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AIRPORT ACCESS/EGRESS SYSTEMS STUDY
VOLUME I: TEXT

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16. Abstract

Studies of airport activities and user characteristics at 34 high volume U.S. Airports indicate that disbursed trip origins cannot economically justify rapid transit corridor investments dedicated to airport access travel. Generally, airports have too much off-roadway parking in central terminal areas and this concentration of vehicular activities near terminal building congests internal roadways. The study proposes a number of low-capital improvement concepts to airport access/egress. These improvements are generally directed towards improving the traffic flow in the central terminal area through better flow controls, diversion of automobile traffic from the central terminal area, and changes in travel patterns. The latter can be changes in mode and/or time of travel. Three specific operational experiments are proposed to evaluate the effectiveness of the proposed concepts. The experiments are a remote parking experiment at Detroit Metropolitan Airport, bus-rail links from LaGuardia and Kennedy Airports in New York and evaluation of a garage-baggage handling system at Seattle-Tacoma Airport. Cost of implementing all these experiments is estimated to be $1.444 million. The report is presented in two volumes; the first includes airport and user characteristics and details on the execution of the operational experiments; and, the second, an appendix volume, describes supporting data and airport master plans collected in the field surveys.

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PREFACE

The Consultants gratefully acknowledge the cooperative support of the respective airport planning, administrative, operating agencies contacted throughout the prosecution of this study, and to the valuable assistance from the TSC Project Coordinator, Mr. K.H. Schaeffer.

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SUMMARY

Of the 746 airports in the United States served by commercial carriers, 20 serve 64 per cent of all commercial passenger movements. Of these 20, about 15 are plagued by ground transportation congestion and delay due to the intense concentration of both vehicle and person activity influenced by the airport and its surrounding land uses.

As an initial phase of the Airport Access/Egress Systems Study, 34 of the United States' airports projected to be serving more than 2.0 million annual enplaned passengers by 1980 were studied to ascertain the types and status of their access/egress problems.

As observed, the basic congestion problem at airports relates to the difference between the capacities of its two primary interfaces used for airport operation (ground transport versus air transport). With ground transportation systems usually constraining the capacity of the overall system, operational experiments have been designed in order to measure benefits of non-capital intensive changes in operations at three specific airports.

Basic Study Findings

Analyses of access/egress congestion at each airport, together with general knowledge of the airport's basic physical design, particular methods of passenger operation, and status of future development, lead to the following conclusions:

1. Off airport ground access/egress problems are a major constraint at only a few of the large U.S. airports;

2. Access/egress problems are more serious at those airports with surrounding major traffic generators such as recreational, industrial or commercial land-use development attracting large numbers of both employees and visitors.

3. While a number of major airports reporting ground access problems have congestion away from the airport, a greater number have internal congestion problems;

4. Airport authorities have generally concentrated physical and operational improvements within the central terminal area (CTA) and have, for the most part, declined to address off-airport access problems; leaving this to regional transportation planning agencies; and,

5. Many airport authorities have a general awareness of problems existing at their airports, but do not have detailed information to adequately quantify, and at times, identify the problem.

Four broad, yet somewhat specific, problem areas were identified:

1. Origins of air travelers presently oriented to the airports are too dispersed to economically justify rapid transit corridor investments;

2. Limited availability or use of primary or secondary access/egress routes to most airports places substantial demand upon a single road system;

3. Too much off-street parking is being provided in the CTA in relation to the capacity of the road system to serve same; and,

4. Too much vehicular activity is concentrated at or near the enplaning and deplaning curbs in the terminal areas.

Apparent remedies to these problems broadly separate into the following types of physical improvements:

- Build additional capacity in the road system;
- Redesign terminal functions and recommend changes in airport operational procedures; and/or,
- Encourage changes in travel patterns and times of travel. This can be accomplished by pricing mechanisms, changing service levels, and by marketing the off-peak service.

<u>Recommended Experiments</u>

After exploring more than 20 candidate operational experiments, ranging from basic traffic engineering techniques to construction of new facilities for implementation and further study, three specific projects emerged as most suitable.

These are:

- Remote Parking - This experiment is designed to evaluate the impact of providing a remote parking facility on alleviating traffic congestion on the airport roadway as well as its impact on present modal split patterns. Basically, the experiment will vary CTA pricing levels as well as offer a number of bus service levels from which to judge user levels.

- Coordinated Bus-Rail Connection - This experiment is designed to take advantage of an existing commuter rail system which serves two major airports. By connecting those selected rail stations to the airports with a bus system, it is believed that a significant diversion to the rail-bus mode will occur which will allow airport users an alternative method of reaching the airport faster and more efficiently.

- Baggage Handling Evaluation - This evaluation study is designed to take advantage of a new type of baggage check-in being installed at an airport. By making before and after studies of traffic flow and passenger utilization, it is anticipated that planning and design guidelines can be established for use at other airports using this system.

The remote parking experiment at Detroit Metropolitan Airport should be conducted for nine full months and will cost about $375,000. The bus-rail connection (one year) serving Kennedy Airport from Jamaica Station will cost about $440,000. If it serves La Guardia Airport from Woodside Station, it will cost about $375,000, and finally, the six-month evaluation study of an automobile baggage check-in system (ABC) at Seattle Airport will cost about $254,000.

Chapter 1

INTRODUCTION

Freedom of mobility in the United States is unmatched anywhere else in the world. Most people have a choice among several alternative transport modes as to how to travel between a given city pair and this choice is generally economically competitive with the modes in both time and cost. However, there exists wide variance in cost and time for particular types of trips, i.e., those within metropolitan areas. Here travelers often do not have a choice of mode. In fact, one of the most perplexing problems is the disparity between the fast airport-to-airport travel speeds in a modern jetliner, and the often frustratingly slow trip to and from the airport via ground transport. Only recently because of the significant increase in demand for airport use have travelers realized that an air trip is really a composite of: time in the air, time spent at the airport, and time on the ground spent between local origin and destination.

A study, conducted by the Human Services Research, Inc., indicated that for United States air travel between representative cities, between 22 and 65 per cent of the total travel time was spent on the ground access portion of the trip (Table 1).[1]

The planning process, even today, expends too much effort and detail on the line-haul air portion of the trip and too little on the modal interfaces or ground modes which could more efficiently accommodate these airport trips. Historically, most of the planning and research funds allocated by the federal government have been used in making either aircraft faster or air terminals more efficient. In fact, the trip to and from the airport has not really been directly considered as part of the metropolitan transportation planning process and instead is still often treated in a separate isolated manner.

Demand for air travel is growing rapidly. As shown in Figure 1, in 1967 the air mode was responsible for more than 60 per cent of all intercity person trips compared to motor bus, rail, and water carriers. Since 1950, air travel has grown nearly 700 per cent, and it has escalated at the expense of the above modes. Because of this, the press of people and vehicles converging upon the terminal areas of airports has caused severe congestion resulting in missed flights and substantial time delay.

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(1) A Study of Transportation Means Between Airports and the Metropolitan Areas They Serve, Human Services Research, Inc., Arlington, Virginia, February, 1961.

Table 1

DATA ON AIR AND GROUND TRAVEL TIMES
Selected U.S. Airports

BETWEEN AIRPORT MILEAGE RANGE (miles)	NUMBER OF AIRPORT PAIRS STUDIED IN EACH RANGE	AIR TRAVEL BETWEEN AIRPORTS		GROUND TRANSPORTATION TO AND FROM AIRPORTS			PER CENT OF TOTAL TRIP TIME SPENT IN GROUND TRAVEL
		Mean Distance (miles)(1)	Mean Flight Time (minutes)(2)	Mean Road Distance (miles) (3)	Mean Travel Time Maximum (minutes) (4)	Mean Travel Time Minimum (minutes) (5)	
0-250	14	178	53	23	99	55	65 - 51
251-500	15	335	83	22	98	54	54 - 39
501-1,000	12	709	119	27	116	63	49 - 35
1,001 and over	9	1,742	246	28	114	68	32 - 22

(1) The minimum air distance between each pair of airports as given by Civil Aeronautics Agency, 1956.
(2) The shortest non-stop air time between the airports as determined from the American Aviation Airline Guide, September, 1960.
(3) Synthesis of figures given by American Automobile Association (AAA) and the Airline Guide for road distances between airports and city centers for each pair of airports. The figures given are sums of the distances on each end of the trip.
(4) Maximum Ground Time: Figures published by Airline Guide on allowable time to reach the airport from the city center. It includes time to check baggage.
(5) Minimum Ground Time: Actual driving time from American Automobile Association and Port Authority of New York and New Jersey.

SOURCE: Human Services Research, Inc.

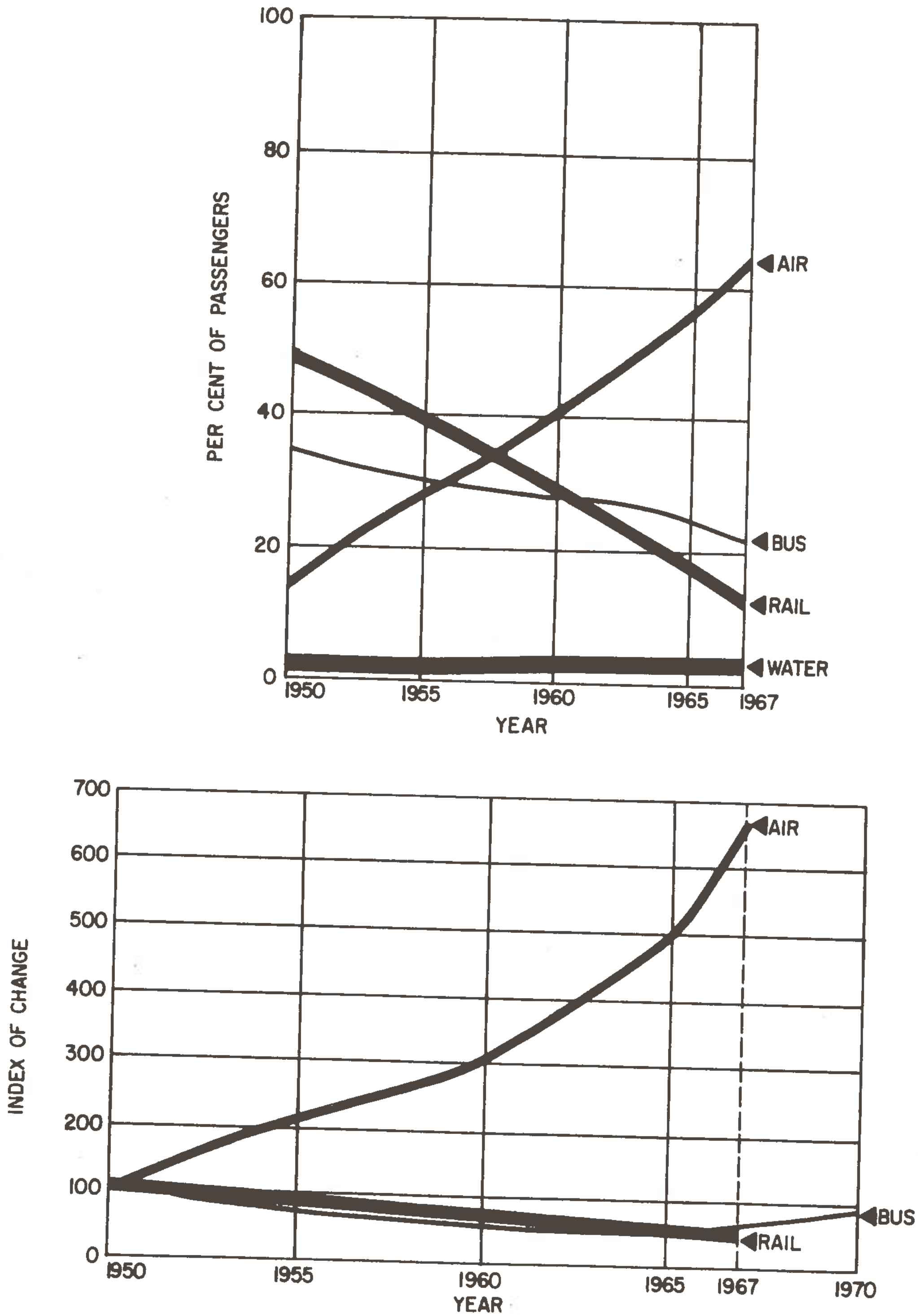
In spite of additional parking facilities, new airport designs which reduce walking distances or reduce vehicle friction by the construction of grade separated roadways, the congestion problem is becoming worse.

At major airports the number of employees often exceeds the number of employed persons in most medium sized cities. These same airports generate a demand for ground transport greater than the central business district (CBD) of a large city. Many times, the airport is the focus of the greatest concentration of person and vehicle activity within the metropolitan area.

By 1980 there will be 33 airports each serving more than 2.0 million annual enplaning passengers--a growth of 12 airports in this category over today's conditions. With larger aircraft being used and introduced, and the continuing trend toward automobile usage in approaching and leaving the air terminal, improvements in ground transport systems are imperative.

Scope of Study

A Civil Aeronautics Research and Development Study (CARD), conducted in 1971 and sponsored by the United States Department of Transportation (DOT) and the National Aeronautics Space Administration (NASA), provided the immediate requirement for the subject study. It identified the major short and long-term



TRENDS ON INTERCITY PASSENGER TRAVEL BY PUBLIC CARRIER
Airport Access/Egress Systems Study

SOURCE: TRANSPORTATION ASSOCIATION OF AMERICA, 1970

FIGURE 1

problems facing commercial airports. These problems were determined to be (1) environmental impact, (2) feasibility for V/STOL airports and aircraft to replace certain short-haul air trips, and (3) the amount of delay and congestion caused by inadequate ground transport systems. The CARD study further recommended that a concerted national effort be made to deal with these areas more effectively and that these three problems be established as priority goals in improving airport functions.

Ground access, for purposes of this study, is defined as the means by which passengers, visitors, employees, personnel baggage, goods and mail are transported between the airport and their origin and/or primary destination. The system usually comprises:

- Regional and local highway facilities;
- Regional and local public transit facilities;
- Vehicle parking areas;
- Curb frontage at the terminal;
- Pedestrian aids linking primary airport facilities;
- Special baggage handling systems; and,
- Special cargo/freight areas and roadways.

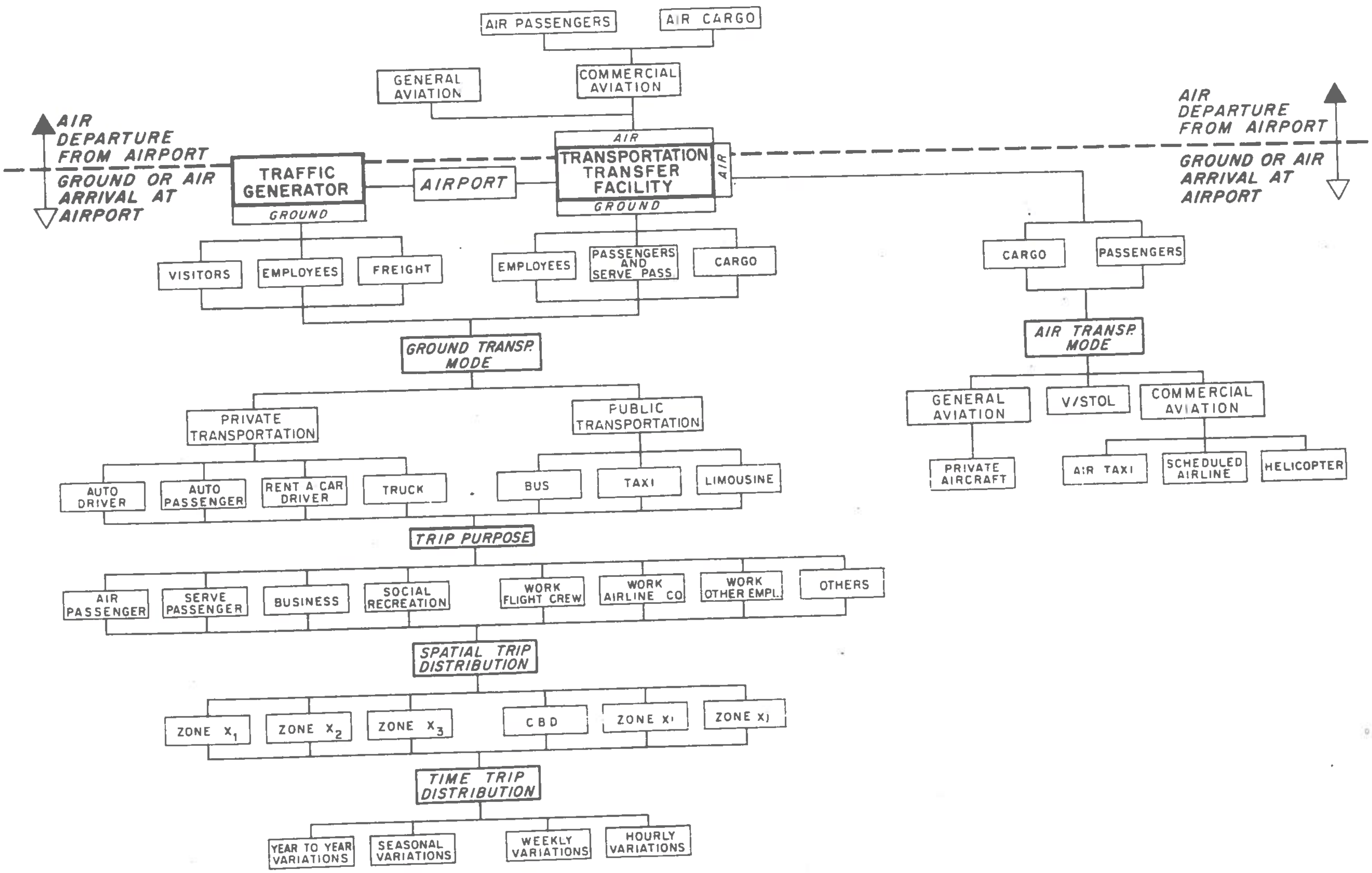
A conceptual diagram showing the relationship of the airport as the collector/distributor of person and vehicle trips to the total ground transportation network is shown in Figure 2. It portrays the important temporal, spatial, trip purpose, and modal choice relationships which impact this ground system.

As some degree of congestion and delay is inevitable in any airport, this study recognizes the normal delays associated therewith. It assumes, however, that some delay is over the above normally accepted delay and cannot be controlled by the person or object involved. The study recognizes that two types of ground delay exist: (1) fixed and (2) operational. It investigates only the operational type of delay.

A review has been made with the appropriate airport planning-operational personnel of any recent improvements and current plans of the authorities operating the major metropolitan airports in the U.S. These plans and improvements have been analyzed in light of their impact and recommendations have been made as to potential site specific operational experiments at several airports. These experiments are based on an evaluation of how well, or how much, the projects:

A. Offer relief to the current access/egress congestion;

B. Improve present ground transport travel times;



CONCEPTUAL DIAGRAM OF GROUND TRANSPORTATION TO AIRPORTS
Airport Access/Egress Systems Study

FIGURE 2

C. Are innovative with respect to existing technology and/or the existing institutional framework;

D. Can be generalized and used for other airports;

E. Require a low lead time to implement and collect data;

F. Require a minimal expenditure of funds which cannot be compensated by a revenue return; and,

G. Offers the possibility of a permanent and long-term improvement to the airport.

The Objective

The objective of this study is to obtain a clear understanding of the present character of surface transportation congestion to and from the nation's major airports. From this base, the study identifies and evaluates the type, cause, and severity of ground congestion at these airports. Recommendations for improving this situation are proposed in terms of low cost operational experiments at selected airports. These experiments are applicable to other airports, easily implemented and have the potential of having a significant impact on the particular airport studied.

This study furthermore organizes these operational experiments into three specific categories believed to affect airport access/egress systems: (1) pricing mechanisms, (2) alternative levels of service, and (3) marketing promotion.

The Approach

With spiraling costs from which to develop and construct new facilities at airports, the overall thrust of this study is to obtain knowledge of how efficiency of airport operations on the ground side of the terminal can be achieved through the present state of technology employing low cost physical improvements. At some airports this might mean reducing peak transport demand through pricing mechanisms, providing better public transit facilities via preferential bus lanes, new and better bus service, widening portions of roadways or reconstructing particularly congested interchanges. Additionally, it might reflect favorably in providing separate access for pedestrians and vehicles, processing airline passengers at remote locations, and/or limiting the air capacity of airports.

This study presents the salient facts gleaned from an extensive literature review, personal interviews with appropriate representatives at each of the major U.S. airports, and the results of a survey questionnaire which was administered and analyzed. Supplementing these data sources have been in-depth interviews with airline, airport-industry, and key federal officials.

Initially, a large number of candidate operational experiments were investigated. These were studied for potential application after analyses of the interviews and data collected in the field studies.

In reflecting on variables for evaluation and the overall technical aspects of the study, one cannot lose sight of the fact that few solutions to airport access are likely to have universal application to other similar, but different circumstances. Therefore, comparison and tentative applications of prospective solutions should be guided by study of many factors such as:

1. Number and type of trips oriented to an airport (demand for ground transportation);
2. Kind of city served;
3. Kind of airport;
4. Destinations in city or region--i.e., strong central orientation or urban sprawl;
5. Type of highway connection--i.e., single or multiple feed from more than one direction; and,
6. Potential for application of various transportation expedient measures.

By definition, the operational experiments were to be conceived in an atmosphere of awareness of:

1. Supporting fund availability;
2. ADAP program goals and objectives;
3. Impact upon airport operation of V/STOL concepts; and,
4. Impact upon airport operation of innovative public transit, baggage handling and people mover (micro-systems).

All appropriate factors in this connection were taken into account in evaluating and conceiving potential operational experiments.

Chapter 2

STUDY FINDINGS AND ANALYSES

It is difficult to make valid generalizations about each airport and airports as a whole in that each varies according to its particular size and shape, level of utilization, regional location, and normal market forces. These variables often form complex and subtle relationships which prevent clear and concise guidelines from being made.

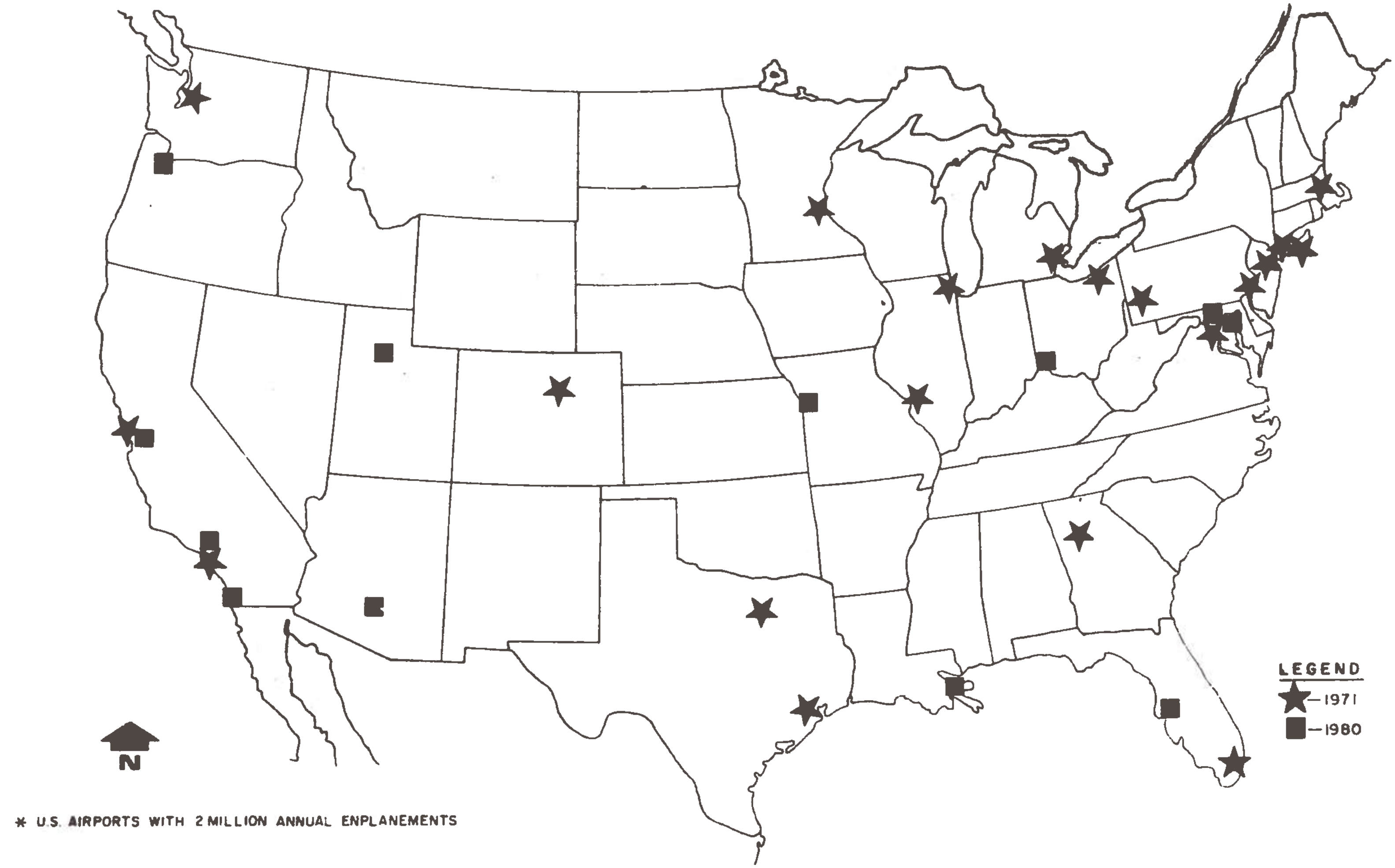
The study airports were, however, classified by size and activity using the data which were collected and analyzed. More importantly, the reasons for ground travel delay to and from the airports and their magnitude were depicted. This identification of type and intensity of travel delay permitted this study to focus on alternatives for solution.

Data Collection

Thirty-four major United States airports were studied in the course of this project (see Figure 3). A questionnaire form was designed (Appendix A) and sent to each of these airports to gather key planning information. This questionnaire specifically addressed existing and projected terminal, air, and groundside activities in and around airports. Supplementing this were discussions with local, state and federal personnel about each airport. The major conclusions from the 22 most active airports were summarized and are presented as Appendix B in addition to a general airport location map and layout plan.[(1)] The 34 airports contacted by the survey are shown below:

Chicago-O'Hare International Airport
Los Angeles International Airport
John F. Kennedy International Airport
Atlanta International Airport
San Francisco International Airport
LaGuardia Airport
Miami International Airport
Dallas-Love Field Municipal Airport
Washington National Airport
Boston-Logan International Airport
Detroit Metropolitan Wayne County Airport
Newark International Airport
Denver-Stapleton International Airport
Philadelphia International Airport
St. Louis, Lambert Field, Municipal Airport
Greater Pittsburgh International Airport
Seattle-Tacoma International Airport
Minneapolis/St. Paul International Airport
Cleveland-Hopkins Municipal Airport
Houston Intercontinental Airport
Baltimore Friendship Airport
Tampa International Airport
Greater Cincinnati Airport
New Orleans International Airport
Salt Lake City International Airport
Kansas City International Airport
Hollywood/Burbank Airport
San Diego International-Lindbergh Airport
Portland International Airport
Metropolitan Oakland International Airport

(1) Altogether 34 individual airports were examined in the course of this study and 20 of these selected for the detailed analysis. Appendix B lists 22 airports. Two of these--Kansas City and Dallas/Fort Worth--were not included in this analysis since they were not completed at the time this survey was taken.



LOCATION OF MAJOR U.S. AIRPORTS SURVEYED
Airport Access/Egress Systems Study

FIGURE 3

Phoenix Sky Harbor International Airport
Kansas City Municipal Airport
Washington Dulles International Airport
Houston-William P. Hobby Airport

Specific Elements of the Problem

Activity focused on each airport and the consequent impact these cause can be indicated in a variety of ways. Aircraft movements, passenger volumes and their temporal characteristics, physical-geometric configuration of highways, and other ground related transport, public transit utilization and/or availability, type and function of the airport, etc., all impact the airport. This section summarizes the most pertinent and significant of these parameters relating to ground access/egress to airports.

Airport Location with Respect to Demand - Airports today need more land than ever before to serve requirements dictated by larger aircraft, more travel and the new environmental planning criteria. With large quantities of land becoming scarce close to the city center, potential new airports are being forced farther into the suburbs and hinterlands outside of present metropolitan areas. Cities requiring two or more airports only magnify this problem of land availability. Recent examples of this trend are: Chicago O'Hare-Midway, Los Angeles-Palmdale, Washington, D.C.-Dulles, Friendship, and New York-LaGuardia, Kennedy, Newark, and others.

More important, however, it is the spatial location of an airport with respect to other traffic generators which can often determine the degree of congestion airports may experience on their ground facilities. Airports farthest from the city center generally have more total roadway capacity than those airports closer to the central areas. And the nearer the airport is to the city center the greater its dependence on public transit, such as limousines, buses, and rail rapid. As Brown and Jordan found in separate studies, airport accessibility is important because it can affect patronage which in turn affects the supporting infrastructure airports need.(2)(3)

The 20 major airports range in distance from 2.0 (Washington National) to 17.5 miles (Detroit Metropolitan) from their respective city centers, with 10 miles representing the average distances, as shown in Table 2.

Airline passenger orientation to center city (CBD) influences ground access planning. With high CBD orientation, the feasibility of constructing rail rapid transit or even bus corridors is enhanced. But with many airports, the CBD trips do not predominate (Table 2). The CBD orientation is only five per cent at Detroit while LaGuardia shows a much higher attraction

(2) Jordan, R., "Airport Location in Relation to Urban Transport" ASCE Journal, Aero Space Transport Division, August, 1962.
(3) Brown, J., "Airport Accessibility Affects Passenger Development," ASCE Journal, Aero Space Transport Division, August, 1965.

Table 2

PERSON ACTIVITIES AT AIRPORTS
Airport Access/Egress Systems Study

AIRPORT	1970 METROPOLITAN AREA POPULATION (000's)	CENTRAL LOCATION WITH RESPECT TO CBD	CENTRAL AREA ORIENTATION(1) (per cent)	DISTANCE TO CBD (miles)	PASSENGERS Enplaned (millions)	PASSENGERS Deplaned (millions)	PASSENGERS Total (millions)	INTER-AIRLINE TRANSFERS (per cent)	EMPLOYEES AT AIRPORTS Airlines (number of persons)	EMPLOYEES AT AIRPORTS Airport Workers (number of persons)	EMPLOYEES AT AIRPORTS Other (number of persons)	EMPLOYEES AT AIRPORTS Total (number of persons)
Chicago O'Hare	6,979	No	N.A.	16.5	14.8	15.1	29.9	50.0	14,000	2,150	1,300	17,450
Los Angeles	7,032	Yes	15	11.0	10.4	10.4	20.8	26.0	29,000	4,000	4,000	37,000
John F. Kennedy	11,529	No	47	11.5	10.1	9.1	19.2	25.0	15,000	700	7,870	23,570
Atlanta	1,390	No	24	7.5	9.0	9.1	18.1	60.0	15,000	2,500	-	17,500
San Francisco	3,110	No	25	12.0	7.1	7.1	14.2	18.0	17,400	2,975	-	20,375
LaGuardia	11,529	Yes	63	5.5	6.7	6.0	12.7	11.0	2,210	290	1,000	3,500
Miami	1,268	No	35	10.0	5.6	5.6	11.2	20.0	23,900	9,240	-	33,140
Dallas-Love Field	1,556	No	N.A.	5.8	5.5	5.7	11.2	10.0	10,420	2,020	30	12,470
Washington National	2,861	Yes	25	2.0	5.4	5.4	10.8	9.0	4,680	2,180	4,690	11,550
Boston Logan	2,754	Yes	14	2.5	4.8	4.8	9.6	14.2	7,700	310	2,010	10,020
Denver Stapleton	4,200	No	30	7.5	3.0	3.9	7.8	30.0	6,000	155	-	6,155
Detroit Wayne County	1,857	No	5	17.5	3.6	3.6	7.2	10.0	N.A.	N.A.	N.A.	6,000
Newark	11,529	Yes	61	10.5	3.3	3.2	6.5	13.0	1,640	140	1,560	3,340
Philadelphia	4,818	No	14	6.3	3.3	3.1	6.4	14.0	3,000	200	1,000	4,200
Pittsburgh	2,401	No	21	12.0	3.2	3.2	6.4	30.0	2,100	2,000	-	4,100
St. Louis-Lambert Field	2,363	No	10	12.5	3.0	3.0	6.0	35.0	N.A.	N.A.	N.A.	2,500
Minneapolis-St. Paul	1,814	No	N.A.	7.3	2.9	2.9	5.8	3.5	8,000	1,500	300	9,800
Cleveland Hopkins	2,064	No	N.A.	10.7	2.5	2.4	4.9	37.5	3,000	1,000	-	4,000
Seattle Tacoma	1,422	No	17	12.0	2.4	2.3	4.7	6.0	4,280	1,810	-	6,090
Houston	1,985	No	38	15.5	2.3	2.3	4.6	10.0	N.A.	N.A.	N.A.	4,100

(1) Central area orientation is defined as that area where most of the air travelers originate or are destined.
Note: Unless otherwise indicated, the above data was collected during 1971.
N.A. - Not Available.

63 per cent as "New York's airport". On an average, the airport-oriented trips by ground modes to the central areas is only about 20 per cent of the total.

<u>Passengers, Interairline Transfers, Visitors, and Employees</u> - Chicago, as the hub of the Midwest, generates the greatest number of total annual airport passengers, almost 30 million, while Houston Intercontinental Airport generates the least at about 4.6 million (Table 2). The total number of passengers are important since they often require ground transport services to and from the airport. Yet the intensity of interairline transfers at the airports reduces this overall need since those transferring passengers normally remain within the airport terminal complex and do not impact the highways serving the terminals. For example, Chicago and Atlanta are reported to have about 50 and 60 per cent of total passengers as interairline transfers. Minneapolis/St. Paul shows the least amount of transfers with 3.5 per cent. When the total annual passengers are adjusted for transfers, Los Angeles International depicts the greatest potential demand upon ground transport facilities with Cleveland-Hopkins the least.

Visitors also account for a great deal of airport activity This study supports that compared with each airline passenger there are between 1.0 and 1.5 airport visitors. Naturally, there is much variance within this statistic at each airport, especially considering the time of day and day of week, as well as the trip purpose of the air traveler.

Most of the largest 20 airports employ more persons than the total work force of a city of about 500,000 population (Table 2). As with visitors, each airport employs about 1.0 person for each daily air passenger using the airport. Los Angeles, Miami, Kennedy and San Francisco, for example, employ 37,000, 33,000, 24,000 and 20,000 persons, respectively.

Typically, the majority of visitors and non-interairline passenger activity occurs between 7:00-9:00 A.M. and 4:00-6:00 P.M. on weekdays. Most airports work on a three-shift basis with the day shift comprising 30 to 65 per cent of the total activity. The early evening shift comprises 20 to 50 per cent of total activity, and the late shift comprises only 10 to 20 per cent of the passenger, visitor, and employer activity. Airport employees generally arrive and depart at about the same time as other workers in non-airport related jobs and this occurs somewhat simultaneously with the demand for air travel. This peaking tends to overlap other peak hour travel causing some additional delay and congestion on regional highways.

<u>Aircraft Movements, Gates, and Cargo Operation</u> - Because air passenger movements correlate well with aircraft movements, Chicago has the greatest number of aircraft movements with Houston Intercontinental the least. General aviation activity at the 20 airports ranges from 10 to about 50 per cent of total

aviation movements, but only accounts for a fraction of the total number of passengers served by commercial flights. These figures are presented in Table 3.

The amount and location of cargo activity is significant since it can interfere with normal passenger processing if not segregated properly. Separate cargo access is provided at six airports: Chicago, Los Angeles, San Francisco, Pittsburgh, Cleveland and Houston. The magnitude of cargo operations is closely related to the market(s) served. Presently, annual cargo operations range from 835,000 tons at Kennedy to 34,000 tons at Houston Intercontinental Airport. And, it is expected air freight movements will escalate at a faster rate than air passenger activity as time goes on.

Travel Characteristics and Mode of Airport Travel - The surveyed airports are often the single most active land-use facility in the entire metropolitan area. Vehicle-miles to and from the airports reflect this comparable attraction. And, there is a tremendous local impact on the highway system at peak periods requiring a major portion of roadway capacity devoted to airport related use. This fact is accentuated as you get closer to the airport.

Discussions with airport officials revealed that air travel is highly seasonal with variations in demand occurring mainly because of business and non-business trip purposes.

Table 3

AIRCRAFT AND CARGO STATISTICS
Airport Access/Egress Systems Study

AIRPORT	AIRCRAFT MOVEMENTS (1)			NUMBER OF GATES	ANNUAL TONNAGE OF CARGO (1)	CARGO ACCESS (1)	
	Commercial	General Aviation	Total			Off-Site Cargo Staging Areas	Separate Cargo Access
Chicago O'Hare	589,300	52,100	641,400	72	720,000	No	Yes
Los Angeles	460,000	67,000	527,000	78	567,000	Yes	Yes
John F. Kennedy	302,900	38,900	341,800	124	834,700	Minimal	No
Atlanta	391,900	45,900	437,800	72	344,500	Yes	No
San Francisco	297,300	64,000	361,300	52	296,500	Yes	Yes
LaGuardia	247,700	68,900	316,600	41	43,300	No	No
Miami	234,000	108,000	342,000	82	289,500	No	No
Dallas Love Field	291,700	103,000	394,700	55	48,000	No	No
Washington National	224,300	111,100	335,400	40	90,200	No	No
Boston Logan	245,800	25,500	271,300	64	135,000	Yes	No
Denver Stapleton	184,700	158,700	343,400	35	68,700	No	No
Detroit Wayne County	193,700	78,100	271,800	49	125,100	Yes	No
Newark	143,400	44,600	188,000	32	135,000	Minimal	No
Philadelphia	215,400	76,800	292,200	39	147,000	Minimal	No
Pittsburgh	195,500	82,000	277,500	38	77,700	Yes	Yes
St. Louis Lambert Field	188,100	110,200	298,300	34	85,000	Minimal	No
Minneapolis-St. Paul	125,000	96,000	221,000	38	65,000	Yes	No
Cleveland Hopkins	128,700	83,200	211,900	40	102,100	Minimal	Yes
Seattle Tacoma	114,400	33,900	148,300	35	91,000	No	No
Houston	107,000	23,300	130,300	40	24,000	No	Yes

(1) Data collected during 1971.
N.A. - Not Available.

Variations within the week are not too significant although Saturday usually produces the least amount of air travel. Sunday is the day usually experiencing the most traffic at the airports.

Distribution of travel among private automobile, taxi, public transit, helicopter, etc., depends upon the availability, level of service, and cost of these services. Most vehicular traffic at airports consists of the private car, and this accounts for nearly 70 per cent of total passenger arrivals at most major airports (Figure 4) other than in the New York area. Buses, taxis, limousines, and trucks, typically account for 13, 10, 4, and 3 per cent of the remaining total,respectively.[4]

The three airports serving New York (Kennedy, LaGuardia, and Newark) show that automobile and taxis account for about 72 per cent of total passenger arrivals. Buses, limousines and trucks account for 15, 8, and 5 per cent of the remainder. This figure shows then that the reliance on the private vehicle is high for all airports with a slightly higher utilization of limousines and buses and more dependence on taxis in New York than elsewhere.

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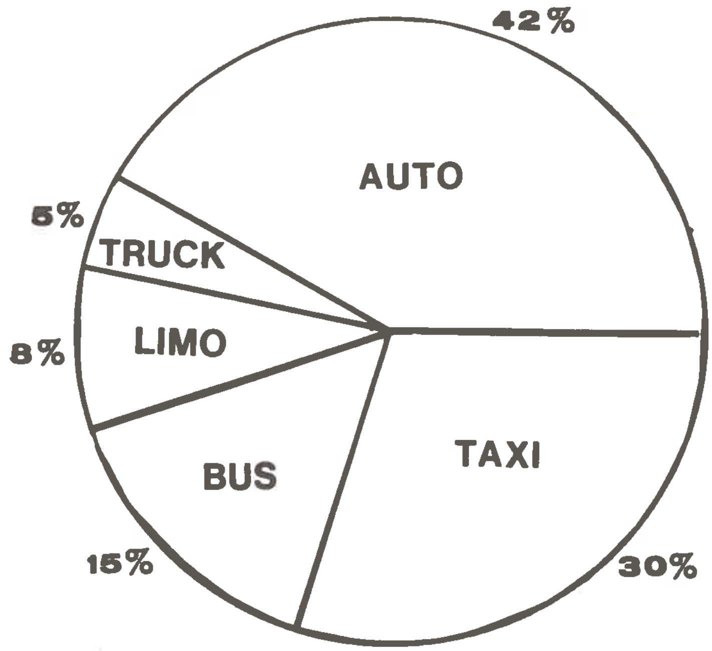
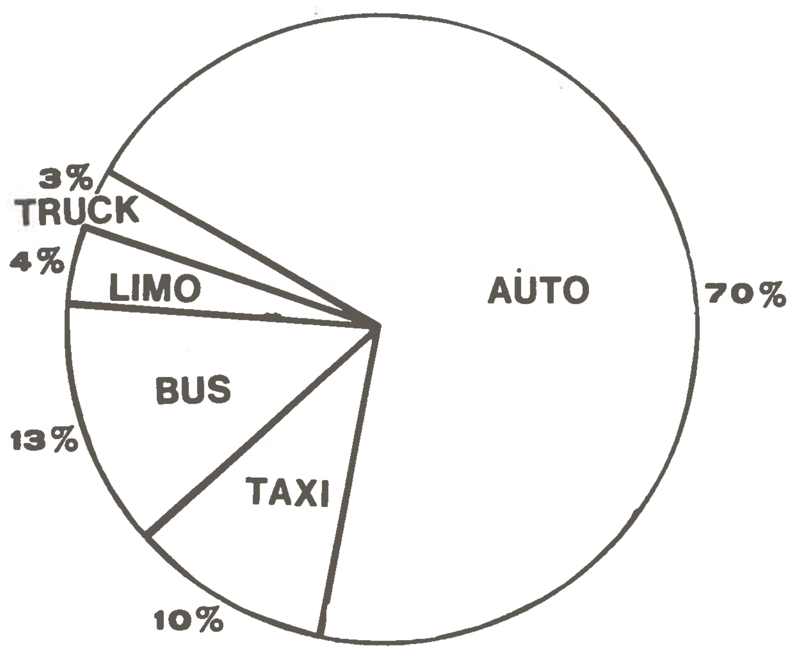
(4) Keefer noted that automobile reliance to airports is higher when all trips are considered, i.e., visitors, employees, service suppliers, freight, etc. He also found that a lower percentage of employees use the automobile than air passengers indicating a potential for diverting employees to public transit.
L. Keefer, "Urban Travel Patterns for Airports, Shopping Centers, and Industrial Parks", NCHRP Report 24, 1966.



NEW YORK AIRPORTS



OTHER TYPICAL U.S. AIRPORTS

PASSENGER ARRIVALS AT MAJOR AIRPORTS BY MODE
Airport Access/Egress Systems Study
1971

FIGURE 4

While all of the surveyed airports have public bus service, only Boston and Cleveland have a passenger carrying rail facility although more are being actively planned. Boston's rail facility does not directly serve the airport and uses a bus to shuttle passengers between the rail stations and airport terminals. The transit services provided major U.S. airports are presented in Table 4.

Only Chicago, New York, San Francisco and Los Angeles have passenger helicopter service as support to their ground transport systems. Patronage is relatively low on this mode primarily because of high costs and restricted use.

<u>External Ground Access Facilities</u> - For most of the major airports, at least one freeway or expressway directly serves primary access/egress. The total number of highway lanes at the 20 subject airports ranges from two to five and traffic volumes on these roadways vary from 20,000 to 60,000 vehicles per day at Philadelphia and Los Angeles, respectively (Table 4). The external road system serving each airport is also important since it carries much of the airport related traffic. The percentage of vehicles with trip ends at the airports using these roadways also varies widely. The normal percentage is about 30 during the day.

Vehicle congestion, however, is generally isolated at principal access interchanges to and from the airport. Other

Table 4

PUBLIC TRANSIT AND PARKING FACILITIES AT AIRPORTS
Airport Access/Egress Systems Study

AIRPORT	NUMBER OF TRANSIT LINES (1)				TYPE OF PARKING (Number of Spaces)							GROSS PARKING REVENUE ($0,000,000)	LINEAR FEET OF CURB			MULTIPLE ACCESS (2)	NUMBER OF ACCESS ROADS TO AIRPORT TERMINAL AREA (3)	SIGNIFICANT CONGESTION ON INTERNAL ROADWAYS (4)	SIGNIFICANT CONGESTION ON EXTERNAL ROADWAYS (5)
					Lot		Garage		Curb										
	Bus	Limousine	Taxi	Rail	Short Term	Long Term	Short Term	Long Term	Short Term	Long Term	Total		Enplaning	Deplaning	Total				
Chicago O'Hare	2	2	3	None	4,800	1,200	-	-	-	-	6,000	N.A.	2,550	1,850	4,400	No	1	Yes	No
Los Angeles	1	2	1	None	900	5,500	1,000	4,000	-	-	11,400	$ 7.318	3,500	3,500	7,000	Yes	2	Yes	Yes
John F. Kennedy	4	8	Many	None	6,500	5,700	-	-	-	-	12,200	N.A.	4,000	3,600	7,600	Yes	2	Yes	Yes
Atlanta	1	1	50	None	2,140	2,130	1,200	-	-	-	5,470	2.024	900	1,200	2,100	No	1	Yes	Yes
San Francisco	2	10	1	None	390	1,480	3,200	-	-	-	5,070	4.000	1,800	1,800	3,600	No	1	No	Yes
LaGuardia	3	10	Many	None	6,110	-	-	-	-	-	6,110	N.A.	1,500	900	2,400	Yes	3	Yes	Yes
Miami	1	1	Many	None	-	1,530	-	4,510	50	-	6,090	1.715	3,750	1,800	5,550	No	1	Yes	Yes
Dallas Love Field	1	2	4	None	540	7,370	-	2,200	-	-	10,110	2.739	900	900	1,800	No	1	No	No
Washington National	2	1	Many	None	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	7,300	2.004	1,300	1,200	2,500	Yes	2	Yes	Yes
Boston Logan	4	5	Many	Yes	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	8,290	4.459	500	900	1,400	Yes	2	No	Yes
Denver Stapleton	3	1	3	None	-	2,200	9,000	1,900	-	-	13,100	2.448	500	500	1,000	Yes	2	No	No
Detroit Wayne County	2	5	3	None	360	1,880	-	3,150	50	-	5,440	3.000	600	400	1,000	Yes	2	Yes	Yes
Newark	10	5	Many	None	920	5,500	-	-	-	-	6,420	N.A.	900	900	1,800	No	1	No	No
Philadelphia	1	3	2	None	740	6,090	-	-	-	-	6,830	2.902	400	1,100	1,500	No	1	Yes	Yes
Pittsburgh	1	1	1	None	650	3,000	40	-	150	-	3,840	1.234	900	1,200	2,100	Yes	2	Yes	Yes
St. Louis Lambert Field	2	3	5	None	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	5,050	2.000	800	800	1,600	No	1	Yes	Yes
Minneapolis St. Paul	1	3	-	None	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	3,700	1.250	800	800	1,600	No	1	No	No
Cleveland Hopkins	-	1	1	Yes	210	1,490	-	2,400	-	-	4,100	1.200	650	650	1,300	No	1	No	No
Seattle Tacoma	2	-	1	None	-	-	-	4,800	-	-	4,800	1.500	1,000	1,000	2,000	Yes	2	No	No
Houston	-	-	Many	None	300	3,500	N.A.	1,500	N.A.	N.A.	5,300	2.147	600	900	1,400	Yes	2	No	No

(1) Includes all transit service in the metropolitan area.
(2) Airports with more than one highway serving it.
(3) Airports served with two or more roadway facilities.
(4) Includes all highway facilities within the airport complex.
(5) Includes those highways affording access to the airport.
Note: Unless otherwise indicated, all data were collected during 1971.
N.A. - Not Available.

points of congestion occur at lane drops near the airport and in restricted areas where demand exceeds capacity like Boston's Callahan Tunnel. Maximum congestion is usually noted during the peak hours (7:00-9:00 A.M. and 4:00-6:00 P.M.).

Parking Spaces - The number of available parking spaces varies widely for each airport and is not always consistent with the magnitude of passenger activity. Chicago O'Hare, for example, the most active airport, (with most interairline transfers) has only 6,000 spaces available for public parkers.(5) In contrast, Denver-Stapleton, with a much lower air-passenger volume, provides over 13,000 parking spaces. Other airports affording substantial numbers of public parking spaces are John F. Kennedy (12,200), Los Angeles International (11,400), and Dallas-Love Field (10,100). Of the airports studied, Minneapolis-St. Paul provides the fewest number of parking spaces at 3,700. An expansion program is underway for more structured parking at Minneapolis, however.

The Federal Aviation Administration (FAA) estimated parking needs for 1980 for the largest airports. They range from 900 spaces per million annual enplaning passengers at the New York airports to 1,200 spaces at Cincinnati. The FAA estimates that 1.5 parking spaces be provided per total peak hour passengers.

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(5) A new parking garage has just opened which will increase the spaces to about 12,000.

The storage of private vehicles for short and long-term parkers is also a critical problem. When parkers cannot find a parking space, they usually recirculate or double park within the airport complex until a vacancy occurs. This reduces the effective capacity of the airports' roadways and results in delays to other vehicles.

An inventory of existing parking spaces for each of the study airports is shown in Table 4. Parking is classified as to the number of spaces located in lots, garages, and along curbs. These are further subdivided into short versus long-term parking.[6]

Parking Revenues-Charges - Revenues from parking comprise a significant and important source of income for the airports. Annual parking revenues collected for each of the subject airports during 1971 range from $1.2 million at Cleveland-Hopkins to $7.3 million at Los Angeles International.

Existing parking charges at the principal airports differ significantly between short versus long-term parking. Most airports charge approximately $0.50 per hour for short-term parking and between $1.00 and $3.00 per day for 24-hour parking. Long-term parkers are often encouraged to use remote parking lots because of lower charges. Buses and other forms of transit

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(6) Short-term and long-term parking is defined as that capacity occurring for less than three hours or more than three hours, respectively.

frequently are employed to connect the remote parking facilities with airport terminal areas. At two new major facilities (Kansas City International and Dallas/Fort Worth) remote parking is being considered with the same kind of importance as central terminal parking. Plans on providing connecting transport linkages are being actively pursued.

Curb Frontage - Many passengers are dropped off or collected at curb locations along airline terminal facilities. Where there is insufficient curb space to meet demand, queuing of vehicles results causing congestion, which can extend to the central terminal roadways. This study found that enplaning passengers require less total curb space (due to less time being spent in this maneuver) than do deplaning passengers. Enplaning passengers and their baggage are usually deposited immediately upon entering the curb location, whereas vehicles waiting to transport deplaning passengers frequently accumulate substantially longer parking times while waiting for passengers to emerge from the air terminal. Major reasons for this are time to load baggage, make telephone calls, etc. Field studies have shown that on an average enplaning passengers use the curb for about two minutes per car, contrasted with about three minutes for deplaning passengers. For other modes deplaning passengers also take longer to interface with ground transportation.

Kennedy International Airport provides the most curb space with 3,600 linear feet for deplaning and 4,000 feet for enplaning passengers. This is probably due to the 10 separate terminals on the airport. Detroit has the smallest amount of deplaning curb frontage with about 400 linear feet. The amount of enplaning and deplaning frontage provided in each airport varies with the terminal configuration. Illustrative of this, John F. Kennedy, Dallas-Love, Detroit Metropolitan Airports all have imbalances in the amount of curb frontage provided for enplaning passengers.

<u>Areas in Need of Improvement</u> - In anticipation of future air travel demands, most of the major airports are planing extensive expansion. In some cases, these plans include the complete rebuilding of terminal areas and construction of new air fields. Provisions are being made at most airports to accommodate larger aircraft. Reliable projections of aircraft movements by 1980 reflect increases of as much as 90 per cent over present conditions. Passenger projections for this same period indicate that activity at airports is expected to at least double, in many cases, within the next seven years.(7)

A priority listing of areas in need of improvement was furnished by the operating agencies at each airport. This listing provides insight as to how the various airport managers perceive their own airport problems. Problem areas identified in Table 5 by order of priority need are:

1. roadway capacity;

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(7) Federal Aviation Administration planning forecasts, 1980.

Table 5

PROJECTED AIRPORT STATISTICS AND PLANNED FACILITIES
Airport Access/Egress Systems Study

AIRPORT	AIRCRAFT MOVEMENTS (1) Commercial	General Aviation	Total	PASSENGERS (2) Enplaned (millions)	Deplaned (millions)	Total (millions)	NEW OF RELIEF AIRPORT PLANNED
Chicago O'Hare	N.A.	N.A.	N.A.	30.0	30.0	60.0	Study
Los Angeles	550,000	30,000	580,000	20.0	20.0	40.0	Yes
John F. Kennedy	230,000	60,000	290,000	17.5	17.5	35.0	Yes
Atlanta	N.A.	N.A.	664,000	20.0	20.0	40.0	Yes
San Francisco	N.A.	N.A.	382,000	15.5	15.5	31.0	No
LaGuardia	235,000	67,000	302,000	12.0	12.0	24.0	Yes
Miami	405,000	80,000	485,000	12.5	12.5	25.0	Yes
Dallas Love Field	—	210,000	210,000	—	--	—	Yes
Washington National	240,000	100,000	340,000	N.A.	N.A.	16.0	No
Boston Logan	321,000	73,000	394,000	8.3	8.3	16.6	No
Denver Stapleton	306,000	165,000	471,000	N.A.	N.A.	19.0	No
Detroit Wayne County	380,000	61,000	441,000	17.0	17.0	34.0	No
Newark	207,000	56,000	263,000	9.5	9.5	19.0	Yes
Philadelphia	230,000	170,000	400,000	7.0	7.0	14.0	No
Pittsburgh	246,000	139,000	385,000	5.8	5.8	11.6	Study
St. Louis Lambert Field	250,000	170,000	420,000	8.5	9.0	17.5	Yes
Minneapolis-St. Paul	243,000	22,000	265,000	5.4	7.6	13.0	Study
Cleveland Hopkins	138,500	131,500	270,000	5.5	5.5	11.0	Study
Seattle Tacoma	210,000	40,000	250,000	N.A.	N.A.	14.0	No
Houston	131,000	52,000	183,000	6.5	6.5	13.0	No

AIRPORT	STATUS OF RAPID TRANSIT FOR METROPOLITAN AREA: Existing or Under Construction	Under Study	Proposed	None	POTENTIAL OF RAPID TRANSIT TO SERVE THE AIRPORT BY 1980: Good	Fair	Limited
Chicago O'Hare	x	-	-	-	x	-	-
Los Angeles	-	-	x	-	-	-	x
John F. Kennedy	x	-	-	-	x	-	-
Atlanta	-	-	x	-	x	-	-
San Francisco	x	-	-	-	x	-	-
LaGuardia	x	-	-	-	x	-	-
Miami	-	-	x	-	-	x	-
Dallas Love Field	-	-	x	-	x	-	-
Washington National	x	-	-	-	x	-	-
Boston Logan	x	-	-	-	x	-	-
Denver Stapleton	-	x	-	-	-	-	x
Detroit Wayne County	-	-	x	-	-	x	-
Newark	-	x	-	-	x	-	-
Philadelphia	x	-	-	-	x	-	-
Pittsburgh	-	x	-	-	-	-	x
St. Louis Lambert Field	-	x	-	-	-	-	x
Minneapolis-St. Paul	-	-	-	x	-	-	x
Cleveland Hopkins	x	-	-	-	x	-	-
Seattle Tacoma	-	-	-	x	-	-	x
Houston	-	x	-	-	-	x	-

AIRPORT	MAJOR IMPROVEMENTS PLANNED: Roadway	Parking Space	Curb Frontage	TYPE OF CONGESTION (3): Airspace	Airfield	Baggage Claim Area	Terminal Functions	Roadway	Pedestrian	Parking
Chicago O'Hare	Yes	Yes	No	(1)	-	-	-	2	-	-
Los Angeles	Yes	Yes	Yes	4	3	-	-	(1)	2	5
John F. Kennedy	Yes	Yes	Yes	-	1	-	-	1	-	1
Atlanta	Yes	No	No	7	1	2	3	(5)	4	6
San Francisco	Yes	Yes	Yes	4	1	6	5	3	7	(2)
LaGuardia	Yes	Yes	Yes	-	1	-	-	1	-	1
Miami	Yes	Yes	Yes	6	2	(1)	4	3	5	7
Dallas Love Field	No	No	No	-	-	1	2	-	-	-
Washington National	Study	Study	Study	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Boston Logan	Yes	Yes	Yes	-	-	-	1	-	-	-
Denver Stapleton	No	No	Yes	5	6	4	7	(1)	2	3
Detroit Wayne County	Yes	Yes	Yes	1	(3)	6	4	(7)	5	(2)
Newark	Yes	Yes	Yes	1	1	1	-	1	-	1
Philadelphia	Study	Yes	Yes	-	1	1	1	1	-	1
Pittsburgh	Yes	Yes	Yes	5	3	4	6	2	7	(1)
St. Louis Lambert Field	No	Yes	Yes	-	4	2	3	(1)	-	-
Minneapolis-St. Paul	Yes	Yes	No	5	2	3	6	4	7	(1)
Cleveland Hopkins	Yes	No	No	7	6	(1)	3	2	5	4
Seattle Tacoma	No	Yes	Yes	7	6	1	3	2	5	4
Houston	Yes	Yes	Yes	7	6	1	3	2	5	4

(1) Data represents estimated 1980 aircraft movements.
(2) Data represents estimated 1980 passenger activity.
(3) Numerals denote the intensity of the problem at the Airport, the number one (1) indicating the most important problem. Duplication of any number indicates equal intensity of the problems. A number in parenthesis indicates the area of congestion that results in the most user delay. A blank space indicates that the interviewee did not consider that area a problem.

N.A. = Not Available

2. baggage handling;
3. air field capacity;
4. lack of parking;
5. air space capacity;
6. terminal functions; and
7. pedestrians.

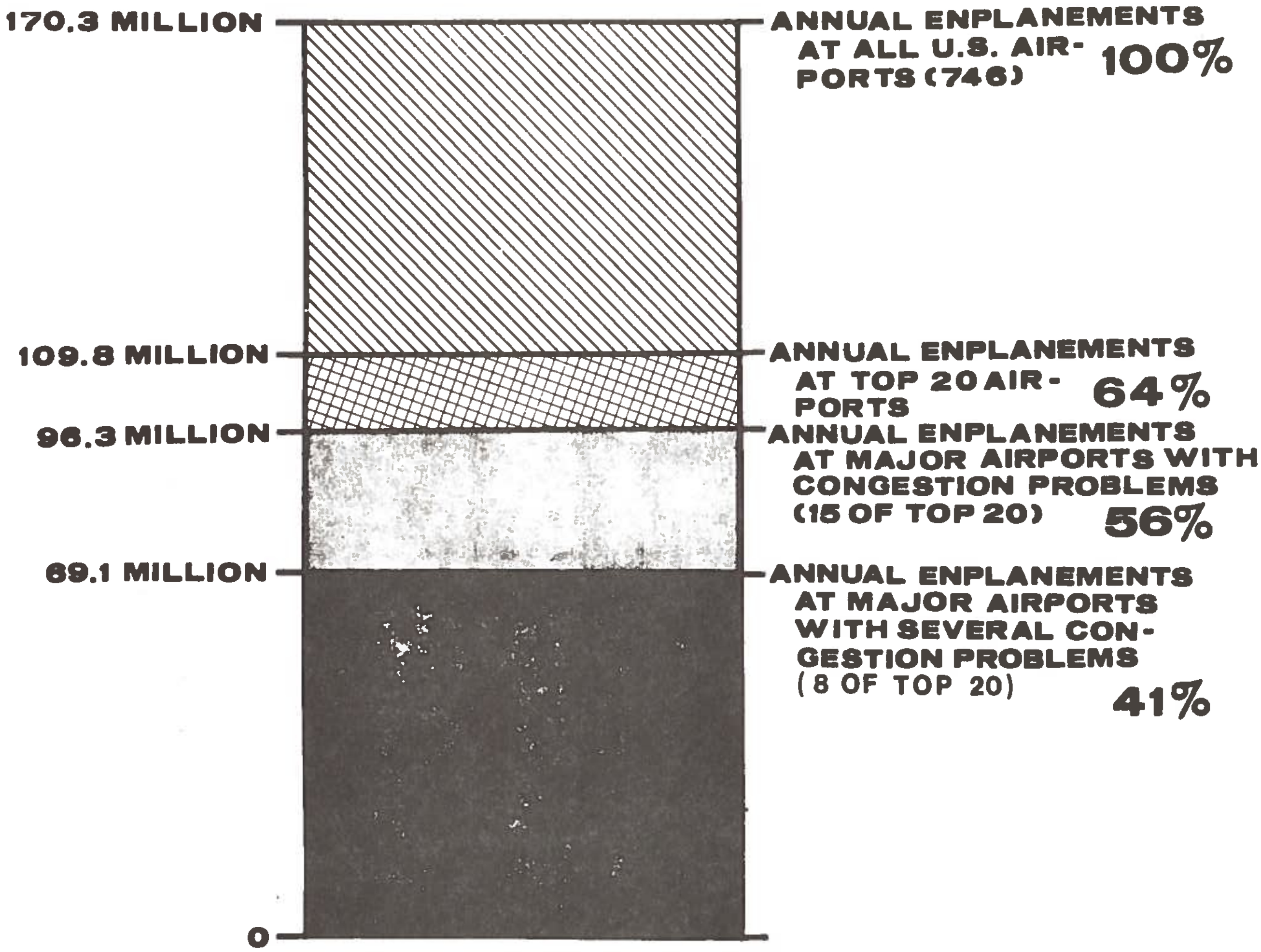
Roadway congestion appears to be the most urgent operational problem at about all of the airports. Other areas which will rank high in importance are baggage handling and lack of air space capacity.

Magnitude of the Problem

The access/egress problem at airports is apparent at about 15 of the top 20 airports (Figure 5) which serve about 56 per cent of the total annual enplaning passengers.(8) Airports which have more than one congestion problem account for 41 per cent of total enplanments.(9) With anticipated increases in the demand for air travel and the likely continued use of the automobile as the primary transport mode, ground congestion will escalate if positive steps are not taken to offset this situation.

This study found that there are five basic types of airports serving the air passenger (see Table 6). The categories

(8) Airports include Chicago, Los Angeles, Kennedy, Atlanta, San Francisco, LaGuardia, Miami, Dallas, Washington, D.C., Boston, Denver, Detroit, Newark, Philadelphia, and Pittsburgh
(9) Airports include Chicago, Los Angeles, Kennedy, Atlanta, San Francisco, LaGuardia, Miami, and Washington, D.C.



ANNUAL U.S. ENPLANEMENTS
Airport Access/Egress Systems Study
1971

FIGURE 5

Table 6

COMPARATIVE ACTIVITY AND FACILITY STATISTICS BY AIRPORT CLASSIFICATION
Airport Access/Egress Systems Study

AIRPORT	CLASSIFICATION	ANNUAL PASSENGERS millions)	PER CENT INTERLINE TRANSFERS	ANNUAL COMMERCIAL AIRCRAFT MOVEMENTS (thousands)	ANNUAL CARGO TONNAGE (thousands)	AIRPORT EMPLOYMENT	NUMBER OF COMMERCIAL GATE POSITIONS	CURB FRONTAGE (linear feet)	NUMBER OF PARKING SPACES	INBOUND ROADWAY VOLUME (vehicles per hour)
Chicago O'Hare	High Volume	18.1	25	303	344	17,450	72	2,100	5,470	1,400
Atlanta	High Interairline Transfer	to	to	to	to	to	to	to	to	to
John F. Kennedy		29.9	60	589	835	23,570	124	7,600	12,200	3,000
Los Angeles	High Volume	11.2	20	234	290	20,375	52	3,600	5,070	2,100
San Francisco	Low Interairline Transfer	to	to	to	to	to	to	to	to	to
Miami		20.8	26	460	567	37,000	82	14,000	11,400	3,000
LaGuardia										
Dallas	Medium Volume	9.6	9	224	43	3,500	40	1,400	6,110	750
Washington National	Low Interairline Transfer	to	to	to	to	to	to	to	to	to
Boston		12.7	14	296	135	12,470	64	2,400	10,110	1,850
Denver										
Pittsburgh	Low Volume	4.9	30	129	69	2,500	34	1,000	3,840	900
St. Louis	High Interairline Transfer	to	to	to	to	to	to	to	to	to
Cleveland		7.8	38	196	102	6,155	40	2,100	13,100	1,350
Detroit										
Newark										
Philadelphia	Low Volume	4.6	4	107	65	3,340	32	1,000	3,700	750
Minneapolis/St. Paul	Low Interairline Transfer	to	to	to	to	to	to	to	to	to
Seattle-Tacoma		7.2	14	215	147	9,800	49	2,000	6,930	1,600
Houston										

of airport character used to further evaluate activity characteristics are:

- High volume-~~Low~~ High transfer (Chicago O'Hare, Atlanta, Kennedy)
- High volume-Low transfer (Los Angeles, San Francisco, Miami)
- Medium volume-Low transfer (LaGuardia, Dallas, Washington National, Boston)
- Low volume-High transfer (Denver, Pittsburgh, St. Louis, Cleveland)
- Low volume-Low transfer (Detroit, Newark, Philadelphia, Minneapolis/St. Paul, Seattle, Houston Intercontinental).

Because of the amount of interairline transfer and the number of annual passengers generated, this functional classification is an index for likely ground impact. One would expect that the high volume-low transfer airports would exhibit the greatest ground congestion because they potentially exert the greatest pressure on highways and other ground facilities. They also have the highest number of employees. The Table also summarizes the ranges of annual passengers, transfer, cargo activity, employment, number of gates, curb frontage, parking spaces, and inbound vehicle volumes. The following sections examine these airports in terms of other physical attributes such as parking and modal split.

Analysis of Demand-Supply Relationships

Analytically, one part of the airport ground problem reduces to the establishment of a relationship between the demand for ground transport and the capacity of existing transportation facilities to meet this demand. This can be used to denote the extent of congestion. Therefore, an initial thrust of this study was to establish an index of demand for ground access and to relate this to existing and proposed access facilities.

To establish relative measures of the magnitude of particular congestion problems, ratios comparing activity levels to capacity indices were calculated and compared to each of the subject airports.

The demand index is a function of the number of person trips oriented to the airports on a daily basis. This relates to the level of service provided at each airport in terms of employment, frequency of airline flights, cities served, location of airport, cost of travel, and overall length (in time) of the air trips, along with other variables. After reviewing this information, the most significant planning variables were found to be numbers of visitors, employees, and passengers. From this, the "person demand index" (PDI) emerged:

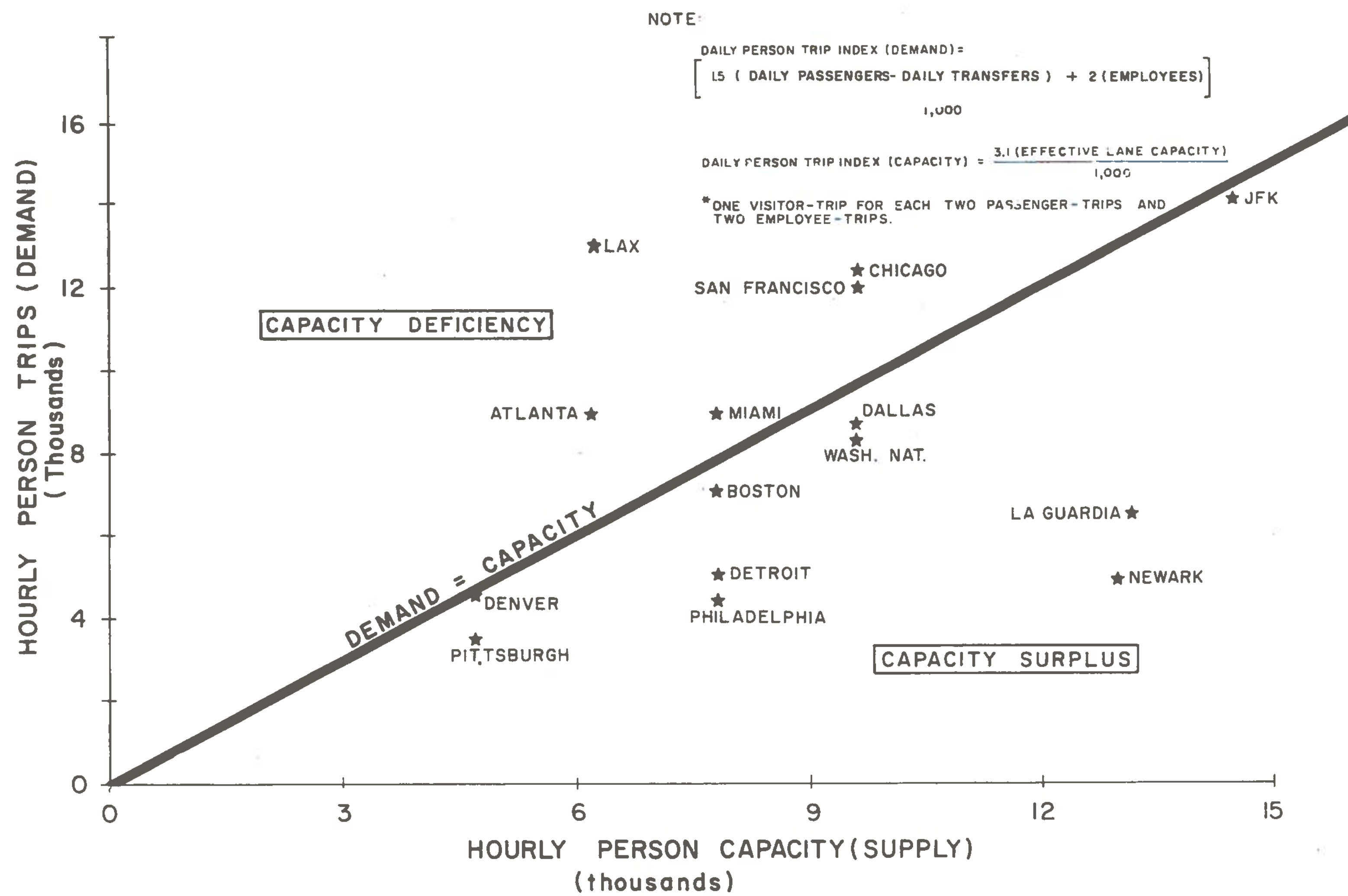
$$(1)\ \text{PDI} = \frac{\left[1.5x\ (\text{Daily Passengers} - \text{interairline transfers}) + 2x\ (\text{number of employees})\right]}{1{,}000}$$

"Supply" in this context is the amount of ground capacity available and is not a random variable. The total number of highway lanes serving each airport were counted applying some judgment where these roads did not provide a primary access facility. On a broad basis, at grade highways with traffic signals were assumed to have a capacity for moving about 500 vehicles per lane per hour. Grade separated facilities (expressways) were estimated to be capable of moving approximately 1,000 vehicles per lane per hour. From this and the fact that the average airport generates a little more than three persons per vehicle, the "person capacity index" (PCI) was developed:

$$(2)\quad PCI = \frac{3.1\ (\text{Effective Lane Capacity in vehicles per hour})}{1{,}000}$$

Figure 6 shows results of the application of these mathematical formulae. It reveals that Los Angeles has the greatest ground access problem of the United States' airports and Newark Airport being relatively uncongested due to substantial highway capacity. Indices of person supply and demand for the major airports are given:

AIRPORT	DEMAND INDEX
Los Angeles International Airport	2.00
Atlanta International Airport	1.50
Chicago-O'Hare International Airport	1.30
San Francisco International Airport	1.20
Miami International Airport	1.20
John F. Kennedy International Airport	1.00
Denver-Stapleton International Airport	1.00



DEMAND AND CAPACITY RELATIONSHIPS
Airport Access/Egress Systems Study

FIGURE 6

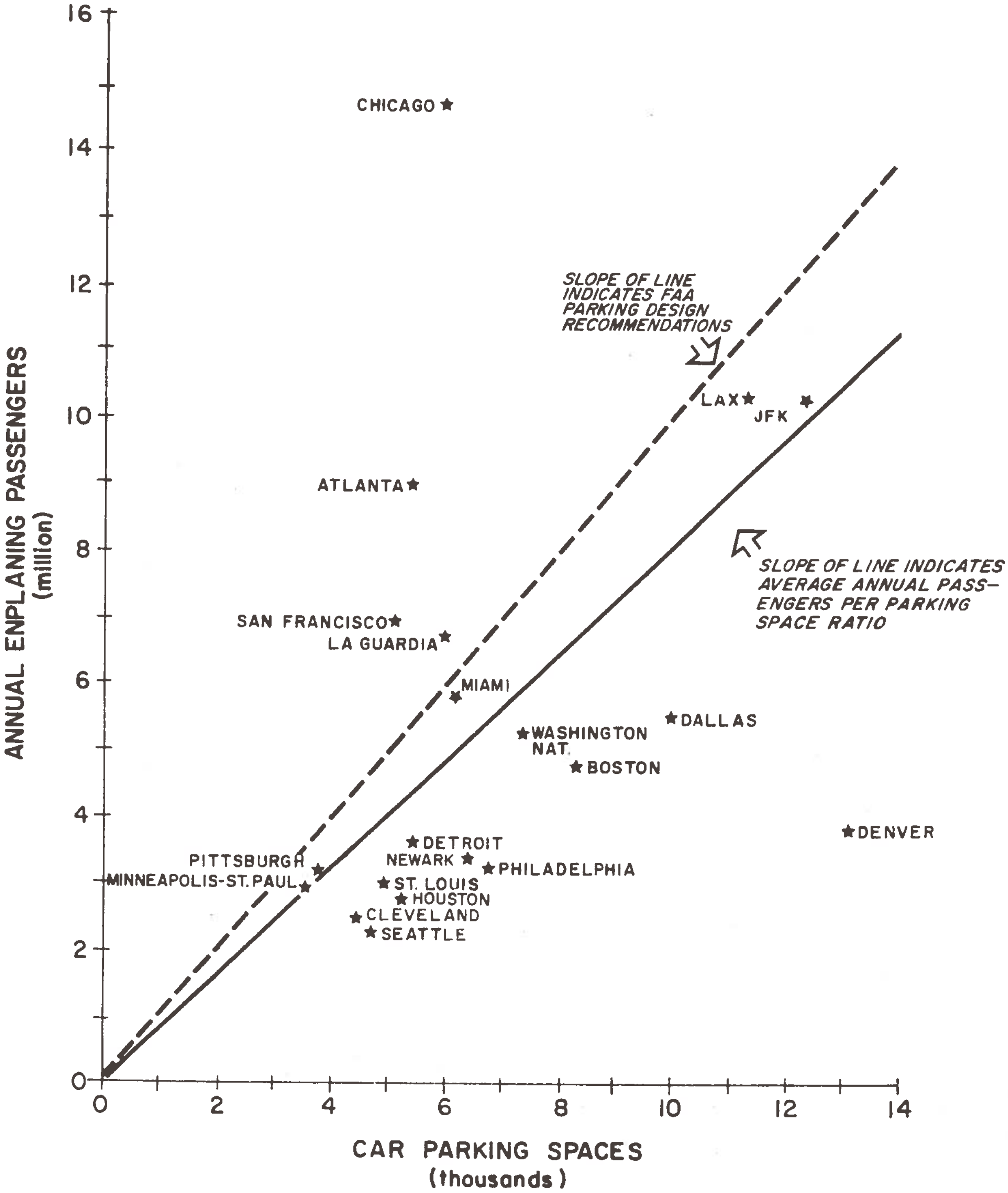
AIRPORT	DEMAND INDEX
Boston-Logan International Airport	0.94
Dallas	0.90
Washington National Airport	0.90
Greater Pittsburgh International Airport	0.70
Detroit Metropolitan Wayne County Airport	0.63
Philadelphia International Airport	0.62
LaGuardia Airport	0.48
Newark International Airport	0.38

Besides supplying enough roadway capacity to meet demand this study found other important planning relationships. Figure 7, for example, shows that airports generally provide more vehicle parking spaces than the FAA recommends for design standards. It also indicates that O'Hare, Atlanta, and San Francisco show major deficiencies in meeting this standard. Figure 8 shows the relation between effective roadway capacity and enplaning curb frontage. It reveals that the Los Angeles and Atlanta Airports, for example, both have an effective airport roadway capacity of 2,000 vehicles per hour and yet Los Angeles has about 7,000 linear feet of enplaning curb frontage compared to less than a 1,000 for Atlanta. There are terminal design considerations which relate to this. For policy considerations, limiting curb frontage may be one means of controlling vehicle use. Finally, Figures 9 and 10 show the relationships between enplaning passengers and enplaning curb frontage and between deplaning passengers and deplaning curb frontage. It shows generally that the same space is provided for both which is not consistent with the previous observations that deplaning passengers generally require more time and have more curb frontage.

Conclusions

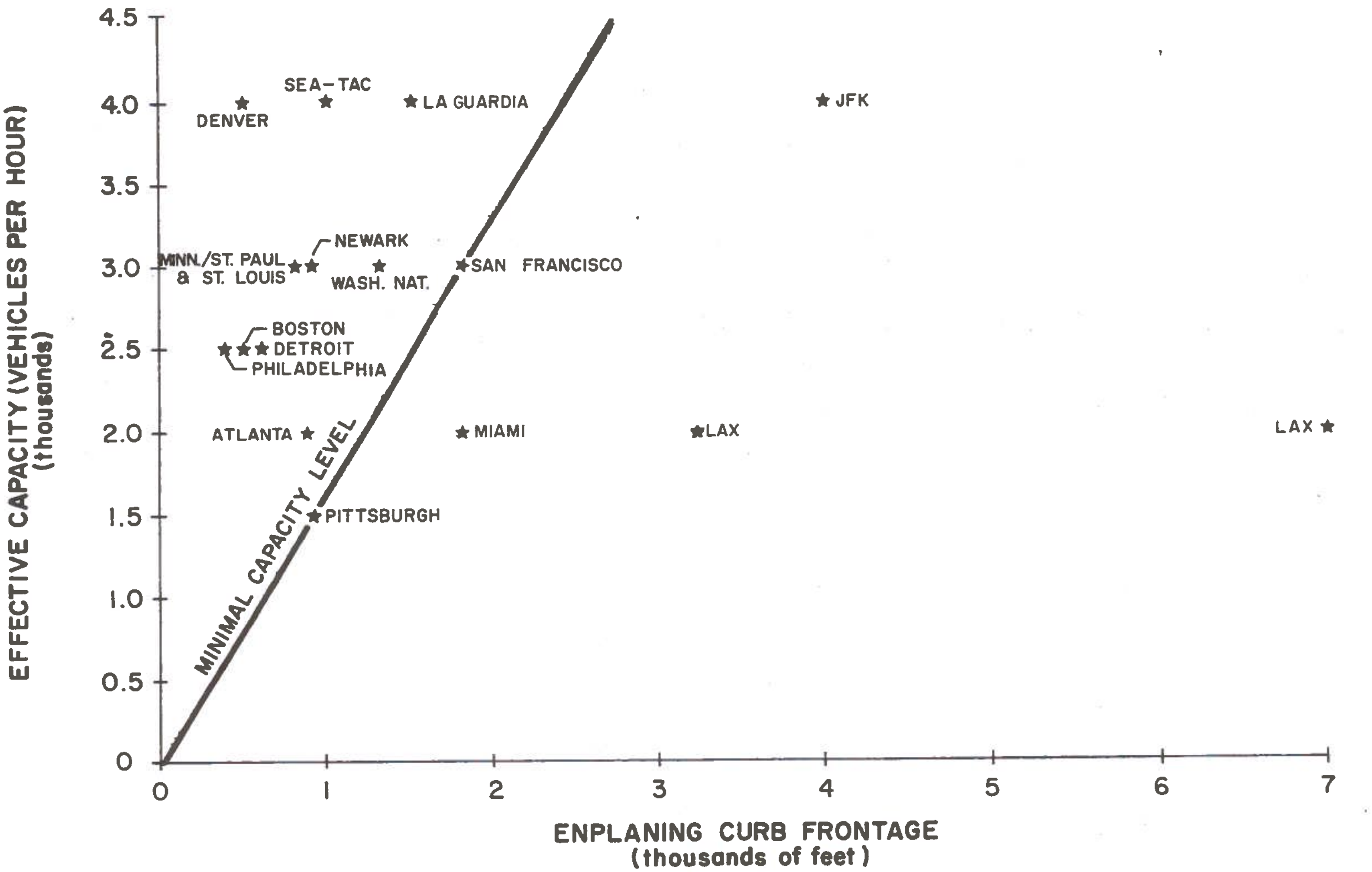
The research material and data already discussed provide insight into findings relating to passenger use of airport access/egress systems. These data present a status of problems and potential solutions concluding that:

1. There is a ground access/egress problem at most of the major airports but the problem reaches critical levels at only about 15 airports. Those airports with only one highway serving ground access needs and those which have roadways serving more than one major land use are especially critical.
2. The airport problem is generally confined to peak hours or certain holiday periods.
3. Because the access demand for airports generally peaks during the same hours as the metropolitan area traffic, and because of the mix of airport traffic to total traffic, in general it is difficult to justify the use of exclusive lanes for airport traffic.
4. The nature of the problem is one of substantial delay and inconvenience occurring on the ground between origin or local destination and air terminal. The problem is mainly limited to



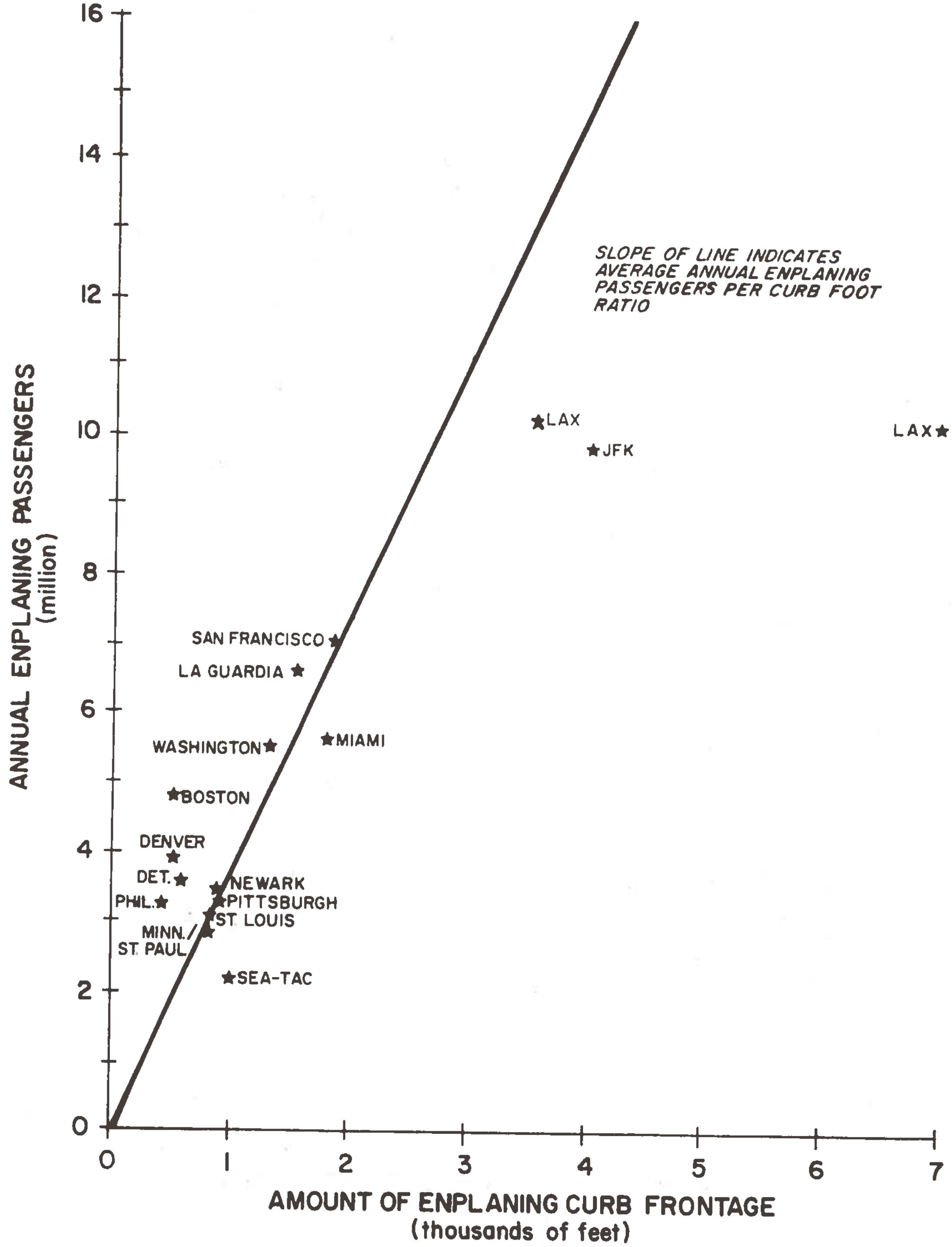
AIR PASSENGERS AND AIRPORT PARKING SPACES
Airport Access/Egress Systems Study

FIGURE 7



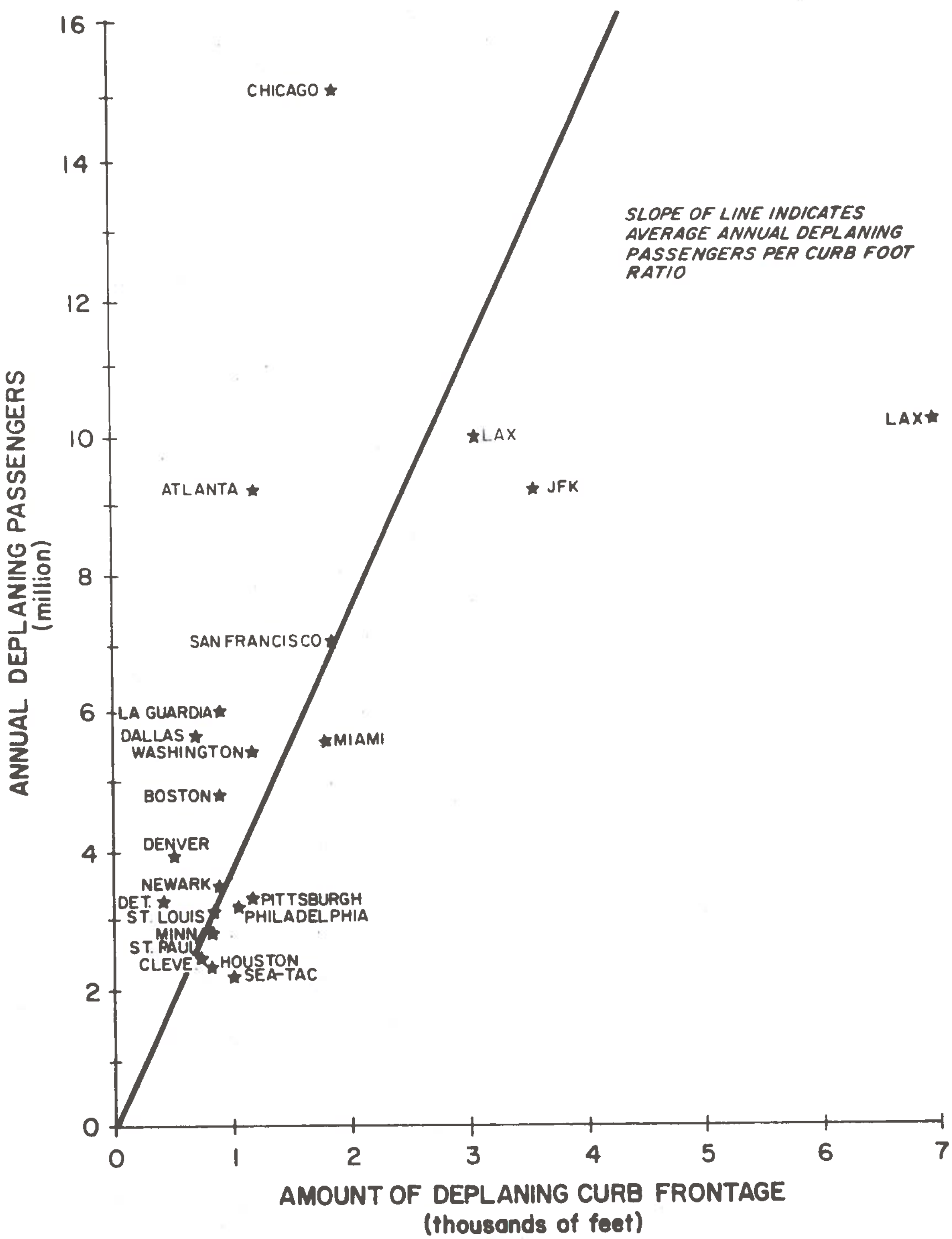
CURB FRONTAGE AND EFFECTIVE HIGHWAY CAPACITY
Airport Access/Egress Systems Study

FIGURE 8



CURB FRONTAGE AND ENPLANING PASSENGERS
Airport Access/Egress Systems Study

FIGURE 9



CURB FRONTAGE AND DEPLANING PASSENGERS
Airport Access/Egress Systems Study

FIGURE 1

congestion on airport roadways or parking facilities except where major freeways or other roads serve a high percentage of airport traffic.

5. Not all airport passengers impact the ground transport system as certain users remain on aircraft after landing or transfer directly to another aircraft after landing without leaving the terminal. This places some high volume-high transfer airports in need of less highway capacity than would be expected.

6. Because ground transport provides the connection between urban land use and air terminal facilities, the amount of congestion is sensitive to changes in either: (1) aircraft landing and departure times, or (2) normal urban travel demands and characteristics.

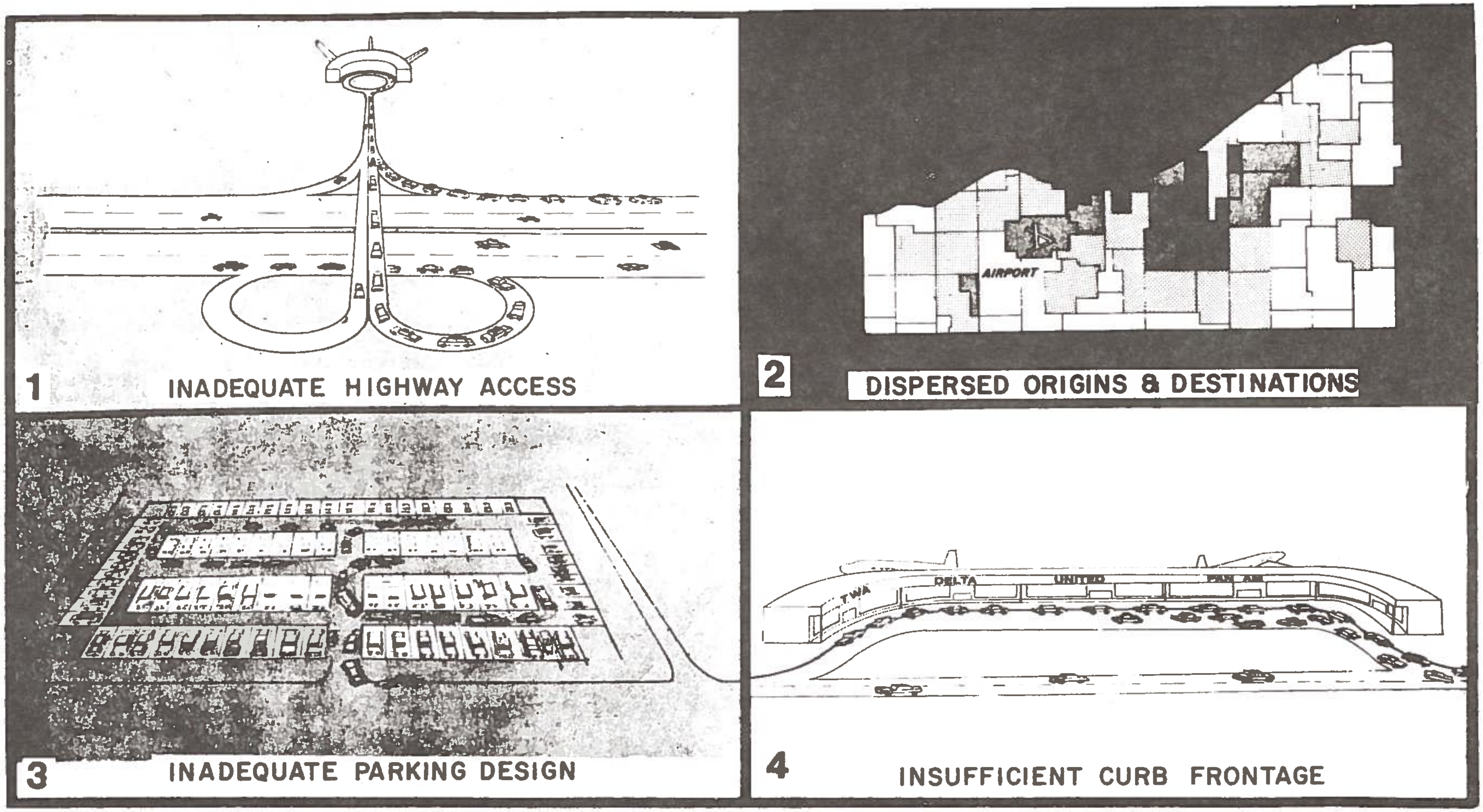
7. Four principal reasons for most of the airport delay (see Figure 11) are:

   - Inadequate highway access;
   - Dispersed origins and destinations;
   - Inadequate parking design; and,
   - Insufficient curb frontage.

8. Practical methods for relieving some of the observed congestion at airports include

providing more roadway capacity, mechanisms to change the demand for peak period airport use or demand for certain airport services, and mechanisms to shift the time patterns of users to less congested periods.

9. The feasibility of providing express public transit such as buses and rail rapid is dependent mainly on the origins and destinations of the airport users and the possibility of sharing its use with non-airport trips.



MAJOR REASONS FOR AIRPORT GROUND DELAYS
Airport Access/Egress Systems Study

FIGURE 11

Chapter 3

ALTERNATIVE OPERATIONAL EXPERIMENTS AND EVALUATION CRITERIA

This chapter identifies and describes those operational experiments with potential application to ease airport ground congestion. The criteria which eventually lead to the selection of the most appropriate experiments is established and the evaluation logic presented.

In conceiving the various types of candidate operational experiments, recognition of the following considerations were maintained:

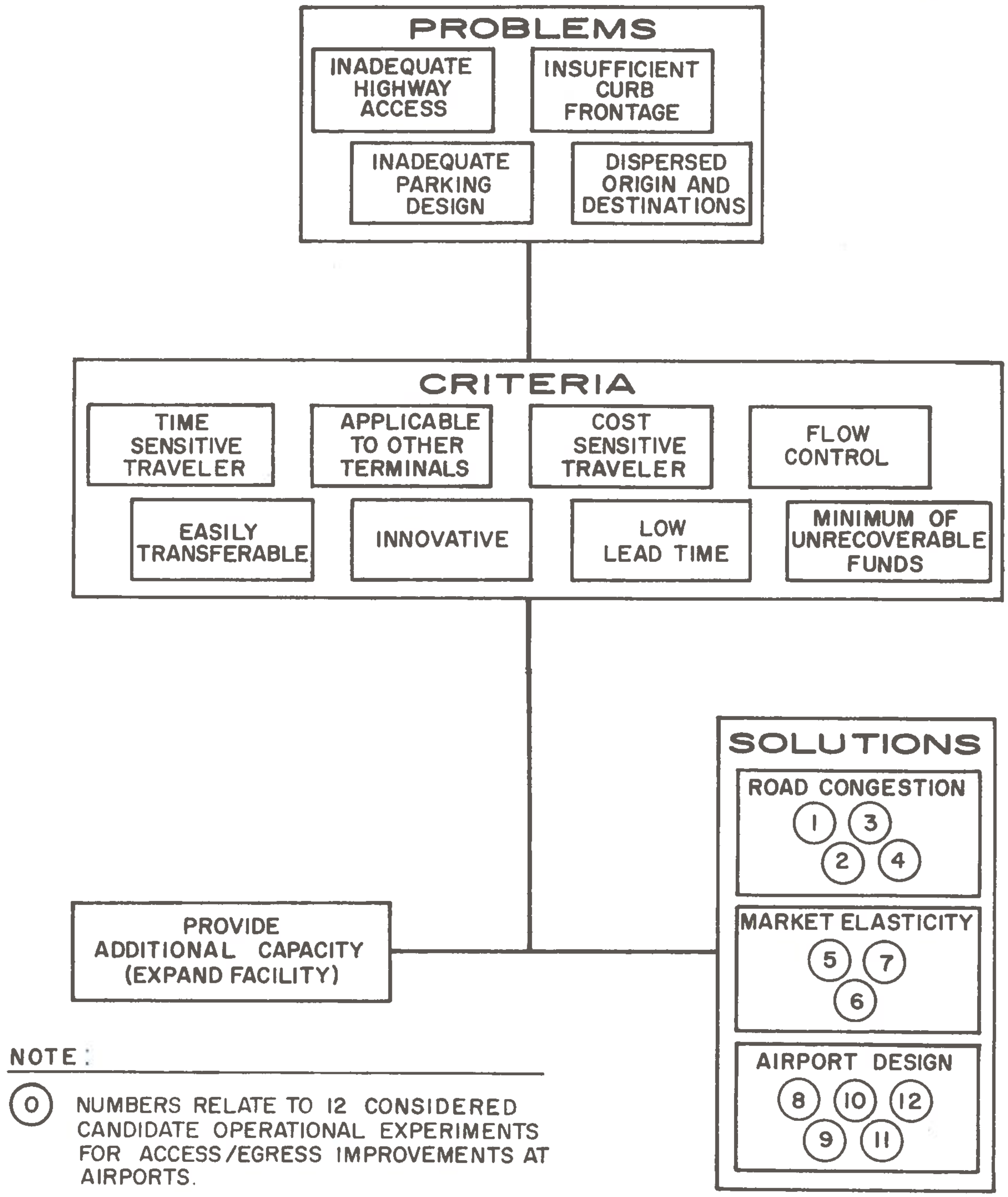
- Availability of supporting funds;
- ADAP program goals and objectives;
- Impact of new technology and the utility of innovative experiments;
- Acceptance by the operating agencies;
- Desirability of balancing costs and revenues;
- Impact on the general public; and,
- Effect on the air carrier/airport operating agency.

To preliminarily assess the potential applicability of the experiments, local planning agencies and municipal/regional airport authorities were personally contacted to review the future short-range plans contemplated for the airports. These plans were vital in structuring the candidate experiments and ensuring appropriateness and viability.

The framework for this evaluation process is sketched in Figure 12, whereby the four major problems producing ground congestion are identified: (1) inadequate highway access, (2) dispersed origins and destinations, (3) inadequate parking design, and (4) insufficient curb frontage.

Eight broad criteria used to evaluate the experiments were established after a thorough search of many others. These are:

1. Impact on the time sensitive traveler;
2. Applicability to other airports;
3. Impact on the cost sensitive traveler;
4. Effect on flow control;
5. Ease of transferability to other airports;
6. Degree of innovation;
7. Low lead time prior to implementation;and,
8. Minimum use of unrecoverable funds and low funding requirements.



METHODOLOGY FOR SELECTION OF OPERATIONAL EXPERIMENTS
Airport Access/Egress Systems Study

FIGURE 12

Potential Experiments

Candidate operational experiments to relieve congestion at the hub airports previously identified with problems were conceived. To accomplish the intended goals, it is clear that without capital intensive projects the remaining alternatives would best be the application of traffic engineering techniques to obtain more efficient use of existing roadways, or to alter travel patterns and habits of the air travelers wherein more off-peak highway capacity would be used. Utilizing this logic, a total of 19 candidate operational experiments were evaluated to relieve airport congestion on the ground side of the terminals. These constituted the following:

1. Graphics
2. Preferential Land Use
3. Lane Controls
4. Surveillance-Guidance Systems Control
5. Police Traffic Supervision
6. Remote/Fringe Parking
7. Curb Space Control
8. Micro-Transit Systems
9. Pedestrian Separation
10. STOL Aircraft
11. Off-Peak Air Service - Differential Pricing
12. Coordination with Existing Rail
13. Coordination of Existing Traffic Signals

14. Improved Car Rental Operations
15. Circumferential Roads, Multiple Access Points
16. Scheduled Priority Ground Transportation
17. Taxi Staging Areas
18. Dial-A-Ride
19. Research and Demonstration Projects

Keeping in mind the cost-effectiveness implications of initiating and completing the experiments, the following 12 possible experiments emerged:

1. Highway Surveillance - Guidance Control;
2. Coordination of Existing Traffic Signals;
3. Multiple Access Roadways;
4. Preferential Lane Use;
5. Bus/Limousine Off-Peak Marketing;
6. Off-Peak Air Service;
7. Dial-a-Ride Marketing (Demand Activated);
8. Motorist Advisory System;
9. Segregated Traffic in CTA;
10. Garage Check-in;
11. Segregated Pedestrian and Vehicular Traffic; and,
12. Balancing CTA and Remote Parking.

A brief description of each experiment follows:

1. Highway Surveillance-Guidance Control

This experiment could monitor vehicular traffic on the airport roadway or on major regional highways leading to/from the airport to instruct approaching vehicles to detour around accidents, bottlenecks, and other points of congestion. It might require television surveillance, radio communications, use of changeable message signs, etc., but it would be demand responsive and give airport vehicles the flexibility needed to reduce travel time. The concept is not new and is only applicable assuming alternative routes to the airport are available.

2. Coordination of Existing Traffic Signals

On some airport roadways traffic delay at uncoordinated signals produces delay and inconvenience to the air traveler. Interconnection and progressive timing of these signals could result in significant time savings. This is beyond the experimental stage as it has been proven nationwide on many arterial streets.

3. Multiple Access Roadways

This experiment would provide an analysis of the before and after utilzation of more than one roadway leading to an airport terminal. The concept was conceived to locate an airport with now a single feed access/egress roadway, but with potential to have another highway connected for this study. The impact of diversion and balance of capacity could then be tested and evaluated. Its cost implications reduce its practical applicability.

4. Preferential Lane Use

The selection of a traffic lane, either with or against the flow of traffic, and designated for particular traffic use was an option that could increase travel speeds for traffic utilizing that lane. This lane could be used to bypass congested areas either on the airport roadway or on the approaches to the airport. Normally, it is used by buses or other high occupancy vehicles and to justify exclusive use of one or more lanes for exclusive airport use proved difficult.

5. Bus/Limousine Off-Peak Marketing

This candidate experiment could encourage greater use of transit vehicles by serving a variety of metropolitan locations on frequent headways. It could serve satellite passenger processing centers, major rail stations, shopping centers, and connect the CBD with the airport. Through a carefully formulated pricing strategy and good service, this experiment can be implemented quickly.

6. Off-Peak Air Service

Because much air travel occurs during the peak traffic hour, roadways are congested and travel times long. This experiment coordinated with the FAA, CAB, and the air carriers could specifically provide the framework for scheduled air service during non-peak periods, thus allowing the air traveler to use ground transport systems when they are relatively uncongested.

7. Dial-A-Ride Marketing (Demand Activated)

This candidate experiment would provide a service to pick up and return air passengers on call in radio dispatched buses. Passengers requiring transportation to the airport would make a reservation in advance of their flight and this bus would collect them at their origin or nearby. This concept is operational in some cities today.

8. Motorist Advisory System

Where terminal congestion is caused by parking problems and where several parking facilities exist, with some being underutilized, this candidate experiment would better facilitate direction of the motorists to the nearest parking facility through variable message signs. It could remove the vehicles from the airport roadway faster and reduce congestion. This concept is used in other situations and offers potential for substantial improvement to airport access problems, although not new to the traffic engineering profession.

9. Segregated Traffic in CTA

Existing secondary airport access roadways at many airports could be used to provide a separate main access to the airport CTA for "public or operator" vehicles proceeding directly to enplaning or deplaning curbs. The air passenger traveling to or from the airport in a private vehicle would then have exclusive use of the current main access road system. By extending the concept of separation of traffic bound for the CTA, airports which now have, or are planning parking structures adjacent to the terminal buildings, could provide separate curb frontages for the vehicles in these garages, thus relieving the existing enplaning and deplaning curbs for "public or operator" vehicles. Once separation of traffic is extended to the CTA, separate curb baggage drop facilities could be provided, augmented by pedestrian access to the terminal from the garages, grade-separated from the enplaning and deplaning roadways. This has now been accomplished at LaGuardia and Toronto Airports.

10. Garage Check-In

This experiment would measure the effects on curb congestion of the provision of curb space with baggage check-in facilities within the CTA parking structures. The concept would likely relieve the existing enplaning and deplaning curbs and allow all public transit vehicles (bus, taxi and limousine) more curb space adjacent to the terminal. Innovative with respect to conventional use of parking structures, curb-in-garage facilities can be generalized for use at other airports with CTA parking garages, and can be suggested for inclusion at airports which are developing CTA parking structures. The experiment seemsa good potential.

11. Segregated Pedestrian and Vehicular Traffic

This candidate experiment could effect pedestrian separation from vehicles by the construction of either tunnels or bridges. It could substantially reduce conflicts and increase safety. Providing the transition vertically at the ends of the passageways are easily accomplished. This is a capital intensive project, however.

12. Balancing CTA and Remote Parking

Fringe or remote parking enables more efficient use of the ground access/egress system through diversion of private automobiles directly to parking areas away from the terminal area and linked by buses. As airports develop micro transit systems, these can be used to provide the linkage necessary. The experiment has good application potential.

Evaluation

This section discusses the evaluation procedure utilized in the final selection process in arriving at specific candidate operational experiments. The 12 recommended operational experiments previously discussed were evaluated from a standpoint of their impacts on time and cost to the air traveler and their general impact on improving vehicle traffic flow. Finally, the criteria considered important in each experiment's implementation are listed and assessed. The ratings of character are subjective in nature but based on a detailed analysis. Because this process is evaluating benefits, they are additive.

<u>Time Sensitivity</u>

In benefiting the time sensitive air traveler three key factors are important: (1) reducing the variance in travel time (better schedule predictability), (2) increasing overall speed, and (3) scheduling more service.

Increasing predictability implies insuring greater accuracy in the adherence of public transportation modes to their schedules. This would allow the time sensitive traveler to rely more heavily upon these services. Giving buses the exclusive use of a right-of-way or access route makes it easier to maintain and insure schedules, and increase reliability. Increasing the speed of a trip benefits the traveler in obvious ways and applies to all modes, while increasing frequency again relates to public services. If vehicles run on reduced headways, and therefore, more frequently, the time sensitive air traveler may prefer to use them in lieu of his private car.

Cost Sensitivity

The most fundamental change implicit with improvement of the cost sensitive traveler's trip is a reduction in the out-of-pocket cost of travel. He may disregard the time of day or the duration of trip to minimize his cost. However, as the cost sensitive traveler is nearly always time sensitive to some degree, it is necessary to minimize and consider any resulting increase in length of trip, loss of speed and frequency of service, and discomfort during the trip.

Flow Control

To improve vehicular and pedestrian flows at airports, increasing the ability of the thoroughfare to process them, or reducing their numbers, is important. The former is possible through experiments such as signal coordination, while the latter may be accomplished by partial diversion to secondary routes or a condensation of the traffic stream to larger vehicles. The increased use of rail access to airports will also reduce the magnitude of traffic by removing some users to new rights-of-way. Improving bus and limousine acceptance and increasing usage will also reduce the number of vehicles and improve traffic flow.

The evaluative rationale incorporated in assessing those candidate operational experiments for implementation necessitated that the experiment be innovative, have potential for general application at other airports, and that it have a low lead time with minimum cost implications, moreover, it should be transferable to other areas and be possible for implementation with a minimum of unrecoverable funds.

Implementation Criteria

Innovation is the ability of an experiment to imaginatively use technology, and/or fully the institutional framework in which it operates. By routing bus/limousine service to certain high demand areas, with a minimum number of satellite pick-up points, and then directing them express to the airport, improvements to the current operational framework would be achieved. Technological innovation can enhance passenger service by providing baggage check-in facilities for the air passenger, eliminating the need to check his bag at the airport, as an example.

The ability of an experiment to be adapted to other airports not initially considered for its implementation is important in that it allows the experiment to benefit more travelers without requiring separate testing at each area.

All operational experiments should have a low lead time in order to minimize the planning effort. An experiment of long duration may lose its relevance over a period of time as conditions are constantly changing.

Any supportive federal funds required to equip and study these experiments should be low as the effort here is non-capital intensive, and the results of any project should be able to be adpated to other airports for all major airports to enjoy the benefit of each experiment. Finally, where some monetary support is required, experiments might consider appropriate user charges to minimize the fiscal outlay.

Evaluation Rating

The matrix shown in Figure 13 is the result of the aforementioned subjective evaluation process. As illustrated, the experiments having the highest overall implementation benefits and there point ratings are:

1. Bus/limousine marketing (27)
2. Balancing CTA and remote parking (24)
3. Garage check-in (22)
4. Coordination of existing traffic signals (21)
5. Off-peak air service (20)
6. Segregated traffic in CTA (20)
7. Preferential lane use (19)
8. Segregate pedestrian and vehicles (15)
9. Highway surveillance (13)
10. Motorist advisory system (12)
11. Multiple access (10)
12. Dial-a-Ride (10)

A rating scheme was also employed (+2 to -2 - positive to negative) on the time and cost sensitive issues. This same procedure was used to rank the impact of flow control and results, by category, of this analysis are also shown.

When the totals are added for each of these groups the benefit ranking becomes:

- Bus/limousine off-peak marketing (36)
- Garage check-in (30)
- Balancing CTA and remote parking (30)
- Segregated traffic in CTA (27)
- Coordination of existing traffic signals (27)
- Preferential lane use (25)
- Off-peak air service (25)
- Segregated pedestrian and vehicular traffic (21)
- Motorist advisory system (14)
- Highway surveillance and guidance system (19)
- Dial-a-Ride marketing (Demand Activity) (17)
- Multiple access roadways (16)

A detailed analysis of the matrix is necessary since the particular experiments were chosen for implementation in rank order by way of the highest assigned points. On the whole, every one of the 12 experiments, because they were specifically selected to appeal to potential users, had high marks for time, cost, and flow criteria. The points varied from positive five

CANDIDATE OPERATIONAL EXPERIMENTS	TIME SENSITIVE CRITERIA			COST SENSITIVE CRITERIA		FLOW CONTROL CRITERIA		Sub Total	IMPLEMENTATION CRITERIA						Sub Total	TOTAL
	T_1	T_2	T_3	C_1	C_2	F_1	F_2		2	3	4	5	6	7		
1. HIGHWAY SURVEILLANCE AND GUIDANCE SYSTEM	+2	+2	0	0	NA	+2	0	+ 6	4	5	0	0	4	0	13	19
2. COORDINATION OF EXISTING TRAFFIC SIGNALS	+2	+2	0	0	NA	+2	0	+ 6	0	5	3	4	5	4	21	27
3. PROVIDE MULTIPLE ACCESS ROADWAY	+2	+2	0	0	NA	+2	0	+ 6	2	3	0	0	5	0	10	16
4. PREFERENTIAL LANE USE	+2	+2	0	0	NA	+2	0	+ 6	4	3	2	4	3	3	19	25
5. BUS/LIMOUSINE MARKETING (OFF-PEAK HOUR)	0	+1	+1	+2	+2	+1	+2	+ 9	4	5	4	4	5	5	27	36
6. OFF-PEAK HOUR AIR SERVICE PRICE DIFFERENTIAL	+1	0	0	+2	+2	NA	NA	+ 5	2	4	5	2	4	3	20	25
7. DIAL-A-RIDE MARKETING (OFF-PEAK HOUR)	0	+1	+1	+2	+2	0	+1	+ 7	5	2	0	0	3	0	10	17
8. MOTORIST ADVISORY SYSTEM	+2	+2	0	0	NA	+2	+1	+ 7	4	3	0	0	4	1	12	19
9. SEGREGATED TRAFFIC IN CTA	+2	+2	0	0	NA	+2	+1	+ 7	3	2	4	4	4	3	20	27
10. GARAGE CHECK-IN	+2	+2	0	0	NA	+2	+2	+ 8	3	3	5	3	5	3	22	30
11. SEGREGATE PEDESTRIAN AND VEHICULAR TRAFFIC	+2	+2	0	0	NA	+2	0	+ 6	3	4	1	1	5	1	15	21
12. BALANCING CTA AND REMOTE PARKING (CTA / REMOTE)	+1 / +1	+1 / -2	0	0 / +2	+1 / -2	+2	+2	+ 6	4	4	4	4	5	3	24	30

LEGEND

T_1 BETTER PREDICTION
T_2 HIGHER SPEED
T_3 FREQUENCY (HEADWAYS)

C_1 LOWER OUT OF POCKET ACCESS COST MODES
C_2 CHANGE OF SPEED AND FREQUENCY

F_1 IMPROVE TRAFFIC FLOW
F_2 REDUCE VEHICLES IN CTA AND/OR HIGHWAY SYSTEM

NA = NOT APPLICABLE
+2 = EFFECTS DIRECTLY (+)
+1 = AFFECTS INDIRECTLY (+)
0 = NO RELATION
-1 = AFFECTS INDIRECTLY (-)
-2 = EFFECTS DIRECTLY (-)

2 INNOVATIVE
3 CAN BE GENERALIZED
4 LOW LEAD TIME
5 LOW FUNDING REQUIREMENTS
6 TRANSFERABILITY
7 MINIMUM OF UNRECOVERABLE FUNDS

RELATIVE BENEFIT
0 = LOW
5 = HIGH

OPERATIONAL EXPERIMENTS AND MATRIX EVALUATION
Airport Access/Egress Systems Study

FIGURE 13

(off-peak hour air service) to positive nine (bus/limousine marketing). The off-peak air experiment merely translated airport demand to another time period, not directly converting potential users to other ground transport modes. The bus/limousine experiment, however, was a direct attempt to convert the automobile user to public transit, and thus was believed to have the greatest potential benefit on users.

In assessing time, cost, and flow criteria by individual category, the matrix shows the greatest benefit to the time sensitive traveler. Surprisingly, the 12 experiments have the least total impact on the cost sensitive traveler, particularly since many of the frequency and speed categories were not applicable. Most experiments, however, do affect the flow of vehicles and this category placed second in overall importance.

In an analysis of the separate criteria within all of three major user classes, better prediction, higher speed, and improved traffic flow all received the greatest point ratings. This seems reasonable since they are related to each other (speed, flow, schedule adherence). In contrast, the lowest point rating was the frequency of service since none of the experiments were truly demand responsive.

More point variance can be observed from an analysis of the six implementation criteria. Here the ratings varied from a low of 10 (provide multiple access and dial-a-ride) to a high of 27 (bus-limousine marketing). Average ratings were about 18 points.

By individual implementation category, transferability to other airports received a total of 52 points (with a range from three to five for each experiment) followed by "can be generalized" which received 43 (and a range from two to five for each experiment). The lowest ratings were low funding (26), minimum of unrecoverable funds (26) and low lead time (28). All of these had large variances in point ratings for individual experiments. This point score also seems reasonable since the 12 experiments were chosen to be adaptable to other geographic areas and one of the objectives of this study was to apply non-capital intensive projects wherever possible.

In analyzing the matrix by each particular experiment, bus/limousine marketing received the greatest total point score of all 12 projects with 36. The only evaluation criteria it did not receive any points in was "better prediction", and yet it still rated the highest in the user-flow category. Multiple access roadways received the least total points, primarily because of the low values it received in implementation (low lead time, funding and unrecoverable funds).

The other experiments which ranked second in importance were garage check-in and remote parking both with 30 points. It was slightly easier to implement remote parking, with garage check-in facilities being rated as more beneficial in the user-flow criteria.

The three candidate operational experiments chosen for implementation and considered to have the greatest potential benefit to airports and their users according to the criteria, turned out to be:

- Bus/Limousine Marketing
- Garage Check-In
- Balancing CTA and Remote Parking

Chapter 4

RECOMMENDED OPERATIONAL EXPERIMENTS

The previous chapter established the framework for evaluating the 12 potential operational experiments. This chapter discusses the three particular experiments which had the greatest potential benefits according to the established criteria. These experiments are:

1. Balancing CTA and remote parking,
2. Bus/limousine service, and
3. Garage baggage check-in.

Each of these three experiments is discussed in detail emphasizing workability, institutional constraints (where applicable), identifying participants and discussing likely coordinative effort.

A research plan depicting levels of service, fares, and data collection/analyses is presented for each experiment. Next, a schedule of activities is presented which describes each particular experiment and recommends a specific time period for operation. And finally the estimated budget and any expected revenues for each project is analyzed.

Balancing CTA and Remote Parking

This operational experiment should measure the impact of a remote parking facility with connecting bus service on the Airport and its environs. It should also investigate the feasibility of coordinating the short-term and long-term Airport parking facilities by means of pricing mechanisms and bus service levels to better meet Airport demands. It should attempt to change the modal split characteristics and the number of private vehicles using the Airport roadway. The following are the specific features of the experiment:

1. The experiment should provide a data base by which other airports in other geographic locations may evaluate their particular parking-access solutions. Airports in cities such as San Francisco, New York, and Chicago, e.g., already have their own versions of remote parking terminals. Others are being planned.

2. The experiment should compare the operations of existing private parking lots with the proposed Airport parking facility at similar service and cost levels to isolate any locational and access effect which may influence driver selection of particular parking facilities.

3. The experiment should evaluate the success of satellite parking in general on such measures of effectiveness

as relieving congestion and delay within the Airport complex and increased patronage. This will involve surveying all remote parking terminals at the Airport.

4. The experiment should investigate the potential of setting coordinated system rates for all Airport-operated parking facilities as part of a study to determine the market elasticity of parkers with respect to price. It will also provide concrete facts to support specific recommendations for establishing equitable and efficient parking rates.

5. Finally, the experiment should make specific recommendations for establishing guidelines in selecting and operating remote parking terminals.

This recommended operational experiment will be one in advertising, operating and evaluating a fringe parking service-bus link. It will be located at the Detroit Metropolitan Wayne County Airport. The lot will be on Airport property and all bus service can utilize Airport roads. It will specifically include:

1. A carefully programmed plan of nine month's duration with the Wayne County Road Commission, the Federal Government, existing private lot operators located near the Airport, and a selected bus operator.

2. A procedure of supervision of:

   a. Operating the satellite parking facility;

   b. Operating bus service to link fringe parking with the Airport;

   c. Varying park-and-ride charges; and,

   d. Varying bus levels of service;

3. A procedure of data collection and analysis to monitor traffic volumes on the road system, attitudes, travel habits, and socio-economic characteristics of users.

Existing Conditions

The Detroit Metropolitan Wayne County Airport (DTW) presently serves about 7.0 million annual passengers. Inter-airline transfers represent about 10 per cent of total passenger flows; thus, the remaining passengers either originate or are destined to the Detroit Metropolitan Area (Figure 14).[1]

The Airport employs about 6,000 persons and provides 5,400 parking spaces for all users. Another 5,000 parking spaces exist on the fringes of the Airport in three separate locations (within two to three miles from the main terminal). These are owned and operated by private interests and free shuttle buses transport Airport-oriented travelers from these parking facilities to the various terminals.

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(1) Airport records taken by Detroit Metropolitan Wayne County Airport, 1971.

A recent study showed that nearly 90 per cent of all arrivals and departures to the Airport are by private vehicle, i.e., automobile, rental car, and taxi.(2) As a result, the very limited and heavily taxed curb frontage (600 feet) for enplaning passengers is insufficient. The Detroit Airport has grade separated its enplaning from its deplaning vehicle roadways to add capacity. These roadways presently serve two terminals--North and South Terminals. They will eventually serve an International Terminal, now under construction.

Two individual bus lines connect the Airport with the Detroit CBD (18 miles); and five separate limousine lines link Detroit, Ann Arbor and Dearborn with Airport functions. All these public transport services carry less than 1,300 total daily riders, however.

Only five per cent of all Airport passenger origins and destinations are to or from the Detroit CBD. The rest appear to be evenly distributed over the metropolitan area, with no single concentrated area for air travel desire.

Air passengers to and from the Airport show use of numerous highways, but with a near exclusive use of I-94 (The Industrial Highway) near the Airport. In fact, about 74 per cent

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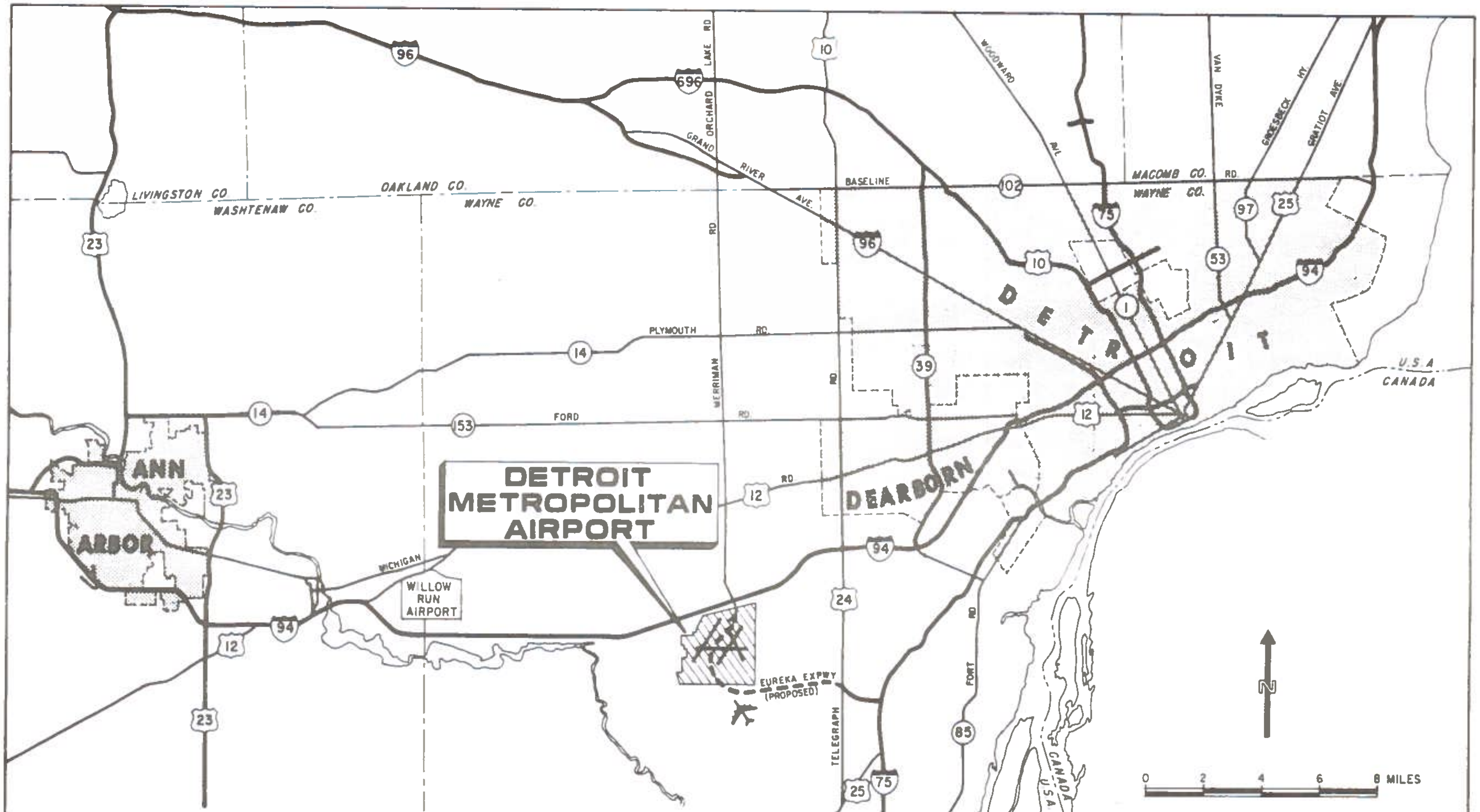
(2) Travel Patterns and Characteristics of Airline Passengers to the Detroit Metropolitan Airport, prepared by Detroit Regional Transportation and Land Use Study, 1968.



LOCATION MAP, DETROIT METROPOLITAN WAYNE COUNTY AIRPORT
Airport Access/Egress Systems Study

FIGURE 14

of all Airport vehicle trips use I-94E; 15 per cent I-94W; and the other six per cent use Merriman, Wayne, and Middle Belt Roads. These traffic flows translate into about 26,000 daily vehicles on I-94 for Airport use alone.

With only one means of roadway access to the Airport (via Rogell Drive), congestion and delay at the I-94 Airport interchange supports its operation at and beyond capacity during peak hour conditions. The Airport, further, shares similar problems of other major hubs in that pressures are continuing to build at its curb frontages and longer walking distances are involved between CTA parking and the terminals. Additional parking spaces are further from the major terminals also. Detroit Metropolitan, in fact, is just completing a new capital improvements program which partially involves additions to its parking needs. About 1,000 new spaces were opened in a new garage and pedestrian walkways now link the terminals.

In recent years, private entrepreneurs at Detroit Metropolitan have recognized these problems and provided remote parking with connecting bus service to the terminal buildings to afford a competitive level of parking service with the inner parking at the Airport. They purchased or rented land bordering the Airport itself, and by offering lower long-term parking rates with a free bus connection, attracted many would-be CTA parkers.

Plans for Expansion

An Airport Master Plan was completed for DTW in 1972, essentially describing a new satellite terminal complex about one-mile southwest of the now existing terminal areas.[3] A prime reason for this positive step in seeking a new terminal complex was due to the added ground access/egress capacity possible from regional highways south, east, and west of the Airport.

In the interim, more off-street parking is now under construction in the CTA, and thought is being given to provision of another fringe or satellite parking lot with improved bus service to the Airport. These plans are being developed by the Wayne County Road Commission.

With a fringe parking lot on Airport property, it will be possible to link this remote facility with fast, efficient bus service having some preferential treatment to improve travel times to the Airport. This concept will further aid in achieving better distribution of vehicular movements in and around the Airport.

This plan, then, provides an arena for experimentation in order to determine the impacts of pricing mechanisms,

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(3) Passenger Terminal and Cargo Facilities Master Plan, prepared by Arnold Thompson Associates, Inc., June, 1972.

reduction in travel times, distribution of vehicular flow on the Airport roads or park-and-ride facilities.

Project Design and Implementation

Planners of the Detroit Metropolitan Airport are making plans to construct and operate a 2,000-space remote parking lot with connecting free bus transfer to its three major airline terminals. This parking facility will be located in the northeast sector of the Airport and border both Wick and Middle Belt Roads. The site is approximately two miles from the North and South Airline Terminals of DTW (see Figure 15).

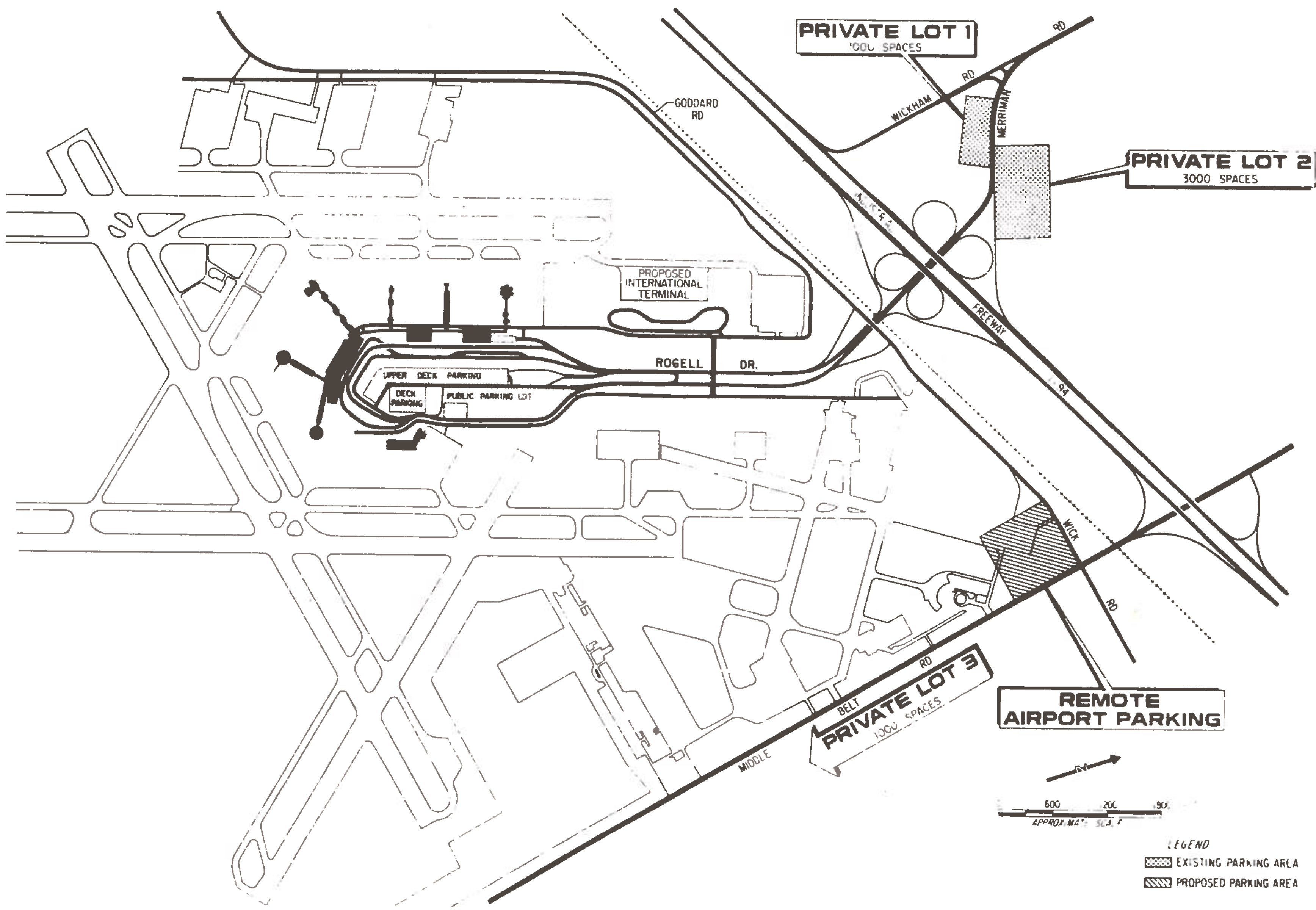
Access from this location to the Airport, will be via Wick Road (West) which connects with Rogell Drive, the Airport Roadway (Figure 16). Wick Road is a two-lane service road bordering the southern sector of I-74. It serves as the connecting link between Middle Belt and Merriman Roads, two parallel facilities, and handles a high percentage of trucks and airport service vehicles.

Two traffic signals regulate traffic movements on the way to the Airport from this parking lot. One is at the entrance to the International Terminal, the second is situated about one-half mile south of this signal, still on Rogell Drive, and permits service and cargo vehicles to gain access to the Airport. Rogell Drive is basically a four-lane divided facility which connects both terminals in the CTA. Just before the North Terminal, it splits into enplaning and deplaning roadways. These merge once again just north of the South Terminal.

Proposed Experiment(s)

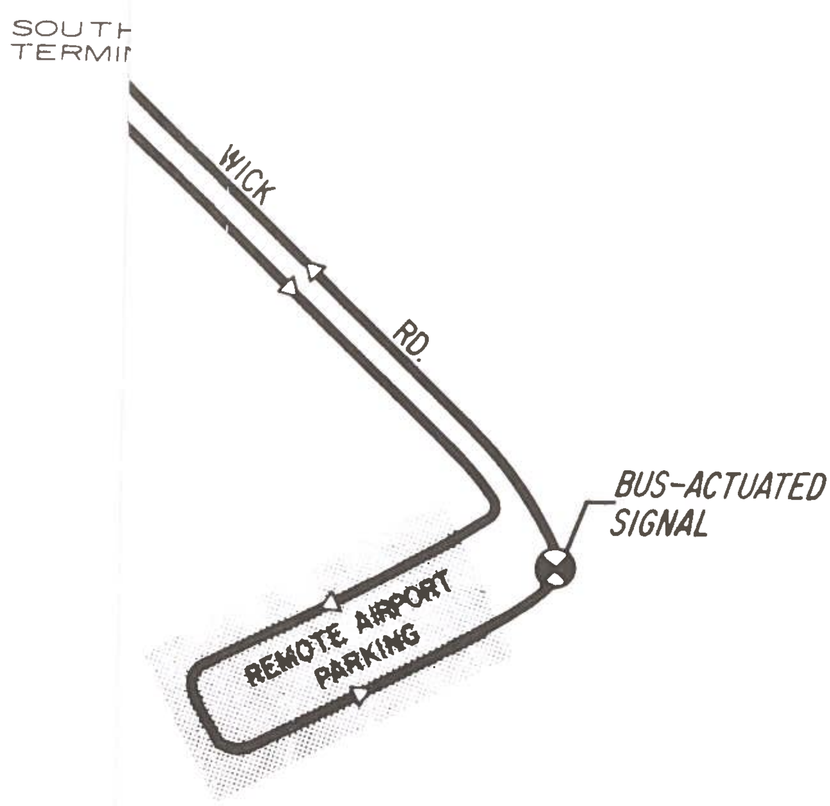
1. Prior to the actual start of this experiment, it is important for the Wayne County Road Commission to gain both the support and cooperation of the three private parking operators, located in the vicinity of the Airport. Since the experiment is attempting to relieve vehicle congestion at the intersection of I-94 and Merriman Road by offering an alternative level of service to all its airport facilities, these private parking operators will be affected since they gain access by way of the intersection. Some of the study recommendations will probably be felt by these operators in terms of such benefits as increased utilization of their lots and less congestion. The Commission should make it clear, however, that they are trying to provide a better service to the public. Studying passenger characteristics and planning for them will encourage more utilization of Airport services, which both the Airport and its supporting industries can enjoy.

2. Not more than one month prior to the opening of the Airport operated satellite parking lot, a pilot sample survey of the habits of the existing remote parker should be conducted in cooperation with the three private lots and Airport. This survey



EXISTING AND PROPOSED REMOTE PARKING TERMINALS, DETROIT METROPOLITAN WAYNE COUNTY AIRPORT
Airport Access/Egress Systems Study

FIGURE 15



SOUTH
TERMI
WICK
RD.
BUS-ACTUATED
SIGNAL
REMOTE AIRPORT
PARKING

FIGURE 16

should ascertain parking characteristics, duration, attitudes, and trip purpose for the inbound portion of the trip to the Airport.

- In addition to administering the pilot on-board survey and passenger count (see Appendices C and D) for one full week throughout the clock, a tabulation of the total vehicle movements into and out of these lots should be maintained and collected. This should be designed as part of a standard weekly reporting procedure, in-corporated at this time, and retained through-out the experiment.

- All vehicular movements should be collected and recorded for the central terminal area parking as well.

- Finally, a 24-hour vehicle classification count should be conducted near the intersection of Wick Road and Rogell Drive. This includes classifying, by at least 15-minute increments, the types and quantities of all inbound vehicles to Detroit Metropolitan.

3. When the Airport parking lot is finished, an extensive, energetic advertising campaign should precede its formal opening. This should include at least newspaper and radio

coverage and highway signing (if permitted) in the vicinity of the Airport. Easy access and egress should be stressed as its key attraction as well as the free bus shuttle to the CTA. Afterwards, it should be opened and operated for three full months. The lot will provide 24-hour service every day of the week.

- The first part of the experiment should attempt to measure the impact of location and access on parking patronage as well as the impact advertising may have had. To do this, the same level of service and parking rates should be offered by the remote parking terminal as presently given by the private operators. (The existing remote parking rate at the West Lot of the Airport is $1.50 per day.)

- As for service, buses will pick up passengers at their car and operate on about ten minute headways in the peak and at 20 to 30 minute headways off-peak. Rates of $1.25 per day should be assigned. The only significant difference will be to offer employees free parking privileges.

NOTE: The experiment should monitor traffic on Middle Belt Road just south of I-94 and on Merriman Road, just north of I-94 to learn of changes in traffic patterns as a result of the Airport remote terminal.

- Every day of the entire experiment, the parking receipts and records of <u>all</u> remote lots should be collected and tabulated according to a standard form. This also includes the Airport CTA parking areas.
- In addition to this, a continuous vehicle traffic count should be conducted and maintainedfor the length of the experiment. An automatic traffic counter installed on Rogell Drive should be arranged.
- After this experiment has operated for three full months, an inbound bus survey, based on the experience and results of the pilot study should be conducted. This would probably still be similar to the forms and procedures outlined (see Appendices C and D). Data should be collected for one week throughout the clock. During this time, another 24-hour vehicle classification count should be conducted.

4. After three months of operation, the experiment recommends that the Airport improve the level of its bus service by the following:

- Offer bus headways at five minutes for the peak period. Retain previous off-peak hours.

- Install an entrance-exit lane from Wick Road into the Airport remote parking lot and a bus-driver actuated signal at this point to allow buses easy transition onto Wick Road.
- Install a bus-driver actuated signal at the exit from the International Terminal onto Rogell Drive.

These improvements should be initiated with additional effort in advertising and retained for the completion of the experiment. Allow the system to operate for three full months and then conduct another bus inbound survey at all remote parking lots for one full week throughout the clock. There should also be another 24-hour vehicle classification count at Wick Road and Rogell Drive.

It would be desirable to offer parking at the remote terminal at a price which encourages use in the off-peak period. Problems with this strategy exist but every effort should be made to determine this feasibility.

5. After six months of operation and with the cooperation of the Wayne County Roads Commission, alter the weekly parking rates of the CTA facilities as shown in Table 7. This modification will only effect the weekly long-term parking rates. After a three month period, another bus survey at all remote

Table 7

SCHEDULE OF PRESENT AND PROPOSED PARKING RATES
DETROIT METROPOLITAN WAYNE COUNTY AIRPORT
AIRPORT ACCESS/EGRESS STUDY

	PRESENT RATE (1)	PROPOSED RATE
SHORT-TERM LOTS		
Each ½ hour	$ 0.35	$ 0.35
Maximum daily	5.00	5.00
CTA PARKING - DECK		
First hour	0.50	0.50
One to three hours	1.00	1.00
Each additional three hours	0.50	0.50
Maximum daily	3.00	3.00
Maximum weekly	15.00	20.00
CTA PARKING - MAIN LOT		
Each hour for one to three hours	0.25	0.25
Each additional three hours	0.25	0.25
Maximum daily	2.00	2.00
Maximum weekly	10.00	13.00
REMOTE PARKING LOT		
All day or fraction thereof	1.25 (2)	1.25 (3)
Weekly rate	7.00 (2)	6.00 (3)

(1) Data obtained from Wayne County Road Commission, 1973.
(2) At West Remote Parking Lot.
(3) At proposed remote Airport parking lot.

parking lots, for one full week around the clock, should be administered. This would also include a 24-hour vehicle classification count at Wick Road and the Airport Roadway.

6. Analyze results and explore the possibility to adopt this project on a permanent basis, to discontinue project, or to study additional alternatives.

Project Requirements

It is recommended that small 8 to 10 passenger van type buses be utilized to connect the remote airport parking lot with the Airport. As with the private operators, the bus should be dirven through the lot to pick up or discharge passengers near their own vehicles. At the airline terminals there should, however, be specific, well identified stops on the enplaning roadways. These stops would include:

1. International Terminal (when completed);
2. North Terminal; and,
3. South Terminal

The Airport should consider assigning special "tripper" buses to serve employees during their two work peaks.(4) These particular buses will probably need to hold 49 passengers each

(4) A "tripper" bus is a specially assigned bus to accommodate heavy passenger demand periods of time.

and could principally be used to shuttle employees to their work areas from the remote parking facility. The actual number of buses would be dependent upon expected demand, but the Airport could arrange the leasing of these buses beforehand by having employees present a special pass issued to them with this experiment.

Table 8 illustrates the expected travel times between the airport remote parking lot, stopping at the above terminals, and return for both peak and off-peak periods. A bus can make a round trip in 24 and 15 minutes for normal operation in the peak and off-peak periods, respectively. With the installation of a bus actuated traffic signal, these travel times can be reduced to 20 and 14 minutes for the peak and off-peak periods, respectively.

Thus, it is recommended (see Table 9) that five (5) small buses be provided, initially and for the first three months, to serve the remote parking lot and the Airport. For the rest of the experiment, seven (7) of these buses should be able to accommodate demand and service irregularity.

Table 10 shows the total personnel requirements by month needed to conduct this experiment over the nine months it will run and including the pilot study prior to its inception. Personnel include the in-bound surveyors, supervisors, crew to conduct vehicle classification counts, parking attendants, and

Table 3

EXPECTED TRAVEL TIMES BETWEEN REMOTE PARKING FACILITY AND METROPOLITAN WAYNE COUNTY AIRPORT TERMINALS AIRPORT ACCESS/EGRESS STUDY

FROM REMOTE AIRPORT PARKING LOT(1)	ROUND TRIP TRAVEL TIME TO DETROIT AIRPORT (Minutes) Peak(2)	Off-Peak(3)
Normal Operation	24	15
With Bus-Actuated Traffic Signal(4)	20	14

(1) Buses will circulate and load/unload parkers at their cars and make one stop at each of the major terminal buildings--International, North, and South. The travel times are based on typical traffic conditions and include line-haul time and necessary layover time, in addition to the stops at the terminals.
(2) 6:00 A.M.-10:00 P.M.
(3) 10:00 P.M.-6:00 A.M.
(4) Placed at the intersection of Wick Road and the Airport Remote Parking Lot and at Rogell Drive and and the exit from the International Building.
NOTE: Estimated by Wilbur Smith and Associates, 1973.

Table 9

NUMBER OF BUSES REQUIRED TO SERVE DETROIT METROPOLITAN WAYNE COUNTY AIRPORT FROM PROPOSED REMOTE PARKING FACILITY
AIRPORT ACCESS/EGRESS STUDY

MONTH OF EXPERIMENT	ESTIMATED NUMBER OF BUSES	
	Peak (1)	Off-Peak (2)
0-3	5	1
3-6	7	1
6-9	7	1

(1) 6:00 A.M.-10:00 P.M.
(2) 10:00 P.M.-6:00 A.M.
NOTE: Smaller 8 to 10 passenger van type buses are recommended for this experiment because of their appeal to users as private vehicles. Additional vehicles are included in these estimates in case of breakdown, maintenance, and to accommodate fluctuations in demand.

Table 10

PERSONNEL REQUIREMENTS NEEDED TO IMPLEMENT EXPERIMENT
DETROIT METROPOLITAN WAYNE COUNTY AIRPORT
AIRPORT ACCESS/EGRESS STUDY

MONTH OF EXPERIMENT	TYPE OF PEOPLE NEEDED	ESTIMATED NUMBER NEEDED DAILY	ESTIMATED TIME (Weeks)
Prior to Start	On Board Surveyers (1)	21	2
	Supervisors (2)	4	2
	Classification of Vehicles (3)	10	0.5
	Subtotal	35	4.5
0-3	Remote Parking Attendants (4)	5	12
	Bus Drivers (5)	11	12
	Supervisor-Surveyer (6)	3	12
	On Board Surveyer (7)	36	2
	Classification of Vehicles (3)	10	0.5
	Subtotal	65	38.5
3-6	Remote Parking Attendants (4)	5	12
	Bus Drivers (8)	13	12
	Supervisor-Surveyor (6)	3	12
	On Board Surveyer (7)	36	2
	Classification of Vehicles (3)	10	0.5
	Subtotal	67	38.5
6-9	Remote Parking Attendants (9)	5	12
	Bus Drivers (8)	13	12
	Supervisor-Surveyer (6)	3	12
	On Board Surveyer (7)	36	2
	Classification of Vehicles (3)	10	0.5
	Subtotal	67	38.5

(1) Assumes that three surveyers will be assigned to each private lot for each work shift from 6:00 A.M.-10:00 P.M. Assumes that one surveyer will be assigned to each lot from 10:00 P.M.-6:00 A.M.
(2) One supervisor per shift to direct all lots and another to coordinate parking receipts.
(3) Three-three man work crews per 24 hours and one extra.
(4) Two attendants per day shift and one at night.
(5) Five drivers per day shift and one at night.
(6) One full time supervisor per shift to collect receipts, monitor traffic count, etc.
(7) Four surveyers assigned to all remote lots (4) for each day work shift and one each at night.
(8) Six drivers per day shift and one at night.

bus drivers. The drivers will also be responsible for maintaining a continual <u>on-off</u> bus count for the length of the experiment. The on-board surveyors will be expected to code the information they have collected and one week is provided each particular survey for this activity.

The estimated project costs and assumptions for this experiment are shown in Table 11. The total operational costs are estimated to be about $533,500, for the nine-month experiment. Advertising and bus operation alone are expected to run about $85,000 and $250,000, respectively. The costs for constructing the remote parking lot are not included in these estimates, as the Airport is developing this facility.

The fare collection plan will permit Airport employees a free bus ride to their jobs with no parking costs. Special buses will probably be required to handle the demand at certain times of the day. Normal daily rates for airport passengers will be set at $1.25. During the experiment, the CTA long term parking rate should be raised slightly making the remote terminals even more attractive.

With 7,000 remote parking spaces provided by both the Airport and private operators and with the establishment of free fare privileges for employees, these parking terminals should significantly alleviate ground congestion at the service road and along the curb parking areas adjacent to the terminals.

Table 11

ESTIMATED PROJECT COSTS AND REVENUES FOR IMPLEMENTING THE REMOTE PARKING-BUS CONNECTION TO DETROIT METROPOLITAN WAYNE COUNTY AIRPORT ACCESS/EGRESS STUDY

COST CATEGORY	ESTIMATED COST
Advertising-Promotion (1)	$ 85,000
Airport Signing (2)	2,000
Roadway Signing (3)	2,000
Bus Operation-including Drivers (4)	250,000
Remote Parking Attendants (5)	15,000
On-Board Bus Survey (6)	50,000
Vehicle Classification Count (7)	4,000
Bus Priority Signal Installation (8)	12,000
Consultant/In-Kind Services (9)	35,000
Supervision of Federal Government (10)	30,000
Contingencies-Ten Per Cent of Total (11)	48,500
TOTAL COSTS	$533,500
PASSENGER REVENUES (12)	$160,000
ESTIMATED NET COSTS	$373,500

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(1) Includes agency fees, television and radio coverage, and information signs.

(2) Includes costs for purchasing and installation within Airport area.

(3) Includes costs for purchasing and installation within area near Airport.

(4) Includes costs of vehicles, maintenance, replacement depreciation, marginal profits, and driver wages based on vehicle-hours operated.

(5) Includes salaries and miscellaneous expenses to provide attendants at remote terminal.

(6) Includes cost of hiring, training, and conducting on-board survey. The supervisors fees are included herein.

(7) Includes cost of hiring a crew to conduct and record three 24-hour vehicle classification counts and includes a permanent loop detector.

(8) Includes cost of installing bus priority signal and providing electronic transponders on all buses to Airport remote lot as well as providing spare parts for replacement. It does not include cost of new signal installation.

(9) Includes estimated cost of contracting with a qualified consultant or obtaining in-kind services from the Wayne County Road Commission.

(10) Includes cost of administration, travel, and other services by Federal Government.

(11) Includes contingencies estimated at 10 per cent to cover unexpected expenses during the nine-month study.

(12) Assumes a moderate user attraction to this facility based on existing private operator trends and a pricing rate of $1.25 per day over a nine-month period.

During the nine month experiment, it is estimated that this airport remote parking lot should generate about $160,000 worth of receipts. These monies can be used to reduce the total monetary outlay required to subsidize this operational experiment to about $372,580 as shown in Table 7. This estimate is based on a moderate growth trend and considers the increased central parking rates and competition from other private parking operators nearby, as well as the level of service offered.

Evaluation

This experiment will evaluate the impact of the remote airport parking terminal on the central parking areas as well as the existing private parking lots.

- It will evaluate the remote airport parking lot by its ability to alleviate traffic congestion at I-94 and Merriam Road.
- It will evaluate the potential of setting coordinated remote central parking rates consistent with the goals and objectives of the Airport.
- The inherent characteristics of the airport lot as pertaining to its location will be fully explained.
- It will evaluate the impact of offering a free parking service to airport employees.

From the data collected, the social and economic characteristics of remote parkers in all lots will be described. Significant differences among lots will be highlighted and reasons for any differences explained. These differences and similarities will provide a base from which other airports can utilize in planning and designing their own remote parking systems.

Experiment Number Two - Coordinated Bus-Rail Feeder Service

1. This experiment should provide a data base and prototype experience which other airports in other geographic areas having somewhat similar characteristics, can determine the potential for coordinated bus-rail application. Airports such as Logan in Boston and San Francisco International are typical potential examples.

2. The experiment should specifically attempt to divert to public transportation those Airport users who can be served by rail and who normally arrive at the Airport by private vehicle. In the process, it is probable that residents of other local areas served by this Airport may be attracted and hence utilize the service. In addition, it is conceivable the new service will attract the "kiss-and-ride" user.

3. The experiment should evaluate the economic impact of various express bus-to-airport fare structures and alternative levels of bus service. Their total effect on patronage will be denoted.

4. The experiment should provide facts to support recommendations for further improvements (where needed) which can make the proposed bus-rail fare structures, such as specially reduced bus-rail tickets, or specially scheduled buses and trains correspond more closely to user demand. Variations in bus frequency should be made part of the experiment.

5. Finally, the experiment should analyze the long-range financial feasibility of the bus-rail service and recommend stable permanent system changes commensurate with the degree of success of the experiment.

This recommended operational experiment should be one in advertising, operating and evaluating a new bus link connecting LaGuardia and Kennedy Airports with the Jamaica and Woodside Stations on the Long Island Rail Road (LIRR). It should involve:

1. A carefully programmed plan of one year's duration with the New York Metropolitan Transportation

Authority (MTA), the Port Authority of New York and New Jersey, the Federal Government, local planning-operating groups and a selected bus operator(s).

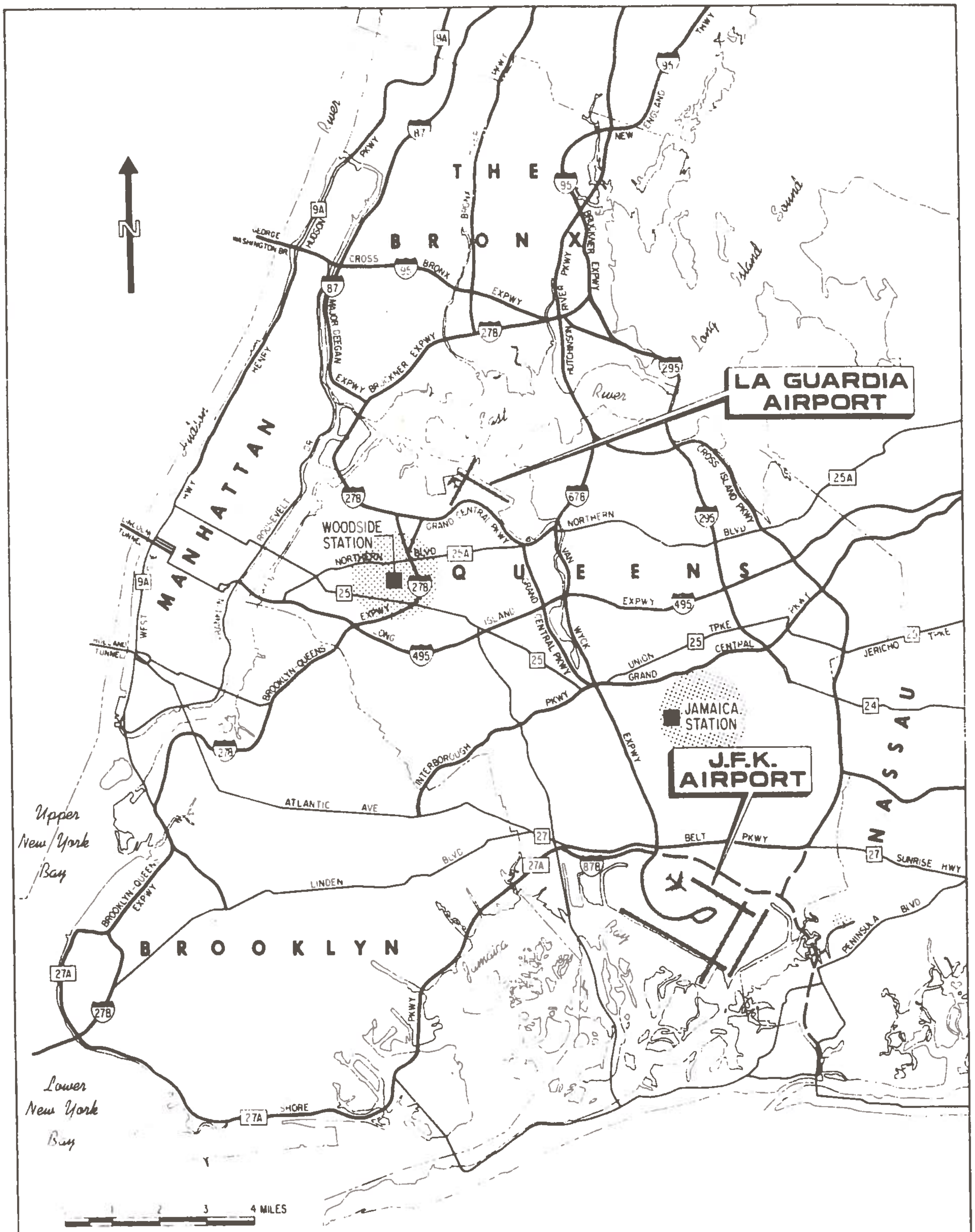
2. A procedure of supervision of:
   a. Operating buses to and from the selected airports and rail stations;
   b. Varying fares; and,
   c. Varying service levels.

3. A procedure of data collection and analyses to monitor attitudes, travel habits, and other socio-economic characteristics of users.

<u>Existing Conditions</u>

LaGuardia and Kennedy International Airports, both located in Queens County (see Figure 17), are approximately 12.5 roadway miles apart. Nearly 72 per cent of passengers at both airports arrive by private vehicle, i.e., automobile or taxi. LaGuardia, in fact, has nearly 50 per cent of all vehicle trips made by taxi with Kennedy generating about 37 per cent.

The primary ground transport problems existing at both airports are (1) inadequate road access, (2) long walking distances (necessary because of the size and location of the parking lots), and (3) insufficient curb frontage for enplaning



LOCATION MAP, LAGUARDIA AND KENNEDY AIRPORTS
Airport Access/Egress Systems Study

FIGURE 17

and deplaning functions. The same regional roadways which serve the air passengers also serve the urban commuter and other major traffic generators. Compounding this problem is the fact that the peak demands for airport facilities and work trips usually coincide.

Rail facilities serving Kennedy and LaGuardia Airports have been and are being explored but approval and implementation are not expected in the near future--at least not before 1977. Either a subway or spur from an existing railroad would no doubt assist in reducing some of the congestion which now exists.

The Long Island Rail Road (LIRR)--the largest commuter rail line in the United States--serves Brooklyn, Queens, Nassau, and Suffolk Counties with extensive rail trackage and a network of stations, prior to terminating at the Pennsylvania Station in Manhattan. Altogether, this rail system carries about 60,000 weekday passengers. The principal passenger lines on the LIRR are shown in Figure 18, revealing its extensive geographic coverage.

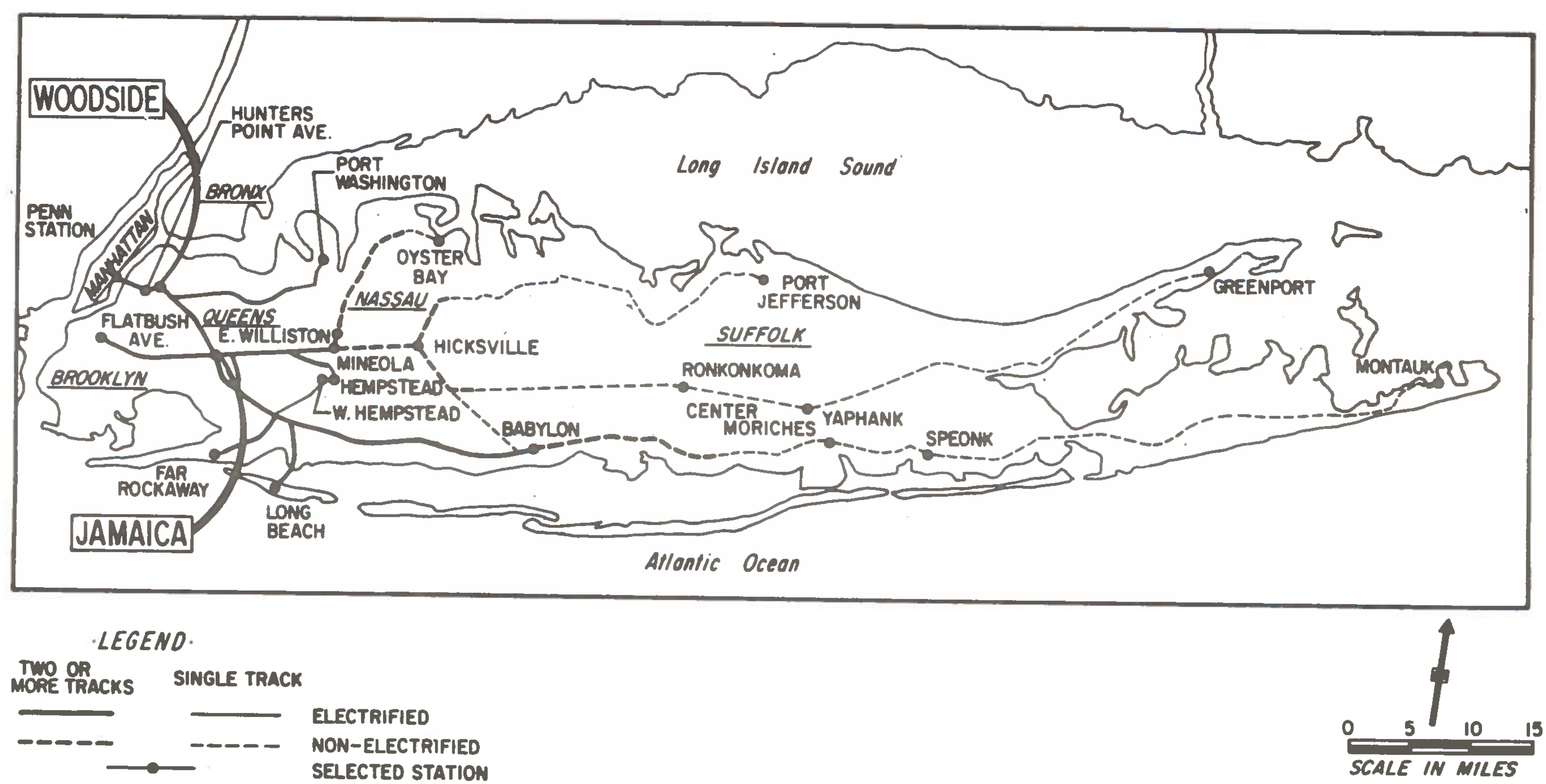
A recent travel study conducted by the Port Authority in 1967-68 concluded that about 30 per cent of all private vehicle trips to Kennedy and LaGuardia have either an origin or destination on Long Island. Furthermore, about one-third of the employees at these airports commute to and from Long Island daily by automobile.[5]

(5) New York's Domestic Air Passenger Market, prepared by the Port of New York Authority, 1967-68.

As the demand for air travel increases, the present road system (now already judged inadequate) will become even more congested for longer and more frequent time periods throughout the day. It is not likely that a new airport facility in the New York Metropolitan area will be constructed soon enough to help alleviate this problem.

Planners have sought solutions to these critical problems by attempting to reduce the amount of ground traffic. The concept of "dispersed terminals" is one alternative frequently discussed. Basically, this offers airport users the use of well located modal transfer terminals. Here, air passengers can be diverted to public vehicles prior to arriving or immediately upon leaving the airport complex. A facility which incorporates baggage handling in addition to possibly offering a ticketing (reservation) function and other passenger amenities, as well as a pleasant and relatively fast transport capability, is believed to be an important potential ingredient for diverting airport users from their cars, thereby helping to relieve highway congestion. New York City is experiencing problems with this concept as the operation of the West Side Airlines Terminal in Midtown Manhattan was terminated in 1972. Some think that permanent closure of the East Side Airlines Terminal is approaching for similar economic reasons.

It is likely that if a similar terminal function is offered at a well chosen LIRR station(s) and linked with suitable



PRINCIPAL PASSENGER LINES, LONG ISLAND RAILROAD
Airport Access/Egress Systems Study

FIGURE 18

bus service to Kennedy and LaGuardia Airports, it could serve a real need by diverting a sufficient number of people from taxi or private modes to the bus with a favorable impact. The fact that the terminal would bypass a lot of ground congestion through its location would be a plus. That concept is the subject of this operational experiment.

Station Locations

Jamaica Station is about 4.2 airline miles from Kennedy Airport. It is one mile south and one-half mile east of Grand Central Parkway and Van Wyck Expressway, respectively, and just south of Jamaica and Hillside Avenues (principal arterials in Queens) and west of Sutphin Avenue. Sutphin Avenue eventually provides secondary access to Kennedy Airport. It is also the prime transfer station of the Long Island Rail Road to all other points of the rail network. Because of this, this Station offers an excellent test bed for this experiment.

Woodside Station is about three airline miles from LaGuardia Airport. It is about one-half mile north and west of Queens Boulevard and the Brooklyn-Queens Expressway, respectively, and, it is just north of Woodside Avenue passing over Roosevelt Avenue. Woodside is not a principal station stop but is the major station for LIRR service on the Port Washington Line. It does offer frequent service.

Access

Bus access from Jamaica Station to Kennedy Airport would primarily be along the Van Wyck Expressway, but alternative access is possible via 150th Street (Sutphin Avenue). Access to LaGuardia Airport from Woodside Station is mainly along the Brooklyn-Queens Expressway.

Alternative Combinations of Experiments

Because of regional proximity of the two stations to each other and to each Airport, and due to the cost implications of operational experiments, three possible test cases emerge for consideration:

- A bus service to and from Jamaica Station and Kennedy Airport;
- A bus service to and from Woodside Station and LaGuardia Airport; and,
- Both experiments together.

Jamaica-Kennedy Alternative

In coordination with the MTA, (The Long Island Rail Road), Kennedy Airport (Port Authority), as well as other appropriate private and governmental agencies, an on-street bus terminal should be sited at Jamaica Station to serve Kennedy Airport travelers-employees. The bus should operate between the rail station and the Airport on a regular scheduled basis which must be fully coordinated with the LIRR, the selected bus operator(s) and the Port Authority. No preferential bus lane treatment or special bus signals are anticipated with this plan because of problems in lane capacity and public acceptance. Limited ramp metering already exists along the Van Wyck Expressway at some interchanges.

Kennedy Airport is active every day of the week and the proposed bus service should be scheduled to serve the 24-hour clock. Following is a list of actual experiments to be conducted over a one-year study period:

1. Initiate a schedule of continuous daily express bus service from Jamaica Station to Kennedy Airport for six full months. Operate the buses from 6:00 A.M. to 12:00 Midnight on a 30-minute headway. From 12:00 Midnight to 6:00 A.M. operate the buses on a one-hour headway. Establish a one-way normal fare of $1.00 during the peak and $0.75 for the off-peak. Establish a $20 monthly employee commuter fare which is good for unlimited bus rides.
2. After six months, increase bus service frequency by employing a 15-minute headway to Kennedy during

the 6:00 A.M. to 12:00 Midnight period. Retain a one-hour bus headway during remaining hours.

3. After nine months and with extensive advertising introduce a fare of $0.75 during the peak and $0.50 for the off peak. Reduce the monthly employee parking to $15. Continue these for remainder of the project.

4. Analyze results and explore needs to adapt this project on a permanent basis, to discontinue project or to study additional alternatives.

<u>Project Implementation</u> - About one month prior to the start of the proposed bus-rail experiment, an extensive advertising campaign should be conducted. This would include at least radio, television, and newspaper coverage. Cooperative support should be solicited from the airlines. Adequate signing at both Kennedy Airport and Jamaica Station and at critical subway stations is recommended. Pennnsylvania Station, Grand Central Terminal, the Port Authority Bus Terminal, and perhaps the East Side Airlines Terminal (if operable) might also be places of intensive signing/advertising.

Every effort should be made to provide effective fluorescent lighting on Sutphin Boulevard underneath the LIRR overpass. Signs, well illuminated, on the rail platforms, in the station lobby, and at the proposed bus stop on Sutphin

Boulevard, should be constructed. The underpass affords natural protection from the elements and is a good passenger transfer point. An average walk from the LIRR platform to the buses (assuming an eight-car train) is about 250 to 300 feet. The station, including the lobby, should be well patrolled by police at all times.

Buses serving Kennedy Airport should make a stop at each of the nine major airline terminals in the loop roadway to receive and discharge passengers. Two stops will likely be needed at the International Arrivals Building because of its length.

Part of the experiment should consist of analyzing and measuring the effectiveness of the new rail-bus connecting service to Kennedy. The survey and data collection phase is therefore the key to the experiment.

Twelve separate on-board surveys and passenger counts should be taken at different periods during the study.[6] Each should be one week in length, in each of the twelve months, and cover only the inbound part of the trip, i.e., the trip from the Jamaica rail-bus station to Kennedy. Trained interviewers should be on board every other bus which is operated to administer this survey, and be under the direction of a qualified supervisor.

(6) An on-board survey is one in which the bus passengers will be asked a series of questions which will reveal the reasons for the trip and their choice of modes.

In addition to the surveys, one week should be budgeted for coding in preparing for the analyses of each sample. Bus drivers should assist survey staff in making boarding and alighting counts during the entire experiment.

Travel Time - The expected round trip travel times from Kennedy to Jamaica Station is shown in Table 12. The particular bus routes for this express bus service are shown conceptually in Figure 19. In most cases the freeways, even during peak hours, provide the fastest routes to the Airport. At certain times, however, 150th Street can provide an alternative route. During peak hours, the round trip bus service including stops is estimated to take 1 hour and 20 minutes. It should take about 45 minutes for a round trip during off-peak times.

Size and Number of Buses - Buses operated from Jamaica Station should be the medium size 35-passenger coach variety common to most New York airport bus service today. A smaller bus may be used during non-peak hours, if available. Buses should be well maintained, clean and climate controlled. They could even be painted special colors to facilitate the advertising program and perhaps titled--"Airport Flyer"--or some other appropriate name.

During peak hours of the first six months of this experiment, four total buses would be required to service the experiment daily. One bus could serve Kennedy in the off-peak period.

Table 12

TYPICAL TRAVEL TIMES BETWEEN JAMAICA STATION AND KENNEDY AIRPORT
AIRPORT ACCESS/EGRESS STUDY

FROM	ROUND TRIP TRAVEL TIME TO KENNEDY AIRPORT	
	6:00 A.M.-12:00 Midnight Peak	12:00-6:00 A.M. Off-Peak
Jamaica Station	80 Minutes	45 Minutes

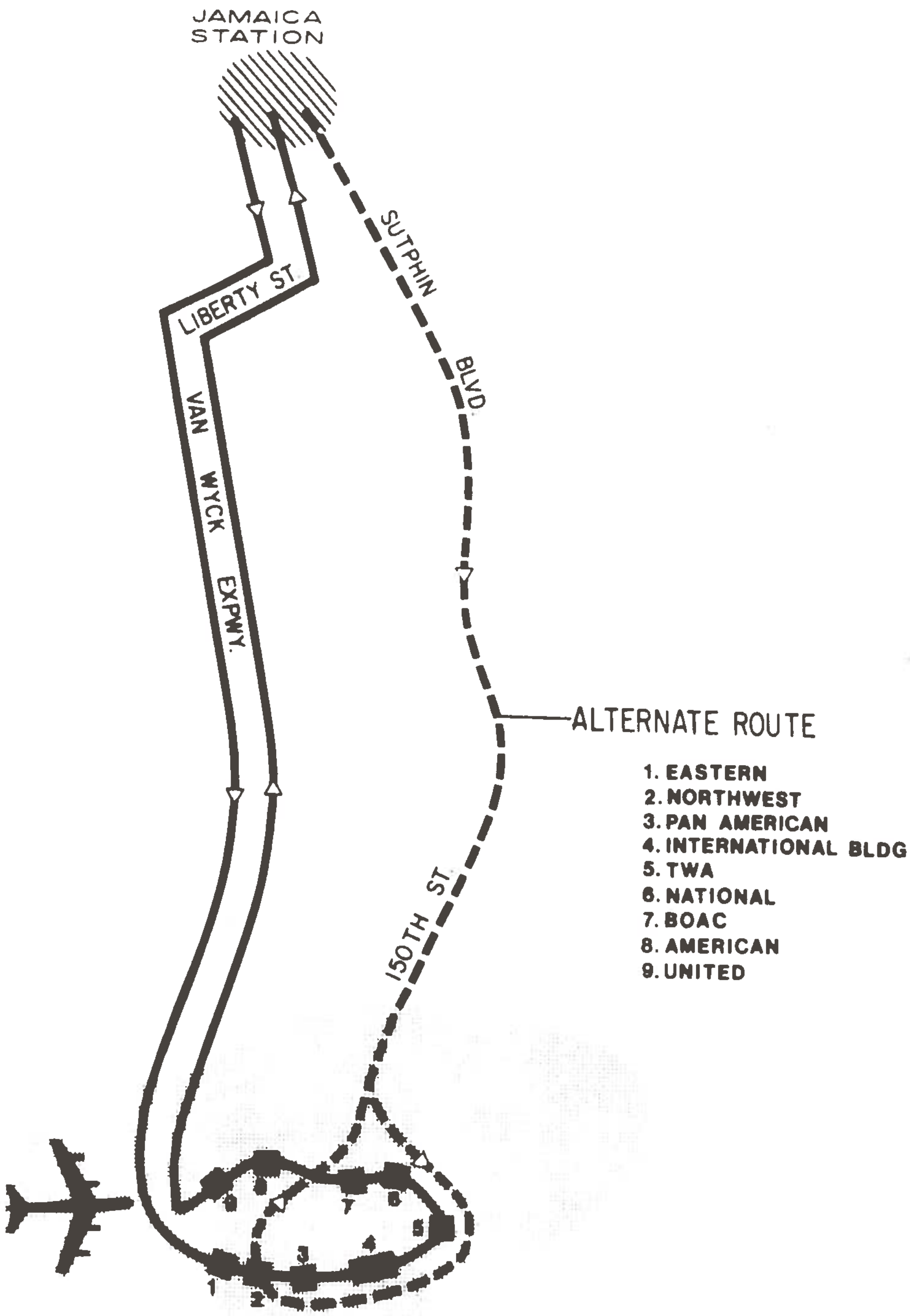
NOTE: Estimated by Wilbur Smith and Associates based on typical traffic conditions to above airport. The travel times are based on average line speed, ten stops within Kennedy Airport (includes expected boarding and passenger alighting times), and adequate layover time.

During the peak hours of the last six months of the experiment, seven buses are needed to serve the project. One bus only would be required to connect Kennedy to Jamaica Station at night. The actual bus requirements, by month of experiment, are shown in Table 13. The number of buses was specifically chosen to allow one to be waiting at each station during the hours it operates. This should help provide a greater sense of system reliability and security. This one additional vehicle can also be used to replace other buses which are being maintained, serviced or repaired.

Carey Bus Company has already been approached by the Port Authority about this type of experiment and has stated they would be able to provide this service.

Personnel - Table 13 also lists the expected types and numbers of people required to staff the airport bus-rail express service and conduct the data collection work. Each bus will require a bus driver and one supervisor should be on hand to regulate bus schedules and provide other service support. The bus driver and the supervisor should be expected to assist with any baggage handling at both trip ends.

The number of personnel conducting the on-bus survey are shown in Table 14. They should convey a neat appearance and be prepared to answer all questions courteously. If requested, they should fill out the forms for the respondent. Since the



CONCEPTUALIZED BUS ROUTING PLANS TO
KENNEDY INTERNATIONAL AIRPORT
Airport Access/Egress Systems Study

FIGURE 19

Table 13

PERSONNEL AND BUS REQUIREMENTS FOR THE JAMAICA-KENNEDY PLAN
AIRPORT ACCESS/EGRESS STUDY

MONTH	NUMBER OF DAILY DRIVERS REQUIRED		NUMBER OF DAILY SUPERVISORS REQUIRED		TOTAL DAILY PERSONNEL REQUIRED	NUMBER OF BUSES REQUIRED	
	Peak(1)	Off-Peak(2)	Peak(1)	Off-Peak(2)	Peak and Off-Peak	Peak(3)	Off-Peak(2)
0-3	6	1	2	1	10	4	1
3-6	6	1	2	1	10	4	1
6-9	12	1	2	1	16	7	1
9-12	12	1	2	1	16	7	1

(1) 6:00 A.M. - 12:00 Midnight.
(2) 12:00 Midnight - 6:00 A.M.
(3) Includes an extra bus in case of breakdown or scheduled service maintenance.
NOTE: This table does not include police surveillance or administrative requirements needed to monitor the experiment such as a consultant and/or review by local, state, and federal authorities.

Table 14

PERSONNEL REQUIREMENTS TO COLLECT AND CODE DATA
FOR THE JAMAICA-KENNEDY PLAN
AIRPORT ACCESS/EGRESS STUDY

DURING MONTH (1)	DAILY NUMBER OF EMPLOYEES TO PERFORM ON-BOARD SURVEYS	DAILY NUMBER OF SUPERVISORS	TOTAL MAN-WEEKS REQUIRED
1	6	2	16
2	6	2	16
3	6	2	16
4	6	2	16
5	6	2	16
6	6	2	16
7	12	2	28
8	12	2	28
9	12	2	28
10	12	2	28
11	12	2	28
12	12	2	28
		TOTAL MAN WEEKS	264

(1) Assumes two weeks per month to collect and code data.

NOTE: A one week sample survey conducted between 6:00 A.M. and 12:00 Midnight is judged adequate to estimate study parameters Questionnaires will not be administered between 12:00-6:00 A.M. The bus drivers will be responsible for making an on-off passenger count.

questions reveal specific attitude information, the surveyers should be instructed not to influence the specific responses. Instructions and suggested questions for the bus surveys are shown in Appendices E and F.

Estimated Project Costs and Revenues - The estimated project costs and assumptions for this plan are shown in Table 15. The total annual operational costs are estimated to be about $742,500. Advertising and bus operation costs for the Jamaica-Kennedy Plan are $150,000 and $423,000, respectively.

The fare collection plan will involve setting two pricing rates during the day. One will be for the peak hours and the other for the off-peak. The experiment will try, by means of pricing mechanisms, to make off-peak travel more attractive. Employees who regularly use the express bus facilities will be offered a discount rate of about 50 per cent from the normal fares.

This service should attract nearly 460,000 annual users generating about $300,000 worth of receipts which can be used as a credit against the cost of providing this service. The users would include both airline employees and air passengers. The assumptions used to generate these estimates are based on a moderate, but realistic, growth trend in bus usage. Total costs, after deducting revenues, are estimated to be $442,500 for the first year of operation.

Table 15

ESTIMATED ANNUAL PROJECT COSTS AND REVENUES FOR JAMAICA-KENNEDY PLAN
AIRPORT ACCESS/EGRESS STUDY

ESTIMATED COSTS	JAMAICA-KENNEDY PLAN
Advertising(1)	$ 150,000
Station Signing	1,500
Airport Signing	2,500
Station Lighting-Underpass(2)	4,000
Bus Operation-including drivers(3)	423,000
On-Board Bus Surveys(4)	40,000
Consultant/In Kind Services(5)	35,000
Supervision of Federal Government(6)	20,000
Contingencies-Ten Per Cent of Total(7)	67,500
TOTAL COSTS	$ 742,500
PASSENGER REVENUES(8)	$ 300,000
ESTIMATED NET COSTS	$ 442,500

(1) Includes agency fees, television and radio coverage, and information signs located in visible and well patronized areas.
(2) Includes the costs for purchasing and installing fluorescent lighting at appropriate locations in the station.
(3) Includes costs of drivers wages, supervision, maintenance costs, rental of bus, and provision for bus replacement if breakdown occurs, insurance, marginal profit, and miscellaneous fees and is based on a vehicle-hour calculation.
(4) Includes the costs of wages and fringe benefits for hiring temporary help to survey buses for 12-two week periods. Also includes forms, pencils, and miscellaneous costs.
(5) Includes cost of obtaining a qualified consultant to monitor and analyze the study results or to obtain in-house services from the Port Authority.
(6) Includes the administrative and technical cost necessary for the Federal Government to monitor and direct this study.
(7) Contingencies include unforeseen operating expenses, diversion to other modes, and loss of revenues to Port Authority, police surveillance, and other unclaimed costs.
(8) Passengers revenues are based on an estimate of the annual users per bus-mile assuming pricing and headways as discussed in the text. This estimate includes both airline employees and air passengers.

Woodside-LaGuardia Alternative

In coordination with the same agencies previously indicated under the Jamaica-Kennedy Plan, an on-street bus terminal should be located at the Woodside Station of the LIRR to serve travelers and employees to LaGuardia Airport.

The buses should operate between the Airport and the Station on a regular scheduled basis, fully coordinated with the LIRR and the selected bus operator(s), as well as the Port Authority. No preferential bus lane treatments or special bus signals are recommended with this plan because of the problems in traffic flow and public acceptance.

Because of wide variations in airline flight schedules over the day, it will be necessary to provide only 16-hour bus service to LaGuardia Airport from the Woodside Station during the proposed one-year experiment.

1. Initiate a schedule of continuous daily service from Woodside Station to LaGuardia Airport for six full months. Operate the LaGuardia buses on 30-minute headways from 6:00 A.M. to 10:00 P.M. The one-way bus fare to LaGuardia Airport will be set at $0.75 during the peak and $0.50 for the off-peak periods. Establish an employee commuter fare of $12 which is good for unlimited rides per month.

2. After six months, increase bus service frequency by employing a 15-minute headway to LaGuardia during the 6:00 A.M. to 10:00 P.M. time period. Retain these headways for the balance of the experiment.

3. After nine months and with extensive advertising, introduce a normal fare of $0.50 for bus service in the peak hours and $0.30 for the off-peak period. Reduce the employee parking to $10 per month.

4. Analyze results and explore needs to adapt this project on a permanent basis, to discontinue project, or to study additional alternatives.

<u>Project Implementation</u> - About one month prior to the start of the proposed bus-rail experiment, an extensive advertising campaign should be conducted. This would include at least radio, television and newspaper coverage. Cooperative support should also be gained from the airlines. Signing at LaGuardia Airport and Woodside Station and at key subway stations is further recommended. Pennsylvania Station, Grand Central Terminal, and perhaps the Port Authority Bus Terminal might also be the recipient of signs advertising effort.

Woodside is located in an active area both residentially and commercially. Nevertheless, lighting and proper signs at the station are necessary since the train station is old. The buses should stop on 61st Street underneath the LIRR overpass. The average walk to this location is about 300 to 350 feet. Above the Woodside Station is the 61st Street subway station of the IRT Flushing line.

About one-half mile from the Woodside Station of the LIRR, four subway lines converge at the Roosevelt Avenue Subway Station serving Jackson Heights in Queens. Three of these subway lines connect Queens with Brooklyn via Manhattan. The fourth connects Queens with Brooklyn directly. As a result, this subway stop could become another vital passenger transfer point, and the bus should be specifically routed to stop there.(7) Adequate signing will be needed at this point.

Buses serving LaGuardia will make a stop at the above subway station and then run express to the Airport. There they will stop at the Eastern Airlines Shuttle Terminal and make two additional stops at the Main Terminal Building.

Part of the experiment consists in analyzing and measuring the effectiveness of the new rail-bus connecting service to LaGuardia. The survey and data collection phase is a key element in the study. Twelve separate on-board surveys and passenger

---

(7) A local bus operation currently provides a link from this station to LaGuardia Airport. The bus is not express, however.

counts should be taken at different periods during the study. Each survey should be one week in length, in each of the twelve months, and cover only the inbound part of the trip, i.e., the trip from the Woodside Station to LaGuardia. Trained interviewers should be on-board every other bus to administer this survey, and be under the direction of a qualified supervisor.

In addition to the surveys,one week should be budgeted for coding in preparing for the analysis for each survey taken. Bus drivers should assist survey staff in making boarding and alighting counts during the entire experiment.

Travel Time - The expected round trip travel times to the proposed transfer station at Woodside for the airport is shown in Table 16. The particular bus routes for this express bus service is shown conceptually in Figure 20. In most cases the freeways, even during peak hours, provide the fastest routes to LaGuardia. From Woodside Station to LaGuardia and return will take about 40 minutes in peak hours, including the stop at Roosevelt-Jackson Heights subway stations. This also includes three stops within the terminal, passenger loading and unloading times, and adequate layover time.

Size and Number of Buses - Buses operated from both stations should be the medium size 35 passenger coach variety which is currently provided by some bus companies operating to the airports. A smaller bus may be used during non-peak hours if

Table 16

PERSONNEL AND BUS REQUIREMENTS FOR THE WOODSIDE-LAGUARDIA PLAN
AIRPORT ACCESS/EGRESS STUDY

MONTH	NUMBER OF DAILY BUS DRIVERS REQUIRED (1)	NUMBER OF DAILY SUPERVISORS REQUIRED (1)	TOTAL DAILY PERSONNEL REQUIRED	NUMBER OF BUSES REQUIRED
0-3	4	2	6	3
3-6	4	2	6	3
6-9	8	2	10	5
9-12	8	2	10	5

(1) 6:00 A.M.-10:00 P.M.

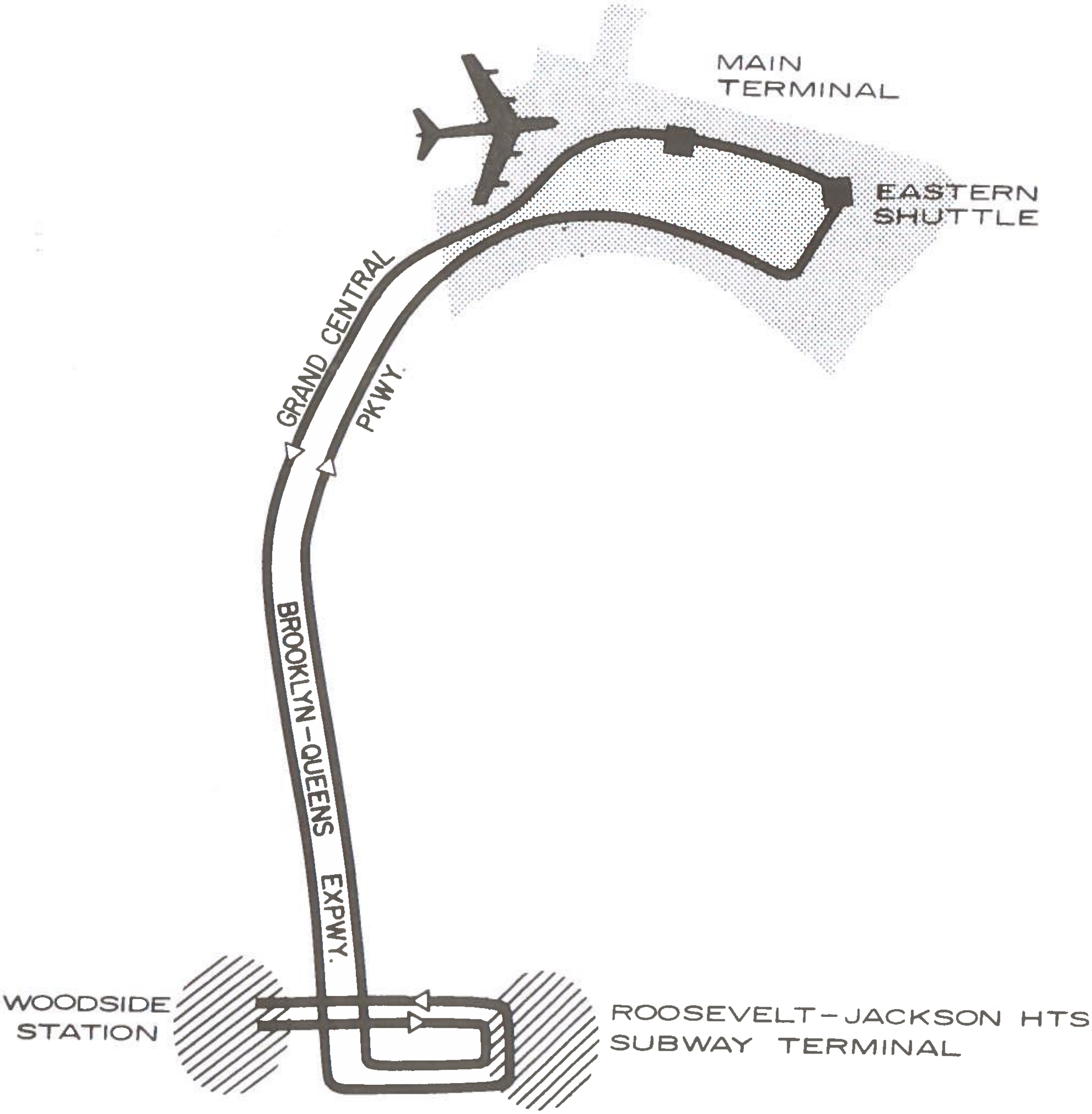
NOTE: This table does not include police surveillance or administrative requirements needed to monitor the experiment such as consultants and/or review by local, state, and federal authorities.

available and demand warrants it. Buses should be well maintained, clean and preferably be air conditioned. They could even be painted special colors to facilitate the advertising program.

During the peak hours of the first six months of the experiment, three buses will be required to serve the Woodside Station during the day. During the peak hours of the last six months of the experiment, five buses are needed to serve LaGuardia. The actual bus requirements by month of experiment are shown in Table 16. The number of buses was specifically chosen to allow one to be waiting at each station during the hours it operates and to provide additional assistance if one is inoperable. This should help provide a greater sense of security at the station.

Personnel - Table 16 also lists the expected types and numbers of people required to provide the airport bus-rail express service from both stations and conduct the data collection. Each bus used will obviously require a bus driver. One supervisor should also be on hand to regulate bus schedules and provide other support. The bus driver and the supervisor should be expected to assist with any baggage handling at both ends of the trip.

The numbers of personnel conducting the on-bus survey are shown in Table 17. They should be dressed neatly and answer all questions courteously. If requested, they should fill out the forms for the respondent. Since the questions reveal specific



CONCEPTUALIZED BUS ROUTING PLANS TO LAGUARDIA AIRPORT
Airport Access/Egress Systems Study

FIGURE 20

Table 17

PERSONNEL REQUIREMENTS TO COLLECT AND CODE DATA FOR THE WOODSIDE-LAGUARDIA PLAN AIRPORT ACCESS/EGRESS STUDY

DURING MONTH[1]	DAILY NUMBER OF EMPLOYEES TO PERFORM SURVEYS	DAILY NUMBER OF SUPERVISORS	TOTAL MAN-WEEKS REQUIRED
1	4	2	12
2	4	2	12
3	4	2	12
4	4	2	12
5	4	2	12
6	4	2	12
7	8	2	20
8	8	2	20
9	8	2	20
10	8	2	20
11	8	2	20
12	8	2	20
		TOTAL MAN WEEKS	192

(1) Assumes two weeks per month to collect and code data.

NOTE: A one week sample survey conducted between 6:00 A.M. and 10:00 P.M. is judged adequate to estimate study parameters. Questionnaires will not be administered between 10:00 P.M. and 6:00 A.M. The bus driver will be responsible for making an on-off passenger count.

attitude information, the surveyer must be careful that he or she does not influence the response. The specific instructions and suggested questions for bus surveys are shown in Appendices E and F.

<u>Estimated Project Costs and Revenues</u> - The estimated project costs and assumptions for this plan are shown in Table 18. The total operational costs are estimated to be about $532,000 for the year. Advertising and bus operation costs for the Woodside-LaGuardia Plan are $150,000 and $260,000, respectively.

The fare collection plan will involve setting two pricing rates during the day. One will be for the peak hours and the other for the off-peak. The experiment will try by means of pricing mechanisms to make off-peak travel more attractive. The employees who regularly use the express bus facility will be offered a discount rate of about 50 per cent from the normal fares.

This bus service should attract about 290,000 annual riders who should generate almost $153,000 worth of receipts which can be used as a credit against the cost of providing this service. Users include airline employees and air passengers. The assumptions used to generate these estimates are based on a moderate, but realistic, modal split process, which recognizes cost and level of service as its principal

Table 18

ESTIMATED ANNUAL PROJECT COSTS AND REVENUES FOR
WOODSIDE-LAGUARDIA PLAN
AIRPORT ACCESS/EGRESS STUDY

ESTIMATED COSTS	WOODSIDE-LAGUARDIA PLAN
Advertising (1)	$150,000
Station Signing	
Woodside Station	1,000
Roosevelt Avenue	500
Airport Signing	2,000
Station Lighting-Underpass, Platform, Stairs (2)	5,000
Bus Operation-including Drivers (3)	260,000
On-Board Bus Surveys (4)	30,000
Consultant/In-Kind Services (5)	20,000
Supervision of Federal Government (6)	15,000
Contingencies-Ten Per Cent of Total (7)	48,350
TOTAL COSTS	$531,850
PASSENGER REVENUES (8)	$155,000
ESTIMATED NET COSTS	$376,850

(1) Includes agency fees, television and radio coverage, and information signs located in visible and well patronized areas.

(2) Includes the costs for purchasing the installation of fluorescent lighting at each station.

(3) Includes costs of drivers wages, supervision, maintenance costs, rental of bus, and provision of bus replacement if breakdown occurs, insurance, marginal profit and miscellaneous fees and is based on a vehicle-hour analysis.

(4) Includes the costs of wages and fringe benefits for hiring temporary help to survey buses for 12 two-week periods. Also includes forms, pencils and miscellaneous costs.

(5) Includes cost of obtaining a qualified consultant to monitor and analyze the study results or to obtain in-house services from the Port Authority.

(6) Includes the administrative and technical costs necessary for the Federal Government to monitor and direct this study.

(7) Contingencies include unforeseen operating expenses, diversion to other modes and loss of revenues to Port Authority, police surveillances and other unclaimed costs.

(8) Passenger revenues are based on estimates of the annual users per bus-mile assuming pricing and level of service as described in the text. Revenues include both airline employees and air travelers.

parameters. Total costs, after deducting revenues, are estimated to be about $377,000 for the first year of operation.

Combination of Above

Under this alternative both of the experiments discussed could be conducted simultaneously. The existing bus service (now operated by Corey Company) connecting LaGuardia to Kennedy Airports would be retained as presently exists and would not be part of the experiment.

Evaluation

By means of an after study, the impact of coordinated bus-rail Airport service and the number and type of air passengers should be evaluated. The criteria and factors which make the travelers to Kennedy and LaGuardia Airports similar to other geographic areas should be denoted and fully discussed. In order to successfully accomplish these goals, much reliance should be placed on the specific travel and socio-economic data collected from the experiment.

The data should facilitate analyses of the bus-rail impact on ground congestion to and from the Airports. The data should also reveal the numbers of vehicles and persons diverted to the new bus-rail service. And, they should depict the impact on other public carriers competing with this system, such as limousines and other motor buses.

A number of useful analyses should be performed. The sensitivity of the bus-rail user should be examined with regard to the following variables:

1. Fares (cost of bus trip);
2. Bus headways;
3. Rail headways;
4. Change of Mode;
5. Distance traveled to Airport;
6. Time of day;
7. Income;
8. Sex;
9. Attitudes; and,
10. Others.

In addition, a number of potential transportation models could be formulated, tested, and calibrated. Typical of these are:

1. Trip distribution models;
2. Benefit-cost models;
3. Cost effectiveness models;
4. Utility or disutility models; and,
5. Cost models for various levels of bus service.

These models should be tested in other geographic areas to help locate bus-rail service to airports and evaluate them prior to their implementation.

Finally, the passenger trends should be predicted. Continuation or discontinuation of the experiment would then be recommended and the potential for application described.

<u>Experiment Number Three - Baggage Check-In Facility Evaluation</u>

This experiment should provide a data base and prototype experience with other airports in other geographic areas planning their own automatic baggage check-in facilities (ABC).

- Other airports may need to know the typical number and type of bags carried by an average passenger in order to design their own system efficiently.
- The relationship between the number and type of airline flights (such as jumbo or normal) and the user, as it affects the baggage system should be clearly analyzed and described for reasons of economy and design, particularly with the advent and use of larger aircraft.

The experiment should be able to measure the effectiveness of the ABC check-in facilities initially provided from a standpoint of traffic flow.

- Criteria of effectiveness would be relief of curb congestion, vehicles diverted, changes in vehicle-miles in and around the parking garage, changes in travel time, overall travel habits, and perhaps changes in Airport functions, design and management procedures.
- The experiment should assess the impact of the present baggage handling system as well as analyze the effectiveness of the planned four additional ABC facilities to be completed later. It might be determined, for example, that the space at each ABC island is insufficient, causing delay to through vehicles in the garage and on the deplaning roadway.

The experiment should indicate and measure the effectiveness of advertising and airport signing. The impact of baggage system failures (if any) on the Airport in terms of delay and inconvenience should be thoroughly discussed.

The experiment finally should evaluate the costs and benefits of the ABC baggage system, and make recommendations in design and operation found to be needed to maximize these benefits.

This recommended operational experiment will be one of planning, monitoring and evaluating the impact of baggage check-in facilities within the parking garage at the new Seattle Airport. It will involve:

1. A coordinated plan, to be executed within six months, in cooperation with the Port of Seattle Commission, the Federal Government, and other local planning-operating agencies.

2. A procedure of supervision of:

    a. Operating the internal Airport road system in the existing conventional manner of receiving enplaning baggage at the enplaning curb position; and,

    b. Operating the internal Airport road system with baggage check-in within the new parking configuration.

3. A procedure of data collection and analysis to monitor the effect of this change on traffic volumes in the garage and on the internal road system, attitudes of users and Airport Management, travel patterns within the Airport and socio-economic characteristics of users.

<u>Existing Conditions</u>

Seattle-Tacoma International Airport (SEATAC) is located about 10 and 20 miles from Seattle and Tacoma, Washington, respectively (Figure 21). Nearly 90 per cent of all traffic on the Airport Access Freeway are automobiles or taxis; the remaining vehicles are either buses or small vans.[8] Most truck traffic presently exits or enters the Access Freeway at 170th Street, one-half mile north of the Airport site. A service road there permits access to all parts of the Airport for these vehicles.

The 1971 air passenger volume at the Airport included over 5.0 million passengers and nearly 84,000 tons of freight. This involved 114,000 individual commercial air carrier operations at 35 gates.

Current estimates indicate that about ten per cent of all passengers are interairline transfers. The rest have origins or destinations to or from the Seattle Metropolitan area. Of these, about 17 per cent are central business district (CBD) oriented, principally to Seattle.

The Airport currently provides about 6,100 jobs. Most of these employees park in a remote lot to the north of the main terminal with connecting bus shuttle provided. Parking space, however, is also reserved by the Port of Seattle in the newly completed 9-story parking garage for its employees. It also allows some parking spaces to be leased by other airport

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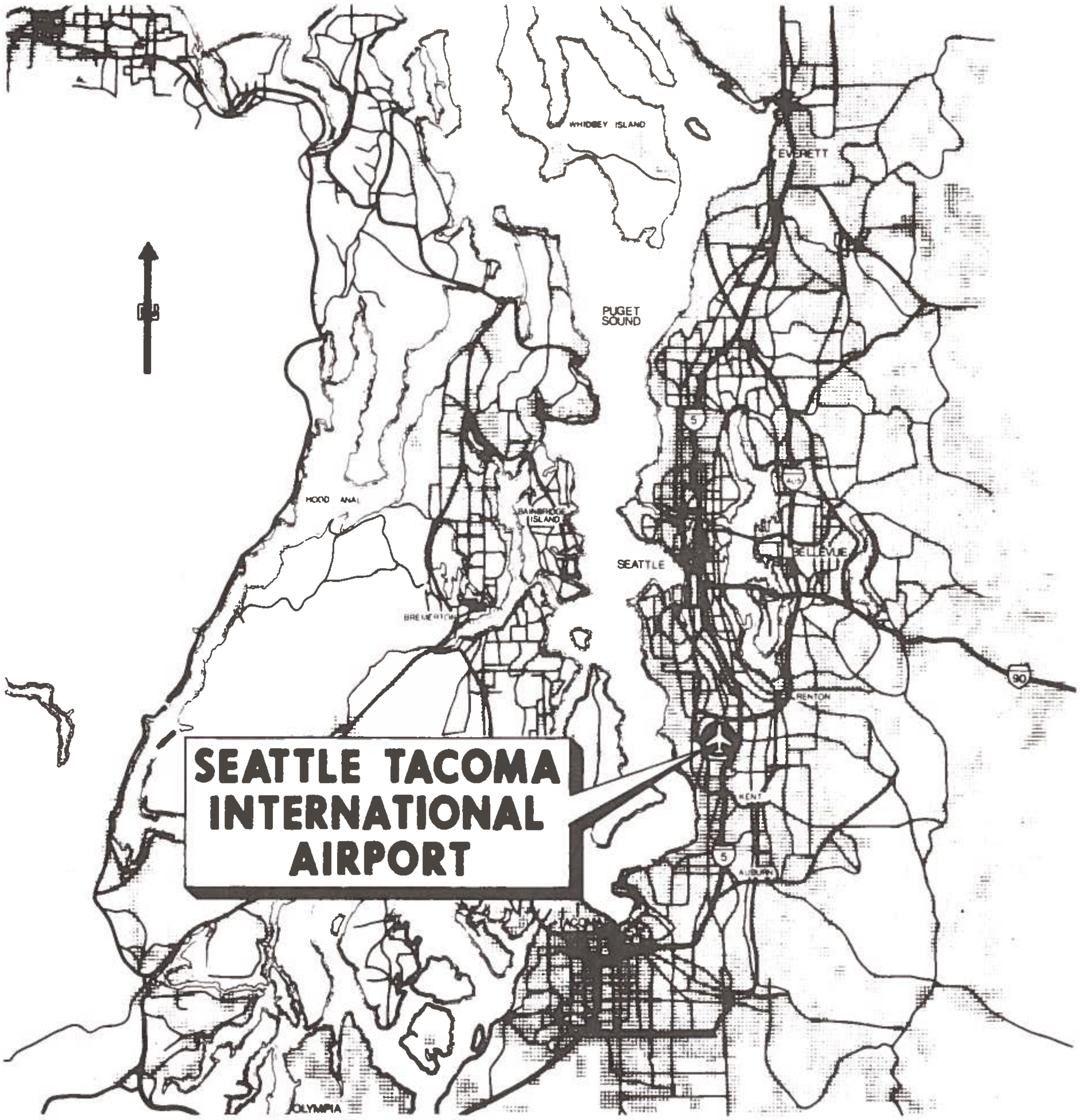
(8) Port of Seattle Commission, 1972.

employees. The garage has a present total capacity of 4,800 vehicles, although it can be expanded.

There is an estimated 1,000 linear feet of enplaning curb space at the main terminal building. This is a fixed dimension and not subject to change. Buses, taxis and limousines are allowed to use this area freely; private cars, however, are discouraged from stopping for too long a time by an active Airport police force.

Plans for Expansion

The Seattle Port Commission, operator of the Airport, anticipates that passenger volumes will reach 20-million annually by 1980. In order to accommodate this increase, a $175 million capital improvements program was launched several years ago. This program included the construction of an efficient grade-separated Airport Access Freeway (which provides four lanes for enplaning and four for deplaning vehicle operations), a central parking garage (with a present capacity of 4,800 spaces), and two satellite Airport terminal buildings, which are connected to the main terminal by a computerized inter-terminal rail transit facility under the airport apron. Further developments at the Airport will be specifically determined by a Master Plan Study now in progress (Figures 22, 23, and 24).

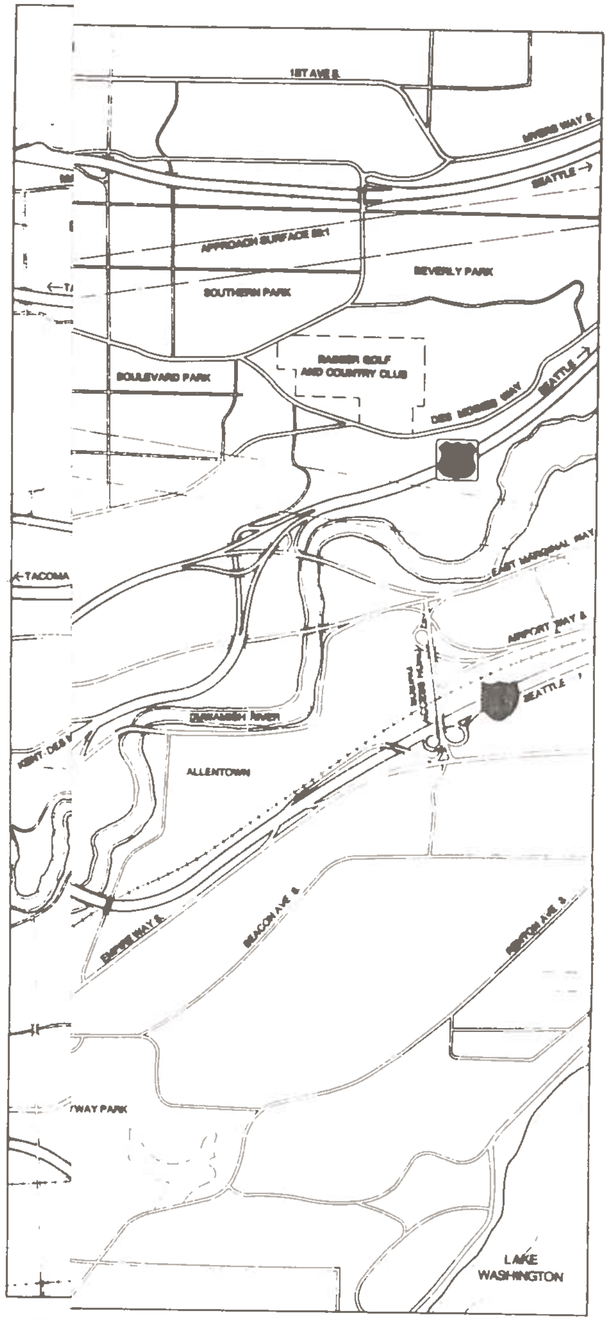


SOURCE: THE RICHARDSON ASSOCIATES
SEATTLE, WASHINGTON

0 4 8 12 MILES

LOCATION MAP, SEATTLE-TACOMA INTERNATIONAL AIRPORT
Airport Access/Egress Systems Study

FIGURE 21



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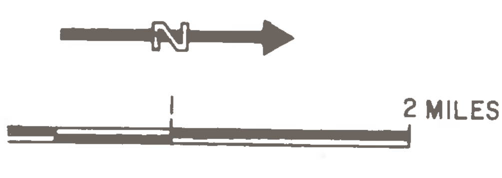


FIGURE 22

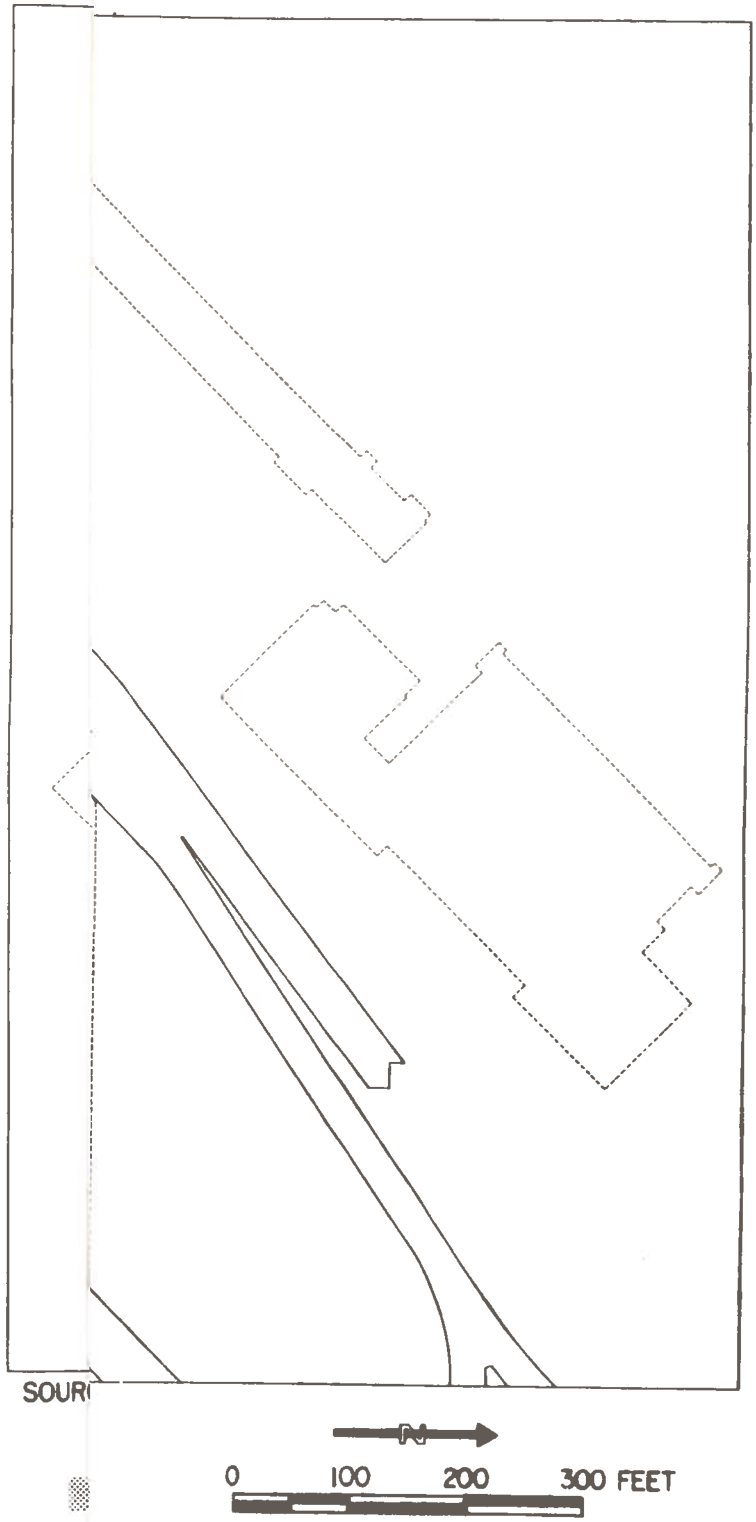
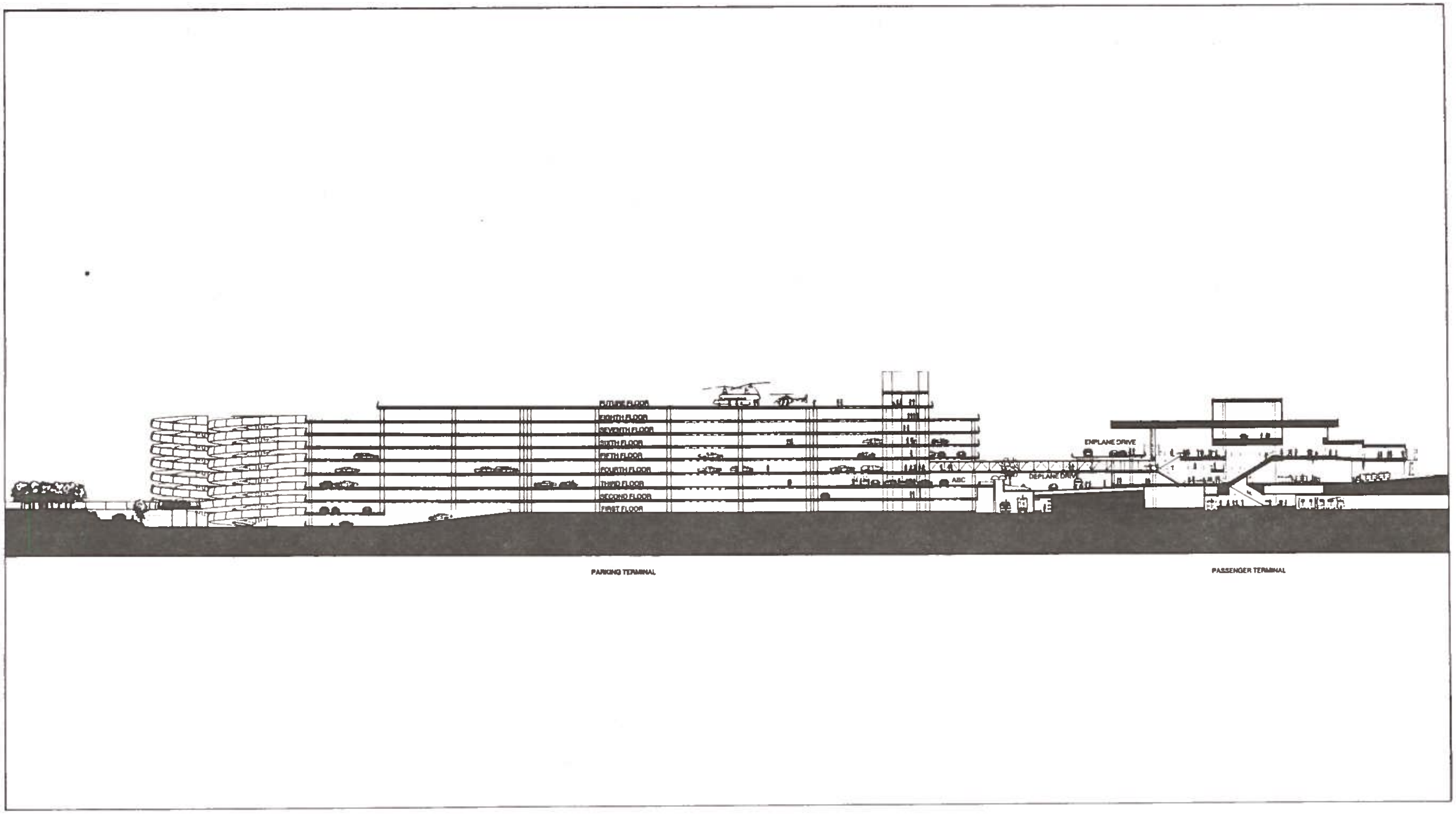


FIGURE 23



SOURCE: THE RICHARDSON ASSOCIATES
SEATTLE, WASHINGTON

CROSS SECTIONAL VIEW, PORT OF SEATTLE PARKING GARAGE,
SEATTLE-TACOMA INTERNATIONAL AIRPORT
Airport Access/Egress Systems Study

FIGURE 24

SEATAC is introducing a novel mechanical baggage transport system in its garage. Late in 1973, an Automobile Baggage Check-In (ABC) conveyance will be opened. This will represent the first airport-owned high speed automated baggage handling system in a U.S. airport, it will cost about 5.5 million (Figure 25).

The ABC system provides an efficient means for handling outbound baggage. Four unique stations will be provided initially for this purpose and will be located at specially constructed traffic islands within the Parking Terminal. Normal traffic will have the option of discharging baggage here and then parking on another level. Six automobiles may be serviced at each island at one time. Stairs are located at each ABC island to take pedestrians to nearby elevators to reach one of four grade separated foot bridges provided on the floor above, which crosses between the enplaning and deplaning roadways and connects the garage with the main terminal (Figure 26).

The air carriers will be responsible for staffing and operating the ABC facilities. The specific functions to be performed at all these facilities by the airline employees is not officially determined. It will, however, include at least tagging and removing the baggage from the car. Later some ticketing and flight information services may be possible.

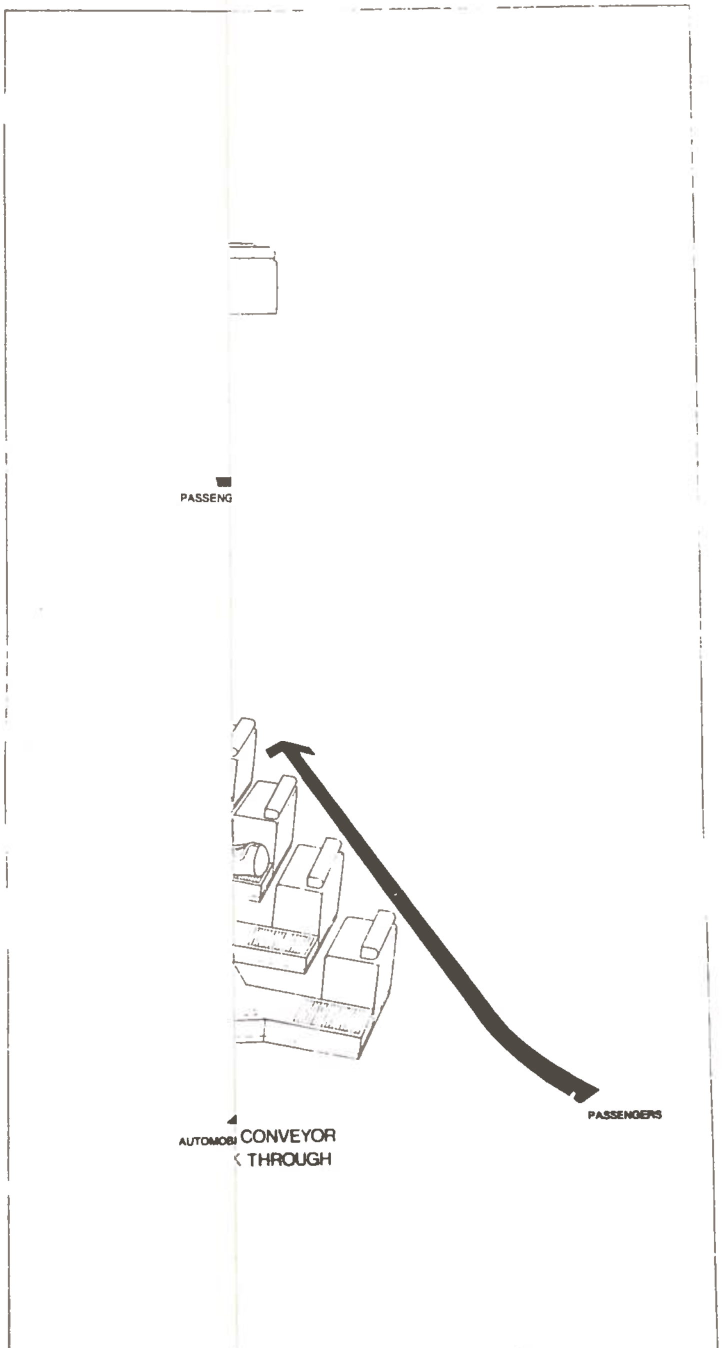
Ultimate plans call for four additional automobile baggage check-in facilities within the garage and another 4,900 spaces in the parking terminal to supply 9,800 total spaces.

Most of the roadways and intersections serving the Airport have been completed. The South 188th Street and U.S. 99 grade-separated highway connection is, however, not expected to be fully completed until mid-1974. Presently, there is temporary access provided.

<u>Project Design and Implementation</u>

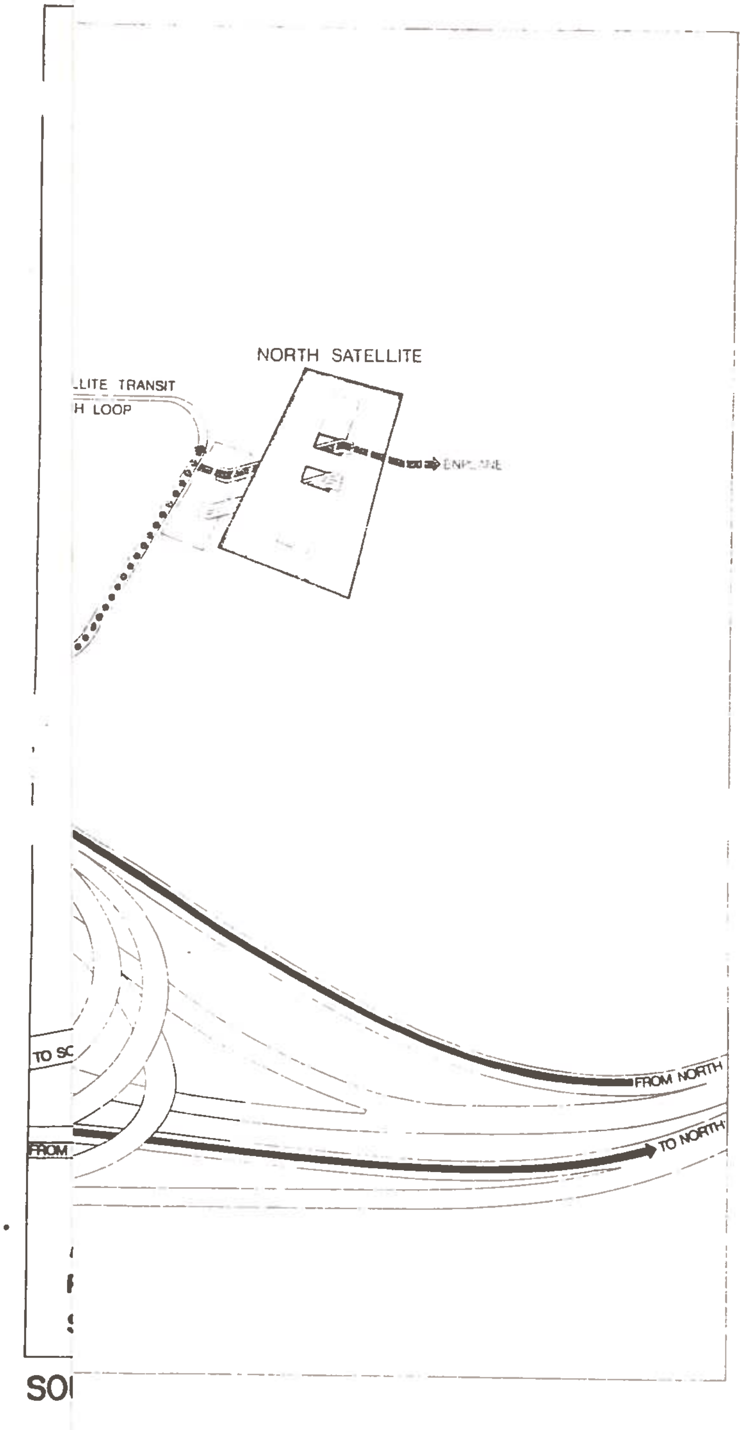
This experiment will be designed specifically to describe the impact of the proposed ABC facilities on its users. Results of this experiment can best be understood in terms of the ease in congestion (if any) on the enplaning curb serving the main Airport terminal building and the type of users. Presently, enplaning passengers must either park in the garage and walk to the terminal or use the enplaning curb to unload their baggage or be dropped off.

1. Drivers who bring passenger(s) to the terminal without waiting for flight departure:
    a. Leave passenger(s) at curb with or without baggage.
    b. Leave passenger(s) at ABC station for baggage removal.



SOURCE: THE
SEA

FIGURE 25



NORTH SATELLITE
LLITE TRANSIT
H LOOP
ENPLANE
TO SC
FROM NORTH
FROM
TO NORTH
SOI

FIGURE 26

2. Drivers who bring passenger(s) to the Airport and remain to see them off:

   a. Leave passenger(s) at curb and then drive to garage.

   b. Drive directly into garage and carry baggage (if any) to terminal.

   c. Deposit baggage at ABC station before parking in garage.

3. Air passengers who drive themselves.

   a. Drive into garage and carry baggage to terminal.

   b. Deposit baggage at ABC station and then park in garage.

Cooperation between the Port of Seattle, the individual airlines, Federal Government, and other local-regional planning agencies should be secured. The airlines will be officially responsible for staffing each ABC station and any particular experiment should meet with their approval before implementation.

NOTE: The composition of the above functional groupings is influenced by trip purpose, residence (local versus visitor) and duration of trip--which in turn are parameters for the number of pieces of baggage carried by the passenger--and hence the demand for the ABC system. This composition is also sensitive to the time of year since business and non-business travel fluctuates by season as well as type of users, i.e. through versus transfer.

The following is a recommended procedure from which to measure the impact of the ABC facilities. The approach basically employs a six month before-and-after study, while carefully selecting the parameters and criteria. It includes a comprehensive, systematic program of counting vehicles in and around the Airport continuously over a six month period. It also includes a program for surveying and monitoring the characteristics of enplaning curb and ABC users.

1. Prior to and not more than one month before the ABC facilities are scheduled to open, the following major work tasks conducted over a typical full week (seven days) should be performed. This experiment should be designed to satisfy traffic engineering requirements and statistical reliability tests:(9)

    a. Place a system of automatic (machine) traffic counters across the major roadways (U.S. 99, Airport Access Freeway, and service roads) providing access to the Airport both north and south of the site. Then obtain a two-way, 24-hour volume count of all vehicular movements crossing this cordon.

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(9) Friday is usually the peak weekday at the Seattle-Tacoma International Airport in terms of airline passenger movements and as such is a good day to obtain data.

b. Place a system of mechanical traffic counters across <u>all</u> connecting ramps and internal roadways serving both the Main Terminal and Garage at the Airport. This will require about 16 separate locations to obtain a 24-hour volume count of all vehicular movements oriented to the Airport.(10)(11)

c. Arrange and collect, along with the above counts, a vehicle classification count for 18 hours from 6:00 A.M. to 12:00 Midnight over a one-week period. This must be accomplished manually to gather data on types of vehicles using Airport roads, i.e. automobiles, taxis, limousines, large trucks, medium trucks, small trucks, and buses. The data collected should be placed on forms similar to that in Appendix G-2. These data will provide quantitative and qualitative information on the manner in which vehicles circulate and utilize the Airport facilities and services prior to opening the ABC baggage system.

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(10) Once the counters are installed, leave them in place for the duration of the six-month experiment to obtain daily and hourly vehicle fluctuations from which to adjust the results of the proposed Airport operational experiment surveys. Further, these data should be transcribed on forms daily in a similar format to that shown in Appendix G-1.

(11) The quality of the counters is extremely important in order to ensure statistical accuracy and to minimize malfunctions.

d. Arrange and conduct an enplaning curb utilization study for at least 18 hours from 6:00 A.M. to 12:00 Midnight over the same week. This will require dividing the curb frontage into subsections for more effective person surveillance. Forms furnished in Appendix G-3 should be used to record these facts. The data will provide a base from which the experiment can measure the impact of the ABC facility, when it is operational. This includes turnover duration, and accumulation of vehicles by category. These data, furthermore, can be related to level of highway service, degree of curb congestion, amount and type of utilization, and measure the intensity of use.

e. With the cooperation of the Port of Seattle Commission and the airlines, arrange and conduct a post card survey of 50 per cent of all enplaning passengers on the Airport itself. This survey should be conducted during the same week and over 18 hours per day from 6:00 A.M. to 12:00 Midnight. Prepaid post card forms (see Appendix G-4) will be distributed to all enplaning airline passengers on each flight. They should be administered by employees of each airline. This survey should obtain data on the mode of passenger arrival at the Airport, trip purpose, income, age, sex, airline destination, number of bags, and local or non-local residency. The purpose of this survey is to obtain before data on the profile of the typical enplaning passenger as to socioeconomic characteristics. These data will then be related to after results collected as part of the experiment.

2. About two weeks prior to opening and for two months afterwards, initiate an energic and vigorous advertising campaign designed to inform the public that a new baggage handling system has been installed which is designed to assist the air traveler, and help reduce travel time, delay, and in essence make the enplaning trip more pleasant by freeing the passenger from his baggage sooner than normal. Signing in the airport approaches should be studied well beforehand to ensure their ready perception and identification by drivers before vehicular decision movements are required.

3. For one day each month during the next five months in which the ABC system is operating, sample surveys of curb and ABC utilization, air passenger characteristics and attitudes, and manual classification counts should be obtained. The procedures for

data collection would be similar to those already outlined, but instead last for only one 18-hour day from 6:00 A.M. to 12:00 Midnight. These surveys allow the experimenter to monitor and comprehend the changes which are likely to occur.

4. Allow the ABC system to function for five full months to ensure that most air passengers have become accustomed to its operation. During the six months perform the following work tasks over a full week.[12]

   a. Arrange and conduct a vehicle classification count for at least 18 hours from 6:00 A.M. to 12:00 Midnight on each day. This will require manual counts at various parts of the Airport roadway network including the ramps leading into and out of the Garage. The type and volume of vehicles such as automobiles, taxis, limousines, trucks, and buses should be recorded by time of day on a form similar to that discussed in Appendix G-2.

   b. Arrange and conduct an enplaning curb utilization study for at least 18 hours from 6:00 A.M. to 12:00 Midnight over each day of this week. This will require dividing the curb frontage into 200-foot sections with one person responsible for

(12) Care must be exercised in adjusting the results of this experiment due to seasonal fluctuations.

each section. Appendix G-3 illustrates the typical format for data collection.

c. With the cooperation of the Port of Seattle Commission and the airlines, conduct a card survey of 50 per cent of the enplaning passengers on the aircraft itself. This survey should be conducted during the same week and for 18 hours from 6:00 A.M. to 12:00 Midnight each day. Prepaid post card forms (See Appendix G-5) will be distributed to all passengers by employees of each airline.

d. With the cooperation of the Port of Seattle Commission and the airlines, arrange and conduct a curbside survey at each of the ABC stations. This survey should be conducted during the same week and for 18 hours (6:00 A.M. to 12:00 Midnight) each day. The data collected here, according to Appendix G-6, will provide the experiment with information as to how each station operates and the service time required for each vehicle. It will also provide turnover, duration, and accumulation of vehicles by category.

Project Cost

Table 19 illustrates the estimated project costs for the ABC system experiment at Seattle-Tacome International Airport.

Table 19

EXPERIMENT COST TO CONDUCT THE

SEATTLE-TACOMA AUTOMOBILE BAGGAGE CHECK-IN SURVEY

Airport Access/Egress Study

ITEM	ESTIMATED MAN-WEEKS	QUANTITY	ESTIMATED COST
Personnel			
Install Machine Counters[1]	8	-	$ 10,000
Conduct Manual Counts[2]	350	-	67,000
Conduct Enplaning Curb Survey[3]	36	-	9,000
Airline Passenger Survey[4]	-	-	30,000
ABC Survey[5]	20	-	4,000
Coders-Analyst[6]	24	-	5,000
Consultant/In-Kind Services[7]	-	-	30,000
Supervision by Federal Government[8]	-	-	20,000
Contingencies (9)	-	-	17,500
Subtotal			$192,500
Equipment/Material			
Purchase/Lease Traffic Counters[10]	-	16	40,000
Stamps[11]	-	-	6,500
Digital Counters[12]	-	16	320
Pencils - Forms	-	-	5,000
Miscellaneous (13)	-	-	4,000
Contingencies (14)	-	-	5,600
Subtotal			$ 61,420
TOTAL			$253,920

(1) Install about 16 traffic counting machines on a permanent basis, provide sustained inspection and maintenance, and read and record data daily.

(2) Includes 16 three-man crews and 4 supervisors each work shift.

(3) Includes 5 surveyers and 1 supervisor per work shift.

(4) Credit individual airlines to make 50 per cent on-board survey.

(5) Includes 4 surveyors and 1 supervisor per work shift for one full week and 5 one-day surveys.

(6) Assumes two coders full time for two months each and one senior analyst.

(7) Includes services of a qualified consultant or in/kind service to monitor, analyze, and publish report.

(8) Includes supervision, administration, and travel expenses.

(9) At ten per cent of personnel cost.

(10) Assumes 16 machines or loop installations.

(11) To conduct post card survey.

(12) Assumes 16 hand counters.

(13) Includes clipboards, stopwatches, et cetera.

(14) At ten per cent of personnel cost.

The total cost is about $254,000 for the six-month experiment. The highest cost items are to conduct the manual traffic counts ($67,000), purchase traffic counters ($40,000), credit individual airlines for on-board survey ($30,000), and hire a consultant or provide typical in-kind services ($30,000).

Evaluation

By means of a before and after study, this experiment will obtain data to make relevant and meaningful comparisons of the baggage handling system in a statistical sense. The profile of the air passengers as they affect and are affected by the ABC system will be fully described as follows:

1. Age;
2. Income;
3. Sex;
4. Number of bags;
5. Trip purpose;
6. Mode of arrival; and,
7. Residency and non-residency.

The sensitivity of the ABC system to airline schedules and concomitant passenger arrivals will be analyzed. The success or failure of the new ABC system in relieving curb congestion will be determined and projections made to describe its operation in the future. It may be possible to develop a predictive model utilizing the data. Multiple regression analysis and the analysis of variance (ANOVA) are two valuable tools which could be used.

To help understand the system operations used by Seattle, frequency cumulative distribution diagrams and histograms will be employed, as well as standard graphics. These will all be adjusted to retain statistical reliance.

If possible, measures of effectiveness will be suggested. These measures of effectiveness might be vehicle-miles saved, speed-delay, travel time, change in airport user attitudes and change in vehicle circulation patterns. In any case, those measures which are found to be most important will be identified and thoroughly examined.

Chapter 5

SUGGESTIONS FOR FURTHER RESEARCH

As a part of continuing research in airport access/egress ground systems, it is assumed that the three specific experiments recommended have been implemented. It is quite possible that the evaluation phases of these experiments will reveal other research areas which should be investigated. In any rate, the following represents a present list of concepts which can be considered for further research in this field:

1. Airport access/egress facilities should be planned in an environment where they are considered part of the metropolitan planning process. Separate needs of the airport and its users should be fully coordinated with the needs of the metropolitan area in general and policy decisions concerning the desired growth and importance of the airport with respect to other metropolitan functions should be made and balanced to arrive at an overall master plan for the long and short-term.

2. Administrators of each airport should attempt to reach a set of design/planning guidelines (a master plan) which in essence balances the capacities of its various subsystems: parking space, roadway capacity, curb frontage, aircraft movements, flight schedules, etc.

3. Generally, person trips between the CBD and the airport show the greatest concentration. These trips, however, already utilize public transit to a greater degree than do trips between the airport and suburban areas. Ways and means should be sought which increase more transit utilization, such as through limousine/bus availability, pricing mechanisms and dispersed or satellite passenger processing centers.

4. The present roadway system, serving airports in general, is the result of planning decisions made 10 to 20 years earlier. Since aviation demand was usually underestimated and the roadways serving the airports underdesigned, much of the roadway congestion appears at the major access points to/from the airport where airport traffic merges or diverges with other vehicular traffic. Single highway access to airports appears to put too much of a strain on the single access points and, hence,