SYSTEMS ANALYSIS OF GROUND TRANSPORTATION AT MAJOR U.S. AIRPORTS

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Of the 746 airports in the United States served by commercial carriers, 20 serve 64 percent 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. 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). Ground transportation systems usually constrain the capacity of the overall system. This paper is based on the results of the Airport Access/Egress Systems Study (1972-1973) sponsored by the U.S. Department of Transportation. The project studied those 34 U.S. airports projected to be serving more than 2.0 million annual enplaned passengers by 1980 in order to ascertain the types and status of their ground transportation problems to be better able to recommend positive solutions. This paper reports on the data for the top 20 of these airports.

ONE of the most perplexing transportation problems today is the fast travel time from airport to airport via a modern jetliner and the slow frustrating trip to and from the airport via ground transport. The planning process, even today, has spent too much time on the line-haul portion of trips and not enough on providing either useful modal interfaces and modal choices or other options (especially for ground transport).

The objective of this paper is to obtain a clear understanding of the present character of surface transportation congestion to and from the nation's 20 major airports. From this the type, cause, and severity of ground congestion will be identified and evaluated and non-capital-intensive approaches offered that can effectively ease these problems.

This study will show the information obtained from personal interviews at each airport and the results of an extensive survey questionnaire. Altogether, 34 individual airports were examined in the course of this study; 20 of these were selected for detailed analysis herein.

ELEMENTS OF THE PROBLEM

Activity focused on each airport and the consequent impact it causes can be indicated in a variety of ways. Aircraft movements, passenger-visitor-employee volumes with their temporal fluctuations, and public transit utilization and/or availability all influence the airport to varying degrees. These are further influenced by the particular physical characteristics present: gates, terminal design, circulation, external access, airport location, etc.

Airport Location With Respect to Demand

Airports today need more land than ever before to serve requirements dictated by larger aircraft, more travel, and environmental planning criteria and standards.

Publication of this paper sponsored by Committee on Passenger and Freight Transportation Characteristics.

With large quantities of contiguous land becoming scarce close to the city center, potential new airports are being forced farther into the suburbs and hinterlands of present metropolitan areas. Cities requiring two or more airports to serve their needs only magnify this problem of land availability. Examples of this trend are Chicago, O'Hare and Midway; Los Angeles, International and Palmdale; Washington, National, Dulles, and Friendship; New York, LaGuardia, Kennedy, and Newark; and San Francisco, International, San Jose, and Oakland.

More importantly, however, it is the spatial location with respect to other traffic generators that can often determine the degree of congestion airports may experience on their ground facilities. Airports farthest from the city center generally show more total roadway capacity to them than those airports closer to the central areas. And the nearer the airport is to the city center the greater appears to be its dependence on public transit, such as taxis, limousines, buses, and rail.

The 20 major airports range in distance from a minimum of 2.0 (Washington National) to a maximum of 17.5 miles (Detroit) from their respective city centers, with 10 miles representing the average distance. Table 1 gives various activity statistics collected at the top 20 airports.

Airline passenger orientation to the 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 1). The CBD orientation is only 5 percent at Detroit, whereas LaGuardia shows a much higher attraction of 63 percent (it is known as New York's airport). On an average, the airport-oriented trips to the central areas are only 20 percent of the total trips.

External and Internal Ground Access Facilities

For all of the major airports, at least one freeway or expressway directly serves as the means of primary access and egress to the terminals (Table 2). The total number of highway lanes at each of the 20 subject airports ranges from two to five, and traffic volumes on these internal roadways vary from 20,000 to 60,000 vehicles per day, serving Philadelphia and Los Angeles, respectively. The external road system serving each airport is also important since it is found to carry 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 typical working hours.

Vehicle congestion, however, is generally isolated at principal access interchanges to and from the airport rather than on the road itself. Other points of congestion occur at lane drops near the airport and in restricted areas where demand exceeds capacity, such as 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

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 in terms of flights, passengers, and interline transfers, has about 12,000 public parking spaces available. In contrast, Denver Stapleton, with a much lower air-passenger volume, provides over 13,000 public 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 provided the fewest parking spaces at 3,700. An expansion program is now under way for more public parking at Minneapolis, however.

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

Table 1. Person activity at U.S. airports.

Airport	1970 Metropolitan Area Population (thousands)	Central Location With Respect to CBD	Central Area Orientation[a] (percent)	Distance to CBD (miles)	Passengers (millions)		
					Enplaned	Deplaned	Total
Chicago O'Hare	6,979	No	N.A.	16.5	14.8	15.1	29.9
Los Angeles	7,032	Yes	15	11.0	10.4	10.4	20.8
New York John F. Kennedy	11,529	No	47	11.5	10.1	9.1	19.2
Atlanta	1,390	No	24	7.5	9.0	9.1	18.1
San Francisco	3,110	No	25	12.0	7.1	7.1	14.2
New York LaGuardia	11,529	Yes	63	5.5	6.7	6.0	12.7
Miami	1,268	No	35	10.0	5.6	5.6	11.2
Dallas Love Field	1,556	No	N.A.	5.8	5.5	5.7	11.2
Washington National	2,861	Yes	25	2.0	5.4	5.4	10.8
Boston Logan	2,754	Yes	14	2.5	4.8	4.8	9.6
Denver Stapleton	4,200	No	30	7.5	3.0	3.9	7.8
Detroit Wayne County	1,857	No	5	17.5	3.6	3.6	7.2
Newark	11,529	Yes	61	10.5	3.3	3.2	6.5
Philadelphia	4,818	No	14	6.3	3.3	3.1	6.4
Pittsburgh	2,401	No	21	12.0	3.2	3.2	6.4
St. Louis Lambert Field	2,363	No	10	12.5	3.0	3.0	6.0
Minneapolis-St. Paul	1,814	No	N.A.	7.3	2.9	2.9	5.8
Cleveland Hopkins	2,064	No	N.A.	10.7	2.5	2.4	4.9
Seattle-Tacoma	1,422	No	17	12.0	2.4	2.3	4.7
Houston	1,985	No	38	15.5	2.3	2.3	4.6

Airport	Inter-Airline Transfers (percent)	Number of Employees at Airport			
		Airlines	Airport Workers	Other	Total
Chicago O'Hare	50.0	14,000	2,150	1,300	17,450
Los Angeles	26.0	29,000	4,000	4,000	37,000
New York John F. Kennedy	25.0	15,000	700	7,870	23,570
Atlanta	60.0	15,000	2,500	—	17,600
San Francisco	18.0	17,400	2,975	—	20,375
New York LaGuardia	11.0	2,210	290	1,000	3,500
Miami	20.0	23,900	9,240	—	33,140
Dallas Love Field	10.0	10,420	2,020	30	12,470
Washington National	9.0	4,680	2,180	4,690	11,550
Boston Logan	14.2	7,700	310	2,010	10,020
Denver Stapleton	30.0	6,000	155	—	6,155
Detroit Wayne County	10.0	N.A.	N.A.	N.A.	6,000
Newark	13.0	1,640	140	1,560	3,340
Philadelphia	14.0	3,000	200	1,000	4,200
Pittsburgh	30.0	2,100	2,000	—	4,100
St. Louis Lambert Field	35.0	N.A.	N.A.	N.A.	2,500
Minneapolis-St. Paul	3.5	8,000	1,500	300	9,800
Cleveland Hopkins	37.5	3,000	1,000	—	4,000
Seattle-Tacoma	6.0	4,280	1,810	—	6,090
Houston	10.0	N.A.	N.A.	N.A.	4,100

Note: Unless otherwise indicated, the data were collected during 1971. N.A. = not available.

[a]Central area orientation is defined as the area where most of the air travelers originate or are destined.

Table 2. Public transit and parking facilities at airports.

Airport	Number of Transit Lines[a]				Type of Parking (number of spaces)						
					Lot		Garage		Curb		
	Bus	Limousine	Taxi	Rail	Short Term	Long Term	Short Term	Long Term	Short Term	Long Term	Total
Chicago O'Hare	2	2	3	None	4,800	1,200	—	—	—	—	6,000
Los Angeles	1	2	1	None	900	5,500	1,000	4,000	—	—	11,400
New York John F. Kennedy	4	8	Many	None	6,500	5,700	—	—	—	—	12,200
Atlanta	1	1	50	None	2,140	2,130	1,200	—	—	—	5,470
San Francisco	2	10	1	None	390	1,480	3,200	—	—	—	5,070
New York LaGuardia	3	10	Many	None	6,110	—	—	—	—	—	6,110
Miami	1	1	Many	None	—	1,530	—	4,510	50	—	6,090
Dallas Love Field	1	2	4	None	540	7,370	—	2,200	—	—	10,110
Washington National	2	1	Many	None	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	7,300
Boston Logan	4	5	Many	Yes	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	8,290
Denver Stapleton	3	1	3	None	—	2,200	9,000	1,900	—	—	13,100
Detroit Wayne County	2	5	3	None	360	1,880	—	3,150	50	—	5,440
Newark	10	5	Many	None	920	5,500	—	—	—	—	6,420
Philadelphia	1	3	2	None	740	6,090	—	—	—	—	6,830
Pittsburgh	1	1	1	None	650	3,000	40	—	150	—	3,840
St. Louis Lambert Field	2	3	5	None	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	5,050
Minneapolis-St. Paul	1	3	—	None	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	3,700
Cleveland Hopkins	—	1	1	Yes	210	1,490	—	2,400	—	—	4,100
Seattle-Tacoma	2	—	1	None	—	—	—	4,800	—	—	4,800
Houston	—	—	Many	None	300	3,500	N.A.	1,500	N.A.	N.A.	5,300

Airport	Gross Parking Revenue (millions)	Linear Feet of Curb			Multiple Access[b]	Number of Access Roads to Airport Terminal Area[c]	Significant Congestion on Internal Roadways[d]	Significant Congestion on External Roadways[e]
		Enplaning	Deplaning	Total				
Chicago O'Hare	N.A.	2,550	1,850	4,400	No	1	Yes	No
Los Angeles	7.318	3,500	3,500	7,000	Yes	2	Yes	Yes
New York John F. Kennedy	N.A.	4,000	3,600	7,600	Yes	2	Yes	Yes
Atlanta	2.024	900	1,200	2,100	No	1	Yes	Yes
San Francisco	4.000	1,800	1,800	3,600	No	1	No	Yes
New York LaGuardia	N.A.	1,500	900	2,400	Yes	3	Yes	Yes
Miami	1.715	3,750	1,800	5,550	No	1	Yes	Yes
Dallas Love Field	2.739	900	900	1,800	No	1	No	No
Washington National	2.004	1,300	1,200	2,500	Yes	2	Yes	Yes
Boston Logan	4.459	500	900	1,400	Yes	2	No	Yes
Denver Stapleton	2.448	500	500	1,000	Yes	2	No	No
Detroit Wayne County	3.000	600	400	1,000	Yes	2	Yes	Yes
Newark	N.A.	900	900	1,800	No	1	No	No
Philadelphia	2.902	400	1,100	1,500	No	1	Yes	Yes
Pittsburgh	1.234	900	1,200	2,100	Yes	2	Yes	Yes
St. Louis Lambert Field	2.000	800	800	1,600	No	1	Yes	Yes
Minneapolis-St. Paul	1.250	800	800	1,600	No	1	No	No
Cleveland Hopkins	1.200	650	650	1,300	No	1	No	No
Seattle-Tacoma	1.500	1,000	1,000	2,000	Yes	2	No	No
Houston	2.147	600	900	1,400	Yes	2	No	No

Note: Unless otherwise indicated, all data were collected during 1971. N.A. = not available.

[a]Includes all transit service in the metropolitan area.
[b]Airport with more than one highway serving it.
[c]Airport served with two or more roadway facilities.
[d]Includes all highway facilities within the airport complex.
[e]Includes those highways affording access to the airport.

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 airport roadways and results in delays to other vehicles. An inventory of existing parking spaces for each of the study airports is given in Table 2.

Revenues from parking comprise a significant and important source of income for the airports, and for this reason it is difficult to reduce vehicle demand by reducing parking supply or pricing parking above existing rates. Annual parking revenues collected for each of the subject airports during 1971 range from $1.2 million at Cleveland Hopkins to about $7.3 million at Los Angeles International.

Existing parking charges at the principal airports differ significantly between short- and long-term parking. Most of these airports charge approximately 50 cents 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 by lower charges to use remote parking lots. Buses and other forms of transit frequently are employed to connect the remote parking facilities with 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.

Curb Frontage

Many passengers are dropped off or collected at curb locations at airline terminal facilities. Where there is insufficient curb space to meet demand, queuing of vehicles results causing congestion that 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 seem to be the time needed to collect and load baggage, make telephone calls, etc. Field studies have shown that, on an average, enplaning passengers use the curb for about 2 minutes per automobile, compared with about 3 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 because there are actually 10 separate terminals. Detroit has the smallest amount of deplaning curb frontage with only 400 linear feet. The amount of enplaning and deplaning frontage provided in each airport varies with the terminal configuration. Illustrative of this are the Kennedy, Dallas Love, and Detroit Metropolitan Airports, which all have imbalances in the amount of curb frontage provided for enplaning and deplaning passengers.

Passengers, Visitors, and Employees

Chicago's O'Hare Airport 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 1). The total number of passengers is important since they usually require ground transport services to and from the airport. Yet the intensity of interline transfers at the airports reduces this overall need because 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 percent respectively of total passengers as interline transfers. Minneapolis-St. Paul shows the least amount of transfers with 3.5 percent. When the total annual passengers are adjusted for transfers, Los Angeles International depicts the greatest potential demand on ground transport facilities, with Cleveland Hopkins the least.

Visitors also account for a great deal of airport activity. With each airline passenger there are between 1.0 and 1.5 airport visitors. Naturally, there is much variance in this statistic at each airport, especially when one includes the time of day and day of week.

Many of the 20 airports employ more persons than the total work force of a city of about 500,000 population (Table 1). 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 visitor and airline passenger activity occurs between 7:00 and 9:00 a.m. and 4:00 and 6:00 p.m. on weekdays. Most of the 20 airports work on a 3-shift basis, with the day shift comprising 30 to 65 percent of the total activity. The early evening shift comprises 20 to 50 percent of total activity, and the late shift comprises only 10 to 20 percent of the passenger, visitor, and employee 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 peak demand for air travel. This peaking tends to overlap other peak-hour travel, causing some additional delay and congestion on regional highways.

Aircraft Movements

Chicago, as expected, has the greatest number of aircraft movements, with Houston Intercontinental the least (Table 3). General aviation activity at the 20 airports ranges from 10 to about 50 percent of total aviation movements but only accounts for a fraction of the total number of passengers served by commercial flights.

Cargo Operations

The amount and location of cargo activity is significant since it can interfere with normal passenger processing if not located properly. Separate cargo access is provided at only six airports: Chicago, Los Angeles, San Francisco, Pittsburgh, Cleveland, and Houston. The magnitude of cargo operations is closely related to the markets served. Presently, annual cargo operations range from 835,000 tons at Kennedy to 34,000 tons at Houston. It is expected that air freight movements will escalate at a faster rate than air passenger activity.

Travel Characteristics

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. Also, 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 with proximity 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. Variations within the week are not too significant, although Saturday usually produces the least amount of air travel. Sunday usually experiences the most traffic at airports.

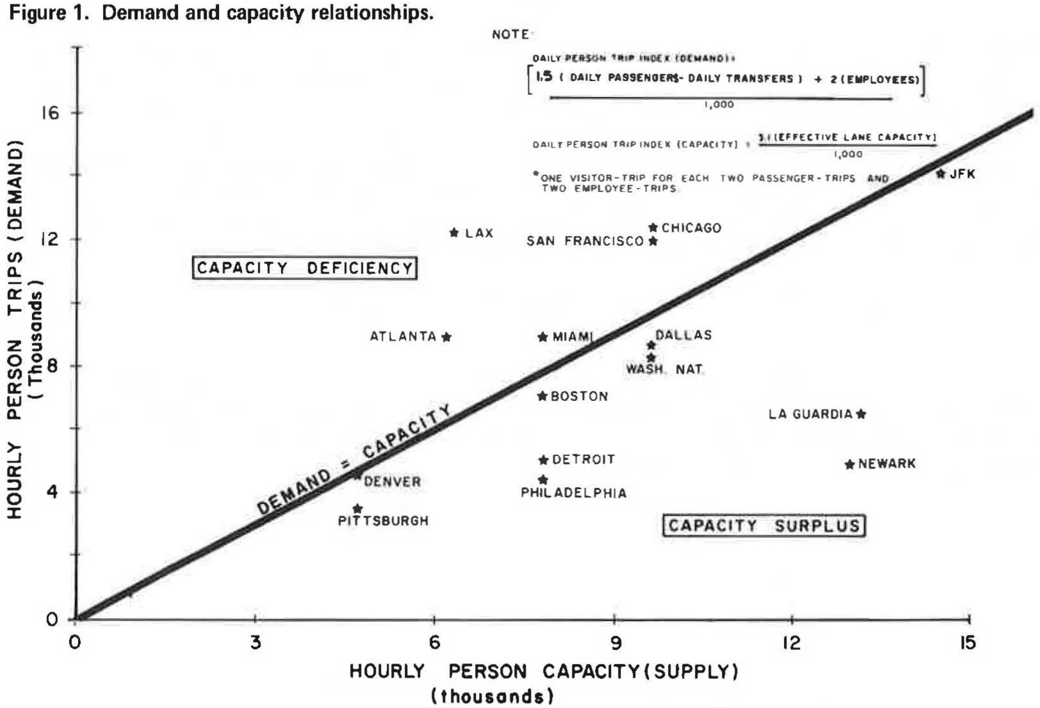
Distribution of travel among private automobile, taxi, public transit, helicopter, etc., depends on the availability, level of service, and cost of these services. Most vehicular traffic at airports consists of the private car, and this accounts for nearly 70 percent of total passenger arrivals at most major airports. Buses, taxis, limousines, and trucks typically account for 13, 10, 4, and 3 percent of the remaining total respectively.

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 station and airport terminals. The transit services provided at major U.S. airports are given in Table 2. 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 availability.

Table 3. Aircraft and cargo statistics (1971 data).

Airport	Aircraft Movements			Number of Gates	Annual Tonnage of Cargo	Cargo Access	
	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
New York 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
New York 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

Figure 1. Demand and capacity relationships.



DEMAND-SUPPLY RELATIONSHIPS

The establishment of an analytical relationship between the demand for ground transport and the capacity of existing transportation facilities to meet this demand is useful in categorizing need. This can be used to denote the extent of congestion. Therefore, an index of demand was established and related 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 for 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:

$$\text{PDI} = \frac{[1.5\ (\text{daily passengers - interairline transfers}) + 2\ (\text{number of employees})]}{1{,}000} \tag{1}$$

"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 was 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 3 persons per vehicle, the "person capacity index" (PCI) was developed:

$$\text{PCI} = \frac{3.1\ (\text{effective lane capacity in vehicles per hour})}{1{,}000} \tag{2}$$

Figure 1 shows results of the application of these formulas. It reveals that Los Angeles has the greatest ground access problem of the U.S. airports and Newark Airport is relatively uncongested because of substantial highway capacity. Indices of person supply and demand for the major airports are as follows:

Airport	Demand Index
Los Angeles	2.00
Atlanta	1.50
Chicago O'Hare	1.30
San Francisco	1.20
Miami	1.20
New York John F. Kennedy	1.00
Denver Stapleton	1.00
Boston Logan	0.94
Dallas Love Field	0.90
Washington National	0.90
Pittsburgh	0.70
Detroit Wayne County	0.63
Philadelphia	0.62
New York LaGuardia	0.48
Newark	0.38

Besides supplying enough roadway capacity to meet demand, this study found other important relationships. Figure 2, for example, shows that 17 of the 20 airports generally provide more vehicle parking spaces than the FAA has recommended as a design standard. It also indicates that O'Hare, Atlanta, and San Francisco show major deficiencies in meeting this standard. Figure 3 shows the relation between effective

Figure 2. Air passengers and airport parking spaces.

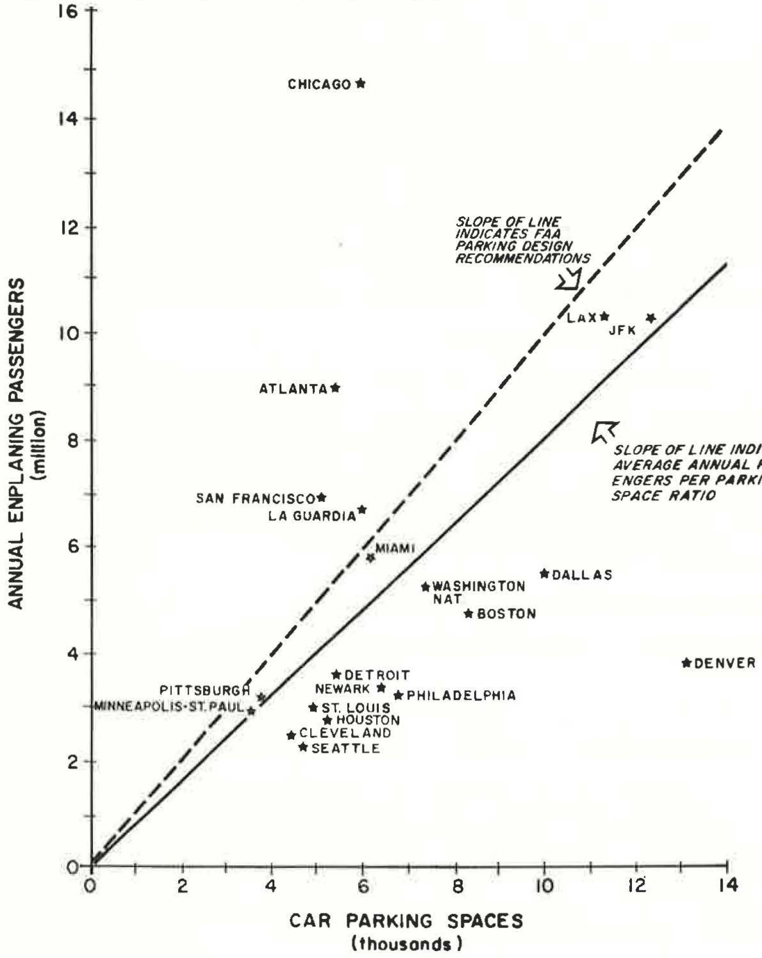
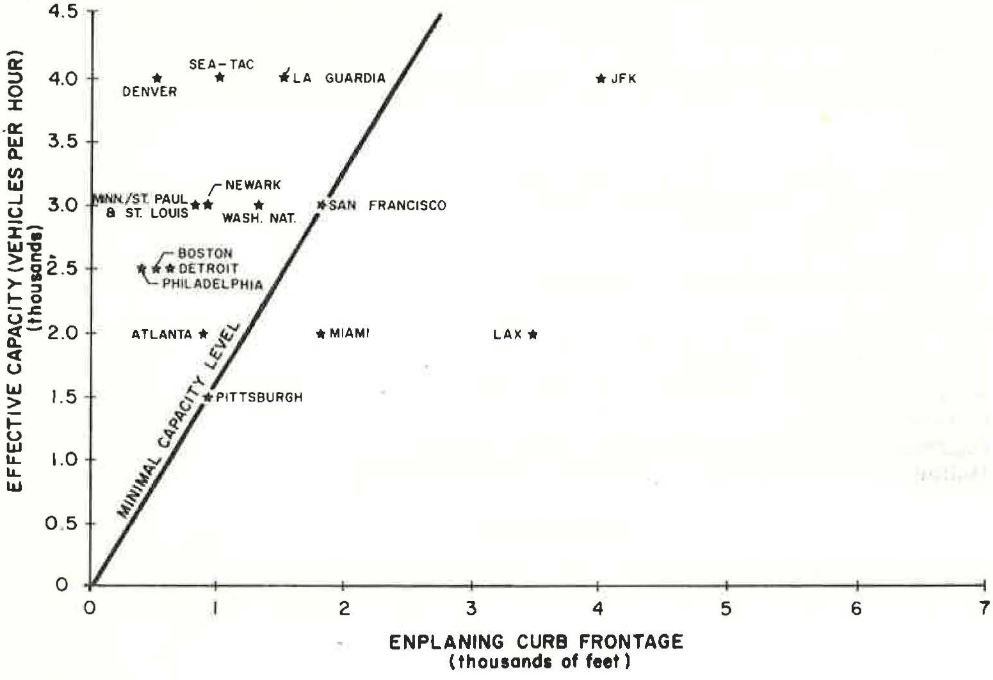


Figure 3. Curb frontage and effective highway capacity.



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 4,000 linear feet of enplaning curb frontage compared to less than 1,000 for Atlanta. For policy considerations, limiting curb frontage may be one means of controlling vehicles. Finally, Figures 4 and 5 show the relationships between enplaning passengers and enplaning curb frontage and between deplaning passengers and deplaning curb frontage. They show generally that the same space is provided for both, which is not consistent with the previous observation that deplaning passengers generally require more time and have more curb frontage.

FUTURE DEMAND

In anticipation of future air travel demands, most of the major airports are planning extensive expansion. In some cases these plans include the complete rebuilding of terminal areas and construction of new airfields. 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 percent 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 7 years (Table 4).

FINDINGS AND RECOMMENDATIONS

Four broad, yet somewhat specific, problem areas were identified (Fig. 6) from this study:

1. Origins and destinations of air travelers presently oriented to and from the airports are too dispersed to economically justify either rapid transit corridor or other main-line investments;
2. Limited availability or intensive use of primary or secondary access and egress routes to most airports places substantial demand on a single road system;
3. Too much off-street parking is being provided in the central terminal area in relation to the capacity of the road system to serve it adequately; and
4. Too much vehicular activity is concentrated at or near the enplaning and deplaning curbs in the terminal areas, which reduces effective capacity.

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 and the cost-effective implications of initiating and completing the projects produced the following 12 possibilities:

1. Highway surveillance and guidance control;
2. Coordination of existing traffic signals;
3. Multiple-access roadways;
4. Preferential lane use;
5. Bus and limousine off-peak marketing;
6. Off-peak air service;
7. Dial-a-ride marketing (demand-activated);
8. Motorist advisory system;
9. Segregated traffic in central terminal area;
10. Garage check-in;
11. Segregated pedestrian and vehicular traffic; and
12. Balancing central terminal area and remote parking.

CONCLUSIONS

This study accentuates the fact that many low-cost measures can be used at airports to alleviate ground traffic congestion and delay. It maintains that these measures can

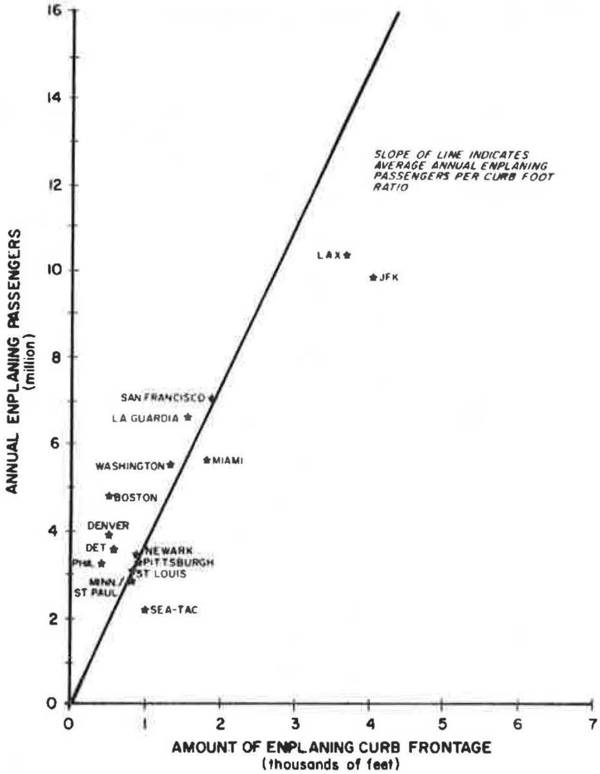


Figure 4. Curb frontage and enplaning passengers.

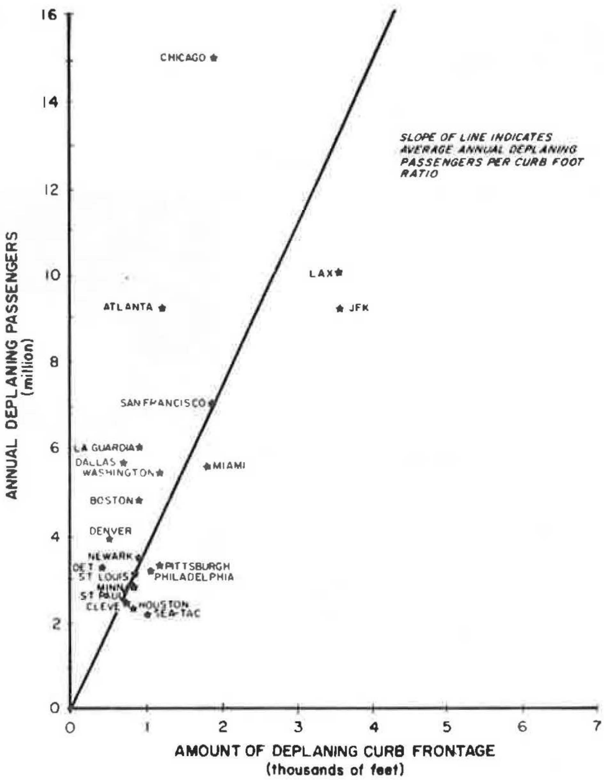


Figure 5. Curb frontage and deplaning passengers.

Table 4. Projected airport statistics and planned facilities.

Airport	Aircraft Movements[a] Commercial	General Aviation	Total	Passengers[b] (millions) Explaned	Deplaned	Total	New or Relief Airport Planned	Status of Rapid Transit for Metropolitan Area: Existing or Under Construction	Under Study	Proposed	None
Chicago O'Hare	N.A.	N.A.	N.A.	30.0	30.0	60.0	Study	x	—	—	—
Los Angeles	550,000	30,000	580,000	20.0	20.0	40.0	Yes	—	—	x	—
New York John F. Kennedy	230,000	60,000	290,000	17.5	17.5	35.0	Yes	x	—	—	—
Atlanta	N.A.	N.A.	664,000	20.0	20.0	40.0	Yes	—	—	x	—
San Francisco	N.A.	N.A.	382,000	15.5	15.5	31.0	No	x	—	—	—
New York LaGuardia	235,000	67,000	302,000	12.0	12.0	24.0	Yes	x	—	—	—
Miami	405,000	80,000	485,000	12.5	12.5	25.0	Yes	—	—	x	—
Dallas Love Field	—	210,000	210,000	—	—	—	Yes	—	—	x	—
Washington National	240,000	100,000	340,000	N.A.	N.A.	16.0	No	x	—	—	—
Boston Logan	321,000	73,000	394,000	8.3	8.3	16.6	No	x	—	—	—
Denver Stapleton	306,000	165,000	471,000	N.A.	N.A.	19.0	No	—	x	—	—
Detroit Wayne County	380,000	61,000	441,000	17.0	17.0	34.0	No	—	—	x	—
Newark	207,000	56,000	263,000	9.5	9.5	19.0	Yes	—	x	—	—
Philadelphia	230,000	170,000	400,000	7.0	7.0	14.0	No	x	—	—	—
Pittsburgh	246,000	139,000	385,000	5.8	5.8	11.6	Study	—	x	—	—
St. Louis Lambert Field	250,000	170,000	420,000	8.5	9.0	17.5	Yes	—	x	—	—
Minneapolis-St. Paul	243,000	22,000	265,000	5.4	7.6	13.0	Study	—	—	—	x
Cleveland Hopkins	138,500	131,500	270,000	5.5	5.5	11.0	Study	x	—	—	—
Seattle-Tacoma	210,000	40,000	250,000	N.A.	N.A.	14.0	No	—	—	—	x
Houston	131,000	52,000	183,000	6.5	6.5	13.0	No	—	x	—	—

Airport	Potential of Rapid Transit to Serve Airport by 1980: Good	Fair	Limited	Major Improvements Planned: Roadway	Parking Space	Curb Frontage	Type of Congestion[c]: Airspace	Airfield	Baggage Claim Area	Terminal Functions	Roadway	Pedestrian	Parking
Chicago O'Hare	x	—	—	Yes	Yes	No	(1)	—	—	—	2	—	—
Los Angeles	—	—	x	Yes	Yes	Yes	4	3	—	—	(1)	2	5
New York John F. Kennedy	x	—	—	Yes	Yes	Yes	—	1	—	—	1	—	1
Atlanta	x	—	—	Yes	No	No	7	1	2	3	(5)	4	6
San Francisco	x	—	—	Yes	Yes	Yes	4	1	6	5	3	7	(2)
New York LaGuardia	x	—	—	Yes	Yes	Yes	—	1	—	—	1	—	1
Miami	—	x	—	Yes	Yes	Yes	6	2	(1)	4	3	5	7
Dallas Love Field	x	—	—	No	No	No	—	—	1	2	—	—	—
Washington National	x	—	—	Study	Study	Study	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Boston Logan	x	—	—	Yes	Yes	Yes	—	—	—	1	—	—	—
Denver Stapleton	—	—	x	No	No	Yes	5	6	4	7	(1)	2	3
Detroit Wayne County	—	x	—	Yes	Yes	Yes	1	(3)	6	4	(7)	5	(2)
Newark	x	—	—	Yes	Yes	Yes	1	1	1	—	1	—	1
Philadelphia	x	—	—	Study	Yes	Yes	—	1	1	1	1	—	1
Pittsburgh	—	—	x	Yes	Yes	Yes	5	3	4	6	2	7	(1)
St. Louis Lambert Field	—	—	x	No	Yes	Yes	—	4	2	3	(1)	—	—
Minneapolis-St. Paul	—	—	x	Yes	Yes	No	5	2	3	6	4	7	(1)
Cleveland Hopkins	x	—	—	Yes	No	No	7	6	(1)	3	2	5	4
Seattle-Tacoma	—	—	x	No	Yes	Yes	7	6	1	3	2	5	4
Houston	—	x	—	Yes	Yes	Yes	7	6	1	3	2	5	4

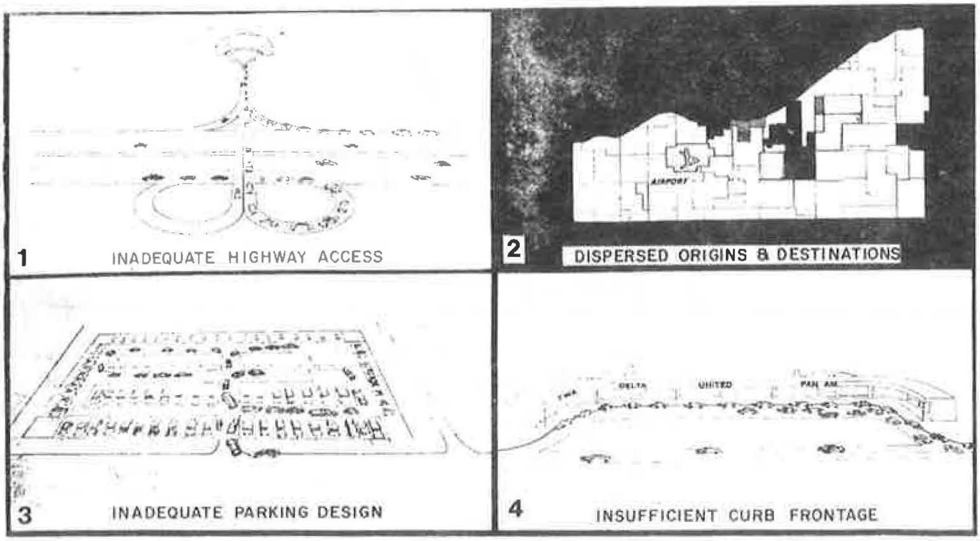
Note: N.A. = not available.

[a]Estimated 1,980 aircraft movements.

[b]Estimated 1,980 passenger activity.

[c]Numerals denote intensity of the problem at the airport, 1 indicating the most important problem. Duplication of any number indicates equal intensity of the problems. A number in parentheses 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.

Figure 6. Major reasons for airport ground delays.



often be more cost-effective than some major capital-intensive construction efforts to ultimately improve roadway capacity. These measures must be properly marketed to travelers through a public relations and advertising program to ensure high use and acceptability on a long-term basis. The measures, furthermore, should be designed to directly address motivation and need for travel—usually a function of time or cost. These measures, finally, should either reduce the travel time significantly or offer service at a low cost or both.

With specific reference to current issues of travel constraint—i. e., environmental concerns and the energy shortage—operational experiments suggested herein will still apply. The non-capital-intensive character of the experiments, added to values of optimizing existing transportation facilities and services, should positively influence implementation of some experiments to improve ground access and egress at selected hub airports.

ACKNOWLEDGMENTS

The authors wish to express appreciation to H. K. Schaeffer and others at the Transportation Systems Center of the U.S. Department of Transportation for their assistance in the conduct of the study.

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