGuardia in New York and for Miami (future rapid transit line).

A recent technique to promote higher usage and occupancy of taxis has been implemented in Boston. The share-a-cab concept provides the same service as regular taxi, i.e., door-to-door service. However, with share-a-cab, the taxi is "shared" by more than one party traveling to a similar location within the metropolitan area. Service is guaranteed within 15 minutes of the request made to the dispatcher. The individual fare is slightly less than one-half the regular taxi fare. The average daily ridership of the service is 300 air passengers, about 22 percent of total taxi ridership and 15 percent of the taxis dispatched at

Logan Airport. Share-a-cab occupancy rates average 2.4 passengers versus 1.6 passengers for regular service.

The cost of improving transit service at the airport will vary considerably depending on the type and demand for services. Costs will be negligible when high market demands allow profitable services to be provided by private carriers. To accomplish this, the airport operator may have to assist in identifying areas of high demand and encouraging the private carrier to demonstrate the new service. In some cases, capital and/or operating subsidies may become necessary. In Los Angeles, the Department of Airports spent \$600,000 to purchase twenty buses to provide shuttle services to its perimeter lots. In addition, it provides an operating subsidy of \$0.65 per passenger for the express bus service from Van Nuys Airport.

In Miami, the park-and-ride express bus services to the airport were developed as part of a broader transportation improvement program and were subsidized with public monies from both federal agencies and the local transit authority. In Boston, the airport operator, Massport, provides an annual subsidy of \$200,000 for dispatching services required for the Share-a-Cab program.

The principal sources of operating funds for transit improvements are private funds, airport revenues, and local funds (in the case of services provided by the transit authority). In some cases, FHWA Section 146 funds can be used to demonstrate a new service. In addition, UMTA Section 3 funds may be available to construct facilities and/or purchase equipment required to implement a new service.

Marketing

The primary objective of marketing within the context of improved transit usage at the airport is communications. A communications program should serve two purposes. First, it should inform the air traveler of the scope of transit services available. Second, it should tell the potential rider how to use the system.

A wide variety of methods for dispensing information at air-

ports is now being employed. The three principal means of ground transportation information dissemination are personnel (at booths or via phone), brochures and signs. Table 4-8 provides a summary of information mechanisms provided at twelve large hub U.S. airports.

Information centers are staffed by ground transportation dispatchers or airport information personnel who are prepared to provide written and verbal information on all modes of ground transportation. This technique provides flexibility, but the cost of maintaining enough personnel to answer questions with little queuing during peak periods can be high.

The brochure is an inexpensive means of providing comprehensive information about a variety of transit modes. It can be made easily available through the airport (and elsewhere) and can be designed for specific locations as well as for specific modes. Although the cost of brochures is low, updating the brochures to account for service changes can be expensive and time consuming.

A well designed sign can provide quick information on where to go, who to call and perhaps provide more detailed information for downtown trips. However, signs are difficult to update, and space constraints limit their comprehensiveness.

The growth of low cost interactive computers has led to interest in their use to supply ground transportation information directly to the passenger. London's Heathrow Airport has such a system in the rail station serving the airport. Systems covering all modes have been proposed at U.S. airports but have not yet been implemented.

The potential impact on overall transit usage to the airport will not change greatly with any single transit improvement. Nevertheless, the major advantage of such action is its ability to produce definable benefits at relatively low cost. Collectively, individual transit improvements at the airport, coordinated with other TSM improvements within the region, could have a substantial impact on the use of transit services for airport access.

TABLE 4-8. GROUND TRANSPORTATION INFORMATION SERVICES

Airport	Brochures	Info. Center In Terminal	Info. Center At Curb	Signs In Terminal	Signs At Curb	Direct Line To Info.
Boston Logan (BOS)	1, 2, 3*, 5B	Dispatcher: 1, 2, 3	No	3*, 5A, 5B	4	Some terminals 2, 3
Cleveland Hopkins (CLE)	No	Info Booth: 1, 2*, 3*	No	No	4	2, 3*
Chicago O'Hare (ORD)	1, 2*, 3*, 4, 5A	Limo Ticket Counter: 2*, 3*	Taxi Dis- patcher, Trans- it Dispatcher: 2, 3	No	4	No
Los Angeles (LAX)	1, 2, 3*, 4, 5A	No	Info Booth: 2*, 3*, 4	1, 5A, 5B	4	1, 2, 3, 4
Miami (MIA)	1, 2*, 4, 5A, 5B	Info Booth: 1, 2*, 3*	Taxi Dispatch- er, Transit Booth: 2, 3, 5B	No	4	No
New York LaGuardia (LGA) New York Kennedy (JFK) Newark (EWK)	1, 2, 3, 4, 5A, 5B	VARIES FROM TERMINAL TO TERMINAL				No
Philadelphia (PHL)	No	No	Dispatchers: Transit Booth: 2, 3	1, 4, 5A	4	1, 3
Greater Pittsburgh (PIT)	Pending: 1, 2, 3*	Info Booth: 1	Dispatchers: 2, 3	No	4	No
San Francisco (SFO)	1, 2, 3*, 4, 5A, 5B	Info Booth: 1, 2, 3	No	1	4	No
washington National (DCA)	No	Traveler's Aid 1, 3*, 5A, 5B	No	No	4, 5A, 5B	No

Types of Information Given: 1 = List of services and phone numbers
 2 = Fares
 3 = Schedules
 4 = Location of stops
 5A = Airport map
 5B = Metro Area map

*Limited Information

4.3.3 Actions to Reduce Vehicle Use

Some techniques may be employed to decrease vehicular traffic and, therefore, reduce traffic congestion within and outside the airport. Two techniques particularly applicable to airports are pricing and employee ridesharing.

Pricing- Pricing mechanisms can influence the number and type of vehicles using airport roadways and entering the passenger terminal areas. The pricing objective is to charge the airport user at a rate commensurate with the quality of access service desired.

Airport parking pricing can be designed to discourage use of parking in proximity to the central terminal area, particularly for long-term parking. For example, Los Angeles utilizes this pricing strategy in conjunction with the implementation of perimeter and remote parking lots. To reduce curb space congestion, metered spaces are provided adjacent to the central terminal with charges of \$0.25 per half hour (with a one-hour maximum). Long-term parking is discouraged within the central terminal lots by charging a daily rate of \$6.00 and encouraged within the perimeter lots with lower daily rates ranging from \$1.50 to \$4.00 (depending upon the distance of the perimeter lot from the terminal). All perimeter lots have free shuttle services to the terminal by private carrier under contract to the Department of Airports. Remote parking is further encouraged through use of the lot at Van Nuys Airport (25 miles from LAX) with a daily rate of \$1.00 and free, high-frequency bus service to LAX.

The airport access toll, collected at a toll barrier across the main entrance roadway, charges all motorists (not only those who park) for the use of the airport roadways. The goals of such a system are to reduce airport congestion as well as contribute to airport revenues.

The access toll concept is used at such airports as Dallas-Ft. Worth (large operation) and Naples, Florida (small operation). In the case of Dallas-Ft. Worth, the access toll is collected as part

of a very sophisticated electronic fee collection system for airport access and parking, basically in terms of elapsed time, starting with 25 cents for the first 30 minutes within the airport up to \$4.00 for 24-hour parking. The rates are reduced if remote parking is used. In Naples, the first 10 minutes are free with the rates then starting at 40 cents for the next 50 minutes and 15 cents for each additional hour up to a 24-hour maximum of \$1.75.

Employee Ridesharing

Ridesharing can take the form of either carpooling, participants using their own cars and rotating driving duties, or vanpooling, participants normally paying a fee to the driver or employer for the cost of providing the service. These systems can be implemented at locations with high employee concentrations, such as airports. Carpools are normally sponsored by employers and include incentives for employee participation. For example, the Port Authority of Portland (owner and operator of the Portland International Airport) provides free carpool parking facilities for their employees. The Authority also contributes 14 cents per mile to carpools with four or more persons traveling a daily round-trip distance of up to 20 miles.

Vanpools utilize mini-buses with 10 to 12 passenger capacities. Under most programs, the employer furnishes the van (leased or purchased) to any employee who is willing to assume driving responsibilities. The fare structure is designed to provide sufficient revenue to break even on capital and operating costs. The employee/driver is not charged a fare and is usually permitted personal use of the van at a minimal cost. Additional vanpool incentives such as free and priority parking are usually provided.

The initial promotional campaign for the employer-sponsored program can be carried out at relatively low cost, using newsletters, staff meetings, or other similar means. As part of this campaign, manual or computerized matching procedures, which identify employee origins, are usually essential to the success of the program. Manual matching methods, the most commonly used means of forming pooled riding, can be quickly implemented at a low cost. Essentially, with the aid of questionnaires or maps, potential

poolers are identified and then encouraged to commute with other interested individuals whose origin and work shift roughly coincide.

Although few programs have been implemented at airports, employee ridesharing programs appear particularly suitable for several reasons. First, the number of airport-based employees required to accommodate travelers has grown to such proportions that work forces at many airports exceed daily passenger totals, and the sheer number of employees contributes heavily to surface congestion in terminal areas. For example, some 6,000 vehicles can be expected to depart New York's JFK Airport during a peak ground traffic hour, and most of these vehicles are occupied by airport-based employees. It has been estimated that the major employee exodus at JFK adds as much as one hour to the surface travel time of the airline passenger. Secondly, employees generally reside away from the CBD in areas which public transportation service is not provided to the airport. This results in a striking dependence of airport employees on the private car. Usually, more than 90 percent of airport employees commute by car, at an occupancy of less than 1.25 persons per car. Thirdly, airport employee work shifts are keyed closely to those in industry, thereby providing large potential employee pools for ridesharing. Most shift changes occur between 7 and 8 am and 4 and 5 pm, also periods of maximum air passenger activity. Finally, as the number of air passengers increases, the number of airport employees will inevitably rise and require additional parking facilities and expanded highway systems.

The airport employee and employer can realize sizable benefits from a ridesharing program. The participating employee's most tangible benefits are a reduction in travel costs and a reduction in the use of his own vehicle for commuting. The airline or airport operator who sponsors a ridesharing program will also benefit from the program. The principal financial effect of the program will be a reduced demand for employee parking facilities. In addition, congestion near the airport will probably be reduced, an added benefit for all airport users.

5. EVALUATE ALTERNATIVE SOLUTIONS

5.1 EVALUATION PROCESS

Chapter 4 presented a wide variety of alternatives for relieving airport access congestion. The final steps in the planning process involve evaluating the relative merits of these alternatives and then recommending a course of action to follow. The process is familiar to most analysts, particularly since the advent of NEPA and the environmental impact statement.

The initial step in the evaluation process is a description of the alternative(s) to be appraised. In some cases an alternative would consist of a combination of improvements, particularly if TSM solutions are contemplated. The description would include enough detail about the alternative so as to estimate potential benefits and provide order-of-magnitude capital and operating costs. A null, or "do-nothing," alternative should always be included.

The second step requires a listing of criteria used to evaluate the alternative(s). The general categories that these criteria fall under are shown in Figure 5-1 and are discussed briefly in this chapter. The selection of criteria is a function of the alternatives to be studied, local characteristics and values, and the level of analysis required. Community input can be very helpful at this stage of analysis.

The third step is tabulation of the data or collection of information on each alternative for each criterion selected in the previous step. These data can be arranged in a matrix to simplify evaluation procedures. The information contained in the matrix should be concise and understandable enough so that it can be readily comprehensible to local citizens and administrative personnel.

The last step is the selection of a proper course of action. The selection process should be based on hard data tempered by community acceptance and political realities. A discussion of

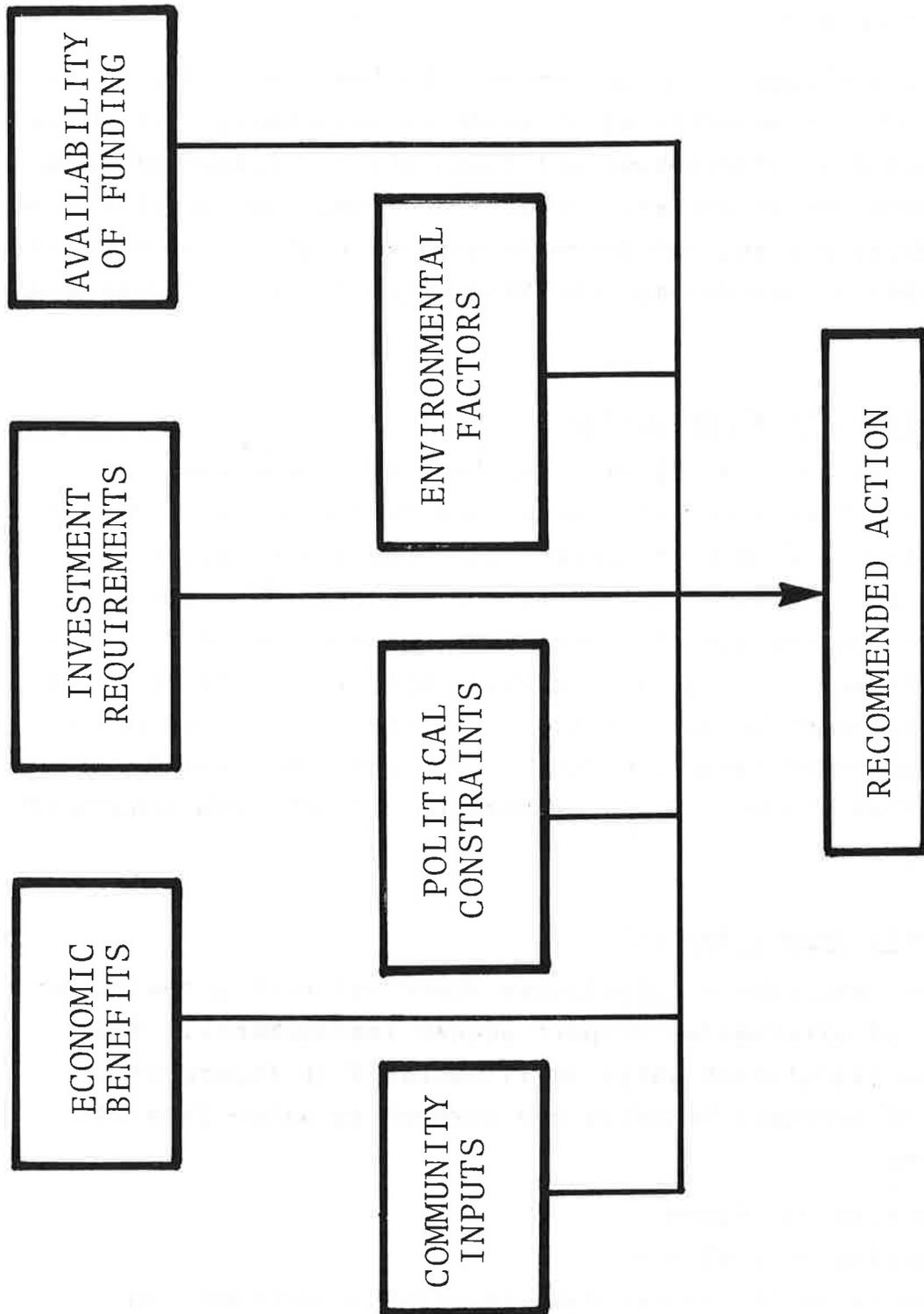


FIGURE 5-1. EVALUATION OF ALTERNATIVE ACCESS IMPROVEMENTS

these factors (with emphasis on economic benefits) is contained in the remainder of Chapter 5.

5.2 ECONOMIC BENEFITS

Tables 5-1 through 5-3 present calculation sheets for estimating the economic benefits of alternative solutions. The primary benefits offered by alternative solutions are the result of reductions in ground access delays. Delay reductions save gasoline, reduce nonproductive time, and increase airport use. Increasing airport use benefits the economic environment in the vicinity of the airport.

5.2.1 Estimating Delay Reduction

Table 5-3 presents a calculation sheet for estimating the ground access delays associated with alternative access improvements. Figure 5-2 illustrates the logic behind the calculation sheet. Some alternatives may affect roadway demand by altering either mode split for airport passengers, or the use of the roadway by non-airport passengers. Roadway capacity may be affected by various construction alternatives. Figure 5-3 is used to estimate the number of hours/year that LOS D and LOS E would be encountered. Then Figure 5-3 may be used to estimate the length of average delays.

5.2.2 Economic Impact Analysis

Table 5-2 provides a calculation sheet estimating the economic impacts of alternative airport access improvements. The logic of this calculation sheet is illustrated in Figure 5-4. Three types of economic benefits are assumed to arise from improved access:

- o reduction in delays
- o reduction in fuel use
- o increase in air travel with associated increases in regional employment.

TABLE 5-1. CALCULATION SHEET FOR ESTIMATION OF THE
NET ECONOMIC BENEFIT OF ALTERNATIVE
AIRPORT ACCESS IMPROVEMENTS

Part I

1. Enter discount rate (e.g., 10%)....._____
2. Complete Part II.
3. Complete the following table for each alternative under analysis.

TABLE 5-1. CALCULATION SHEET FOR ESTIMATION OF THE NET ECONOMIC BENEFIT OF ALTERNATIVE AIRPORT ACCESS IMPROVEMENTS
Part I (cont'd)

Year	Benefits	Costs	Net Benefit	Discount to Present	Net Present Value
(1)	(2)	(3)	(4)	(5)	(6)
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					
Total					

CALCULATION SHEET FOR ESTIMATION OF THE NET ECONOMIC BENEFIT
OF ALTERNATIVE AIRPORT ACCESS IMPROVEMENTS

Part I (cont'd)

Notes to Columns:

Column (2): From Part II, Line 31; interpolate or otherwise estimate data in intermediate years.

Column (3); Capital costs in years in which they accrue.

Column (4): Column (2) minus Column (3); may be negative.

Column (5): $(1 + \text{Part 1, Line 1})$ raised to the power of Column (1).

Column (6): Column (4) x Column (5).

TABLE 5-2. CALCULATION SHEET FOR ESTIMATION OF THE NET ECONOMIC BENEFIT OF ALTERNATIVE AIRPORT ACCESS IMPROVEMENTS

Part II

Alternative: 8-Lane I-95

Year: 1990

1. Complete Part III.
2. Estimate reduction in vehicle-hours delay/day (Part III, Line 8 + Line 10, Column 1 - Column 2)..... _____
3. Estimate average fuel use/vehicle-hour at idle (gals.) 1/..... _____
4. Compute annual savings in fuel due to delay reduction (Gals.) ([2] x [3] x 365)..... _____
5. Estimate annual savings in fuel due to shift in mode split, if applicable..... _____
6. Estimate price of fuel (\$/gal.)..... _____
7. Calculate savings due to fuel use reduction (\$) (([4] + [5]) x [6])..... _____
8. Enter savings in time, air passengers (Part III, Line 9) Column 1 - Column 2)..... _____
9. Estimate value of time, air passenger (\$/hr.) 2/..... _____
10. Compute savings in time value, air passenger ([8] x [9])..... _____
11. Estimate non-airport vehicle occupancy 3/.... _____
12. Compute savings in time, non-air passenger ([11] x 365 x Part III, Line 10, Column 1 - Column 2)..... _____
13. Estimate value of time, non-air passenger (\$/hr.) 2/..... _____
14. Compute savings in time value, non-air passenger ([12] x ([13])..... _____
15. Estimate average passenger trip time (flight + terminal + access/egress) 4/..... _____
16. Enter decrease in access delay (Part III, Line 7, Column 1 - Column 2)..... _____

TABLE 5-2. CALCULATION SHEET FOR ESTIMATION OF THE NET ECONOMIC BENEFIT OF ALTERNATIVE AIRPORT ACCESS IMPROVEMENTS

Part II

Alternative: 8-Lane I-95

Year: 1990

- 17. Compute fraction trip time decrease to savings in access time $([16] \div [15])$ _____
- 18. Estimate trip time elasticity of air travel^{5/} . _____
- 19. Compute stimulation in demand due to delay reduction in access $((1 - [17] * [18]))$
- 20. Enter forecasted annual passengers (Table 3-2, Line 2)..... _____
- 21. Enter airside passenger capacity (Table 3-2, Line 3)..... _____
- 22. Compute airside-constrained annual passengers (minimum of [2] and $([19] * [20])$)..... _____
- 23. Estimate future year, base-case Airport/Airline/Airport-related (Airport hotels, car rentals, etc.) employment..... _____
- 24. Estimate change in direct employment $([23] * ([22] - \text{Table 3-2, Line [4]}) \div \text{Table 3-2, Line [4]})$ _____
- 25. Assume a regional economic multiplier^{6/}..... _____
- 26. Estimate change in regional employment $([24] * [25])$ _____
- 27. Estimate dollar value of employing one person (\$/year) ^{7/}..... _____
- 28. Compute employment benefits of alternative $([26] * [27])$ _____
- 29. Estimate employment in construction industry generated by alternative under analysis (only in years under construction)..... _____
- 30. Compute value of construction jobs $([27] * [29])$ _____
- 31. Gross benefit $([7] + [10] + [14] + [28] + [30])$

1/ If data unavailable, use 0.3.
2/ If data unavailable, use \$20.00/hr.
3/ Accuracy is not critical.

CALCULATION SHEET FOR ESTIMATION OF THE NET ECONOMIC
BENEFIT OF ALTERNATIVE AIRPORT ACCESS IMPROVEMENTS

Part II (cont'd)

- 4/ Default value: 4 hours.
- 5/ Default value: -1.0.
- 6/ Default value: 1.5.
- 7/ Default value: Welfare rate.
- 8/ Default value: Municipal bond index at community's rating.

TABLE 5-3. CALCULATION SHEET FOR ESTIMATION OF THE NET ECONOMIC BENEFIT OF ALTERNATIVE AIRPORT ACCESS IMPROVEMENTS

Part III: Estimation of Delay

Alternative: 8-Lane I-95

Year: 1990

	<u>Null Alternative</u>	<u>Alternative to be Analyzed</u>
	(1)	(2)
1. Enter two-roadway volume from Table 3-2, Line 11.....	_____	_____
2. Enter two-way hourly capacity at LOS E, per <u>Highway Capacity Manual</u>	_____	_____
3. Compute ratio of daily volume to hourly capacity (line 1 ÷ Line 2)	_____	_____
4. Estimate number of hours/year that LOS E would occur..... This depends on the peaking characteristics of roadway volume. (Default: multiply Line 3 by Table 3-5, Line 3. Find this product on the horizontal axis of Figure 3-5).	_____	_____
5. Enter miles of roadway affected by alternative being analyzed.....	_____	_____
6. Enter speed limit on roadway (mph).	_____	_____
7. Estimate average minutes delay/vehicle (use Figure 5-3).	[]	[]
8. Compute annual air passenger vehicle-hours delay/day (line 7 x Table 3-2, Line 8 ÷ 60).....	_____	_____
9. Compute annual air passenger hours delay (Line 8 x Table 3-2, Line 5)	_____	_____
10. Compute non-airport vehicle-hours delay/day (Line 7 x Table 3-2, Line 10 ÷ 60).....	_____	_____

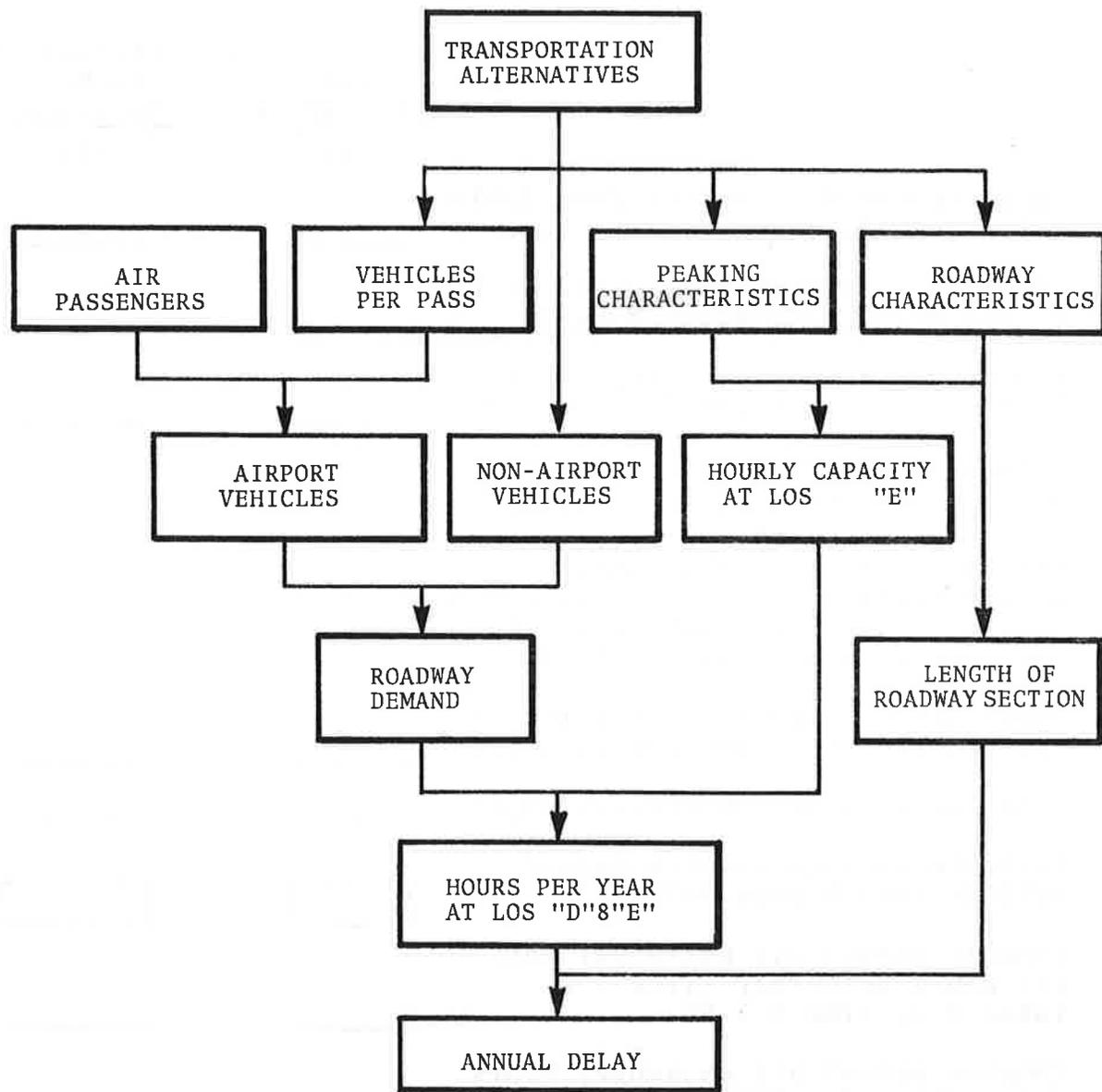


FIGURE 5-2. METHOD FOR ESTIMATING ACCESS DELAY

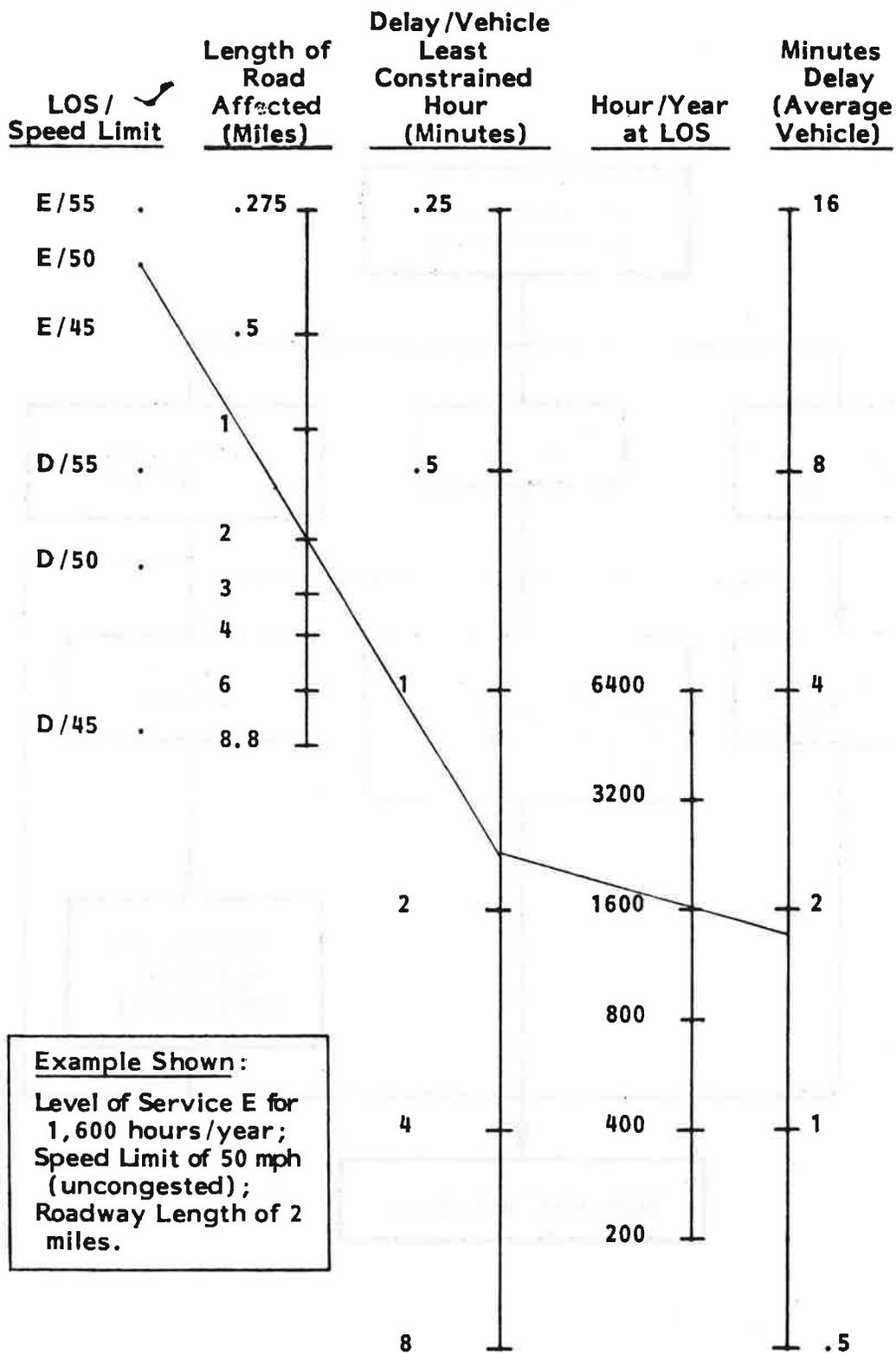


FIGURE 5-3. ESTIMATION OF DELAY (to be completed)

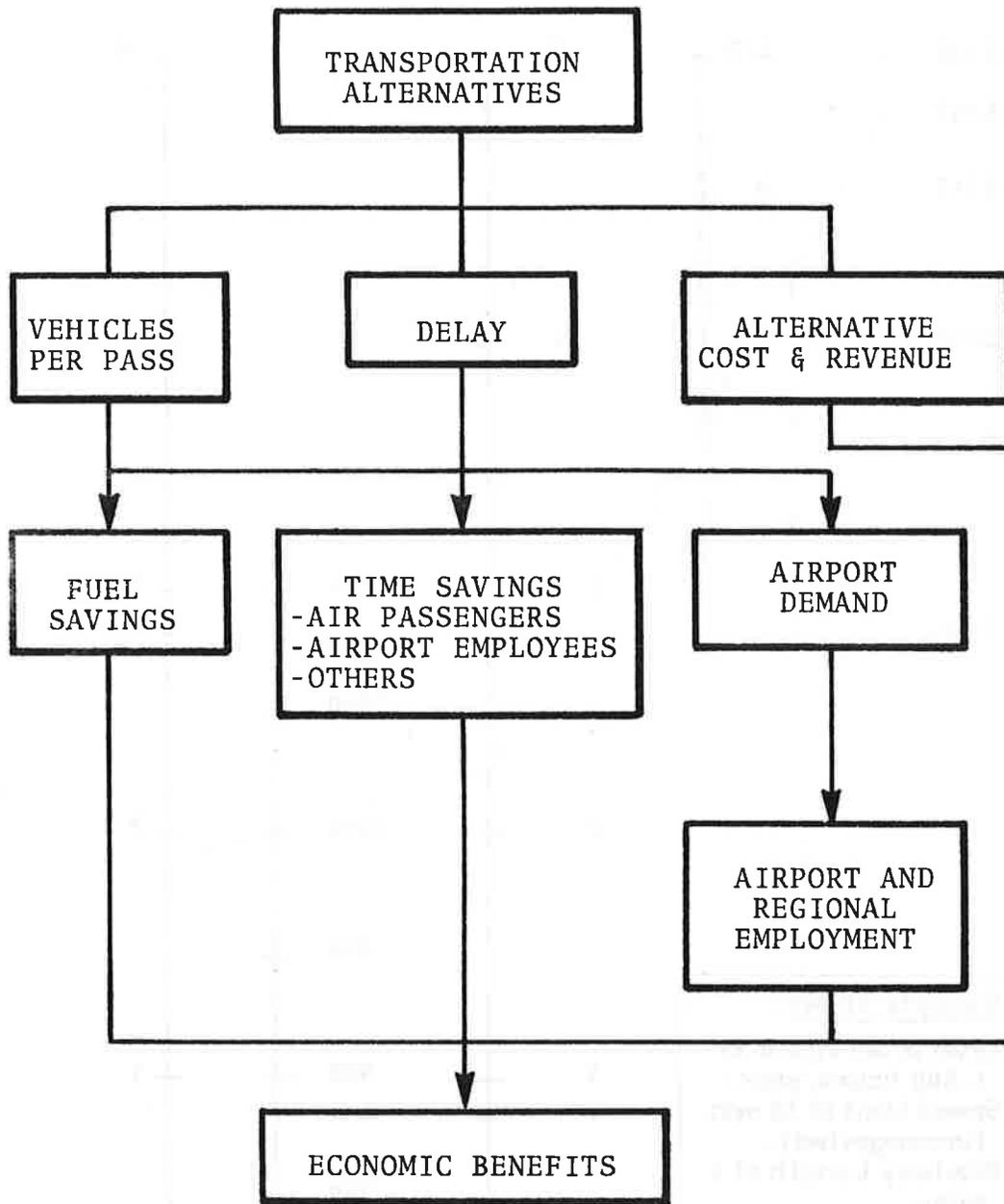


FIGURE 5-4. ESTIMATING NET ECONOMIC BENEFIT OF ACCESS ALTERNATIVES

The loss of productive time in the access trip is rather serious in that it affects a large number of travelers. For example, in Fiscal Year 1978, the average large hub enplaned over six million passengers, of which an estimated five million were originating. An average two-minute delay at \$15/hour calculates to a cost of \$5 million annually in access and egress at the average large hub. At many hubs, delays are much more serious, and costs are greater. There is some question as to what percentage of time saved by reducing delay could be used productively rather than simply increasing the time at the airport. It is usually assumed that passengers gauge their departures from home and work with a view toward arriving at the airport with a certain amount of lead time before flight departure. In addition, it may be assumed that passengers are reasonably able to gauge their delays, but leave extra time when delays are somewhat uncertain. Consequently, estimates of savings in productive time derived from estimates of savings in average delay are likely to be conservative.

Estimates of fuel savings are obtained in Table 5-2 on the basis of average vehicle fuel use per hour at idle. Savings in fuel are valued at the price of fuel, although this is likely to be conservative given the importance of fuel conservation in modern society.

Other benefits of saving access time are harder to quantify. Reducing access time may attract industry which is dependent upon air transport to the region. Also, since increases in ground access time negatively affect the demand for air travel [6, 7, 8], it is reasonable to assume that savings in access time stimulate air travel. This increases air carrier revenues and stimulates new air services, which benefit not only the new travelers, but also those who would have been traveling in the first place. In turn, it stimulates travel related employment--airport/airline, hotel/motel, car rental, restaurant, etc.--in the region. Finally, this increase in employment increases the wealth of the region and generates jobs in secondary support industries such as clothing and food retailing. The impact on employment is quantified and valued

via the calculation sheet.

In Table 5-1, the net economic benefit of an airport access improvement project is evaluated for all future years by subtracting from the quantified benefit the costs of the project. The net benefit is discounted to a net present value, which can be used to compare alternatives (including the null alternative, having a net present value of zero) for improving airport access.

5.3 COMMUNITY INPUT

Community reaction is particularly important in evaluating alternatives with direct impact on neighborhoods in the vicinity of the airport. These neighborhoods are often well organized and anti-airport to begin with because of aircraft noise. Thus, they are likely to be quite sensitive to actions which are perceived as causing potential further adverse impacts on their lives.

Every effort should be made to ensure that the planning process is open to public participation. This can be accomplished directly with community participants (in workshops and public meetings or through attitudinal surveys, etc.) or indirectly with representatives at regularly scheduled meetings. The intent of this interaction is threefold:

- o To maximize cooperation and credibility in the planning process
- o To provide for the greatest possible dissemination of data and technical findings to the public at large
- o To allow the planning staff to benefit from the personal knowledge of informed local residents.

The process of generating and selecting alternatives can suffer if inadequate attention is accorded to community input. Without such participation, the community will most likely oppose the solutions recommended and reduce the chances for successfully implementing the action program.

5.4 POLITICAL CONSTRAINTS

Political considerations are always important and airport access improvements face particular problems in this area. The airport user constituency is a smaller proportion than, say, the daily commuter and thus airport access improvements sometimes are given lower local priorities. Often, of course, the improvement benefits others as well as the airport user. Therefore, it is important to stress how the proposed action benefits the entire region in addition to providing improved airport access.

5.5 INVESTMENT REQUIREMENTS

The factor titled "investment requirements" is cited because even though some alternatives may show the highest net economic benefits, they still may require an investment beyond that which can realistically be expected to be available through either local or Federal funding sources. Related to this is the question of funding availability. Improvements which are beyond local funding capacity may be eligible for Federal funding (Figure 5-5). Funding availability (by source) for the investment required for each potential alternative must be considered and incorporated as part of the recommended action.

5.6 ENVIRONMENTAL FACTORS

Environmental factors become particularly important in evaluating the probability of implementing alternatives requiring major construction or alternation of existing land use. Such alternatives as new highways or rail extensions require stringent compliance with Federal/state environmental regulations and planning procedures as a prerequisite for funding and implementation. Inevitably, major construction alternatives require the preparation of an Environmental Impact Statement (EIS) to assess the expected environmental (social, physical, economic) impacts associated with the project. Preparation of an EIS requires considerable time and effort, with subsequent approval of the project based on its ability to generate substantial overall benefits with minimum harm to

U.S. Department of Transportation

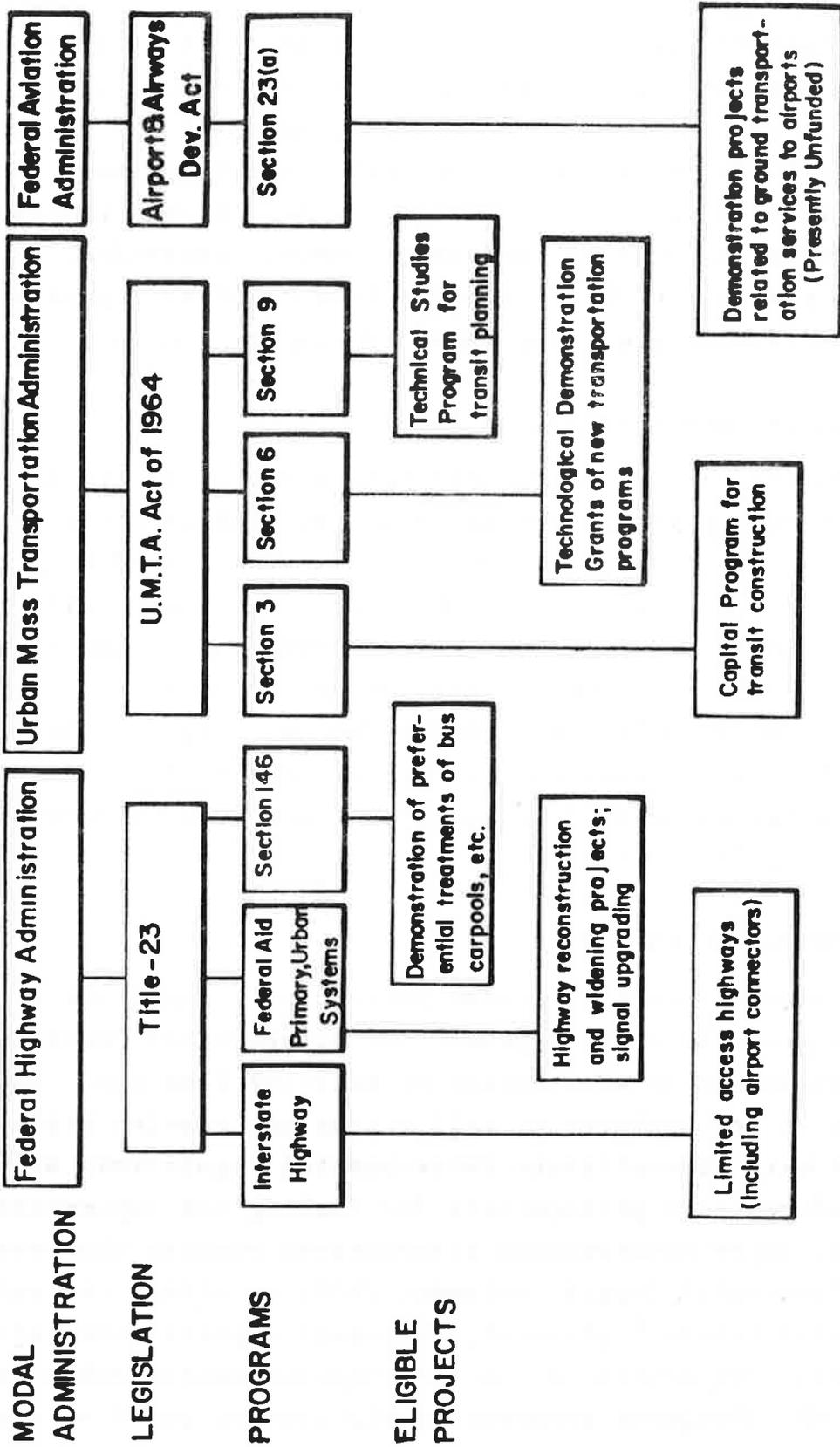


FIGURE 5.5 SOURCES OF FUNDS

the environment. Due to the time normally required for EIS development and approval, in addition to design and construction, major construction alternatives must be considered as long-range solutions.

1. The first part of the document discusses the importance of maintaining accurate records of all transactions and activities. It emphasizes the need for transparency and accountability in financial reporting.

2. The second part of the document outlines the various methods and techniques used to collect and analyze data. It highlights the importance of using reliable sources and ensuring the accuracy of the information gathered.

3. The third part of the document discusses the challenges and limitations of data collection and analysis. It notes that while technology has advanced significantly, there are still many obstacles to overcome, such as data privacy and security concerns.

4. The fourth part of the document provides a detailed overview of the data analysis process, including the selection of appropriate statistical methods and the interpretation of results. It stresses the importance of critical thinking and logical reasoning in drawing conclusions from the data.

5. The fifth part of the document discusses the ethical considerations surrounding data collection and analysis. It emphasizes the need to protect individual privacy and to use data responsibly, avoiding any potential for misuse or discrimination.

6. The sixth part of the document provides a summary of the key findings and conclusions of the study. It highlights the importance of ongoing research and the need for continued collaboration between researchers and practitioners in the field.

7. The seventh part of the document discusses the implications of the findings for future research and practice. It suggests several areas for further investigation and offers practical recommendations for improving data collection and analysis processes.

8. The eighth part of the document provides a final summary and conclusion. It reiterates the importance of data in decision-making and the need for a systematic and ethical approach to data collection and analysis.

9. The ninth part of the document discusses the limitations of the study and the need for further research. It acknowledges that the findings are based on a specific sample and may not be generalizable to all situations.

10. The tenth part of the document provides a final summary and conclusion. It emphasizes the importance of data in understanding the world and the need for a rigorous and ethical approach to data collection and analysis.

APPENDIX A

URBAN TRANSPORTATION PLANNING AND AIRPORT ACCESS

Urban transportation planning is an interdisciplinary process of developing and monitoring transportation plans and transportation improvement programs. The Department of Transportation through its modal administrations, the Federal Highway Administration (FHWA), the Urban Mass Transportation Administration (UMTA) and to a far lesser degree, the Federal Aviation Administration (FAA), has the responsibility for encouraging and participating in urban and regional transportation planning. Federal legislation mandates a continuing, comprehensive, and cooperative transportation planning (called 3C) process within each urbanized or urbanizing area.

Federal Planning Coordination

Federal involvement with transportation planning is confined to reviewing and certifying the local transportation planning process. The identification and prioritization of projects (such as airport ground access) for Federal funding is largely a responsibility of the appropriate local planning agencies.

At the Federal level intermodal coordination is provided by the Intermodal Planning Group (IPG) established in each of the Federal Regions by the Department of Transportation. The members of the IPG include the Regional Administrators of the Federal Aviation Administration, Federal Highway Administration, Federal Railroad Administration and National Highway Traffic Safety Administration, Regional Directors of the Urban Mass Transportation Administration and the District Commanders of the United States Coast Guard. The objective of the IPG is to develop and improve intermodal transportation planning and to provide a unified DOT presence in the regions. One of the major responsibilities of the IPG is to provide technical assistance in the development and review of local plans and projects submitted in order to receive DOT planning assistance funds. However, in most instances, the IPG's

role has been one of review only, rather than development.

The Metropolitan Planning Organization (MPO)

In order to develop and maintain the local 3-C Process, Federal statutes and regulations require the governor of each state to designate a Metropolitan Planning Organization (MPO) to carry out the urban transportation planning process for each defined urbanized area (Figure A-1). Essentially, the MPO is a policy body consisting of locally elected officials. The MPO is designated by the governor to review and select, for priority assignment, all transportation planning and program proposals for the region that require funding.

In addition to providing the forum for cooperative decision-making of local transportation policy and programs, the MPO is responsible for developing the area's Prospectus, Unified Work Program, Transportation Plan, and Transportation Improvement Program.

The Prospectus establishes a multiyear framework within which the unified work program is accomplished. It includes a summary of the important transportation issues facing the area and a description of the working relationships and responsibilities of each participating agency.

The Unified Work Program (UWP) is a listing of tasks or projects that are in the planning or problem-definition phases of analysis. In effect, the unified work program is the annual element of the prospectus. The program includes regionwide and sub-area planning activities anticipated within the area during the next one or two year period, regardless of funding sources for all specific transportation planning activities, e.g., aviation, highway, bikeway, railway, transit, and port and harbor activities. Transportation planning studies not included in the UWP are ineligible for Federal funding.

The Transportation Plan defines a program of proposed projects for the area. The transportation plan consists of two elements: the transportation systems management element and the long-range

URBAN TRANSPORTATION PLANNING PROCESS

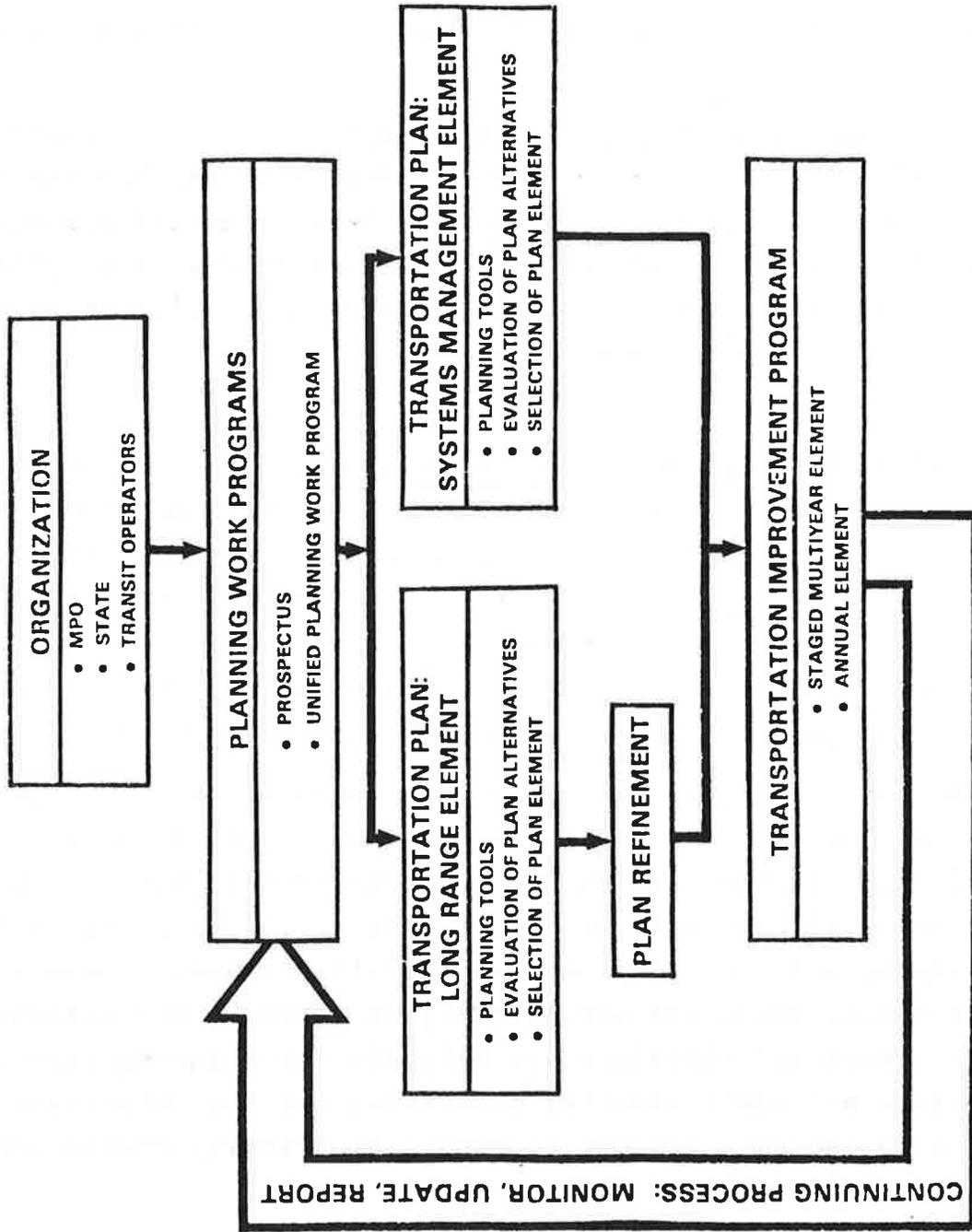


FIGURE A-1. URBAN TRANSPORTATION PLANNING PROCESS

element. The transportation systems management element consists of short-range, relatively low cost improvements which will make more efficient use of the existing transportation systems. The long-range element identifies major programs which lead to substantial improvements or additions to the area's existing transportation systems.

The Transportation Improvement Program (TIP) is a multiyear program of projects which have been endorsed by the MPO for implementation. The program consists of both an annual and multi-year list of projects consistent with the transportation plan. Federal funding for program implementation is contingent upon the program endorsed within the TIP.

Funding for Airport Access Planning-Grants for urban transportation planning are available to the MPO from the Federal Highway and Urban Mass Transportation Administrations. There is currently no single planning program within the U.S. Department of Transportation which deals exclusively with airport ground access. Essentially, airport ground access planning is included within the transportation funding programs provided by both the FHWA and UMTA.

The Federal Highway Administration administers the Federal aid highway program through the states and metropolitan areas. As part of that program, states are required to designate 0.5 percent of the total highway aid funds appropriated to the designated MPO for carrying out the 3C urban transportation planning process. Airport access roads are specifically included in the Federal-aid highway system and therefore are eligible for planning funds. Legislative and administrative directives for the interstate system clearly indicate airport terminals as priority consideration in locating routes.

The Urban Mass Transportation Administration provides assistance for airport access planning within the Technical Studies Program (Section 9 grants). Typical activities are short-range transit studies, system planning studies, rapid transit engineer-

ing studies, and special studies. These grants are provided to the MPO and eligible public transportation authorities.

Although the FAA administers a Planning Grant Program under Section 13a of the Airport and Airway Development Act, airport access planning is limited in scope to general studies necessary for airport master planning.

Based on the present Federal policy and funding mechanisms cited briefly above, the division of responsibility within the U.S. Department of Transportation for the funding of airport ground access planning and programs are under the jurisdiction of both FHWA and UMTA. FAA funding is essentially confined to programs within the boundaries of the airport.

At the local level, the recipient of planning funds to identify, develop and prioritize specific off-airport access programs is primarily the MPO.

The airport operator and staff must participate actively in local 3C planning in order to promote more effective coordination between local highway-transit interests and the ground access needs of the airport. Historically, intermodal planning has been hampered by inactive participation in the MPO by the airport operator, compounded by minimal financial support of the MPO by the FAA. The importance of participating in the MPO was outlined earlier. All transportation planning studies, including airport access, must be included in the MPO's Unified Work Program (UWP) in order to be eligible for federal funding assistance provided by FHWA and UMTA.

1. The first part of the document discusses the importance of maintaining accurate records of all transactions and activities. It emphasizes that this is crucial for ensuring transparency and accountability in the organization's operations.

2. The second part of the document outlines the various methods and tools used to collect and analyze data. It highlights the need for consistent data collection procedures and the use of advanced analytical techniques to derive meaningful insights from the data.

3. The third part of the document focuses on the implementation of data-driven decision-making processes. It discusses how the collected data is used to identify trends, assess risks, and make strategic decisions that align with the organization's goals and objectives.

4. The fourth part of the document addresses the challenges and limitations of data analysis. It acknowledges that while data provides valuable insights, it is not infallible and must be interpreted with care and context.

5. The fifth part of the document discusses the importance of data security and privacy. It emphasizes the need for robust security measures to protect sensitive information and ensure compliance with relevant regulations and standards.

6. The sixth part of the document explores the future of data analysis and the role of emerging technologies. It discusses how artificial intelligence, machine learning, and big data are transforming the way organizations collect, analyze, and use data.

7. The seventh part of the document provides a summary of the key findings and conclusions. It reiterates the importance of a data-driven approach and the need for continuous improvement in data collection and analysis processes.

8. The eighth part of the document includes a list of references and sources used in the research. It provides a comprehensive overview of the literature and resources that informed the analysis and conclusions.

9. The ninth part of the document contains a list of appendices and supplementary materials. These include detailed data sets, charts, and additional information that supports the main text of the document.

10. The tenth part of the document provides a final conclusion and a call to action. It encourages the organization to embrace a data-driven culture and to continue exploring new ways to leverage data for improved performance and growth.

APPENDIX B

THE INFLIGHT SURVEY

Introduction

The inflight passenger survey is a self-administered questionnaire distributed and collected on the airplane by the flight attendants. Advantages of the inflight survey include ample time to complete the survey (allowing for an extensive series of questions), high response rates, and relatively low cost. Logistically, it is far easier to sample only enplaning passengers, since material can be put on board aircraft at a central location. Generally, most deplaning characteristics are "mirror images" of enplaning characteristics. However, some data such as mode choice will vary somewhat and should be checked through other sources such as direct counts or ground transport operator data.

Questionnaire Content

Information requested within the survey is obviously based on the particular data needs of the airport under study. However, the inflight survey normally requests data within three categories:

1. The passenger's Ground Trip
2. The Passenger's Air Trip
3. Profile of the Air Passenger

Data on the passenger's ground trip will include trip origin, trip destination, mode of access, cost of access trip, routing to airport, airport arrival time, and number of persons accompanying air traveler to airport. Such data are important in evaluating the existing and projected adequacy of airport ground access systems by time period. In addition, such data is relevant to the assessment of on-airport curbspace, parking lots, and circulation roadways.

The passenger's air trip will include data such as information concerning flight transfers, air travel frequency, trip length, and trip purpose. Such data are essential for evaluating on-airport

facilities like ticket counters, baggage facilities, and waiting areas, and to expand and cross-correlate information on the ground trip.

The air passenger profile asks general questions dealing with the socioeconomic characteristics of the traveler. Cross-correlation of such data with ground access data is often helpful in forecasting future access characteristics.

A sample inflight survey questionnaire with flight attendant instructions follows this section.

Sample Design

The sample size needed to adequately estimate characteristics of airport populations is not closely related to airport size. The size required to provide a predetermined degree of statistical reliability is primarily a function of the nature of the question and variation to it. The questionnaire asks many questions and would require a variety of sample sizes to provide comparable accuracy for each question. Therefore, the conservative approach to ensure reliability of all questions is to take the sample size required by the most important question.

The required sample size can be taken as:

$$N' = \frac{p(1-p)Z^2}{e^2}$$

Where

N' = required sample size

p = the estimated proportion of the most important question (for example, the proportion of all passengers arriving at the airport by private auto)

Z = a statistic which relates the confidence level required to the normal curve, Values of Z for various confidence levels are shown below

e = confidence interval, error from "true" value to be tolerated (e.g., 2 percent, 5 percent, etc.)

Z - Values As Related To Confidence Levels

<u>Confidence Level</u>	<u>Z</u>
90%	1.64
95%	1.96
99%	2.58
99.5%	2.81
99.9%	3.29

The sample size N' has a maximum size when $p=50$ percent and if 50 percent is a possible value for p , calculation of N' should be based on $p=50$ percent. The above equation for estimating sample size assumes a normally distributed population that is reasonably large. However, if the relative size of the sample to the total population (N) is large, i.e., if N'/N is greater than 10 percent, then N' should be reduced to a correct size N'' as shown in Figure B-1. This will ensure that the sample is the smallest possible to obtain the results required. If the sample correction is not made, the sample will be larger than necessary and hence wasteful of survey effort. The sample size should be increased to allow for estimates of cancelled flights, administrative errors, low passenger loads and non-response.

Once a sample size has been set, a sampling technique should be developed. Depending on airport size, this might involve sampling all flights for a week, all flights for a day or perhaps a selected sample of flights for a week or longer period. Generally, it is desirable to sample for at least a week's duration so that any variation by day of week can be accounted for.

The primary sources for control data are individual airline statistics during the survey period. For the specific flights surveyed, counts should be compiled by flight number for the day on which these flights are surveyed. For airport operations as a whole, counts should be compiled by airline for each day of the survey period.

Costs

Figure B-2 shows the cost of conducting a typical inflight

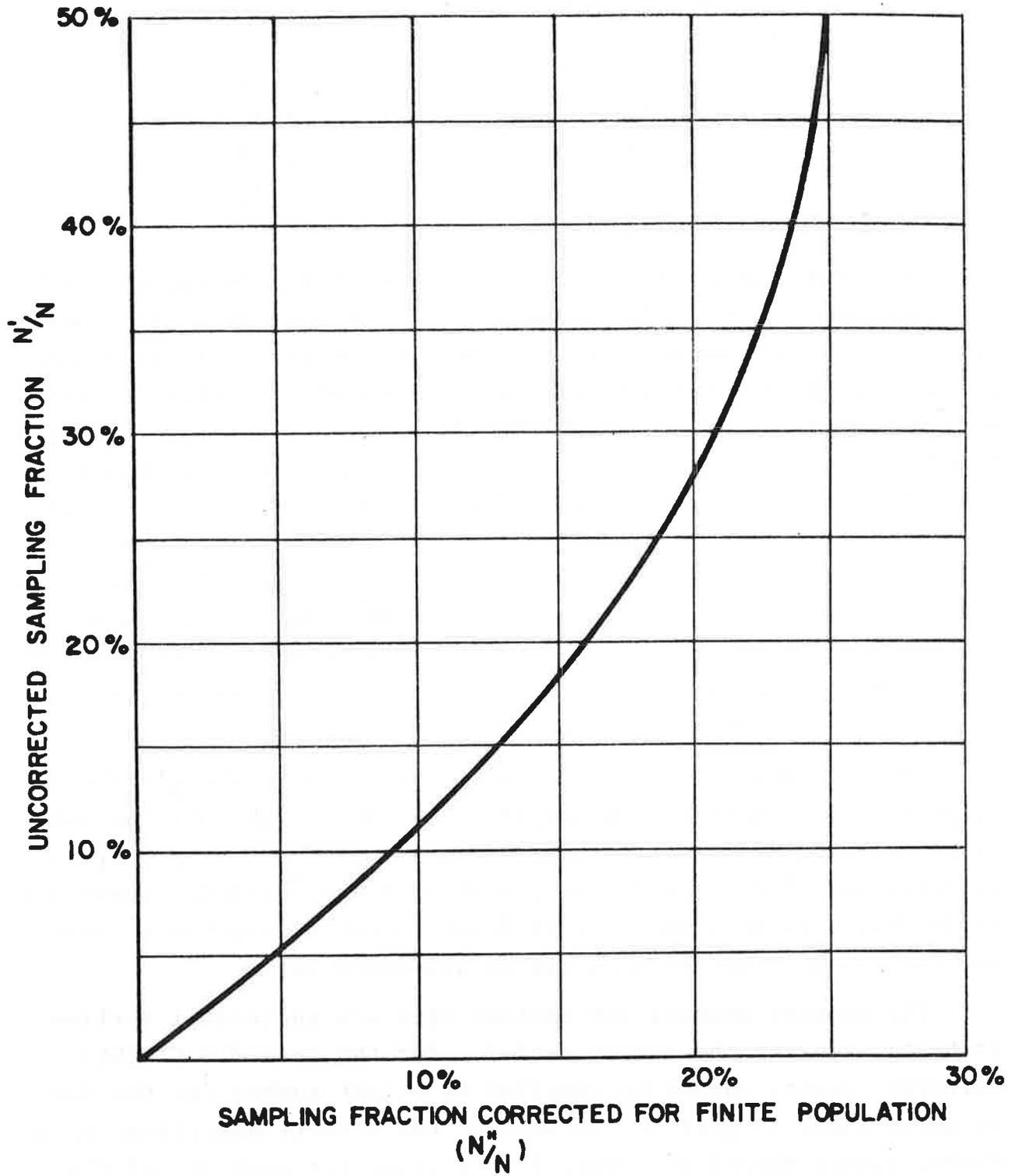


FIGURE B-1. FINITE POPULATION CORRECTION

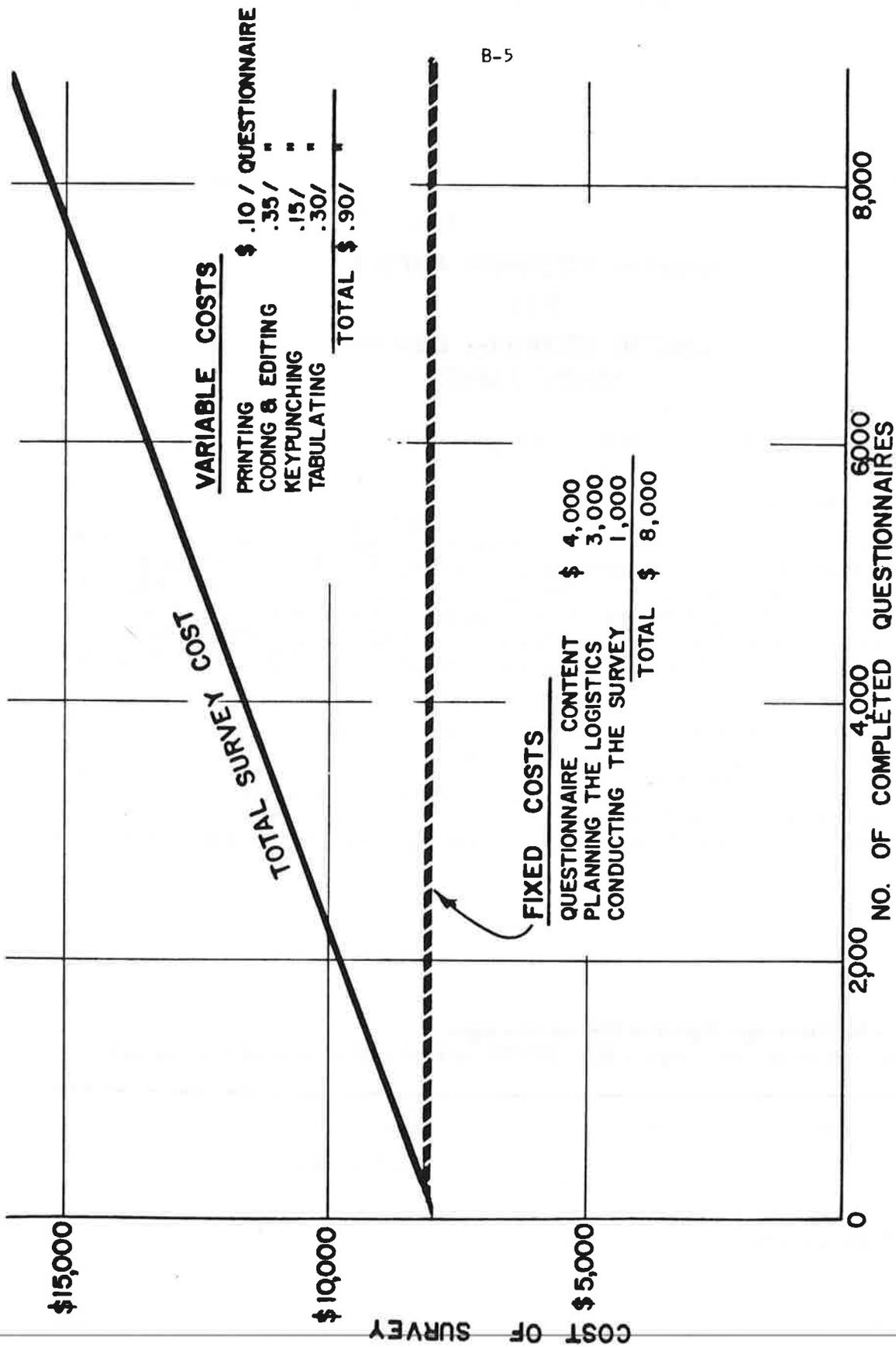


FIGURE B-2. COST OF A TYPICAL INFLIGHT SURVEY

SAMPLE INFLIGHT QUESTIONNAIRE

Return Immediately To:

_____ Manager

Airlines

**GREATER PITTSBURGH AIRPORT
PIT
GREATER PITTSBURGH AIRPORT
INFLIGHT SURVEY**

Contents

This envelope contains air passenger survey questionnaire forms, and pencils for those passengers who need them.

Stewardess Announcement

The following announcement should be made over the aircraft public address system:

LADIES AND GENTLEMEN — THE ALLEGHENY COUNTY DEPARTMENT OF AVIATION AND THE AIRLINES SERVING PITTSBURGH ARE CONDUCTING A ONE-WEEK SURVEY OF PASSENGERS LEAVING FROM AND PASSING THROUGH THE GREATER PITTSBURGH AIRPORT. WE HOPE YOU WILL COOPERATE IN THIS SURVEY BY FILLING OUT THE QUESTIONNAIRE WE HAVE GIVEN (WILL GIVE) YOU. A STEWARDESS WILL COLLECT THE COMPLETED QUESTIONNAIRE BEFORE PASSENGERS DEPLANE AT THE NEXT STOP. WE HAVE PENCILS IF YOU NEED ONE. THANK YOU.

Instructions for Stewardess

1. Make above announcement and hand out questionnaire to all passengers.
2. Do not force any passenger to fill out a questionnaire.
Do not wake sleeping passengers.
3. Put all completed and incomplete questionnaires back in this envelope and hand it to the passenger agent at the First stop after Pittsburgh.
4. If the questionnaires could not be distributed or collected, please explain what the problem was below:

Instructions for Passenger Agent or Station Manager

This envelope is to be sent via Company Mail (COMAT) to Pittsburgh as soon as it is received.

Questionnaire Nos.

To

Date

Airline

First Destination:

Flight No.

Scheduled Departure Time

GREATER PITTSBURGH AIRPORT INFLIGHT QUESTIONNAIRE

Dear Traveller

Will you take just
5 minutes

to complete this questionnaire ?

The Allegheny County Department of Aviation is planning a new air terminal at the Greater Pittsburgh Airport. The information you provide in this survey will help us in the design of this terminal and also aid in improving air service from Pittsburgh.

The information you provide on the questionnaire will remain confidential. Only statistical summaries of data will be published. Please DO NOT sign your name. Your flight attendant will collect the completed questionnaires.

Thank you for your cooperation.

Sincerely,
Martin J. Griffin
Director, Allegheny County
Department of Aviation

For Office Use Only

Airline _____ []
Flight No. _____ [][][][]
Date _____ Day of Week _____ []
Scheduled Departure Time _____ [][][][]

For Office Use Only

SECTION A FOR ALL PASSENGERS

1. What Class Ticket Do You Hold For This Flight?
 First Class (1)
 Coach or Tourist (2)
 Airline Employee (3) []

2. What Was Or Is Your Principal Reason For Making This Trip?
 If you are returning from a flight to Pittsburgh, give the reason for coming to Pittsburgh:
 Business (1)
 Attend a convention (2)
 Vacation (3)
 Visit friends or relatives (4)
 Transfer from another flight (5)
 Other (6) Please specify: _____ []

3. At What City Did You Board This Airplane?
 Pittsburgh (1)
 Other (2) _____ Name of City _____ [][][]

4. To What City Are You Flying?
 If you plan to transfer to another flight at the end of this one, enter the destination of the second flight:
 _____ Name of City _____ [][][]

5. What Is Your Home Address?
 Street Address: _____ (City, Borough, Township) _____
 State: _____ Zip Code: _____ [][][][][]

SECTION B FOR PASSENGERS WHO BOARDED THIS AIRPLANE IN PITTSBURGH ONLY (Passengers who did not board this plane in Pittsburgh please skip to Section C.)

6. How Many Pieces Of Luggage Did You Check In With The Airline? []

7. How Did You Get To The Pittsburgh Airport?
 Go to question 8: Private Auto (Driver) (1)
 Private Auto (Passenger) (2)
 Rented Car (3)
 Taxi (4)
 Airport Limousine (5)
 Hotel Motel Limousine (6)
 Airport Bus (7)
 Transit Bus (8)
 Another Airplane (9) Airline _____ Arriving From _____ [][][][]

For Office Use Only

8. Was The Car In Which You Arrived
 Driven to the Terminal only and not parked (1)
 Driven directly to parking (2)
 Valet parked (3)
 Driven to the Terminal and then parked (4) []

9. What Were The Total Number Of Persons Who Arrived In The Car?
 Include yourself: _____ [] []
 How Many Were Air Passengers? _____ []

10. How Long Was The Car Parked Or How Long Will It Be Parked?
 Car not parked (1)
 Less than 1 hour (2)
 1 - 2 hours (3)
 3 - 18 hours (4)
 Over 18 hours (5) []

11. Where Did Your Trip To The Pittsburgh Airport Originate?
 Your Home (1)
 Other (2) _____ Street address of location of home or building hotel, etc. _____
 City, Borough or Township: _____ State: _____ Zip Code: _____ [][][][][]

12. How Long Before The SCHEDULED Departure Time Of This Flight Did You Arrive At The Airport?
 Hours _____ Minutes _____ [] []

13. How Many Persons Accompanied You Into The Terminal Building To See You Off? []

14. What Was The Cost Of Your Trip To The Airport?
 (Rent auto passengers only)
 Less than \$1 (1)
 \$1 (2) \$4 (3)
 Over \$4 (4) []

15. When You Arrive Home After This Trip How Many Nights Will You Have Been Away From Home? [][]

For Office Use Only

SECTION C FOR ALL PASSENGERS

16. What Kind Of Work Do You Do?
 Housewife (1)
 Student (2)
 In Armed Forces (3)
 Professional, Technical (4)
 Manager, Official (5)
 Secretary, Clerk (6)
 Craftsmen, Foreman (7)
 Operator, Laborer (8)
 Farmer (9)
 Salesman (10)
 Retired (11)
 Other (12) _____ (Please Specify) _____ [][][]

17. Sex? Male (1) Female (2) []

18. Age?
 Under 12 (1)
 12 - 17 (2)
 18 - 24 (3)
 25 - 34 (4)
 35 - 44 (5)
 45 - 54 (6)
 55 - 64 (7)
 Over 65 (8) []

19. What Was Your Family's Income In 1967?
 Before taxes:
 Under \$3,000 (0)
 \$3,000 - \$6,000 (1)
 \$6,000 - \$7,000 (2)
 \$7,000 - \$10,000 (3)
 \$10,000 - \$16,000 (4)
 \$16,000 - \$20,000 (5)
 \$20,000 - \$25,000 (6)
 \$25,000 - \$30,000 (7)
 \$30,000 - \$35,000 (8)
 Over \$35,000 (9) []

Do you have any additional comments concerning the Greater Pittsburgh Airport or air service at Pittsburgh?

Office

survey. This cost includes fixed charges for survey design and planning, as well as variable costs for printing, coding, tabulating, etc. It covers the operation from design of the questionnaires to editing and processing the coded data. It does not include the cost of interpreting the data.

APPENDIX C
SAMPLE COMPLETION OF CALCULATION SHEETS

TABLE 3.2 CALCULATION SHEET FOR IDENTIFICATION OF ACCESS CONSTRAINTS

Part I: Location of Constraints

Roadway: I-95

Year: 1990

1.	Complete Parts II and III.	
2.	Enter annual airport passenger unconstrained demand (enplaned and deplaned).....	<u>11,800,000</u>
3.	Enter airport passenger capacity (Part III, Line 5).....	<u>33,500,000</u>
4.	Compute annual passenger volume (minimum of 2 and 3)	<u>11,800,000</u>
5.	Estimate annual passengers/daily two-way vehicles (default: Part II, Line 3)	<u>168</u>
6.	Compute daily two-way airport vehicles (Line 4 ÷ Line 5)	<u>70,238</u>
7.	Estimate fraction of Line 6 that uses roadway under analysis (default: Use current year figure from Part II, Line 5)	<u>.25</u>
8.	Compute two-way airport vehicles using roadway (Line 6 x Line 7)	<u>17,560</u>
9.	Estimate growth rate for non-airport traffic (this line may be omitted if data for Line 10 can be obtained from planning documents)...	<u> </u>
10.	Estimate non-airport vehicles using roadway (two-way) (from planning documents, or apply the growth rate of Line 9, above, to the base volume of Part II, Line 7).....	<u>150,780</u>
11.	Compute two-way roadway volume (Line 8 + Line 10).....	<u>168,340</u>
12.	Complete Part IV.	
13.	Enter two-way roadway capacity (Part IV, Line 8).....	<u>151,576</u>
14.	Is there an access constraint? Answer YES if and only if Line 11 is greater than Line 13)	YES

TABLE 3.3 CALCULATION SHEET FOR IDENTIFICATION OF ACCESS CONSTRAINTS

Part II: Base Year Data

Roadway: I-95

1. Annual passengers, enplaning and deplaning (MAP).....	<u>4,200,000</u>
2. Daily vehicles entering airport (two-way) ^{1/}	<u>24,970</u>
3. Annual passengers/daily vehicles ([1] ÷ [2]) ^{1/}	<u>168</u>
4. Average daily traffic (ADT) (two-way)	<u>100,338</u>
5. Fraction of airport-destined vehicles that use roadway	<u>.25</u>
6. Airport-destined vehicles using roadway ([2] x [5]).....	<u>6,242</u>
7. Non-airport vehicles using roadway ([4] - [6]).....	<u>94,096</u>

^{1/} If Line 2 is unknown, it may be estimated from Figure 3.4, or Line 3 may be estimated from Table 3.6 and Line 2 computed as [1] ÷ [3].

TABLE 3.4 CALCULATION SHEET FOR IDENTIFICATION OF ACCESS CONSTRAINTS

Part III: Airside Constrained Passenger Capacity

Year: 1990

1. Enter airside capacity in operations/year ^{1/} ..	<u>437,500</u>
2. Enter maximum percent by air carrier	<u>.75</u>
3. Estimate seats/departure (average aircraft capacity) ^{2/}	<u>146</u>
4. Estimate enplaned load factor at airport capacity (the ratio of enplaned passengers to departing seats) ^{3/}	<u>.70</u>
5. Compute maximum annual passengers (Line 1 x Line 2 x Line 3 x Line 4)	<u>33,500,000</u>

1/ Sources: Airport Capacity Manual, FAA models, airport master plans.

2/ Table 3.7 provides some historical and forecasted data at selected airports.

3/ Table 3.7 provides some historical data at selected airports. Table 3.8 provides estimates of passengers/operation at selected airports; enplaned load factors may be estimated from this and Line [2].

TABLE 3.5 CALCULATION SHEET FOR IDENTIFICATION OF ACCESS CONSTRAINTS

Part IV: Roadway Capacity

Roadway: I-95

Year: 1990

1. Enter required quality of service	
a. Level of service	<u>E</u>
b. Number of hours/year not to be exceeded	<u>200</u>
2. Estimate two-way hourly capacity at LOS of Line 1.a., per <u>Highway Capacity Manual</u>	<u>12,000</u>
3. Estimate the ratio of daily traffic flow to hourly capacity (at traffic levels resulting in the quality of service of Line 1). This is a function of the peaking characteristics of roadway volumes (default: Use nomograph of Figure 3.5).....	<u>12.5*</u>
4. Compute daily two-way capacity if airport and roadway volumes peak at the same time. (Line 2 x Line 3).....	<u>150,000</u>
5. Estimate coincident peaking factor (Airport vehicles in peak roadway hour ÷ airport vehicles in peak airport hour) (default: 0.9)	<u>.9</u>
6. Compute fraction of roadway vehicles that are airport-related (Part I, Line 8 ÷ Part I, Line 11)	<u>.1043</u>
7. Compute adjustment to capacity due to non-coincident peaking (1 + (Line 5 x Line 6) - Line 6)	<u>.9896</u>
8. Compute adjusted two-way capacity (Line 4 ÷ Line 7)	<u>151,576</u>

* Use of the nomograph gives a default of 9.6. However, because of recreational travel in Florida, the off-peak capacity of the highway is used exceedingly well, allowing higher daily flows to be realistically achieved without violating the level of service constraint.

TABLE 5.2 CALCULATION SHEET FOR ESTIMATION OF THE NET ECONOMIC BENEFIT OF ALTERNATIVE AIRPORT ACCESS IMPROVEMENTS

Part II

Alternative: 8-Lane I-95

Year: 1990

1.	Complete Part III.	
2.	Estimate reduction in vehicle-hours delay/day (Part III, Line 8 + Line 10, Column 1 - Column 2)	<u>3,367</u>
3.	Estimate average fuel use/vehicle-hour at idle (gals.) <u>1/</u>	<u>0.3</u>
4.	Compute annual savings in fuel due to delay reduction (Gals.) ([2] x [3] x 365)	<u>368,687</u>
5.	Estimate annual savings in fuel due to shift in mode split, if applicable	<u>-</u>
6.	Estimate price of fuel (\$/gal.)	<u>1.50</u>
7.	Calculate savings due to fuel use reduction (\$) (([4] + [5]) x [6])	<u>\$ 553,030</u>
8.	Enter savings in time, air passengers (Part III, Line 9) Column 1 - Column 2)	<u>58,968</u>
9.	Estimate value of time, air passenger (\$/hr.) <u>2/</u>	<u>20</u>
10.	Compute savings in time value, air passenger ([8] x [9])	<u>\$1,179,360</u>
11.	Estimate non-airport vehicle occupancy <u>3/</u> ...	<u>1.3</u>
12.	Compute savings in time, non-air passenger ([11] x 365 x Part III, Line 10, Column 1 - Column 2)	<u>1,431,092</u>
13.	Estimate value of time, non-air passenger (\$/hr.) <u>2/</u>	<u>10</u>
14.	Compute savings in time value, non-air passenger ([12] x ([3]))	<u>\$14,310,920</u>
15.	Estimate average passenger trip time (flight + terminal + access/egress) <u>4/</u>	<u>240 minutes</u>
16.	Enter decrease in access delay (Part III, Line 7, Column 1 - Column 2).....	<u>1.20</u>

TABLE 5.2 CALCULATION SHEET FOR ESTIMATION OF THE NET ECONOMIC BENEFIT OF ALTERNATIVE AIRPORT ACCESS IMPROVEMENTS

Part II Alternative: 8-Lane I-95

Year: 1990

17.	Compute fraction trip time decrease to savings in access time ([16] ÷ [15])	<u>.005</u>
18.	Estimate trip time elasticity of air travel ^{5/}	<u>-1.0</u>
19.	Compute stimulation in demand due to delay reduction in access ((1 - [17] * [18])	<u>1.0050</u>
20.	Enter forecasted annual passengers (Table 3.2, Line 2)	<u>11,800,000</u>
21.	Enter airside passenger capacity (Table 3.2, Line 3)	<u>33,500,000</u>
22.	Compute airside-constrained annual passengers (minimum of [2] and ([19] x [20])).....	<u>11,859,000</u>
23.	Estimate future year, base-case Airport/Airline/Airport-related (Airport hotels, car rentals, etc.) employment.....	<u>4,000</u>
24.	Estimate change in direct employment ([23] x ([22] - Table 3.2, Line [4]) ÷ Table 3.2, Line [4]	<u>20</u>
25.	Assume a regional economic multiplier ^{6/}	<u>1.5</u>
26.	Estimate change in regional employment ([24] x [25])	<u>30</u>
27.	Estimate dollar value of employing one person (\$/year) ^{7/}	<u>6,000</u>
28.	Compute employment benefits of alternative ([26] x [27]).....	<u>\$180,000</u>
29.	Estimate employment in construction industry generated by alternative under analysis (only in years under construction)	<u>0</u>
30.	Compute value of construction jobs ([27] x [29])	<u>0</u>
31.	Gross benefit ([7] + [10] + [14] + [28] + [30])	<u>\$16.2 million</u>

1/ If data unavailable, use 0.3.

2/ If data unavailable, use \$20.00/hr.

3/ Accuracy is not critical.

CALCULATION SHEET FOR ESTIMATION OF THE NET ECONOMIC
BENEFIT OF ALTERNATIVE AIRPORT ACCESS IMPROVEMENTS

Part II

- 4/ Default value: 4 hours.
- 5/ Default value: -1.0.
- 6/ Default value: 1.5.
- 7/ Default value: Welfare rate.
- 8/ Default value: Municipal bond index at community's rating.

TABLE 5.3 CALCULATION SHEET FOR ESTIMATION OF THE NET ECONOMIC BENEFIT OF ALTERNATIVE AIRPORT ACCESS IMPROVEMENT

Part III: Estimation of Delay

Alternative: 8-Lane I-95

Year: 1990

	Null Alternative <u>(1)</u>	Alternative to be Analyzed <u>(2)</u>
1. Enter two-roadway volume from Table 3.2, Line 11	<u>168,340</u>	<u>168,340</u>
2. Enter two-way hourly capacity at LOS E, per <u>Highway Capacity Manual</u>	<u>12,000</u>	<u>16,000</u>
3. Compute ratio of daily volume to hourly capacity (Line 1 ÷ Line 2)..	<u>14.0</u>	<u>10.5</u>
4. Estimate number of hours/year that LOS E would occur	<u>400 (1,400)</u>	<u>0 (420)*</u>
This depends on the peaking characteristics of roadway volume. (Default: multiply Line 3 by Table 3.5, Line 3. Find this product on the horizontal axis of Figure 3.5).		
5. Enter miles of roadway affected by alternative being analyzed.....	<u>5</u>	<u>5</u>
6. Enter speed limit on roadway (mph).	<u>55</u>	<u>55</u>
7. Estimate average minutes delay/vehicle (use Figure 5.3),.....	<u>1.20</u>	<u>0</u>
8. Compute annual air passenger vehicle-hours delay/day (Line 7 x Table 3.2, Line 8 ÷ 60)	<u>351</u>	<u>0</u>
9. Compute annual air passenger hours delay (Line 8 x Table 3.2, Line 5).	<u>58,968</u>	<u>0</u>
10. Compute non-airport vehicle-hours delay/day (Line 7 x Table 3.2, Line 10 ÷ 60)	<u>3,016</u>	<u>0</u>

* Default values in parentheses. See footnote on page C-4.

REFERENCES

- 1 Abt Associates, Inc., Washington-Baltimore Airport Access Survey, Volume 1: Summary Report. May 1968.
- 2 Air Transport Association, Airline Airport Demand Forecasts, Boston Report, Air Transport Association of America, January 1971.
- 3 Airborne Instruments Lab, Airport Capacity Handbook, Second Edition, DOT, FAA, SRDS, June 1969.
- 4 Airborne Instruments Lab, Capacity of Airport Systems in Metropolitan Areas--Methodology of Analysis, Clearinghouse for Federal Scientific and Technical Information, Report No. AD 623134, 1964.
- 5 "Airport User Traffic Characteristics for Ground Transportation Planning," Traffic Engineering, Vol. 46, No. 5, May 1976.
- 6 Akiyama, T., "The Airport Access Problem in Tokyo," Highway Research Record, No. 330, Highway Research Board, 1970.
- 7 Alan M. Voorhees, "Airport Access, Circulation, and Parking," Journal of the Aerospace Transport Division, ASCE, January 1966.
- 8 Alan M. Voorhees & Associates, Inc., "Air Passenger Survey Data Collection Program," Dallas Love Field Airport, June 1969.
- 9 Alan M. Voorhees & Associates, Inc., Atlanta Airport Transportation Studies, City of Atlanta, Department of Aviation, November 1968.
- 10 Alan M. Voorhees & Associates, Inc. and Crawford, Bunte, Roden, Inc., An Analysis of Airport Travel Demands--Lambert-St. Louis Municipal Airport, October 1969.
- 11 Allen, R., "Advanced Transport Systems for Airports," Airport Forum, Vol. 2, No. 4, December 1972.
- 12 Allen, W. B., "Regulatory Constraints and Impacts on Airport Landside Capacity," Airport Landside Capacity, Transportation Research Board Special Reports, No. 159, 1975.

- 13 Altshuler, E. and W.H. Lathrop, Jr., "Patronage and Revenue Estimates for the San Francisco Airport Access Project," Traffic Quarterly, Vol. 27, No. 1, January 1973.
- 14 American Automobile Association, Airport Accessibility and Urban Travel, the Linkage Between Air Travel and Urban Transportations, (Federal Aviation Administration Library), May 1970.
- 15 American Society of Civil Engineers, Committee on Research, Highway Division, "Access to Airports: Basic Policy Development Issues," Transportation Engineering Journal, V. 95, TE3, August 1969.
- 16 American Society of Civil Engineers, Committee on Transportation To and From Airports, Technical Council on Urban Transportation, "Survey of Ground Access Problems at Airports," Transportation Engineering Journal, Vol. 95, No. TE1, February 1969.
- 17 Anthony, F. L., "Improvements in Airport Access: The Ground Side," remarks before the Engineering Society of Detroit, Michigan: Detroit Metropolitan Wayne County Airport, May 21, 1969.
- 18 Apelbaum, J.A., "Airport Ground Traffic Model," Road Research, Vol. 8, No. 2, June 1978.
- 19 Arnold Thompson Associates, Inc., Master Plan Report, Reno International Airport and Reno/Stead Airport, The City of Reno, Nevada, April 1976.
- 20 Arthur D. Little, Inc., Airport Land Needs--Critical Issues in Urban Management.
- 21 Ashford, N. and P. McGinity, "Access to Airports Using High Speed Ground Modes," High Speed Ground Transportation Journal, Vol. 9, No. 1, March 1975.

- B -

- 22 Baerwald, J. E., ed., Transportation and Traffic Engineering Handbook, Institute of Traffic Engineers, 1976.
- 23 Baker, R. F. and R. M. Wilmotte, Technology and Decisions in Airport Access, Urban Transportation Research Council, American Society of Civil Engineers, 1970.

- 24 Barnum, J. W., "Importance of Airport Landside Capacity," Airport Landside Capacity, Transportation Research Board Special Reports, No. 159, 1975.
- 25 Barton-Aschman Associates, Inc., Analysis of Transit Operations--John F. Kennedy International Airport, Port of New York Authority, February 1972.
- 26 Barton-Aschman Associates, Inc., Airport Travel Survey Manual, U.S. Department of Transportation, Washington, D.C., July 1973.
- 27 Batchelder, J.H. and D.E. Ward, Intercity Transportation Effectiveness Access/Assignment Model, Peak, Marwick, Mitchell, and Co., November 1971.
- 28 Bather-Wolsfeld, Inc., Twin Cities Airport Transportation Study for Metropolitan Council, June 1, 1970.
- 29 Battelle-Columbus Laboratories, A Study of the Existing Aviation System and Its Extensions. Part E--The Ground Access Element, (NTIS), January 1972.
- 30 Battelle-Columbus Laboratories, "Airports Demand/Capacity Analysis Methods," An Addendum to the Final Report, DOT-TSC, September 20, 1974.
- 31 Baxter, R.G., Dulles International Airport Access, Consortium of Universities, No. URT-11, 1970.
- 32 Beimborn, E.A., "Terminal Access and the Choice of Intercity Modes," Transportation Engineering Journal, V. 95, TE3, August 1969.
- 33 Beinhaker, P.H., "Primer for Analysis of Airport Landside Capacity," Airport Landside Capacity, Transportation Research Board Special Report No. 159, 1975.
- 34 Bender, L.E., "Airport Surface Traffic Demands," Traffic Quarterly, Vol. 24, No. 3, July 1970.
- 35 Berge, S., "Airport Access in the Seventies," New York, 1969, 13 p. American Society of Civil Engineers. Meeting Preprint 996. Presented at ASCE Annual and Environmental Meeting, Chicago, October 13-17, 1969.
- 36 Bergmann, D.R., R.C. Lowell, R.E. Schmely, and H. Singh, "A Comparison of Automated People Mover and Accelerating Moving Walkway Costs and Effectiveness," Transportation Planning and Technology, Vol. 4, No. 2, 1978.

- 37 Biscoe, V., "Study of Service Times and Delays for Airport Parking Garage," California University, Berkeley, August 1975.
- 38 Boles, Claude E., Planning for Non-Aviation Development in the Future of Airports, unpublished Master's Thesis, Graduate Program in City Planning, Georgia Institute of Technology, 1969.
- 39 Bovy, P.H., "Ground Traffic at Major U.S. Airports," Traffic Engineering and Control, II, June 1969.
- 40 Bower, L.L., "Elasticity of Air Travel Demand with Respect to Airport Access Cost," Transportation Research, 10, June 1976.
- 41 Boyd, A.S., "Can VTOL Aircraft Solve the Airport Congestion Problem?" Vertiflite, v. 14, February 1968.
- 42 Brant, A.E., Jr., P.J. McAward, Jr., A.C. Cremer and R. D. Tilles, Simulation of Interface Systems at Airports, IEEE Conference, 1972.
- 43 Brink, M. and J.C. Orman, "Important Considerations in Airport Planning," Airport Management, Institute of Transportation and Traffic Engineering, September 1970.
- 44 Brown, D.G., "The Balance of Time and Cost," Aeronautical Journal, Vol. 79, No. 779, November 1975.
- 45 Brown, J.F., "Airport Accessibility Affects Passenger Development," ASCE Journal of the Aerospace Transport Division, 91, No. AT1, April 1965.
- 46 Brown, J.F., Air Passenger Trip Characteristics Affect Airport Accessibility Planning, AIAA Paper No. 68-1070, Landrum and Brown, October 1968.
- 47 Brown, L., et al., A Survey of Airport Access Analysis Techniques-Models, Data and a Research Program, (DOT-TSC-OST-72-17), June 1972.
- 48 Brown, K.V., "Future Airports: How Are We Going to Get 'em Out to the Field," Popular Mechanics, v. 130, August 1968.
- 49 Browne, S.D., "Comparison of Airport Access Systems," Report of Special Subjects Session Airport Operators Council International Annual Meeting and Conference, St. Louis, Missouri, October 1968.

- 50 Bruggeman, J.M. and R.D. Worrall, "Passenger Terminal Impedances," Highway Research Record, No 322, Highway Research Board, 1970.
- 51 Bruton, M.J., Introduction to Transportation Planning, Hutchinson Technical Education, 1969.
- 52 Buck, T., "Shortening the Airport Trek," Commerce, April 1968.
- 53 Buckley, James C., "The Effect of Airport Distance on Traffic Generation," Journal Air Transport Division, Prac. ASCE, May 1956.
- 54 Bureau of Aviation Planning, The New Jersey State Airport System Plan, 1975 Summary Report, New Jersey Department of Transportation, 1975.
- 55 Burke and Associates and Fromherz Engineers, Economic and Technological Feasibility of a Rapid Transit Type of Service Between New Orleans Union Passenger Terminal and the New Orleans International Airport, Supplement, UMTA (No. LA-T9-1), February 1970.
- 56 Burrows, W., "Airports: When Will the Ground Catch Up With the Sky?" Holiday, v. 46, July 1969.
- 57 Byers, R.J., C.B. Shields, and R.E. Thompson, "Improving the Efficiency of Airports," Research Outlook, Vol. 3, No. 2, 1971.

- C -

- 58 California Division of Highways, District 11 Urban Planning Department, San Diego International Airport Access Survey, June 1971.
- 59 Campbell, H.S., D.M. Landi, and A.J. Rolfe, Systems for Air Transportation Serving the New York Metropolitan Area, 1975-1980, The Rand Corporation, August 1969.
- 60 Chance, M.O., Airport Access and Ground Traffic Study Review, The Institute of Transportation and Traffic Engineering, University of California, August 1968.
- 61 City of Chicago, Department of Public Works, Bureau of Engineering, O'Hare Passenger Survey-1969, September 1970.

- 62 Claveloux, B.A., Dulles Airport Rapid Transit Study, George Washington University, 1973.
- 63 Comsis Corporation, Airport Access Study: Impact of Airport-Oriented Vehicle Trips on Highway Facilities, Federal Aviation Administration Library, July 1972.
- 64 Cook, K.E., "Mass Transit to Airports--An Overview," Highway Research Record, No. 330, Highway Research Board, 1970.
- 65 Cooper, T., D. Cuming, R. Siftar, and P. Stangas, Courses ES 251-252-Transportation, Project E, Topics on Airport Access in the Washington Metropolitan Area, 1976, George Washington University, National Science Foundation (ES-251-252-E), April 1976.
- 66 Corradino, J.C., "Airport Access-A Data Collection Methodology," Traffic Engineering, Vol. 42, No. 1, October 1971.
- 67 Corradino, J.C., "Airport Access and Circulation Systems for Airports: Problems and Solutions," Institute of Traffic Engineers, Proceedings, September 1972.
- 68 Corradino, J.C. and M.G. Ferreri, "In-Flight Origin-Destination Study at Philadelphia International Airport," Highway Research Record, Number 274, Highway Research Board, 1969.
- 69 Corradino, J.C. and C.C. Schimpeler, "Airport Access and Circulation," Airport World, Vol. 6, June 1973.
- 70 Corradino, J.C., "The Philadelphia Airport Origin-Destination Survey-A Statistical Analysis." Highway Research Record, No. 330, Highway Research Board, 1970.
- 71 Coverdale & Colpitts, Report on Logan Airport Travel Study, Bureau of Transportation Planning and Development, Massachusetts Department of Public Works, October 31, 1972.
- 72 Curry, G.L., A. DeVany, and R.M. Feldman, "A Queueing Model of Airport Passenger Departures by Taxi: Competition With a Public Transportation Mode," Transportation Research, Vol. 12, No. 2, April 1978.

- 73 Dajani, J.S. and W.J. Snyder, "Role of Helicopters in Airport Access," Transportation Engineering Journal, ASCE, Vol. 104, No. TE6, November 1978.
- 74 DeLeuw, Cather and Company of Canada Limited, Investigations of Ground Transportation Requirements-Toronto International Airport, John B. Parkin Associates, October 1967.
- 75 DeLeuw, Cather & Company, Gin Wong Associates, The Ralph M. Parsons Company, Draft Environmental Impact Assessment Report (EIAR/EIR), LAX Ground Access Study, March 1978.
- 76 DeLeuw, Cather, and Company, Gin Wong Associates, The Ralph M. Parsons Company, Survey of LAX Passengers Mode of Ground Transportation and Place of Origin and Destination, LAX Ground Access Study, June 1977.
- 77 de Neufville, R., Airport Systems Planning, Massachusetts Institute of Technology Press, 1976.
- 78 de Neufville, R. and C. King, Airport Access and Airline Fares and Frequency: Effects on Airport Traffic, American Society of Civil Engineers, 1979.
- 79 de Neufville, R., F. Koller, and R. Skinner, "A Survey of New York City Airport Limousine Service: A Demand Analysis," Highway Research Record, No. 348, Highway Research Board, 1971.
- 80 de Neufville, R. and E. Mierzejewski, "Airport Access Cost-Effectiveness Analysis," ASCE Journal of Transportation Engineering, Proceedings, Vol. 98, No. TE3, August 1972.
- 81 de Neufville, R. and E. Mierzejewski, Marketing Access Services: Baltimore-Washington Report No 1: Immediate Airport Access Study Action Improvements, Metropolitan Washington Council of Governments, 1970.
- 82 de Neufville, R., H.M. Moore, III, and J. Yaney, Optimal Use of Vehicular Systems in the Design of Airport Terminals, Civil Engineering Systems Laboratory, MIT, 1972.
- 83 de Neufville, R., "The Demand for Airport Access Services," Traffic Quarterly, Vol. 27, No. 3, October 1973.

- 84 de Neufville, R., N. Wilson, H. Moore, III, W. Gelerman, and U. Landau, U. Airport and Air Services Access, Massachusetts Institute of Technology, (NR 72-35), March 1973.
- 85 Detroit Regional Transportaton and Land-Use Study, Travel Patterns and Characteristics of Airline Passengers, Detroit Metropolitan Airport, Wayne County Road Commission, November 1969.
- 86 Dewar, R.E., J.G. Ells, and P.J. Cooper, "Evaluation of Roadway Guide Signs at a Large Airport," Transportation Engineering, Vol. 47, No. 6, June 1977.
- 87 "Direct Connecting Ramps to and from Major Terminals," Traffic Engineering, Vol. 45, No. 12, December 1975.
- 88 Drefuss and Blackford, Traffic Study of San Francisco International Airport, Final Report, San Francisco, 1966.
- 89 Dunlay, W.J., Jr., Airport Access Volumes from Airline Schedules and Employee Work Shifts, American Society of Mechanical Engineers, (DOT-OS-30093), 1976.
- 90 Dunlay, W.J., Jr., T.G. Caffery, L. Henry, and D.W. Wiersig, Survey of Ground Transportation Patterns at the Dallas/Ft. Worth Regional Airport. Part I. Description of Study, Texas University, Austin, Department of Transportation (DOT/TST-76/78), August 1975.
- 91 Dunlay, W.J., Jr. and L. Henry, Towards Estimating the Impact of the Dallas-Fort Worth Regional Airport on Ground Transportation Patterns, Texas University, Austin, (DOT-OS-30093 RM 17), September 1974.
- 92 Dunlay, W.J., Jr., "Model of Airport Employee Access Traffic," Transportation Engineering Journal, ASCE, Vol. 104, No. TE3, May 1978.
- 93 Dunlay, W.J. and D.W. Wiersig, "Airport Access Volumes from Airline Schedules," Transportation Engineering Journal, ASCE, Vol. 103, No. 1, 1976.
- E -
- 94 Eager, W.R., San Francisco International Airport Public Parking Demand, Graduate Report, University of California, Berkeley: Institute of Transportation and Traffic Engineering, 1960.

- 95 Ellis, R.H., J.C. Bennett, and P.R. Rassam, (Peat, Marwick, Mitchell & Co.), "Approaches for Improving Airport Access," Journal of Transportation Engineering, ASCE, Vol. 100, No. TE3, August 1974.
- 96 Ellis, W.W., N.C. Booker, and I.S. Fellstein, Forecast of Landside Airport Access Traffic at 211 Major U.S. Airports to 1990, Verve Research Corporation Final Report (FAA-RD-75-12) February 1976.
- 97 Engineering Foundation, N.Y. and Engineering Foundation Research Conference, Access to Airports: Basic Policy Development Issues, Summary report, University School, Milwaukee, Wisconsin, July 29-August 2, 1968.
- 98 Evans, Henry K., "Balanced Highway Airport Design," Transportation Engineering Journal, ASCE, Vol. 95, No. TE 1, Proc. Paper 6420, February 1969.

- F -

- 99 Fowler, W.K., "A Mass Transit Man Looks at the Future of Airport Access," Airport Services Management, Vol. 16, No. 2, February 1975.

- G -

- 100 Ganesan, M., Components of the "Ground Time" at San Francisco International Airport, Graduate Report, Berkeley: Institute of Transportation and Traffic Engineering, University of California, 1966.
- 101 Gardner, J.B. and L.J. Mountain, "Traffic Data Collection-An Alternate Method?," Traffic Engineering and Control, October 1978.
- 102 Gellman, A., "Conference Summary," Airport Landside Capacity, Transportation Research Board Special Report, No. 159, 1975.
- 103 Genest, B., "An Analysis of Accessibility Effects of Terminal Locations and Configurations," Massachusetts Institute of Technology, M.S. Thesis, 1970.
- 104 Gibbs and Hill, Inc., Airport Access Study: Friendship International Airport, (Massachusetts Institute of Technology), September 1970.
- 105 Goldberg, A.H., "Airport Ground Access: Traffic Management Concepts," Airport Services Management, June 1978.

- 106 Goldberg, A.H., "Tolls As An Airport Ground Traffic Management Concept," ITE Journal, November 1978.
- 107 Golob, T.F. and W.W. Recker, "Modal Choice Prediction Using Attitudinal Data: A Procedure and Some Results," Transportation, Vol. 6, No. 3, September 1977.
- 108 Goodrich, W.D. and J.R. Doll, A Value-of-Time Demand Analysis for Airport Access in San Francisco, ASME Paper 70-Tran-38, July 1970.
- 109 Gorstein, M., Airport Access Case Studies Boston-Los Angeles-Philadelphia, (DOT-TSC-FA632-WP-76-4), February 1977.
- 110 Gorstein, M., L. Frenkel, and R. Marek, Airport Ground Access, U.S. Department of Transportation, FAA, (FAA-EM-79-4), October 1978.
- 111 Graham, J.L., "Ground Access-The Key to Airport Development," Proceedings of the Workshop: Air Transportation Demand and Systems Analysis, Massachusetts Institute of Technology, August 1975.
- H -
- 112 Hamilton, Graeme D., "Citizen Participation in the Transportation Planning Process: A Review," Transportation Engineering, Vol. 47, Number 9, September 1977.
- 113 Harvey, R.C., "Airport Accessibility," The Engineer, November 19, 1965.
- 114 Havlin, F., "Stolport to Decongest New York," PATCO Journal, October 1969.
- 115 Hazard, J.L., Transportation, Management-Economics-Policy, Cornell Maritime Press, Inc., 1977.
- 116 Heathington, K.W., "Introduction," Airport Landside Capacity, Transportation Research Board Special Reports, No. 159, 1975.
- 117 Heathington, K.W. and D.H. Jones. "Identification of Levels of Service and Capacity of Airport Landside Elements," Airport Landside Capacity, Transportation Research Board Special Report No. 159, 1975.

- 118 Hendrickson, W.B., Jr., "People Moving: And This Is How Things Stand," Airport Service Management, February 1978.
- 119 Highway Research Board, Highway Capacity Manual, Special Report #87, National Academy of Sciences, 1965.
- 120 Highway Research Board, "Public Transportation to Airports," Highway Research Record, No. 330, 1970.
- 121 Hoffman, G.A., Urban Underground Highways and Parking Facilities, Memorandum RM-3680-RC, Rand Corp., August 1963.
- 122 Hole, G., "Airport Access to Heathrow Airport, London," Highway Research Record, No. 330, Highway Research Board, 1970.
- 123 Holt, P.W., "Airport Access Transportation Systems," Airport World, v. 3, March 1970.
- 124 Homburger, W.S. and W. Eager, "Automobile Parking Requirements at An Airport," Journal of Aerospace Transport Division, 90, (AT2) American Society of Civil Engineers, October 1964.
- 125 Homburger, W.S., "Ground Access to Airports," Airport Management, Selected Papers on Planning and Administration, University of California, Berkeley, September 1970.
- 126 Horonjeff, R., Planning and Design of Airports, New York: McGraw-Hill Book Co., 1962.
- 127 Human Sciences Research, Inc., A Survey of Local Origins and Destinations of Users of Washington National Airport, Human Sciences Research, Inc., February 1961.
- 128 Hurst, F., Public Parking at Port Authority Airports, Massachusetts Institute of Technology Press, 1974.

- I -

- 129 Icenogle, W., "Providing Ground Access to the Kansas City Airport," Highway Research Record, No. 330, Highway Research Board, 1970.
- 130 Institute Transport Aerien, "The Airport-Access By Air and Land," Presented at the 5th ITA Symposium, (Federal Aviation Administration Library), 1972.

- 131 ITE Technical Council Committee 6F-4, "Airport User Traffic Characteristics for Ground Transportation Planning," Traffic Engineering, Vol. 46, No. 5, May 1976.

- J -

- 132 J.E. Greiner Company, Inc., The Master Plan of Savannah Municipal Airport, Savannah, Georgia, Savannah Airport Commission, July 1969.
- 133 Jordan, R.H., Airport Location in Relation to Urban Transport, American Society of Civil Engineers Convention, October 1961.
- 134 Jordan, R.H., An Appraisal of the Problem of Location of Commercial Airports in Metropolitan Areas in Relation to Use and to Ground Access Time, Institute of Transportation and Traffic Engineering, University of California, September 1961.

- K -

- 135 Kaiser Engineers-DMJM, High Speed Ground Transportation. Documentation of Preliminary Engineering, Los Angeles International Airport and the San Fernando Valley, (NTIS), April 1972.
- 136 Kaiser Engineers, High Speed Ground Transportation Airport Access Route Study, (Air Transport Association of America Library), September 1970.
- 137 Kaiser Engineers, Transit Access to Oakland International Airport, (No. CAL-T9-9), (NTIS), October 1970.
- 138 Keefer, L.E., Urban Travel Patterns for Airports, Shopping Centers, and Industrial Plants, National Cooperative Highway Research Program Report 24, 1966.
- 139 Kerr, L.W., "Determination of O-D Zones By Means of Land-Use Data," Trip Characteristics and Traffic Assignment, Highway Research Board, 1962.
- 140 Kiernam, J., Bibliography on Air Travel and Associated Ground Transportation, Institute for Defense Analyses, June 1970.

- 141 Koeritz, K.W. and C.A. Robson, "Systems and Environmental EMC Control Program for the Airtrans Automated Ground Transportation System," IEEE Transactions on Electro-magnetic Compatibility Proceeding, 1975.
- 142 Kole, C.P., "Automated Parking System Reduces Airport Confusion and Congestion," Traffic Engineering, March 1974.
- 143 Koller, F. and R.E. Skinner, An Airport Access Demand Study, Massachusetts Institute of Technology, 1971.
- 144 Koller, F. and R. Skinner, Modal Split Models for Airport Access, Massachusetts Institute of Technology, R70-47, August 1970.
- 145 Koussios, D. and W.S. Homburger, Vehicular Traffic Patterns at an Airport in Relation to Airline Passenger Volumes, Institute of Transportation and Traffic Engineering, Research Report No. 44, University of California, Berkeley, May 1967.
- 146 Kraft, W.H. and N.E. Matheson, "Control of a High-Volume Interchange Area," Traffic Engineering, Vol. 46, No. 4, April 1976.
- 147 Kurz, T.W., "Ground Transportation to Airports," High Speed Ground Transportation Journal, Vol. 9, No. 1, April 1975.
- L -
- 148 Lampert, S. and F.T. Carroll, "Driver Response to an Airport Radio Information System," Traffic Engineering, Vol. 46, No. 10.
- 149 Landrum and Brown, Study on the Effect of Airport Accessibility on Realization of Air Passenger Potential, New York-New Jersey Metropolitan Areas, Cincinnati, Ohio, April 1961.
- 150 Landrum and Brown, Inc., "Effects of Accessibility on Traffic Volume," A Report on Airport Requirements and Sites in the Metropolitan New Jersey-New York Region, Port of New York Authority, 1966.
- 151 Landrum and Brown, Survey of Los Angeles International Airport Scheduled Air Passenger Market, Los Angeles Department of Airports, 1968.

- 152 Lardiere, S.G. and F.E. Jarema, "Impact of Projected Air Travel Demand on Airport Access," Access to Airports-4 Reports, Highway Research Record, Number 274, Highway Research Board, 1969.
- 153 Lardiere, S.G. and E.T. Herlihy, "Surface Access for Major Metropolitan Airports," Meeting Preprint 966, ASCE National Meeting on Transportation Engineering, Washington, D.C., July 21-25, 1969.
- 154 Lawler, C.A., "Trends in Automobile Parking at Airports," ASCE Proceedings, New York, 1964.
- 155 Lawrence, D.S., "Airports Again: Access or Avoidance?" Traffic Quarterly, Vol. 24, No. 1, January 1970.
- 156 Lebowitz, S., "Horizontal People Movers," Design and Environment, Vol. 1, No. 2, 1970.
- 157 Leder, W.H., "An Analysis of the Desirability of Satellite Terminals to Improve Airport Access," (Master's Thesis, Massachusetts Institute of Technology), February 1970.
- 158 Lewis, R., "Compatible Land Use Planning for the Airport and Its Neighbors," unpublished notes utilized in FAA Academy Course A-110, Airport Systems Planning, October 1967.
- 159 Lisco, T.E., "Airport Access: Driving Times Between O'Hare Airport and Downtown Chicago," CATS Research News, Sept.-Oct. 1963.
- 160 Los Angeles Department of Airports, Automobile Parking for Los Angeles International Airport, Los Angeles, California, 1963.
- 161 Los Angeles Department of Airports, High Speed Ground Access Study, Los Angeles International Airport, (DOT-UT-312), April 1972.
- 162 Lyles, R.W., "Modal Split Model Considering Carpool Mode," Transportation Engineering Journal, Vol. 105, No. TE2, March 1979.
- M -
- 163 Massachusetts Bay Transit Authority and Massachusetts Port Authority, A Study of Improved High-Speed Public Transportation Between Logan International Airport and Downtown Boston, Massachusetts Bay Transit Authority and Massachusetts Port Authority, December 18, 1969.

- 164 Massachusetts Department of Public Works, Inventory of Service Facilities and Highway Access for Massachusetts Airports, UMTA (No. MASS-T9-7), May 1970.
- 165 Massport Master Plan Study Team, Logan Airport Master Plan Study, Massachusetts Port Authority, September 1975.
- 166 Maxwell, W.W. and E.L. Rockwell, "Rail Access to Major Airports," Institution of Civil Engineers Proceeding, ASCE, 1976.
- 167 Mayer, A.J. and R.B. Smack, "The Continuing Traffic Study: Methods of Keeping O-D Data Up to Date," Traffic Origin-and-Destination Studies, Appraisal of Methods, Bulletin 253, Highway Research Board, 1960.
- 168 Mayer, A.J. and J.L. Wallace, "A New Method of Obtaining Origin and Destination Data," Trip Characteristics and Traffic Assignment, Highway Research Board, 1962.
- 169 McCabe, L. and T.F. Carberry, The Application of Simulation Methods to Intra-Airport Landside Problems, Transportation Systems Center, Federal Aviation Administration, (FAA RD-75-169, TSC-FAA-75-12), September 1975.
- 170 McGinnis, N.F., The Role Ground Transportation Can Play in the Airport Site Selection Process, American Society of Mechanical Engineers Paper 73-ICT-70, September 1973.
- 171 McKenna, D., "The Rail Contribution," Airports for the Future, Institution of Civil Engineers Proceedings, London, April 1967.
- 172 Mennie, D., "People Movers," IEEE Spectrum, Vol. 13, No. 7, July 1976.
- 173 Metropolitan Washington Council of Governments, The Future of Washington's Airports, Technical Supplement, Vol. 2, December 1975.
- 174 Michael, R.S., "Airport Landside Capacity: Role of Management," Airport Landside Capacity, Transportation Research Board Special Reports, No. 159, 1975.
- 175 Mierzejewski, E., "Cost-Effectiveness Analysis of Alternative Airport Access Modes," S.M. Thesis presented to the Department of Civil Engineering, Massachusetts Institute of Technology, Cambridge, Mass., March 1971.

- 176 Miller, D.R., T.K. Dellaway, and W.H.T. Holden, "The Remote Airport: A Study of Access Feasibility," Transportation Engineering Journal, ASCE, Vol. 100, No. TEL, February 1974.
- 177 MITRE Corporation, FAA Report on Airport Capacity, (FAA-EM-74-5-I), January 1974.
- 178 Mo, C.Y. and J.P. Braaksma, "Effectiveness Measures for Airport Departure Curbs," Transportation Engineering Journal, September 1978.
- 179 Moore, C.A., "Access to Los Angeles International Airport-Landside Restraints," Institution of Civil Engineers Proceeding, ASCE, May 1976.
- 180 Moore, H.L., III, Forecasting Demand at Airports, Civil Engineering Thesis, Massachusetts Institute of Technology, 1973.
- 181 Muehlberger, R., "Airport Access Plans for Boston," Highway Research Board, No. 330, Highway Research Board, 1970.
- 182 Mullet, L.B. and P.T. Corcoran, "Access to Airports--Surface Links to Urban Centers," Institution of Civil Engineers Proceeding, ASCE, London 1973.
- 183 Munds, A.J., Ground Access to Major Airports in the United States: Summary of Present Characteristics and Evaluation of Future Requirements, Massachusetts Institute of Technology, January 1969.

- N -

- 184 Navin, F.P.D. and R.P. Wolsfeld, Jr., "Analysis of Air Passenger Travel in the Twin Cities Metropolitan Area," Highway Research Record, No. 369, Highway Research Board, 1971.
- 185 Negrette, A.J., Airport Accessibility in the San Francisco Bay Area, Metropolitan Transportation Commission, 1974.
- 186 Niedowski, R.S., Airport User Traffic Characteristics for Ground Transportation Planning, Institute of Transportation Engineers, 1976.

- 187 Olcott, E.S., "Ground Transportation Between City and Airport," Airport Terminal Facilities, American Society of Civil Engineers and the Airport Operators Council International Specialty Conference, 1967.
- 188 Organisation for Economic Co-Operation and Development, Air Transport Access to Urban Areas, Organization for Economic Co-Operation and Development, June 1971.
- 189 Orman, J.C., "Parking's Place in Airport Planning," Traffic Engineering, Vol. 41, No. 5, February 1971.
- 190 Osgood, F.W., The Control and Protection of Land Uses in the Vicinity of Airports, Unpublished Master's Thesis, Graduate Program in City Planning, Georgia Institute of Technology, 1960.

- 191 Palmer, R.K., "List of Information Sources for Airport Planners," Transportation Engineering Journal, ASCE, February 1972.
- 192 Park, R.E., "Airport Accessibility and Air Passengers," Journal of the Aerospace Division, Proceedings of the ASCE, Vol. 92, No. AT-2, November 1966.
- 193 Park, R.E., "Airport Accessibility and Detroit Passengers," Journal of the Aerospace Transport Division, ASCE, Vol. 92, No. AT2, November 1966.
- 194 Parsons, Brinckerhoff-Tudor-Bechtel, San Francisco Airport Access Project, (NTIS), October 1972.
- 195 Parsons, Brinckerhoff-Tudor-Bechtel, San Francisco Airport Access Project-Summary, (NTIS), May 1972.
- 196 Paullin, R.L., "Airport Access--A Look Ahead," American Society of Civil Engineers Proceeding, March 1975.
- 197 Paullin, R.L., The Airport/Urban Interface, (DOT-TST-75-12), July 1974.
- 198 Peat, Marwick, Mitchell & Co., Airport Access in the Baltimore-Washington Region: Immediate Action Improvement Program and Planning Guide, Metropolitan Washington Council of Governments, No. TRD-63, March 1971.

- 199 Peat, Marwick, Mitchell & Co., Airport Facility Requirements, PIA Master Plan, Port of Portland, February 10, 1978.
- 200 Peat, Marwick, Mitchell & Co., Airport System Alternatives for the Denver Metropolitan Region, Denver Regional Council of Governments, March 1974.
- 201 Peat, Marwick, Mitchell & Co. and Denver Regional Council of Governments Planning Staff, Denver Regional Airport Systems Plan, Denver Regional Council of Governments, March 1974.
- 202 Peat, Marwick, Livingston & Co., Honolulu International Airport Transfer Study, Department of Transportation, State of Hawaii, February 1970.
- 203 Peat, Marwick, Mitchell & Co. and McDonnell-Douglas Aircraft Co., Airfield Capacity and Delay Handbook (Report FAA-RD-74-124), Prepared for the U.S. FAA, 1974.
- 204 Peat, Marwick, Mitchell & Co., A Review of Ridership Projections and Financial Analyses of the Proposed High Speed Ground Access System and Intra-Airport Transit System: Los Angeles International Airport, City of Los Angeles, Department of Airports, April 1972.
- 205 Phoenix Sky Harbor International Airport, Airport Master Plan Study-Report No. III: Airline Passenger-Vehicular Traffic Survey, City of Phoenix, Arizona, December 1970.
- 206 Port of New York Authority, Central Planning Division, "Kennedy Airport Access Project: Travel Time and Cost Study," New York, September 1968.
- 207 Port Authority of New York and New Jersey/Aviation Economics Division, New York's Domestic Air Passengers, February 1972 Through January 1973, The Port Authority of New York and New Jersey/Aviation Economics Division, 1973.
- 208 Port Authority of New York and New Jersey, Preliminary Landside Capacity Analysis, Port Authority of New York and New Jersey, August 1977.

- 209 Puckett, H.K. and J.C. Williamson, "Houston Airport's Low Cost People Mover," Transportation Engineering Journal, ASCE, Vol. 100, No. TEL, February 1974.

- Q -

- 210 Quarmby, D., "Ground Access for Airports," The Aeronautical Journal, Vol. 82, No. 809, May 1978.

- R -

- 211 Rach, K., "Airport-Bound Motorists 'Talked In' By Radios," Better Roads, Vol. 43, No. 7, July 1973.
- 212 Ramspeck, R., "Problems of Ground Transport to Growing Air Terminals," Traffic Quarterly, July 1948.
- 213 Regional Planning Commission, Cuyahoga County, Cleveland-Hopkins Airport Access Study: Data File Editing and Preliminary Analysis; Data File Formats and Code Descriptions; Selected Tabulations, Air Passenger Study, (No. TRD-36), May 1970.
- 214 Regional Planning Commission, Cuyahoga County, Cleveland-Hopkins Airport Access Study: Survey Procedures, (UMTA), May 1970.
- 215 Regional Planning Commission, Cuyahoga County, Cleveland-Hopkins Airport Access Study-Survey Results, June 1970.
- 216 Rich, R.C., "Airport Parking Demands Bold New Concepts," Air Transport World, August 1968.
- 217 Robbins, J.B., Access to Airports: Selected References, Council of Planning Librarians, Exchange Bibliography No. 61, November 1968.
- 218 Robinson, J.P. and P.G. Nordlie, "A Survey of Local Origins and Destinations of Users of Washington National Airport," Appendix B, Airport Transportation-A Study of Transportation Means Between Airports and the Metropolitan Areas They Serve, Bureau of Research and Development of the Federal Aviation Agency, February 1961.
- 219 Robinson, W., "Employees Are Big Congestion Factor," American Aviation, November 25, 1968.
- 220 Roeseler, W.G. and W. Icenogle, "Rapid Transit Airport Service: The Kansas City Case," Traffic Quarterly, Vol. 24, No. 4, October 1970.

- 221 Roggeveen, V.J. and L.V. Hammel, "Ground Transport of People to and from the Civil Airport," Journal of the Air Transport Division, Proc. ASCE, July 1959.
- 222 Ronan, W.J., "Airport Access by Rail: The Problems and the Promise," Astronautics and Aeronautics, October 1968.
- 223 Ronan, W.J., "International Metropolitan Railways Committee-Airport to City Communications," International Union of Public Transport Technical Paper, No. 3a, 1971.
- 224 Ross, H.R., Airport Ground Access: An Overview of Current Modes, Society of Automotive Engineers, (SASI-75-1086), April 1975.
- 225 Rubin, D.L., "Aviation Systems Planning," Transportation Engineering, Vol. 47, No. 6, ASCE, June 1977.
- 226 Rubin, D.L., Planning An Airport in a Competitive Environment, 1975.
- 227 Russell, A.F.D., "Motor Vehicles at European Airports," Traffic Engineering and Control, in 3 parts, July, August, September 1969.
- S -
- 228 Saunders, A.H., "Coordination of Airport and Road Transport Facilities to Expedite Intermodal Movement," International Road Federation, Road Seminar, 1969.
- 229 Saunders, L., The Value of Time for Air Travellers on the Land Feeder Journey to an Airport, R&D Report No. 13, Reading University, England, January 1972.
- 230 Schimpeler-Corradino Associates, Ground Access at Standiford Field, Louisville and Jefferson County Air Board, October 1973.
- 231 Shanahan, R.J., "German Ground Handling Studies," from the proceedings of a Conference on Airports of the Future, April 1967.
- 232 Sheppard, W.V., "Airport Access Planning in California," Traffic Engineering and Control, Vol. 17, May 1976.
- 233 Sherman, L., Airport Access-A Case Study Approach, Massachusetts Institute of Technology, 1971.

- 234 Shields, C.B. and H.W. Lindell, Performance Standards for Intra-Airport People-Moving Systems, Society of Automotive Engineers, April 1970.
- 235 Sibert, E.G., "The Role of Local Planning Authorities in Relation to the Siting and Development of Airports," Airports for the 80's. Proceedings of the 4th World Airports Conference, London, England, April 1973.
- 236 Silence, S.M., "A Preliminary Look at Ground Access to Airports," Highway Research Record, No. 274, Highway Research Board, 1969.
- 237 Silence, S.M. and L.M. Chesshir, "Reevaluation of Ground Access to Airports," Highway Research Record, No. 439, Highway Research Board, 1973.
- 238 Sampson and Curtin, Ground Transportation to Philadelphia International Airport-Now to 1992, City of Philadelphia, July 31, 1968.
- 239 Simpson, R.W., A Review of Techniques for Estimating Airport Landside Capacity, Massachusetts Institute of Technology, 1974.
- 240 Skidmore, Owings and Merrill and Alan M. Voorhees & Associates, Inc., Massport Master Plan Study, Ground Access, Massport, August 27, 1975.
- 241 Skidmore, Owings & Merrill, "Evaluation of Airport Surface Transportation," PIA Masterplan, Port of Portland, December 9, 1977.
- 242 Skinner, R., "Access Requirements for Offshore Airports," International Conference on Offshore Technology, AIAA, 1974.
- 243 Sklar, B. and F. Coleman, Airport Access Criteria as a Basis for Locating VTOL, STOL and Conventional Airports, Transportation Engineering Conference 1968, Defining Transportation Requirements. New York, American Society of Mechanical Engineers, 1969.
- 244 Spaulding, J.J., Ground Transportation System for Bradley International Airport, Connecticut Department of Transportation (SAE 750627).
- 245 Stafford, P.H., "Economics of Parking Structures at Airports," Journal of Aerospace Transport, Vol. 92, No. ATL, ASCE, January 1966.

246 Suloway, Marshall, Ground Transportation for O'Hare Airport, (ASCE Annual Meeting), October 13-17, 1969.

- T -

247 Thaler, D., "Is There a Better Way to Get to the Airport?" Railway Age, Vol. 168, No. 4, March 1970.

248 Theodore, C.A., Airport Access Survey Methods, Volume III, U.S. Department of Transportation, November 1, 1967.

249 Theodore, C.A. and J.C. Hodder, "A New Approach for Airport Access Surveys," Transportation Science, Vol. 3, No. 4., November 1969.

250 Theriault, P.W. and G.N. Sarames, A Systems Approach to Airport Accessibility, American Institute of Aeronautics and Astronautics, Annual Meeting and Technical Display, 5th, Philadelphia, Pa., Oct. 21-24, 1968.

251 Tilles, R.D., "Airport Traffic Generation Model," Conference on Computers in C.E., American Society of Civil Engineers, June 1978.

252 Tilles, R.D., "Curb Space at Airport Terminals," Traffic Quarterly, Vol. 27, No. 3, October 1973.

253 Tippetts-Abbett-McCarthy-Stratton, Responsibility for Intermodal Coordination at Airports, International Road Federation, African Highway Conference, Addis Ababa, Ethiopia, October 1969.

254 Tippetts-Abbett-McCarthy-Stratton, Traffic and Parking Study, Seattle-Tacoma International Airport, Prepared for Port of Seattle Commission, June 1966.

255 Traffic Engineering Handbook Editorial Board, Traffic Engineering Handbook, Institute of Traffic Engineers, Washington, D.C., 1965.

256 TransPlan Incorporated, Airport Requirements and Terminal Redesign, Standiford Field Louisville, Kentucky, 1974-1985, Louisville and Jefferson County Air Board, August 1974.

257 TransPlan Incorporated and Seelye Stevenson Value & Knecht, Inc., Planning Stewart Airport Development, Metropolitan Transportation Authority, January 1973.

- 258 Transportation Research Board, Airports-Bibliography, Department of Transportation, Federal Aviation Administration, Washington, D.C. (DOT-FA76WA-3872), October 1977.
- 259 Transportation Research Board, Airport Landside Capacity, Transportation Research Board Special Report, No. 159, 1975.
- 260 Transportation Research Board, "Public Transportation to Airports," Transportation Research Record, No. 330, 1970.
- 261 Tri-State Regional Planning Commission, Highway Access To Airports, (ANV-240), April 1976.
- 262 Tri-State Transportation Commission, Improving Access to Newark Airport, February 1969.
- 263 Tri-State Regional Planning Commission, Public Policy Toward Aviation-A Regional Plan for Airport Accessibility and Efficiency, Tri-State Regional Planning Commission, November 25, 1977.
- 264 Tri-State Regional Planning Commission, Public Policy Toward Aviation-A Regional Plan for Airport Facilities and Accessibility, Tri-State Regional Planning Commission, May 1978.
- 265 Tri-State Regional Planning Commission, Public Transportation Access to Airports, Tri-State Regional Planning Commission, Interim Technical Report 4571-V240), April 1976.
- 266 TRW; DeLew, Cather & Company; Gin Wong Associates; and The Ralph M. Parsons Company, Cost-Effectiveness Report, LAX Ground Access Study, December 1977.
- 267 TRW Systems Group, High-Speed Jetport Access: Feasibility Study of a Demonstration Project in Southern Florida, Prepared for Office of High-Speed Ground Transportation, Department of Transportation, December 1969.
- U -
- 268 United States Civil Aeronautics Board, "Effect on Total Market Traffic of Changes in Quality of Service (Service Related Elasticity) in 292 One and Two Carrier Markets," Docket 22908, Exhibit BOR-2, Washington, D.C., 1970.

- 269 United States Civil Aeronautics Board, Origin-Destination Survey of Airline Passenger Traffic, Government Printing Office, Washington, D.C., Quarterly.
- 270 U.S. Department of Transportation, Federal Aviation Administration, Airport Capacity Criteria Used in Long Range Planning, U.S. DOT (AC 150/5060-3A), December 1969.
- 271 U.S. Department of Transportation, Federal Aviation Administration, Airport Capacity Used in Preparing the National Airport Plan, U.S. DOT (AC 150/5060-1A).
- 272 U.S. Department of Transportation, Airport Ground Access, U.S. Department of Transportation, FAA, Washington, D.C. (No. 95-268), April 1978.
- 273 U.S. Department of Transportation, Airport Master Plans, U.S. Department of Transportation, FAA, (AC 150/5070-6), February 1971.
- 274 U.S. Department of Transportation, Federal Aviation Administration, A Survey of Local Origins and Destinations of Users of Washington National Airport, U.S. Department of Commerce, Office of Technical Services (AD 259960).
- 275 U.S. Department of Transportation, A Report on the Dimensions of the Airport Ground Access Problem, U.S. DOT, Federal Railroad Administration, Office of High Speed Ground Transportation, May 1969.
- 276 U.S. Department of Transportation, Federal Aviation Administration, FAA Aviation Forecasts, March 1978.
- 277 U.S. Department of Transportation, Federal Aviation Administration and Airport Operators Council International, Planning the Metropolitan Airport System, U.S. DOT, FAA Airports Service, May 1970.
- 278 U.S. Department of Transportation, FAA, Planning the State Airport System, U.S. Department of Transportation, FAA, National Association of State Aviation Officials, (AC 150/5050-3A), June 1972.
- 279 U.S. Department of Transportation, Bibliography of Selected Publications for Aviation Planning in the Terminal Area, U.S. DOT (NTIS), July 1978.

- 280 U.S. Department of Transportation, Federal Highway Administration, Bureau of Public Roads, 1968 National Highway Functional Classification Study Manual, (Federal-Aid Highway Act), April 1969.
- 281 U.S. Department of Transportation, Federal Highway Administration, Airport Access: A Planning Guide, October 1971.
- 282 U.S. Department of Transportation, Federal Highway Administration, Highway Access to Airports, September 25, 1972.
- 283 U.S. Department of Transportation, Federal Highway Administration, Traffic Control Systems Handbook, U.S. Government Printing Office, Washington, D.C., June 1976.
- 284 U.S. Department of Transportation, Manual D: Airports and Other Intercity Terminals (1970-1990) U.S. DOT, FAA and Office of the Secretary, April 1971.
- 285 U.S. Department of Transportation, Office of Administrative Operations, Library Services Division, Airport Problems: Access and Traffic Congestion, Selected Readings, Bibliographic List No. 4, February 1971.
- 286 U.S. Department of Transportation, Transportation Systems Center, A Survey of Airport Access Analysis Techniques, Models, Data and A Research Program, (NTIS), June 1972.
- 287 U.S. Department of Transportation, Federal Highway Administration, Urban Transportation Planning, General Information and Introduction to System 360, March 1972.
- 288 Urban Systems Associates, Manual No. 7-The Airport Travel Survey, Prepared for the Rhode Island Department of Public Works and the Rhode Island Statewide Planning Program, October 1970.
- 289 Urban Travel Patterns for Airports, Shopping Centers, and Industrial Plants, National Cooperative Highway Research Program Report 24, Highway Research Board, National Research Council, National Academy of Sciences, National Academy of Engineering, Washington, D.C., 1966.

- V -

- 290 Vance, J.A., "Airport Access and Parking," Readings in Airport Planning, 1972.
- 291 Vogt, Sage, and Pflum, Press Memorial Airport Origin and Destination Survey: Survey Findings and Conclusions, Prepared for the Indiana State Highway Commission and the Southwestern Indiana and Kentucky Regional Council of Governments, February 1971.

- W -

- 292 Washington Metropolitan Area Transit Authority, Dulles Airport Rapid Transit Service. A Feasibility Study, NTIS, July 1971.
- 293 Watson, Peter L., The Value of Time; Behavioral Models of Modal Choice, Lexington Books, D.C. Heath and Company, Lexington, Massachusetts, 1974.
- 294 Wall, Robert F., "Ground Transportation," Journal of the Air Transport Division, Proc. ASCE, July 1959.
- 295 Weinberg, M.I., "Airplanes, Airports, and Access-Better Balance Is Needed," Astronautics and Aeronautics, April 1970.
- 296 Whitlock, E.M. and E.F. Cleary, "Planning Ground Transportation Facilities for Airports," Highway Research Record Number 274, Highway Research Board, 1969.
- 297 Whitlock, E.M., E.F. Cleary S.M. Silence, S.A. Lardiere, F.E. Jarema, J.C. Corradino, and M.G. Ferreri, Access to Airports: 4 Reports, Highway Research Record, No. 274, Highway Research Board, 1969.
- 298 Whitlock, E.M., H.M. Mirsky, and F. LaMagna, (Wilbur Smith and Associates), "Ground Transportation Planning Implications of Airline Shuttle Passengers," Transportation Research Record, No. 499, 1974.
- 299 Whitlock, E.M. and D.B. Sanders, Airport Access/Egress Systems Study, U.S. DOT, Transportation Systems Center (DOT-TSC-OST-73-32-1 and -2), September 1973.
- 300 Whitlock, E.M. and D.B. Saunders (Wilbur Smith and Associates), "Systems Analysis of Ground Transportation at Major U.S. Airports," Transportation Research Record, No. 499, 1974.

- 301 Whyte, N.J. and R.L. Alexander, "Tomorrow's Airports and the Ground Barrier," Traffic Quarterly, January 1969.
- 302 Wiggers, G.F., "Cleveland Rail Transit Airport Service," Highway Research Record, No. 330, Highway Research Board, 1970.
- 303 Wilbur Smith and Associates, Airport Access, (Scientific and Technical Aerospace Reports) June 1970.
- 304 Wilbur Smith and Associates, Analysis of Terminal Traffic, Eastern Airlines Terminal Building, John F. Kennedy International Airport, 1968.
- 305 Wilbur Smith & Associates, Ground Access and Parking Requirements, Proposed Eastern Airlines Terminal, LaGuardia Airport, 1973.
- 306 Wilbur Smith & Associates, Regional Airport Systems Study: Airport Access, Report to Association of Bay Area Governments, San Francisco, California, 1971.
- 307 Wilbur Smith and Associates, Traffic Access Study-Stapleton International Airport-Denver, Colorado, City of Denver, Colorado, October 1968.
- 308 Wilbur Smith and Associates, Traffic Study: San Francisco's International Airport, Public Utilities Commission, City and County of San Francisco, December 1967.
- 309 Wiley, J.R., V/STOLPORT Accessibility Considerations, AIAA Paper #70-1311, PONYA, N.Y., October 1970.
- 310 Williams, W.B., Airport Access Plans for Boston, American Transit Association, Rail Transit Conference, Cleveland, Ohio, May 1, 1969.
- 311 Witheford, D.K., "Airports and Accessibility," Traffic Quarterly, April 1969.
- 312 Wohl, M., "Analysis and Evaluation of the Rapid Transit Extension to Cleveland's Airport," Transportation Research Record, No. 417, (Transportation Research Board), 1972.
- 313 Wohl, M., A Not So Common View of the Ground Transportation Problem, Rand Note P-3736, November 1967.

- 314 Yaney, J.C., New York Airport Access Demand Study, Massachusetts Institute of Technology, 1972.
- 315 Yee, S., "Meeting Airport Ground Access Demands for the 1980's at Los Angeles International Airport," 1977 International Air Transportation Conference, American Society of Civil Engineers, April 1977.