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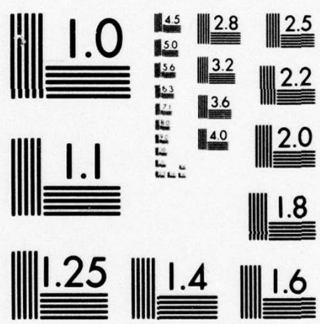
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SATELLITE AIRPORTS: ANALYSIS OF DEVELOPMENT POTENTIAL

JUNE 1976

DEPARTMENT OF TRANSPORTATION

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16. Abstract

This report provides an analysis of the potential for developing satellite, or secondary airports in major metropolitan areas, and an estimate of the benefits satellite airport development might provide.

Approximately 365 satellite airport candidates were identified in the 23 largest metropolitan areas (large hubs). These airports have the capacity to support additional air traffic which might be diverted from the larger more congested air carrier airports in each area. Maximum utilization of these satellite facilities could maintain aircraft congestion and delay at the top 25 airports at or below 1975 levels for up to 15 years.

While the analysis shows there is additional capacity available at satellite airports, there appear to be insufficient incentives at present for aircraft operators to use these facilities. Without additional motivation, large scale diversion of air traffic to satellite airports is not anticipated.

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1.0 Executive Summary

This report provides an analysis of the potential for developing satellite, or secondary airports in major metropolitan areas, and an estimate of the benefits satellite airport development might provide. The analysis of satellite airports was initiated by the Federal Aviation Administration (FAA) in response to a 1974 request by the Office of the Secretary of Transportation.

The use of satellite airports has often been considered as an economical means of relieving the increasing congestion at major commercial airports serving the principal metropolitan areas of the country. There exists, in proximity to most of these metropolitan areas, a number of under-utilized or potentially available airports which could, with a minimum investment, support a portion of the air traffic which has created the congestion at the principal hub airport. The question has been raised whether or not satellite airports could support a substantial diversion of traffic activity away from the congested facilities, and what impact this diversion might have on airport system delay.

To answer this question, satellite airports which offered possibilities for increased utilization by general aviation and/or commercial operators were identified, and the capacity of each satellite airport candidate to accept additional numbers and types of traffic was assessed. The constraints to expanded utilization of satellite facilities were identified and considered. It was assumed, then, that air traffic diversions did occur. Airport system delays before and after the traffic diversions were computed and compared.

Approximately 365 satellite airport candidates were identified in the 23 largest metropolitan areas (large hubs). These airports have the capacity to support additional air traffic which might be diverted from the larger more congested air carrier airports in each area. Maximum utilization of these satellite facilities could maintain aircraft congestion and delay at the top 25 airports at or below 1975 levels for up to 15 years.

While the analysis shows there is additional capacity available at satellite airports, there appear to be insufficient incentives at present for aircraft operators to use these facilities. Without additional motivation, large scale diversion of air traffic to satellite airports is not anticipated.

2.0 Introduction

The Federal Aviation Administration (FAA) is engaged in major Engineering and Development (E&D) programs to provide new and improved air traffic control capabilities for the 1980's and 1990's. When these developments are completed, implemented and integrated with existing facilities, the result will be the "Upgraded Third Generation Air Traffic Control System (UG3RD).

The Under Secretary of Transportation by memorandum of March 13, 1974, to the Assistant Secretary for Systems Development and Technology requested a comprehensive technical review of the entire UG3RD program. As a result of the Under Secretary's request, the FAA has been asked to undertake economic evaluations of technical and operational features of the UG3RD.

Technical features of the UG3RD include Aerosat, Flight Service Station Automation, Wake Vortex Avoidance (WVAS), Airport Surface Traffic Control, Area Navigation (RNAV), Microwave Instrument Landing System (MLS), Discrete Address Beacon System and Intermittent Positive Control (DABS/IPC), and automation. 1/ In addition, to these technical features, there are numerous noncapital or relatively low capital program alternatives that might be introduced. One of these alternatives is the development of satellite or secondary airports in major metropolitan areas in order to relieve the air traffic congestion at larger commercial air terminals. The question has been raised whether increased utilization of satellite facilities would complement improvements provided by the technical features of the UG3RD.

The use of satellite airports has often been considered as one of the most economical means of relieving the increasing congestion of many of the major commercial airports serving the principal metropolitan areas of the country. There exists, in close proximity to most of these metropolitan areas, a number of under utilized or potentially available airports which could with a minimum investment support a portion of the air traffic which has created the congestion at the principal hub airport. A substantial diversion of general aviation and commercial traffic to these satellite airports may have a beneficial impact on airport system delay.

1/ For an explanation of these components, refer to the National Aviation System; Challenges of the Decade Ahead, 1977-1986, DOT, FAA, 1976.

In most cases, however, efforts to develop satellite airports have resulted in little success as the airlines and the traveling public tend to shun satellite facilities and congregate at the primary hub airports. Previous studies have been able to confirm and to some degree quantify the existence of this public preference and the economic pressures on the air carriers to concentrate at a single airport. Indeed, some researchers have concluded that there is little hope in attempting to develop a system of satellite airports. 2/

Yet, there has been some degree of success in a few areas. The most noticeable of these is the Los Angeles--San Francisco Bay area city-pair where more than 20 percent of the total air traffic is using satellite airports. Furthermore, the degree of congestion at major airports along with the increasing cost of fuel has placed a much higher premium on achieving a solution to the airport delay problem. The purpose of this research is to examine the potential for developing satellite airports.

Two broad categories of satellite users are suggested here. First, general aviation operators could be drawn away from principal large hub airports, "relieving" the larger facility of substantial part of its total traffic load in order to make more runway, taxiway and air space available for commercial use. 3/ This concept of reliever airports is not new. The 1972 National Airport System Plan, for example, identifies 150 designated reliever airports for general aviation traffic. 4/ No estimates are made, however, of the number and type of operations each reliever might support, nor of the impact of increased reliever use on air traffic congestion and delay at the larger commercial facilities.

Another potential user group at satellite airports is the commercial aviation traffic diverted from a larger airport in order to participate in a market stimulated by the close proximity of the satellite to a major residential or commercial center, or diverted, perhaps through regulatory or economic action. The use of secondary airports by commercial traffic is a relatively untested concept.

2/ Gelerman, Walter and Neufville, Richard de, "Planning for Satellite Airports, "Transportation Engineering Journal, August 1973, page 537.

3/ General aviation traffic activity at the top 25 commercial airports as a percentage of total operation ranges from 16 percent (O'Hare) to 59 percent (Las Vegas).

4/ National Airport System Plan, 1972, DOT, FAA, 1972

This analysis identifies the satellite airports in each of the 23 large hub areas that offer potential for increased utilization by general aviation and/or commercial operators. Next, the capacity of each of these satellite airport candidates to accept additional numbers and types of traffic is assessed. Finally, assumptions are made that: (1) full use of satellite airports is made by additional traffic, and (2) all of this traffic is diverted from the primary commercial airport in the area. Air traffic delay at the commercial airport before and after traffic diversion is computed and compared, with the difference in total delays identified as the potential benefit of expanded satellite airport use.

This report presents an analysis of the potential for developing satellite airports in major hub areas, and an assessment delay reduction that might be anticipated if satellite airports were fully utilized by commercial and general aviation operators. However, it is neither a forecast nor an action plan for diverting aircraft to satellite facilities.

The following chapter describes the approach used for this analysis. Results of the analysis, and the conclusions drawn from these results are presented in the final chapters of the report.

3.0 Approach

The diversion of significant numbers of aircraft operations away from congested commercial airports to under-utilized facilities in major metropolitan areas is constrained by a multiplicity of factors. These factors include:

- The inaccessibility of the airport to large residential and/or commercial areas
- Conflicting air traffic control requirements at neighboring airports
- The inacceptability of airport growth to local citizens, due to incomplete land use patterns, and concerns about the environment among other things
- The inability of the airport to finance continued airport operation and/or expansion
- Local zoning ordinances limiting airport growth

The reality of these constraints, the obstacle they pose to satellite airport growth, and the magnitude of reasonable benefits that might be derived from likely satellite candidates have never been rigorously addressed in the context of the use of satellite airports as a means of relieving air traffic congestion at larger facilities. This analysis was undertaken to accomplish these objectives. The project was divided into four major elements, identified below and described in the remaining sections of this chapter.

- Identification and classification of potential satellite airports
- Definition of constraints
- Evaluation of satellite airport capacity
- Computation of potential delay savings

3.1 Identification and Classification of Potential Satellite Airports

There are over 12,000 airports, heliports and seaplane bases in the United States and its possessions. Of these airports, approximately 520 receive scheduled air carrier service. The 25 most active commercial airports account for approximately 70 percent of all national passenger enplanements and almost 40 percent of all air carrier operations. 1/ These 25 airports also account for almost 75 percent of all air carrier airport delay. 2/ At these airports, the problem of aircraft delay is most severe, and the potential benefits of satellite airports most pronounced. Consequently, this analysis of satellite airport feasibility focuses upon the top 25 air transportation centers. These are listed in Table 3.1.

A computer search at the FAA's National Flight Data Center was undertaken to identify all airfields with development potential. The search identified 2,591 possible landing sites within a 90-mile square (8,100 square miles) centered on the central business district (CBD) of the major city in each of the 25 largest metropolitan areas. This search identified all possible landing facilities in these areas, and served as the upper limit of potential satellite airport candidates. By excluding obviously unsuitable facilities, such as helipads and seaplane bases, the number of potential satellite airports was reduced to 1,066, distributed fairly equally among the hubs.

Airports were then classifed according to the type aircraft each was capable of handling. Normally, the most critical aircraft performance characteristics with regard to airports are the runway length and weight-bearing capacity required for takeoff under maximum gross weight conditions. For this study, the airport classification schedule shown in Table 3.2 was used. For each category airport, maximum runway length and wheel trucks weights, as well as critical aircraft types, are listed. Airports not meeting the requirements of Category E were assumed to have limited development potential and were excluded from further consideration as satellite candidates.

1/ Terminal Area Forecasts: 1976-1986, Department of Transportation, Federal Aviation Administration, September 1974, Table II.

2/ Airline Delay Data: 1970-1974, Department of Transportation, Federal Aviation Administration, February 1975, page 22.

TABLE 3.1

TOP 25-AIR CARRIER AIRPORTS

City-Airport/State	Airport
Chicago-O'Hare, Ill.	ORD
Los Angeles-Int'l., Calif.	LAX
Atlanta, Georgia	ATL
New York-Kennedy, N.Y.	JFK
San Francisco, Calif.	SFO
New York-La Guardia, N.Y.	LGA
Dallas-Fort Worth Int'l., Texas	DFW
Washington-National, D.C.	DCA
Miami, Fla.	MIA
Boston, Mass.	BOS
Denver, Colorado	DEN
Honolulu, Hawaii	HNL
Detroit, Mich.	DTW
Philadelphia, Pa.	PHL
Pittsburgh, Pa.	PIT
Newark-Newark, N.J.	EWR
St. Louis, Mo.	STL
Minneapolis, Minn.	MSP
Cleveland, Ohio	CLE
Houston, Texas	IAH
Las Vegas, Nev.	LAS
Seattle, Washington	SEA
Tampa, Fla.	TPA
New Orleans, La.	MSY
Kansas City, Mo.	MCI

TABLE 3.2

AIRPORT CLASSIFICATION SCHEDULE

Airport Classification	Critical Aircraft 1/	Maximum Truck Wt. Reqmts. 2/	Maximum Runway Length Reqmts. 3/
A	DC-8,10	150,000 lbs.	10,000'
	B-747,707		
B	DC-9	50,000 lbs.	6,500'
	B-727		
C	F-27	25,000 lbs.	5,000'
	Gulfstream I, II		
D	Aero Commander	5,000 lbs.	2,500'
	Apache		
E	Cherokee	2,000 lbs.	1,900'
	Cessna 150-210		

1/ "Specifications," Aviation Week and Space Technology, March 11, 1974, pages 131-134.

2/ FAA Airport Construction and Standards Branch.

3/ FAA Airport Construction and Standards Branch, standard day, sea level.

3.2 Definition of Constraints

There are numerous potential constraints on limitations which could impact any of the satellite airports in a way which would either prevent them from accepting additional operations, or prohibit physical growth to accommodate larger aircraft. Any of these constraints could limit the capacity of an airport to relieve traffic congestion at a larger facility.

This analysis makes an estimate of the constraints to expanded utilization of each satellite airport, and, where no constraints are evident or predicted, concludes that some growth is possible. In order to realistically assess the limitations to growth, it was important that the definition of constraints as used in this study was sufficiently broad to include all possible constraining conditions. With this in mind, a listing of possible constraints to expanded airport utilization was developed. These constraints are shown in Table 3.3 and are explained in the sections which follow.

TABLE 3.3

CONSTRAINTS TO EXPANDED UTILIZATION OF SATELLITE AIRPORTS

FAA UG3RD EVALUATION
COMPLEMENTARY POLICY STRATEGIES
OFFICE OF AVIATION POLICY

CONSTRAINT		DEFINITION OF CRITERIA	
1.	AIRPORT CHARACTERISTICS	1.1	CURRENT TRAFFIC LEVELS AT OR ABOVE MAXIMUM AIRPORT CAPACITY.
		1.2	RUNWAY LENGTH AND WEIGHT BEARING CAPABILITY BELOW STANDARDS FOR AIRCRAFT TYPE.
2.	LOCAL TRANSPORTATION INTRASTRUCTURE	2.1	DRIVING TIME TO SATELLITE FACILITY IN EXCESS OF ONE HOUR FROM CBD.
3.	AIR TRAFFIC CONTROL SYSTEM (ATC)	3.1	CONFLICTS WITH FAA ORDER 7480.1A: GUIDELINES FOR AIRPORT SPACING AND TRAFFIC PATTERN AIRSPACE AREAS, AUGUST 3, 1971.
4.	MILITARY REQUIREMENTS	4.1	MILITARY PREEMPTION OF FACILITY.
		4.2	COMMERCIAL AND/OR PRIVATE CIVILIAN TRAFFIC NOT AUTHORIZED UNDER OFFICIAL JOINT USE AGREEMENT.
5.	MARKET FACTORS	5.1	PUBLIC PREFERENCE FOR PRIMARY AIRPORT.
		5.2	ECONOMICS OF AIR CARRIER OPERATION.
6.	POLITICAL FACTORS	6.1	ORGANIZED CITIZEN OPPOSITION TO AIRPORT EXPANSION BASED UPON ENVIRONMENTAL CONCERNS AND OTHER FACTORS
		6.2	PROBLEMS WITH MULTIJURISDICTIONAL GOVERNMENTS.
7.	LEGAL/LEGISLATIVE	7.1	ZONING OR STATUTE LIMITATIONS ON AIRPORT UTILIZATION OF EXPANSION.
8.	FINANCIAL	8.1	INABILITY OF AIRPORT SPONSOR TO FINANCE AIRPORT OPERATION AND/OR EXPANSION.

3.2.1 Limitations of the Local Transportation Infrastructure

Growth of an airport is generally constrained if there is no convenient ground access to and from the central business district (CBD) of the major urban area within the hub. There is nothing surprising here. The same concept, limitations of the local transportation system, was applied to satellite airport growth potential.

The extent to which an airport realizes its scheduled airline air passenger potential depends, along with other factors, upon the location of the airport relative to passenger origins and destinations. It is useful, in a discussion of airport accessibility, to describe airports in terms of distance and travel time from the area's CBD. 3/ Previous work supports the argument that airport travel time and distance from the CBD do have an effect on passenger traffic, and that the effect is in the expected direction. For example, an early (1953) study in Buffalo, New York, found that on a per thousand population basis, the area within a 15- to 25-mile ring from the airport generated 38 percent fewer passengers than the area 0-15 miles from the airport, and even fewer passengers were generated in the area from 25 to 35 miles from the airport. 4/

In an analysis (1955) of 21 airports in California, the air passenger generation per thousand population in the band 10 to 20 miles from the airport was less than in the 0- to 10-mile band, even when city population in the farther band was larger. 5/ Similarly, an analysis in Green Bay, Wisconsin, (1963) showed a progressive decline in air passenger generation per thousand population in each successive 10-mile band extending to a distance of 70 miles from the city center. 6/

3/ It is recognized that only 25 percent of air travel O&D's fall within the CBD. The CBD, however, can be envisioned as a passenger centroid, equidistant from all regional O&D's.

4/ A Report on Airport Requirements and Sites in the Metropolitan New Jersey-New York Region, the Port of New York Authority, May 1961, page 82.

5/ "Airport Accessibility Affects Passenger Development," John F. Brown, Journal of the Aerospace Transport Division, Proceedings of the American Society of Civil Engineers, April 1965, page 52.

6/ Ibid.

More recently (1971) a survey of on-board passengers on major airlines was carried out at 32 commercial airports in California. The results showed a decreasing percentage of total passengers for all trip purposes correlated to increased travel time to the airports. Moreover, the analysis showed that only 8 percent of all passengers traveled more than 1 hour to reach the airport, and less than 2 percent were willing to travel 2 hours or more. 7/ These findings appear to support the use of a 60-minute maximum origin to airport travel time as an accessibility criteria in judging transportation infrastructure as a constraint on satellite airport feasibility.

Sixty minutes of ground travel time from CBD, in other words, defined each metropolitan local area. 8/ With several exceptions, airports farther than 60 minutes from CBD were excluded from further consideration. These exceptions were: all A and B Category airports (see Table 3.2), military fields and designated reliever airports as identified in the NASP.

The 60-minute highway constraint reduced the number of potential satellite airports in the major metropolitan areas from 1,066 to 365. These airports are listed and classified by category in Appendix A.

7/ "The Remote Airport: A Study of Access Feasibility," David R. Miller, T. Keith Dellaway, William H. T. Holden, Transportation Engineering Journal of ASCE. Proceedings of the American Society of Civil Engineers, Vol. 100, No. TE 1, February 1974, page 184.

8/ Based upon peak-hour highway speeds and highway distances.

3.2.2 Air Traffic Control System Constraints

One recognized constraint to expanded use of an airport is imposed by the air traffic control (ATC) system. Specifically, there may be limitations to the joint use of airspace and/or navigational devices by aircraft operating from adjoining airports. Each potential ATC constraint was identified and estimates placed on its impact on satellite airport growth.

The approach used for analyzing potential ATC constraints was based upon FAA guidelines governing Instrument Flight Rule (IFR) approaches 9/ and Visual Flight Rule (VFR) traffic patterns. 10/ The FAA's Airports Service Division has developed template overlays which represent the protected airspace for each of the IFR approaches executed from navigational facilities in present use. Additional overlays were constructed, in accordance with Terminal Instrument Procedures (TERPS), to represent airspace used during VFR operations. These overlays were used to depict on sectional aeronautical charts of the 23-large hubs the airspace used by primary and satellite airports in each area.

Review of all sectionals indicated VFR airspace conflicts between selected airports were nonexistent. Some VFR/IFR conflicts and more numerous IFR/IFR conflicts were identified, however. In most of these cases a pattern was observed. For example, three small airports in the Chicago area share the same navigational facility for instrument approaches. Consequently, simultaneous instrument landings at these airfields cannot be executed. Assuming 10 percent of the capacity estimate for an airport represents IFR operations, then these three airports would be impacted only 10 percent of the time. Each airport's capacity would be reduced by the factor (2/3) x 10%, or $\frac{n-1}{n}$ x 10% where n represents the number of airports with traffic conflicts.

In circumstances in which two airports had potentially conflicting radar arrivals, the airport judged capable of handling more and larger traffic was given priority and reduction factors were applied to the lesser of the airports. In the few situations involving conflicts between a VFR pattern and IFR operations, the VFR airport's capacity was adjusted downward.

9/ U.S. Standard for Terminal Instrument Procedures (TERPS), FAA, February 1970.

10/ FAA Order 7480.1A, Guidelines for Airport Spacing and Traffic Pattern Airspace Areas, August 3, 1971, pages 8-11.

3.2.3 Potential for Civilian/Military Joint Use of Military Airfields

Both the Federal Aviation Administration and Department of Defense (DOD) maintain regulations which allow for joint use of military airfields by other than DOD aircraft. DOD policy permits joint use of facilities where it has been determined that such use will not conflict with military operations. Presently, 90 military airfields are under joint-use agreements.

There are 38 military airports operating within the 23-large hubs under review in this report. Joint use of these facilities is limited by any of several problems, including:

- Military preemption.
- Concurrence of the local community that civilian aviation at the military airfields is desirable.
- Civilian use often necessitates increased base security as well as additional and/or separate landing and terminal facilities. Neither DOD nor the local community are always willing to assume these additional costs.
- Incompatible air traffic operations.

At FAA request, the Office of the Secretary of Defense (OSD) provided a listing of the joint-use potential of military airfields in large hub areas for the 1980-1990 period. OSD indicated that some degree of civilian use would be acceptable at 11 of these installations. These are shown in Table 3.4. Short of a policy change in DOD, no civilian use of the remaining facilities is anticipated.

TABLE 3.4

POTENTIAL JOINT-USE MILITARY AIRPORTS

Airport	City	Joint-Use Potential (1975 DOD Decision)
Haley AAF	Chicago	Not available due to military mission
Glenview NAS	Chicago	Not available due to military mission
McGuire AFB	Philadelphia	Not available due to military mission
Dobbins AFB	Atlanta	Possible joint use by scheduled air carriers
El Toro MCAS	Los Angeles	Not available due to military mission
Los Alamitos NAS	Los Angeles	Not available due to military mission
Dallas NAS/Hensley	Dallas	Not available due to military mission
Carswell AFB	Dallas-Ft. Worth	Not available due to military mission
Andrews AFB	Washington, D.C.	Not available due to military mission
Tipton AAF	Washington, D.C.	Not available due to military mission
Patuxent River NAS	Washington, D.C.	Not available due to military mission
Davison AAF	Washington, D.C.	Not available due to military mission
Homestead AFB	Miami	Not available due to military mission

TABLE 3.4

POTENTIAL JOINT-USE MILITARY AIRPORTS (cont'd.)

Airport	City	Joint-Use Potential (1975 DOD Decision)
Alameda NAS	San Francisco	Not available due to military mission
Travis AFB	San Francisco	Limited Joint use in effect, possible increased use by scheduled air carrier
Moffett NAS	San Francisco	Not available due to military mission
Hamilton AFB	San Francisco	Declared excess by USAF, actions underway to transfer airfield to Marin County, CA
Buckley ANGB	Denver	Not available due to military mission
Otis ANGB	Boston	Decision authority on joint use rests with State of Massachusetts, not USAF
South Weymouth NAS	Boston	Not available due to military mission
Pease AFB	Boston	Not available due to military mission
Barbers Point NAS	Honolulu	Not available due to military mission
Kanehoe Bay MCAS	Honolulu	Not available due to military mission
Wheeler AFB	Honolulu	Not available due to military mission
Selfridge ANGB	Detroit	Not available due to military mission
Warminster NAF	Philadelphia	Not available due to military mission

TABLE 3.4

POTENTIAL JOINT-USE MILITARY AIRPORTS (cont'd.)

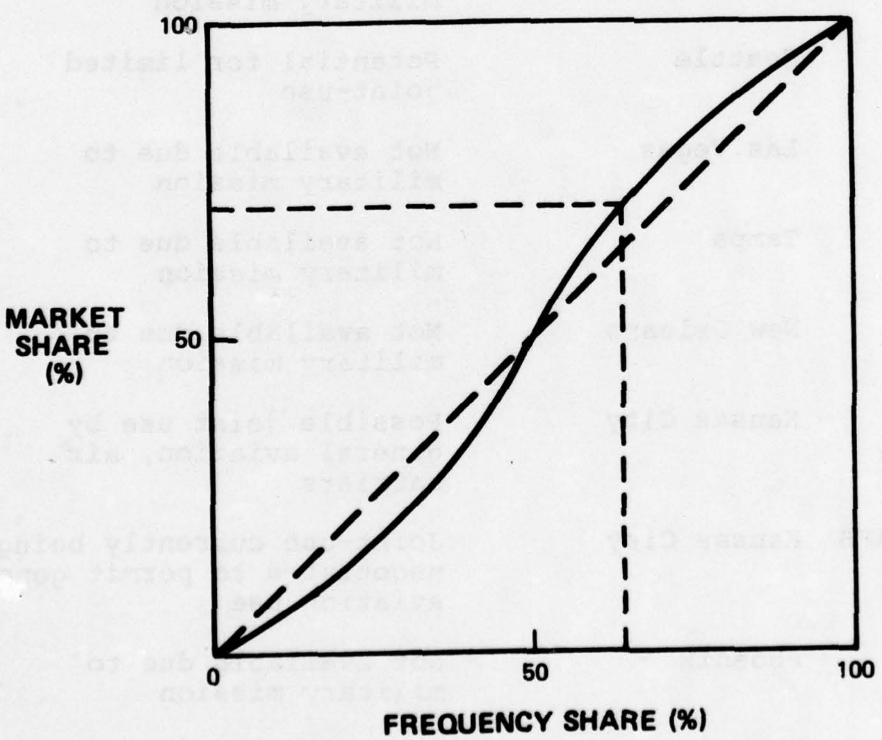
Airport	City	Joint-Use Potential (1975 DOD Decision)
Willow Grove NAS	Philadelphia	Not available due to military mission
Scott AFB	St. Louis	Not available due to military mission
Ellington AFB	Houston	Declared excess by USAF, negotiations underway to place airfield under civilian management
Gray AAF	Seattle	Not available due to military mission
McChord AFB	Seattle	Potential for limited joint-use
Nellis AFB	Las Vegas	Not available due to military mission
MacDill AFB	Tampa	Not available due to military mission
New Orleans NAS	New Orleans	Not available due to military mission
Sherman AAF	Kansas City	Possible joint use by general aviation, air carriers
Richards-Gebaur AFB	Kansas City	Joint-use currently being negotiated to permit general aviation use
Williams AFB	Phoenix	Not available due to military mission
Luke AFB	Phoenix	Not available due to military mission

3.2.4 Market Constraints

Passenger demand preferences and the economics of airline operations limit the development of a viable satellite airport system. This is explained in the discussion which follows.

In the competition for passengers or market share, it is recognized that the airline providing the greatest frequency of flights will generally capture a larger share of the market and that share will increase more rapidly than the increase in frequency. 11/ In a simplified two airline competition, the comparison between market share or percentage of departing flights takes the form of an "S" shaped curve, shown in Figure 3.1. From the figure it is obvious that

FIGURE 3.1
COMPARING MARKET SHARE VERSUS FLIGHT FREQUENCY SHARE OF AN AIR CARRIER MARKET



11/ Gelerman, Walter, and Neufville, Richard de, "Planning for Satellite Airports," Transportation Engineering Journal, August 1973, page 544.

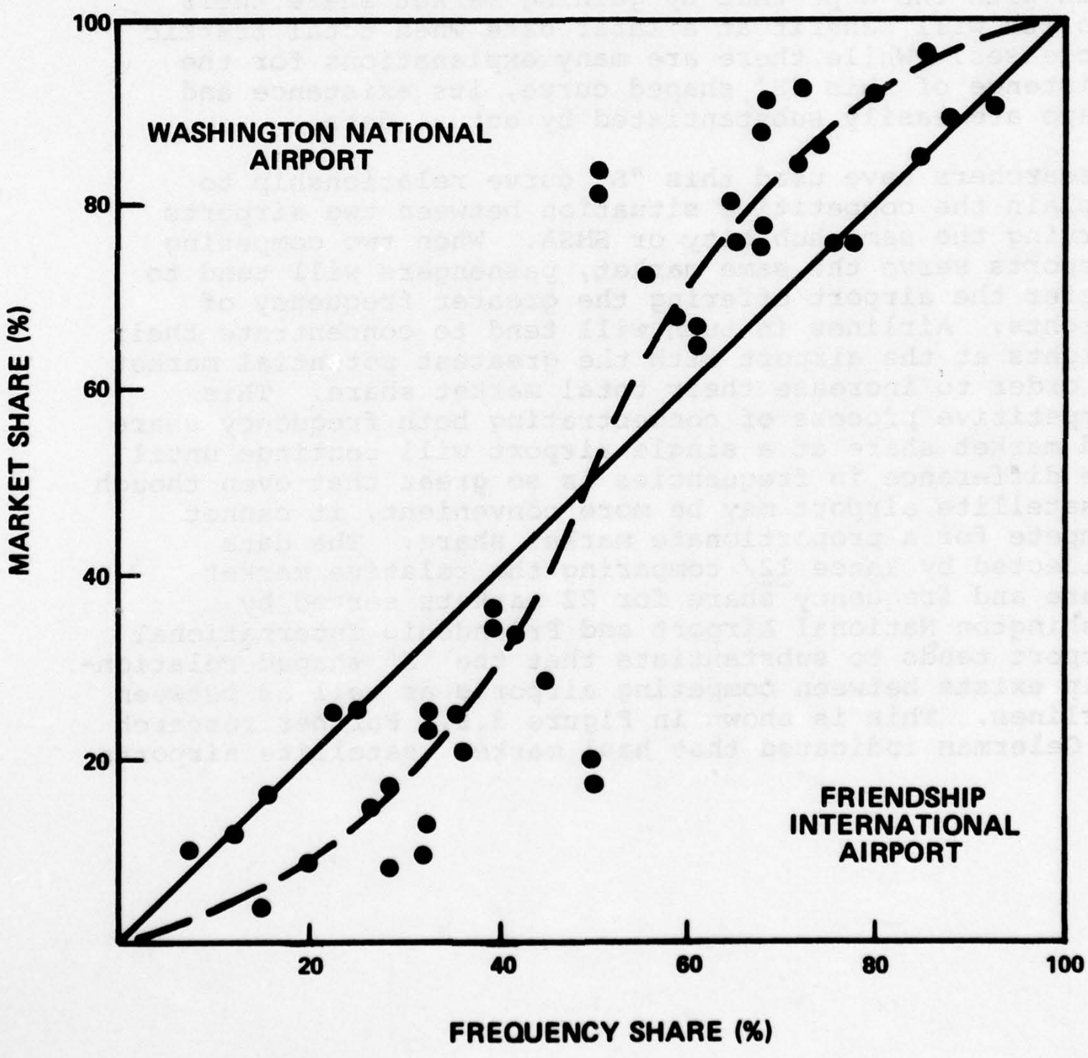
the airline which offers, say, 60 percent of the available flights will gather more than 60 percent of the available passengers. Since the cost of providing increased frequency is relatively linear, it follows that the airline with the proportionately larger market share will increase its revenues more rapidly than its expenses, thereby enhancing its profit potential. In the extreme case, such as the New York-Chicago market, competing airlines may increase the total number of flights until none are profitable, each with the hope that by gaining market share their profits will benefit at a later date when total traffic increases. While there are many explanations for the existence of this "S" shaped curve, its existence and shape are easily substantiated by actual data.

Researchers have used this "S" curve relationship to explain the competitive situation between two airports serving the same hub city or SMSA. When two competing airports serve the same market, passengers will tend to prefer the airport offering the greater frequency of flights. Airlines in turn will tend to concentrate their flights at the airport with the greatest potential market in order to increase their total market share. This competitive process of concentrating both frequency share and market share at a single airport will continue until the difference in frequencies is so great that even though a satellite airport may be more convenient, it cannot compete for a proportionate market share. The data collected by Yance 12/ comparing the relative market share and frequency share for 22 markets served by Washington National Airport and Friendship International Airport tends to substantiate that the "S" shaped relationship exists between competing airports as well as between airlines. This is shown in Figure 3.2. Further research by Gelerman indicated that haul market, satellite airports

12/ "Airline Demand for Use of an Airport and Airport Rents," Yance, J.V., Transportation Research, Vol. 5, No. 4, December 1971, pages 267-287.

FIGURE 3.2

FREQUENCY SHARE vs. MARKET SHARE TWENTY-TWO COMPETITIVE MARKETS



even population distribution has little effect on the relative demand between primary and secondary or satellite airports. He concluded that air traffic at satellites will probably not exceed more than 5 percent to 10 percent of the total air traffic in a metropolitan region and that "satellites will not, in general play a significant role in air transportation as long as existing conditions prevail." 13/

In a subsequent study by Charles Rivers Associates 14/ a mathematical model was developed to illustrate the incentives and disincentives for an airline to establish satellite airport services in competition with the services offered at the primary airport. This model will be described here. The authors began the model by assuming that several airlines were providing air service between airport A in one city and airport O in another city. It was assumed that the traffic level was T and the fare was F. Each airline had a fixed cost, U, which included the cost of operating its schedule and part of the cost of its facilities at each airport A and O. It also had a variable cost, m, per passenger, the incremental cost of adjusting capacity so as to carry one additional passenger.

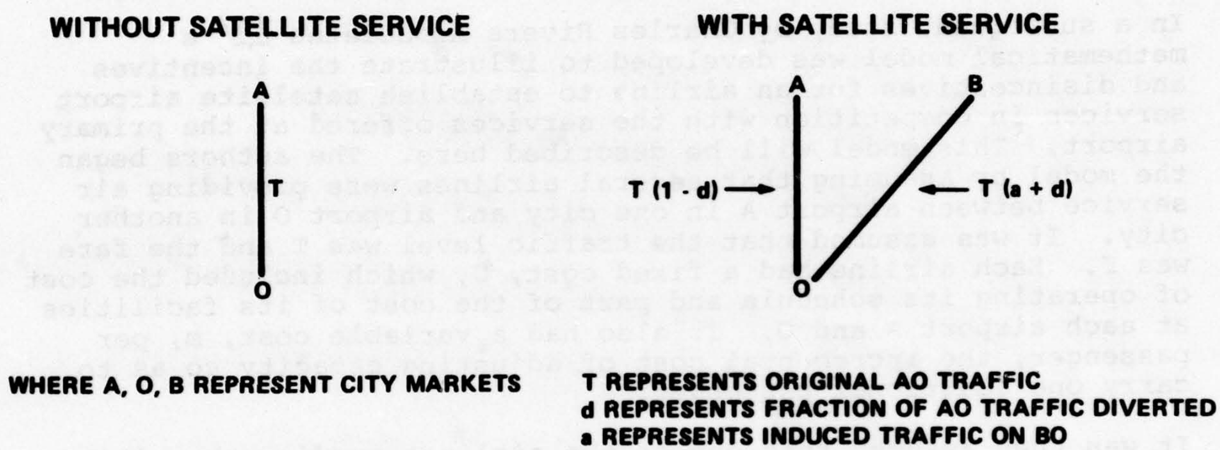
It was then assumed that one of the airlines serving the city-pair, whose share of the market was the fraction S, considered introducing service between airports B and O at the same fare as for A-O, where B is a satellite airport in the same city as A. They then assumed that a fraction, d, of the original traffic on route A-O would be diverted to B-O. In addition, the improved access for people resulted in an overall increase in the amount of traffic between the two cities of A-T. The original traffic pattern and the resulting traffic pattern are shown in Figure 3.3.

The airline initiating satellite service would expect variable costs to be the same for the new service as for the original service, m per passenger and the fixed cost for the new service would be V.

13/ Gelerman, Walter and Neufville, Richard de, "Planning for Satellite Airports," Transportation Engineering Journal, August 1973, page 538.

14/ Charles River Associates, The Use of Satellite Airports, Report Number CRA-177-2 prepared for the U.S. Department of Transportation under contract DOT-OS-20106, February 1973.

FIGURE 3.3
SCHEMATIC REPRESENTATION OF AIRPORT TRAFFIC



The revenue and the cost for the airlines, assuming the diverted traffic was proportional to market shares would be:

	Without Satellite Service	With Satellite Service
Revenue	FTS	FT[(1-d)S + a + d]
Cost	U + mTS	U + mTS(1-d) + mT(a+d) + V

Since it was assumed that an airline would only introduce the new service if it expected the revenues to increase more than the costs, it then follows that this would only occur if:

$$FT[(1-d)S + a + d - S] > V + mT(a+d) - mTSd,$$

and collecting and rearranging terms they obtained:

$$T(a+d)(F-m) - V > TSd(F-m)$$

It is further assumed that F-m was greater than zero since there would be no incentive to operate unless the fare was greater than the variable cost of operation. The right hand side of the equation must therefore be positive and both sides of the equation can be divided by it to obtain:

$$\frac{T(a+d)(F-m) - V}{STd(F-m)} > 1$$

The numerator on the left side of the expression is the airline's expected profit on route B-O. The denominator is the profit on A-O lost by the airline introducing the new service. The inequality states that the profit to be gained on the new service must be greater than the profit to be lost on the original service if there is to be any incentive for the airline to introduce the new service.

The quantity Td(f-m) in the denominator is the aggregate loss of profit of all airlines on route A-O. The profit lost by a particular airline depends on its share of the market.

The inequality above was rearranged as follows:

$$S < \frac{T(a+d)(F-m) - V}{Td(F-m)}$$

The authors concluded that market share was of crucial importance. The numerator shows the profit gained by the airline on route B-O, as before; but the denominator shows the total profit lost by all the airlines on route A-O.

From the model it was concluded that an airline would only introduce satellite airport services if it could divert enough traffic from the primary airport to cover the variable costs associated with operating from two separate airports.

In order to do this, the satellite operation must divert more traffic than the airline would have gained by increasing frequency at the primary airport. It also follows that the aggregate losses by all airlines at the primary airport must be greater than the profit gained at the satellite airport. Therefore an airline would only introduce satellite airport service if it expected to divert more traffic from a competitor's market share than it diverted from its own market share at the primary airport. From this it can be concluded that introduction of satellite airport service would only be attractive to an airline with less than a proportionate share of the market at the primary airport in hopes of raiding his competitors' market shares. On the other hand, those airlines remaining at the primary airport and losing a greater portion of their market share will have a substantial incentive to retaliate. One form of retaliation is to introduce competing service at the satellite airport. If enough service is offered the market becomes diluted until none of the airlines' operations at the satellite are profitable and eventually all are forced to return to the primary airport.

This discussion indicates that in the general case, market constraints can limit the possibilities for using satellite airports to relieve congestion at major commercial airports. However, because there are examples where there have been some degree of success in developing satellite operations, there must be exceptions to the generalized situation. By identifying these limitations or exceptions it may be possible to determine the conditions under which satellite airport development is possible, and, in addition, the market satellite airports might attract.

Several metropolitan areas were examined in order to identify those marketing criteria which appeared to influence satellite airport development potential. Five major hubs were selected as representative of the full spectrum of conditions existing at the large hub areas; Chicago, New York, Los Angeles, Dallas-Ft. Worth, and Washington. At each of these areas there has been some attempt to develop a satellite airport system, and at four of the five, some degree of satellite airport operation is now in existence.

The review of each of the five metropolitan areas 15/ indicated that satellite airport operation could be successful under certain combinations of conditions or factors, and furthermore, the occurence of one or more of these factors, could be used as basic criteria for evaluating market constraints and for estimating the potential for satellite airport development in any metropolitan area.

The first of these factors was the degree of congestion or saturation of the primary airport. A primary airport will tend to attract flight frequencies, develop ground access, and expand its convenience to the exclusion of satellite airports unless there is some overriding physical, regulatory, cost or convenience consideration. Airlines and municipalities tend to contribute to this centralization either to minimize duplication of expenditures and improve their competitive position or to maximize the utilization of existing facilities. When the primary airport becomes congested or saturated, however, the traveling public is more likely to accept the relative accessibility and availability of flights from a satellite airport.

A second consideration was the type of air traffic or air travel market peculiar to a given metropolitan area. In a dispersed metropolitan area with a significant short-haul market, satellite operations can more readily compete in that market segment due to the greater importance of accessibility when flight times are short. The competition will tend to be limited to a small geographical area and each satellite airport may be limited to approximately 5-10 percent of the market. 16/ The collective traffic diverted to two or more satellites can, however, offer significant relief at the primary airport. When there is a large long-

15/ The market conditions observed during evaluation of these areas are summarized in Appendix B.

16/ Taneja, N.K., "Airline Competition Analysis," Massachusetts Institute of Technology, Flight Transportation Laboratory, unpublished.

haul market, satellite airports have difficulty competing with the primary airport unless the primary airport is limited by physical or regulatory constraints and the satellite is capable of handling efficient long-range aircraft. Long-haul traffic frequently involves transfer passengers and connections to flights of short or medium segment lengths. Typically the long-haul passenger is less sensitive to ground access time and even airport to airport transfer inconvenience.

A third consideration was the percentage of transfer passengers. An air traffic hub with a large percentage of transfer passengers will normally be resistant to the development of satellite airports unless the primary airport is limited by physical or regulatory constraints. Where these constraints do exist and a segment of the transfer passengers are forced to use a satellite airport, roughly an equivalent number of nontransfer or connecting flights will be attracted to the satellite airport.

Fourth, the viability of a potential satellite airport appeared to be dependent upon its location relative to the primary airport, the central business district, and the residential growth areas. As observed in several of the examples, access time is more significant than actual distance as a factor in choice of airport. Ground transportation facilities and transportation costs may also affect relative accessibility.

Finally, although there is a very limited experience with price differentiation, intrastate air carriers have been successful in diverting passengers to satellite airports. These carriers generally offer fares 20 percent to 50 percent below the CAB regulated fares and depend heavily on high load factors. Experience to date has necessarily been limited to protected short-haul markets within state boundaries. The use of price differentiation on an interstate basis would require the designation of route certificates on an airport-specific basis.

In summary, five primary criteria were used to evaluate the feasibility of developing satellite airport operations in each of the 25 largest metropolitan areas. These criteria include:

1. Level of saturation or congestion at or in the vicinity of the primary airport including physical or regulatory limitations.

2. Type of air traffic or air travel market in terms of short-, medium-, or long-haul market segments.

3. Percentage of transfer passengers and the ability of primary airport or satellite airports to offer convenient connecting flights.

4. Relative locations of the primary airport and potential satellite airports with respect to each other, the central business district, and the residential growth areas.

5. Potential for price differentiation as a means of diverting traffic from the primary airport to satellite airports.

These criteria were applied to each of the 25 large hub areas, shown in Table 3.1, in order to: (1) identify the primary constraints to the development of satellite airport operations, (2) indicate the best potential satellite airport candidates, and (3) provide an estimate of the potential traffic diversion or relief that might be expected in the event an active satellite airport policy was pursued. Most of the pertinent data used in the analysis is summarized in Appendices B and C.

A summary of market constraints to satellite development, as well as a listing of satellite airport candidates is provided in Table 3.5. Estimates of the potential traffic which might be diverted to satellite airport operations were based upon market segments, percentage of transfer passengers, potential capacity and airport capabilities. These estimates never exceeded 30 percent of the primary airport market, and are available in airport-by-airport form in the working papers supporting this analysis.

TABLE 3.5

ESTIMATED MARKET CONSTRAINTS TO SATELLITE AIRPORT DEVELOPMENT

Large Hub Area	Principal Market Constraint to Satellite Airport Development	Satellite Airport Candidate
Chicago	Predominately medium and long haul markets. High percentage of transfer passengers. Lack of convenience airport(s) with long runways.	Glenview Meigs
New York	Newark, accessibility and identity problem. Kennedy less accessible than primary airport. Islip and White Plains small suburban airports, limited accessibility.	Newark Kennedy White Plains Islip
Atlanta	Extremely high percentage of transfer passengers. Lack of airport within convenient transfer distance.	
Los Angeles	High volume of long haul flights. Lack of accessible airport with long runway.	Ontario Burbank Orange County
Dallas-Ft. Worth	Low utilization of primary airport. Satellite operation already exists at Dallas-Love Field.	
Washington, D.C.	Predominate short haul market. Ease of access to primary airport.	Dulles
Miami	Identity problem. Accessibility of primary airport. Lack of access and conveniences at satellite airport. Lack of more accessible satellite airport relative to primary airport.	Hollywood
San Francisco	Accessibility of primary airport. Long connecting time between airports for transfer passengers.	Oakland
Denver	Heavy medium and long haul market segments. High percentage of transfer passengers. Less than saturation of primary airport by scheduled air carriers.	Buckley
Boston	Extremely heavy short haul market segment. Relative accessibility of primary airport. Lack of accessible alternate airports with long runways.	Hanscom Beverly Municipal

TABLE 3.5

ESTIMATED MARKET CONSTRAINTS TO SATELLITE AIRPORT DEVELOPMENT (Continued)

Large Hub Area	Principal Market Constraint to Satellite Airport Development	Satellite Airport Candidate
Honolulu	Lack of available airports to develop as satellites.	
Detroit	Low utilization of primary airport. Limited runway length at more accessible alternates.	Detroit City
Pittsburg	Low utilization of primary airport.	Allegheny County
Philadelphia	Low utilization of primary airport by scheduled air carriers. Relative accessibility of primary airport.	N. Philadelphia
Newark	Low utilization of primary airport. Needs to be developed as a satellite serving New York metropolitan area.	See New York Estimate
St. Louis	Low utilization of primary airport. Relatively high transfer passenger percentage. Lack of accessible airports capable of handling commercial aircraft.	Spirit of St. Louis Civic Memorial Bi-State Parks
Minneapolis-St. Paul	Low utilization of primary airports. Relative accessibility of primary airport. Lack of alternates with long runways	St. Paul Downtown
Houston	Low utilization of primary airport. Hobby Airport already operates as a satellite airport.	
Cleveland	Low utilization of primary airport. Lack of accessible alternates with long runways.	Burke Lakefront
Seattle-Tacoma	Low utilization of primary airport. Only King County airport more accessible than primary airport.	
Las Vegas	Low utilization of primary airport by scheduled air carriers.	
Tampa-St. Petersburg	Low utilization of primary airport.	
New Orleans	Low utilization of primary airport.	
Kansas City	Low utilization of primary airport.	Kansas City Municipal

3.2.5 Financial Constraints

The satellite airports studied in this work program can be divided into two groups: publicly owned and privately owned. The financial constraints to satellite airport growth differ somewhat for the publicly and privately held airports, as discussed below.

Publicly Owned Airports

Publicly owned airports are generally owned and operated by either a municipality, a county, a state or an authority created for the purposes of owning and operating airports. With the exception of the authorities, financial constraints operating on publicly owned airports are all similar. To the extent that airport expenses are not matched by airport revenues, the municipality or owning governmental agency is required to make up the difference from its general operating fund. A government-owned airport must rely on the bonding power of the governmental body to raise funds for capital expansion. The implicit constraint in these conditions is that the financial viability of the airport (if it is not self-supporting) is directly tied to the financial viability of its sponsoring community and the priorities assigned by the sponsor to the airport relative to other projects requiring the governmental support. The attitude of the local population varies markedly across the country. In some areas, airport support is enthusiastic and airport projects have little difficulty in being funded. In other areas, the airport is not regarded as favorable and funding is considerably more tenuous. In some areas, enthusiasm for airports exceeds the financing capabilities to the communities and on at least two occasions airports were found which had nearly bankrupted their sponsors because of operating deficits. Each of these situations and the implicit constraints of financial condition must be regarded on a case-by-case basis.

Private Airports

Privately financed airports differ considerably from publicly financed airports. Private airports must earn a profit or be subsidized by the owners. Private airports must compete for capital either with the other investments available to the owners or in the public capital markets. To the extent that a private airport is not profitable, its ability to raise capital is impaired. A private airport cannot fall back on a "subsidy" arrangement to insure its survival. There are some exceptions to this, however. There are several cases encountered where an airport is owned by a public body such as a municipality but operated by a private individual on a long-term lease. Here an association between public and private sectors uses the municipal bonding power to support airport capital expansion while relying on private management to insure minimal operating losses. As a practical matter, however, this is much more closely akin to a public airport than a private airport. Several exceptions were also encountered wherein privately sponsored airports accepted short-term losses either to fulfill a noneconomically motivated desire on the part of the airport owners to be associated with the aviation industry or as land speculators.

The most important single financial constraint which impacts privately held airports appears to be the relationship of airport land values to its surroundings and the opportunity cost of continued operation of the airport. An airport, for example, which occupies 100 acres of land valued at $5,000 an acre today (regardless of its original purchase price) represents an investment of $500,000. If this airport earns $20,000 a year (in real terms adjusted for tax shelters, etc.), then the return on investment is about 4 percent. Assuming the airport property could be used for other purposes, the $500,000 could possibly bring a higher rate of return. The difference between what the land returns from airport operations and what it might return in another application is the opportunity cost of the airport. As opportunity costs increase, there is increasing pressure to develop shopping centers, condominiums, etc., out of airport property.

In the course of this study, approximately 30 airports were encountered wherein surrounding land values had escalated to the point where owners were seriously considering turning the airport over for additional use. This has long-term applications for the future of close-to-the-urban areas airports.

3.2.6 Political Constraints

To a large extent, the political constraints to airport growth represent the distillation of the concerns, fears and prejudices of the community in which the airport operates. Often, the operation of a political constraint is through the legislative or financial process, in the sense that political constraints can be manifested in terms of jet bans, restrictive zoning ordinances, curfews, prohibitions of certain services or through refusal to support referendums for additional taxation to support airport growth, and/or budgetary constraints imposed through elected officials (i.e., a community which is reluctant to subsidize an airport can in fact restrict the amount of money released to the airport thereby causing reduction in services and effectively limiting airport growth capability).

The early stages of political constraints can be manifested through the operations of various public review processes (town council meetings, public hearings, etc.) related to airport growth and operations. In the assessment then, of political limitations to growth, the identification of precurser events such as public hearings or picketing is particularly important.

Political factors do not generally impact airport operations directly, but instead operate through legislative financial or other mechanisms already established. Typically, therefore, there is a time delay between the emergence of a political constraint and its embodiment as a legislative or financial limitation to airport growth. There are exceptions to this rule, however. Occasionally, airport sponsors more sensitive to political pressure (manifested through picketing, public hearings) decide not to force a politically controversial airport expansion issue. In this way, political constraints may impact airport growth directly.

The two focal points of these political pressures are usually, (1) environmental issues, such as noise, air pollution and visual pollution, and (2) financial issues--particularly higher taxes. However, there is no continuity in political reaction to airports and airport growth. Cities in the urban megapolis of the northeast tend to be highly responsive to environmental issues; this is also true in the far west. On the other hand, there are many areas, particularly in the middle west and the plains, where industrial growth is being encouraged and where the airport is enthusiastically supported.

3.2.7 Legislative Constraints

For the purposes of this study legislative constraints are construed to mean laws already on the books which impact an airport's ability to grow either in terms of number of operations or size of aircraft handled. These laws can operate on a local, state-wide, regional, or national level. Presented below is a discussion of the types of legislation which can impact an airport's growth ability.

Enabling Legislation for Airport Sponsor

Many publicly owned airports are owned and operated by an airport authority, port district or some other regional body empowered to own and operate transport facilities. These authorities are usually created by state legislation. The enabling legislation creating these authorities differs from state-to-state across the country. In many cases, the nature of these regulations present a constraint to airport change. For example, the taxing ability of an airport authority may be limited to a certain millage rate on neighboring properties. In many such cases, millage rates are already at the limit. Additional taxation may require a referendum vote which is increasingly more difficult to successfully attain. 17/

Enabling legislation can also limit airport size as, for example in San Jose, California, where a limit of 3,000,000 enplanements per year has been established.

Zoning Ordinances

To the extent that land adjacent to an airport has zoning ordinances applied to it, these ordinances may impose restrictions to airport growth. Should the land be zoned for industrial, residential or commercial purposes, rather than for airport purposes, these lands will rapidly become developed and, as a practical matter, lost to the airport. Conflicting zoning of this sort can also create problems in acquisition of land for clear zones and for other appurtenances such as navigation equipment.

17/ See Airport Passenger Head Tax, W. R. Fromme, DOT, FAA, July 1974.

Environmental Legislation

Some communities have, with mixed success, attempted to institute bans on jet aircraft (such as Morristown, New Jersey), installed curfews restricting hours of operations for all or certain types of aircraft or have instituted other health and safety legislation all of which pose constraints to airport growth. For example, the City of Torrance, California, has instituted laws prohibiting storage (and thereby preventing sale) of jet fuel at the airport. This legislation, which in no way impinges on the rights of jet aircraft to land or take off at this field, does (because of the cost of the jet operations) effectively ban most jets from using the field without substantial inconvenience. This legislation represents a de facto exclusion of jet aircraft.

3.2.8 Assessing Financial, Political and Legislative Constraints

Legislative, financial and political constraints to satellite airport development were assessed by Gellman Research Associates (GRA). A four-step process was developed for the task:

- o Interviews with FAA Regional Officials
- o Review of Airport Master Plans
- o Interviews with Metropolitan Planning Organization (MPO) Representatives
- o Interviews with Local Airport Officials

Through a series of conference calls, FAA representatives were interviewed on their assessment of legislative, financial and political constraints to satellite airport development. These conference calls were made with a total of 16 FAA regional and airport district offices. Discussion groups ranged from three to eight individuals. An interview format was developed for these discussions and submitted to each FAA field office prior to the interview (see Appendix D). During each discussion probing questions were asked about potential limitations to airport expansion. Records were kept of conversational results in anecdotal form. In total, 30 regional and district FAA officials, identified in Appendix E, participated in this phase of the analysis.

Local planning organizations were contacted for master plans and other published planning information. Again, the principal goal was to identify political, legislative and financial constraints to airport growth. The presence of a master plan, often dictated the extent to which a given satellite airport would be able to grow or modify its operations in order to provide relief to the primary hub airport. In all 19 master plans were obtained and evaluated.

Where master plans and other documents were unavailable, individual contacts were made with MPO representatives to verify results of earlier interviews and to expand the data base. As appropriate, preliminary findings were modified to reflect the MPO's assessment of prevailing conditions. Interviews with approximately 40 additional officials were conducted for this phase of the study.

Finally, where information obtainable from FAA officials, master planning documents, and MPO representatives was inadequate to support an evaluation of political, financial and/or legislative constraints to airport expansion, individual airport officials were contacted. Interviews with 25 airport officials were conducted to complete the field data. A listing of officials interviewed is presented in Appendix E.

Data obtained during this phase of the analysis was evaluated, and estimates made of the political, financial, and legislative constraints to satellite airport growth. These limitations, then, were factored into the calculation of potential additional operations a satellite candidate might support. That is, the estimates of political, financial, and legislative constraints, derived on the basis of detailed interviews with approximately 100 local planning officials, were translated into reduced airport capabilities for handling air traffic, or inability of an airport to expand to accommodate larger aircraft. This is explained more fully in Section 3.3.

3.3 Evaluation of Satellite A/P Capacity

3.3.1 The Concept of Potential Additional Operations (PAO)

One of the objectives of this analysis was an assessment of the capacity available at satellite airports for air traffic diverted from larger terminals. The capability of an airport to accept traffic in excess of its current level of activity may be measured as potential addition operations (PAO) the airport can accommodate. The PAO of an airport is a function of the current operations and the practical annual capacity (PANCAP) of that airport. That is, PAO = PANCAP - Current Operations. A forecast of PAO for any future year is dependent upon current operations, PANCAP, and, in addition, the projected growth in current aircraft operations.

The measure of PANCAP, and consequently, PAO is also sensitive to the type of aircraft operating at the airport. An airfield suitable only for small aircraft will have zero capacity and, therefore, zero PAO for Boeing 707 type airlines. For purposes of this report, five categories of aircraft are defined:

Category A	4 engine jet and larger
Category B	2 and 3 engine, 4 engine piston and turbo prop
Category C	executive jet and transport size twin engine piston
Category D	light twin engine piston and larger single engine piston
Category E	light single engine piston

These categories are based upon the aircraft classification system promulgated in FAA Advisory Circular 150/50601A. Appendix II of that document contains a listing of specific aircraft in each category noted above.

3.3.2 Computing PAO for Future Years

If the mix of aircraft operating at an airport is known, separate PAO estimates can be computed for each aircraft type.

The PAO of any airport by aircraft type, the, can be assessed from the following independent variables:

- o PANCAP
- o Current operations level
- o Mix of current operations (and future operations)
- o Planned growth of operations

A methodology for determining the PANCAP of various airport runway configurations is available in FAA Advisory Circular 150/50603A. This approach was developed for long-range airport planning projects. The advisory circular displays a series of different configurations of runways and identifies for each configuration a number of alternative practical annual capacities. Four PANCAP's are shown for each airport, one for each of four design mixes or "groupings" of aircraft. The composition of each aircraft mix is shown in Table 3.6. Table 3.6 shows, for example, that aircraft mix #1 consists of 10 percent Category C aircraft and 90 percent of Category D and E aircraft.

Airports are assigned mix designation reflecting the type of aircraft currently operating at the facility. For instance, general aviation airports have a mix designation of zero (0). With business jet activity, a general aviation airport could be classified as mix 1. Some of the largest air carrier airports are identified as mix 4. Other commercial airports are classified either as mix 2 or mix 3, depending upon whether or not jet aircraft operations are conducted.

Each satellite candidate (365 total) was assigned a mix category according to present mode of operation. PANCAP for each was then determined using the methodology from AC 150/5060-3A. Next, air traffic activity levels for each airport were obtained from current statistical reports, 18/ or from airport operators directly, if necessary. Finally, a uniform traffic growth rate of 4 percent per year was assumed for all airports and aircraft categories.

Given these four items, PAO forecasts were developed for each satellite airport candidate through the year 2000 by applying the following decision rules:

1. PAO = PANCAP - Forecast Traffic Operations by category aircraft.

18/ Terminal Area Forecasts: 1976-1986, DOT, FAA, 1974. Also Military Air Traffic Activity Report, CY 1973, DOT, FAA 1974.

TABLE 3.6

Description of Aircraft Mixes 1/

Aircraft Mix Designation	Percent Aircraft by Category A	B	C	D & E
0	0	0	0	100
1	0	0	10	90
2	0	30	30	40
3	20	40	20	20
4	60	20	20	0

1/ Airport Capacity Criteria Used in Long-Range Planning, AC 150/5060-3A, DOT FAA, December 24, 1969, page 2. These figures have a tolerance of $\pm$ 10 percent for critical categories in each mix. The large aircraft in the mix is critical. Interpolation from this table is explained in the cited reference.

2. When an airport reaches PANCAP PAO = 0. That is, no additional PAO is available after the airport reaches PANCAP.

3. If current operations level is greater than or equal to PANCAP no PAO is available.

An additional set of decision rules was adopted to allow for possible airport growth. Specifically:

1. Airport growth could change the aircraft mix handled (i.e., to accommodate larger, heavier aircraft) but not increase the airport's PANCAP. This was a conservative assumption. Quantum increases in PANCAP are provided only by additional runway construction. This analysis assumed that runways could be lengthened and/or improved, but no new runways would be built at the satellite candidates.

2. All airport growth will take place between the years 1975 and 1980 so that the 1980 PANCAP and PAO figures should reflect the "changed" airport.

3. If airport growth changed the mix of aircraft accommodated in such a way that the PANCAP for a given aircraft type was exceeded by current operations, all aircraft (of a given type) currently using that field would be accommodated before a larger aircraft would be handled. That is, only surplus capacity for operations would be used to accommodate larger aircraft. However, once PANCAP for a given aircraft type was reached, PAO was set to zero, and no additional operations of this type of aircraft were allowed. It was assumed that smaller aircraft which could no longer be accommodated would divert to other general aviation fields not identified as satellite airport candidates.

3.3.3 Introducing Capacity Constraints to the Equation

This set of decision rules allows the determination of PAO for any satellite airport, by aircraft type, assuming maximum utilization of that facility, (i.e., an unconstrained (PAO). In addition, however, it is also possible to cast the political, market, ATC, and other constraints to airport growth discussed in Section 3.2 in terms of reduced ability to handle aircraft or in terms of inability of airport to expand to accommodate larger aircraft. These constraints, in other words, can be translated into reduced PAO, or constrained PAO. Given that the constraints defined were measures of the true limitations to expanded airport use, constrained PAO estimates represent the amount of additional aircraft activity that satellite airports can realistically support.

The technique for determining PAO for satellite airports can best be illustrated by several examples. For instance, a hypothetical general aviation field currently has a mix "0" (i.e., it handles 100 percent small aircraft), and it has the financial resources to lengthen the runway to accommodate business jets. However, because of environmental pressure and local complaints over aircraft noise the airport cannot be expanded. In the unconstrained condition, it is estimated the airport could grow to mix "1" (i.e., 10 percent biz jets, 90 percent light aircraft). However, it was determined that political factors would limit aircraft to mix "0." The (constrained) PAO would show capacity available only for additional general aviation Category D&E aircraft.

A second example would be an airport such as San Jose Municipal, where legislation prohibits commercial passenger enplanements from exceeding a certain figure. This legislative constraint could be cast in terms of a reduction of effective PANCAP of the airport. Because of the legislation, the effective number of operations at the field would be limited, the PANCAP at the airport would be reduced, and the PAO would be the difference between actual operations for a given year and the reduced PANCAP.

3.3.4 Developing a Computer Program for PAO

Many combinations of constraints which would operate on PANCAP or mix could be hypothesized. With 365 airports, four aircraft types, six types of constraints, five possible aircraft mixes, and six time periods (5-year intervals 1975-2000), the number of possible data points rapidly becomes extremely high. A computer program was developed to process this large amount of data.

The computer program was designed to translate airport mix, operations, PANCAP data and constraint estimates into PAO forecasts for each satellite candidate through the year 2000.

For each satellite candidate the program identified the most limiting constraint to growth, forecast operations by aircraft type through the year 2000, weighed these operations against PANCAP and mix and computed PAO by aircraft type (PAO = PANCAP - Constraint - Forecast Operations). The computer then aggregated the PAO's by hub. The summation of PAO's over each satellite candidate in a given hub provided the measure of relief available for air traffic at the primary air carrier airport. These estimates of PAO are listed by airport, aircraft category and year in Appendix G.

3.4 Terminal Area Aviation Forecasts

This report presents an assessment of the potential impact of satellite airport use on air traffic delays at the largest U.S. air carrier airports. Annual forecasts of terminal area activity at the top 25 air carrier airports through the year 2000 were provided by the FAA Aviation Forecast Branch. These forecasts are shown in the form of average daily operations in Table 3.7.

Terminal area air traffic can be divided into three separate groups of users: air carrier, general aviation, and military. Forecast activity levels for the first two of these groups are derived from econometric models. Military flight activity, based on information provided by the Department of Defense, is projected to remain nearly constant throughout the period 1975-2000.

The fundamental assumptions underlying the air carrier and general aviation econometric models are that various measures of aviation activity are related to the level of economic activity and that the various activity measures are dependent on one another in a predictable way. 19/ The air carrier model is based upon economic data from the years 1964 through 1973. It relates level of air carrier activity to the total consumption of services, the number of civilians employed, investment expenditure in the aircraft industry, the price of air travel relative to that of other modes of transportation, and purchases of automobiles. Tests of the model show that an increase in automobile purchases of air fares can be expected to result in a decrease in domestic revenue passenger miles, revenue passenger enplanements, and terminal operations; whereas increasing the portion of the population that uses air carrier services, improving the level of service, or increasing the consumption of services can be expected to increase these variables.

The general aviation forecasting model is based upon socio-economic statistics compiled over the period 1964-1974. The driving economic variables in the general aviation model are real per capita personal disposable income, civilian employment, capital investment in the aircraft industry, and factory sales of automobiles. Tests of the model show that increases in any but the last of these variables can be expected to increase fleet size and activity levels. For example, as discretionary income increases, it is likely that the number

19/ For a quantitative discussion of the forecasting methodology, the reader is referred to Appendix A in *Aviation Forecast--Fiscal Years 1976 to 1987*; 1975. Department of Transportation, Federal Aviation Administration.

TABLE 3.7

FAA TERMINAL AREA FORECASTS

City-Airport/State	Airport Code	Average Daily Operations 1975	1980	1985	1990	1995	2000
Chicago-O'Hare, Ill.	ORD	1865	2014	2036	2055	2074	2085
Boston, Mass.	BOS	753	959	1014	1041	1071	1151
San Francisco, Calif.	SFO	926	1115	1211	1370	1452	1507
St. Louis, Mo.	STL	915	1097	1227	1337	1447	1479
Denver, Colorado	DEN	1038	1099	1151	1205	1260	1315
Los Angeles-Int'l, Calif.	LAX	1277	1411	1477	1567	1616	1644
Seattle, Washington	SEA	427	509	551	630	726	822
Philadelphia, Pa.	PHL	866	1077	1137	1233	1301	1370
Cleveland, Ohio	CLE	701	863	577	890	870	890
New York, N.Y.	JFK EWR LGA	2518	2898	3219	3438	3685	3863
Washington-National, D.C.	DCA	992	852	822	786	805	822
Atlanta, Georgia	ATL	1375	1616	1753	1767	1973	2041
New Orleans, La.	MSY	427	611	781	932	1123	1151
Minneapolis, Minn.	MSP	668	956	1205	1315	1397	1479
Detroit, Mich.	DTW	704	858	932	959	986	1014
Kansas City, Mo.	MCI	482	847	825	1014	1205	1233
Dallas, Ft. Worth, Int'l.	DFW	948	1156	1318	1458	1600	1663
Honolulu, Hawaii	HNL	836	932	1014	1068	1096	1123
Houston, Texas	IAH	521	645	822	959	1096	1233
Miami, Fla.	MIA	896	996	1101	1225	1304	1370
Pittsburgh, Pa.	PIT	625	986	1110	1233	1301	1370
Tampa, Fla.	TPA	532	759	1071	1362	1589	1643
Las Vegas, Nev.	LAS	644	904	1014	1096	1178	1232

of active GA aircraft and activity levels will increase. An increase in the sales of automobiles, a principal substitute for air travel, is likely to accompany a decrease in the number of general aviation aircraft and operations.

The assumptions and the forecast economic variables for both the air carrier and general aviation activity models relate to those variables used by the Council of Economic Advisors. Several of these key economic indicators are discussed in Appendix H.

3.5 Delay Calculations

In concept, a network of satellite airports could relieve aircraft congestion and delay at the larger air carrier airports. The estimation of airside delays at these major airports is usually based either on queuing theory or on computer supported simulation. Alternatively, an extensive data collection program on delays at the airport of interest can be initiated. The work described here uses a simple and practical tool, A Handbook for the Estimation of Airside Delays at Major Airports (A Medeo Odoni and Peeter Kivestu, NASA Contractor Report, June 1976), from which airport delays can be estimated using the knowledge of a few basic variables associated with any given airport. The handbook can be used to provide estimates of the potential delay reductions attributable to expanded satellite airport utilization.

The basic quantity with which the handbook deals is that of average total daily delays (TDDEL)s, i.e., the total delays experienced in the course of a typical day by aircraft attempting to use the runways of an airport. The delays referred to here are solely those due to normal runway congestion and do not reflect problems that may be due, for instance, to exceptional weather conditions or to other causes. No distinction is made between delays suffered by landing aircraft which have to queue in the air and delays to departing aircraft on the ground.

3.5.1 The Handbook of Airport Delays

The Handbook of Airport Delays is a collection of data statistics for a set of demand profiles specifically chosen to represent observed current demand patterns at air carrier airports. These profiles are used by computing airport delays by matching the demand profile under observation with that profile it most closely resembles in the Handbook of Airport Delays.

Standard profiles in the handbook were developed from traffic patterns at the top 100 U.S. airports. 19/ Two basic descriptions of demand characterize the profiles developed.

1. The number of daily peak periods. This identifies the general shape of the demand profile.
2. The "peak-hour operations as a percent of total daily operations." This is a rough indicator of the sharpness of the peaks and valleys in the demand profile. 20/

Ten profiles were developed which are representative of the airport traffic patterns actually observed. These include the following profiles:

NP7 - no peak 7%	OP7 - one peak 7%	TP7 - two peak 7%
NP8 - no peak 8%	OP8 - one peak 8%	TP8 - two peak 8%
	OP9 - one peak 9%	TP9 - two peak 9%
	OP10- one peak 10%	TP10- two peak 10%

The graphs of TDDEL, for each of the ten profiles, plotted against an average "hourly" capacity, are provided in the handbook with the computational techniques described in this section. These ten TDDEL graphs are the core of the handbook. The user selects one of the ten profiles most closely matching the observed airport profile. Knowledge of the airport capacity then allows straightforward graphical lookup from the appropriate TDDEL graph. The procedure is illustrated in Figure 3.4 for an airport assumed to resemble most closely the "two-peak, 8 percent" (TP8) standard profile. Figure 3.5 illustrates the "standard" TP8 profile of airport traffic activity.

3.5.2 Delay Programs

The primary tool used for the computation of the TDDEL graphs was the DELAYS set of computer programs developed at the Flight Transportation Laboratory of MIT.

19/ Profiles of Scheduled Air Carrier Airport Operations Top 100 U.S. Airports, Department of Transportation, Federal Aviation Administration, November 1973, and August 1974.

20/ For the generalizations made to fill out the shape of the remainder of the profile the reader is referred to the handbook.

FIGURE 3.4
AIRPORT DELAY VALUES

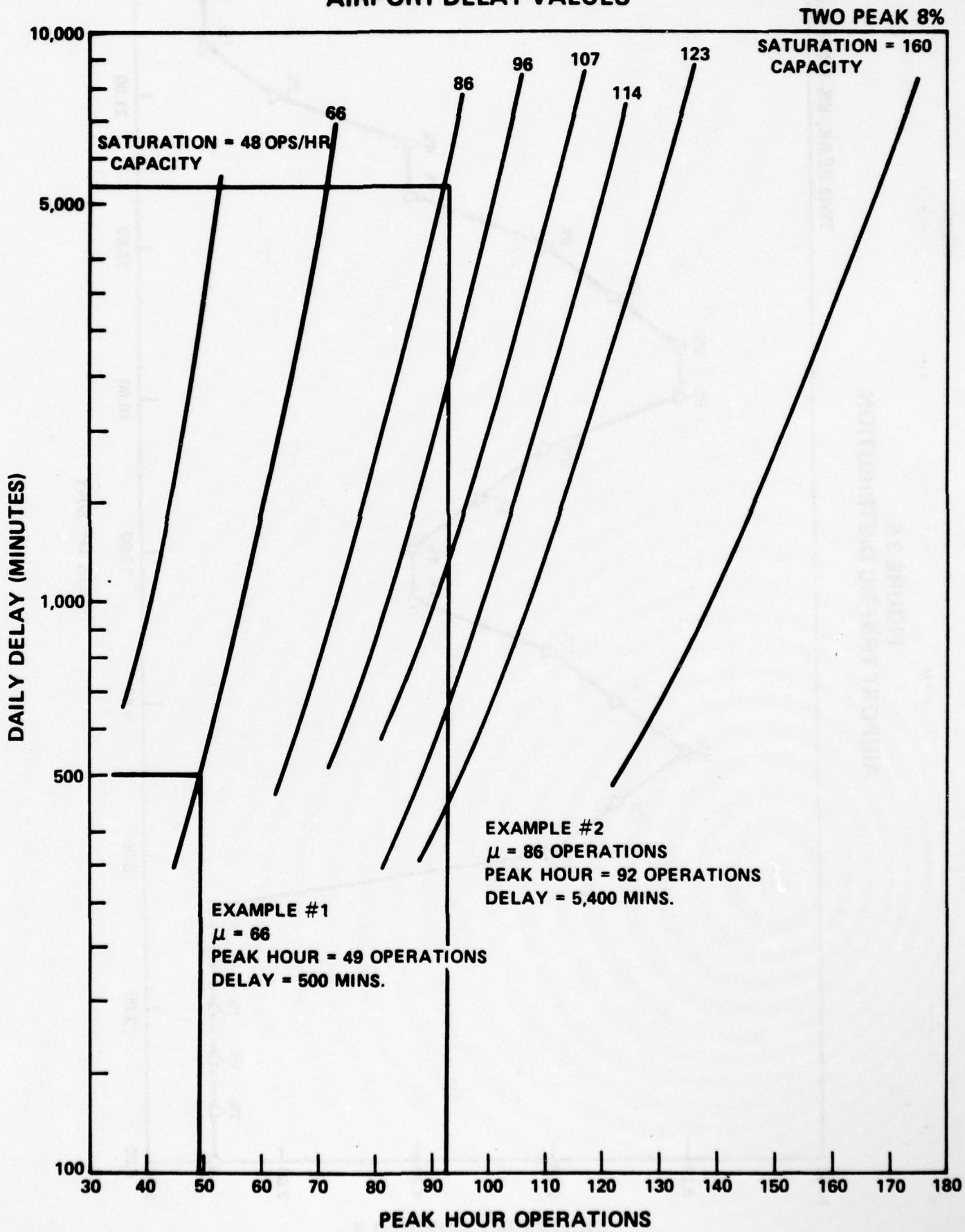
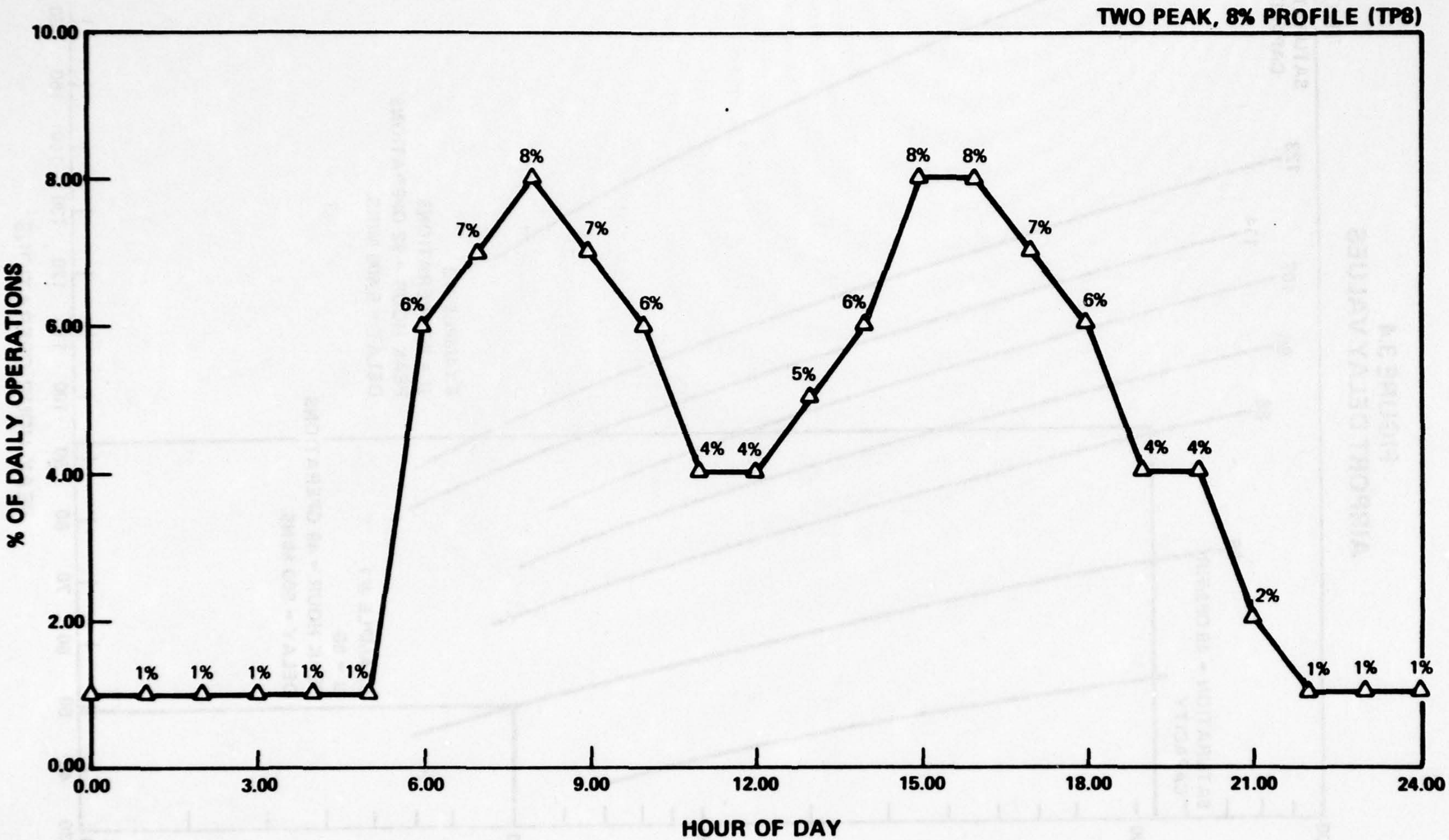


FIGURE 3.5
AIRPORT TRAFFIC DISTRIBUTION



Briefly, the programs are used as follows:

1. The input information consists of the "standard" hourly profiles of total demand (total of demanded landings and takeoffs); the average hourly saturation (or "maximum throughput") capacity and the number of runways assumed.

2. The output of the computer programs provides estimates on various delay-related statistics. The quantity of concern in the work under discussion here is the (average) TDDEL in minutes for each of the standard profiles and for each value of saturation capacity.

3. In order to compute the various quantities of (2), the computer programs obtain <u>upper bound</u> estimates and <u>lower bound</u> estimates for each quantity of interest. A weighted average is then computed from these two limits. The upper bound estimates are computed from a so-called M/M/k (negative exponential service times) queuing model and the lower bound from a M/D/k (deterministic service times) queuing model.

Throughout this report the weighting formula used to compute average total daily delay is:

$$TTDEL = 1/3\ (TDDEL_{M/M/K}) + 2/3\ (TDDEL_{M/D/K})$$

That is, the upper bound estimate of average total daily delays receives a weight of 1/3 and lower bound receives a weight of 2/3. The details and the validity of this procedure are discussed in Appendix I.

3.5.3 Delay Computation

The procedure adopted in this analysis for applying the delay model to compute airport delays at primary large hub airports is explained in the following paragraphs. Two sets of airport delay estimates were computed; one set for the standard terminal forecasts, and a second set based upon the assumption of expanded satellite airport utilization. These delay values were then compared.

Primary Airport Delay, Terminal Area Forecasts

The first set of aircraft delay estimates were computed for the 25 primary large hub terminals using air traffic activity projections from the 1975-2000 terminal area forecast, (see Section 3.4). These estimates represent delays anticipated given the assumption there would be no traffic diversion away from the large airports to satellite facilities.

One of the inputs required for computing air traffic delay is the saturation capacity or throughput rate of the airport being observed. Capacity estimates for each of the 25 primary large hub airports were provided by the MITRE Corporation. 21/ These capacities reflect the schedule of conventional airport improvements planned at each facility through the year 2000. Capacity estimates are listed in Appendix J.

Next, the profile of flight activity at each of the primary large hub airports was categorized by number of traffic peaks, and the percentage of total daily traffic operating in the peak hour. 22/ This categorization allowed the computation of airport delays in the manner explained in Section 3.5.1.

21/ Airport capacities and improvement schedules under each scenario are defined in the MITRE Corporation memorandum, WA 43-1277, July 31, 1975.

22/ Profiles Scheduled Air Carrier Operations by Stage Length-Top 100 U.S. Airports, DOT, FAA, May 1975.

Finally, average daily delay estimates were computed for each capacity configuration at the top 25-air carrier airports (see Section 3.5.1). These average delays were weighted by the relative percentage of occurrences of each capacity condition, and aggregated by airport. The annual air traffic delays derived by this method are shown in Table 3.8. These estimates represent the delays that can be anticipated given the Terminal Area Forecast and the assumption that no air traffic diversions to satellite facilities occur through the forecast period (year 2000).

<u>Expanded Satellite Airport Utilization</u>

Diversion of aircraft operation away from the primary airport to satellite facilities would relieve air traffic delays at the more congested terminals. In order to develop airport delay estimates reflecting this scenario, the assumption was made that aircraft were diverted away from the top 25-commercial airports up to the limit of available capacity at satellite facilities (PAO). Delays at the primary airports were then recomputed under reduced air traffic conditions.

The terminal area forecast shown in Table 3.7 provided the starting point for these calculations. At each airport, traffic activity forecasts were reduced each year by an amount equal to the PAO estimates for the area. 23/ In this manner, the assumed traffic diversion was accomplished. In the process of "diverting" traffic, the unique requirements of different aircraft categories (D,C,B,A) at each primary airport were observed. For example, Category D or C aircraft were not diverted from Logan Airport if additional capacity for these type aircraft was unavailable at satellite facilities in the Boston area. Nor, in any year, were diversions in any category allowed in excess of the additional satellite capacity available for that category and year. The overall result of the traffic diversions was a revised aircraft schedule of average daily operations for each primary airport.

23/ The potential additional satellite airport capacity available in each hub is defined in Section 3.3 and shown by aircraft type and year in Appendix G.

TABLE 3.8

AIRPORT DELAY ESTIMATES

City-Airport/State	Airport Code	Annual Aircraft Delay (Minutes x 10^6) 1975	1980	1985	1990	1995	2000
Chicago-O'Hare, Ill.	ORD	6.7	7.3	7.4	7.6	7.7	7.8
Boston, Mass.	BOS	0.4	1.0	1.0	1.1	1.2	1.6
San Francisco, Calif.	SFO	1.4	6.2	8.1	8.1	8.1	8.1
St. Louis, Mo.	STL	2.5	7.2	7.2	7.2	7.2	7.2
Denver, Colorado	DEN	1.8	3.0	6.8	8.0	8.9	8.9
Los Angeles, Calif.	LAX	0.6	1.7	2.8	3.2	3.3	3.9
Seattle, Washington	SEA				0.3	1.3	2.8
Philadelphia, Pa.	PHL	2.5	7.0	7.0	7.0	7.0	7.0
Cleveland, Ohio	CLE	1.1	3.0	3.3	3.8	3.8	3.8
New York, N.Y.	JFK EWR LGA	6.2	15.4	20.2	20.2	20.2	20.2
Washington-National, D.C.	DCA	2.9	1.3	1.2	1.0	1.1	1.2
Atlanta, Georgia	ATL	1.0	2.3	3.8	4.2	12.5	14.2
New Orleans, La.	MSY		0.1	1.7	5.2	6.6	6.6
Minneapolis, Minn.	MSP	0.6	3.0	3.3	3.7	4.2	5.2
Detroit, Mich.	DTW						0.1
Kansas City, Mo.	MCI				0.9	2.2	3.1
Dallas, Ft. Worth Int'l.	DFW			0.3	0.8	2.2	3.3
Honolulu, Hawaii	HNL 1/	2.9	6.5	6.5	6.5	6.5	6.5
Houston, Texas	IAH				0.5	1.5	4.5
Miami, Fla.	MIA				0.3	0.6	0.9
Pittsburgh, Pa.	PIT		0.4	1.0	2.3	3.6	5.8
Tampa, Fla.	TPA			0.2	1.3	3.3	4.0
Las Vegas, Nev.	LAS		0.3	0.8	2.0	2.9	7.7
Total All Airports		27.7	59.2	76.1	88.7	109.4	127.4

1/ Estimates not included in total.

These revised schedules are shown in Table 3.9. [24]

As the final step, air traffic delays at each primary airport were recomputed using the revised traffic schedule of Table 3.9. [25] Results are shown in Table 3.10. The revised estimates represent delays that could be anticipated at the primary air carrier airports if aircraft activity were diverted away from these larger facilities.

Comparison of the delay estimates with and without aircraft diversion provides an indication of the potential benefits of expanded utilization of satellite airports. However, the present distribution of air traffic indicates there are insufficient incentives for aircraft operations to use satellite facilities. Without some external motivation, in the form of a pricing or regulatory action, for example, diversion of significant numbers of aircraft to satellite airports is not anticipated.

It was noted that for many airports, expanded use of local satellite facilities relieved air traffic congestion to the point where no significant delays were encountered (e.g., Seattle, Cleveland, Detroit, Pittsburgh). There are other terminals, however, with few satellite airport options. Honolulu, Atlanta, and Los Anageles for example, have limited satellite development potential.

24/ The information presented in Table 3.9 is not a forecast. It indicates only the capacity of satellite airports to relieve congestion at the larger terminals.

25/ In applying the methodology described earlier, the assumption was made that the profile of observed aircraft activity did not vary with changes in total numbers of aircraft operations. See Section 3.5.1.

TABLE 3.9

REVISED SCHEDULE OF AIRPORT OPERATIONS

City-Airport/State	Airport Code	Daily Operations Reflecting Expanded Use of Satellite Airport 1980	1985	1990	1995	2000
Chicago-O'Hare, Ill.	ORD	1134	1436	1430	1460	1468
Boston, Mass.	BOS	515	682	792	877	981
San Francisco, Calif.	SFO	518	745	951	1077	1225
St. Louis, Mo.	STL	79	107	190	184	247
Denver, Colorado	DEN	529	682	775	636	1058
Los Angeles-Int'l, Calif.		LAX	1145	1340	1468	1504
Seattle, Washington	SEA				277	277
Philadelphia, Pa.	PHL		452	578	668	737
Cleveland, Ohio	CLE				515	515
New York, N.Y.	JFK EWR LGA	2118	2400	2512	2679	2849
Washington-National, D.C.		DCA				
Atlanta, Georgia	ATL	1258	1421	1512	1668	1772
New Orleans, La.	MSY		523	622	739	775
Minneapolis, Minn.	MSP					331
Detroit, Mich.	DTW					443
Kansas City, Mo.	MCI					
Dallas, Ft. Worth Int'l.	DFW			1246	1381	1493
Honolulu, Hawaii	HNL	932	1014	1068	1096	1123
Houston, Texas	IAH					701
Miami, Fla.	MIA					1070
Pittsburgh, Pa.	PIT					759
Tampa, Fla.	TPA					
Las Vegas, Nev.	LAS					594

TABLE 3.10

REVISED AIRPORT DELAY ESTIMATES
ASSUMING EXPANDED SATELLITE AIRPORT USE

City-Airport/State	Airport Code	Annual Aircraft Delay (Minutes x 10^6) 1980	1985	1990	1995	2000
Chicago-O'Hare, Ill.	ORD		0.9	0.9	1.1	1.1
Boston, Mass.	BOS		0.1	0.7	0.9	1.0
San Francisco, Calif.	SFO		0.4	1.6	4.4	8.1
St. Louis, Mo.	STL					
Denver, Colorado	DEN					
Los Angeles-Int'l, Calif.		LAX		0.8	2.7	3.0
Seattle, Washington	SEA					
Philadelphia, Pa.	PHL				0.3	0.8
Cleveland, Ohio	CLE					
New York, New York	JFK EWR LGA	1.6	4.3	6.2	9.4	14.7
Washington-National, D.C.		DCA				
Atlanta, Georgia	ATL		0.8	1.3	3.1	4.2
New Orleans, La.	MSY			0.2	0.9	1.6
Minneapolis, Minn.	MSP					
Detroit, Mich.	DTW					
Kansas City, Mo.	MCI					
Dallas, Ft. Worth Int'l.	DFW				0.8	1.0
Honolulu, Hawaii	HNL 1/	2.9	6.5	6.5	6.5	6.5
Houston, Texas	IAH					
Miami, Fla.	MIA					
Pittsburgh, Pa.	PIT					
Tampa, Fla.	TPA					
Las Vegas, Nev.	LAS					
Total All Airports		1.6	7.3	13.6	24.9	35.5

1/ Estimates not included in total.

This section completes discussion of the analysis of satellite airport development potential. The findings and conclusions which emerge from the analysis are presented in the following chapters of the report.

4.0 Findings

1. The results of this analysis indicate there are approximately 365 satellite or secondary airports in the 25 largest metropolitan areas of the country which appear to offer potential for expanded use. These secondary or satellite facilities could relieve some of the air traffic congestion which occurs at the larger air carrier airports. The extent of the potential relief, in the form of potential additional aircraft operations the satellite could support through the year 2000, is shown in Appendix G. These estimates were based upon an assessment of the constraints imposed by the local transportation infrastructure, the ATC system, military requirements, market factors, and political, legislative, and financial limitations.

2. Assuming diversion of commercial and general aviation air traffic away from a congested airport to the limit of additional capacity available at satellite facilities, aircraft delays at the primary air carrier airport in each hub were estimated before and after satellite airport use. Results are shown in Figure 4.1.

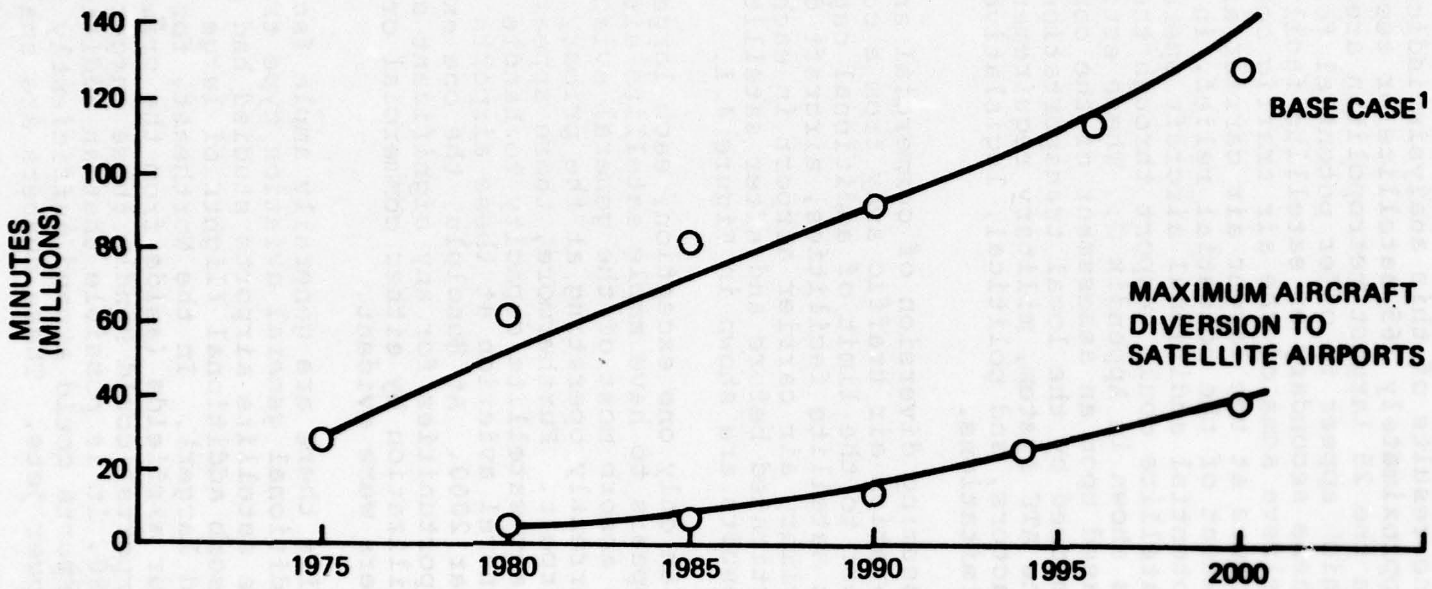
3. With only one exception, each large hub area appears to have ample satellite airport capacity to absorb most of the general aviation traffic currently operating at the primary air carrier airport. Furthermore, there appears to be sufficient satellite capacity to handle the growth of general aviation at these airports through the year 2000. At Honolulu, the one exception, no opportunities for any significant satellite airport utilization by either commercial or general aviation users were evident.

4. While there are generally ample facilities for additional general aviation type traffic, few of the satellite airports studied had potential to absorb additional flights of large jets (707 type and larger). In the Northeast, for example, only four airfields (aside from the primary air carrier airports) could handle these larger aircraft. By 1980, it is possible that an additional eight airports could expand sufficiently to accept the bigger jets. These numbers are small considering

FIGURE 4.1
ANNUAL AIRCRAFT DELAY AT PRIMARY LARGE HUB AIRPORTS

FAA UG3RD EVALUATION
COMPLEMENTARY POLICY STRATEGIES
OFFICE OF AVIATION POLICY

PRIMARY AIRPORTS IN THE
23 LARGE HUBS



[1] ASSUMING FAA TERMINAL AREA FORECASTS, NO DIVERSION TO SATELLITE AIRPORT

the Northeast area covers approximately one fourth of the 48 contiguous states. Other regional areas are similarly constrained. It points to the fact that satellite airport development would be necessarily limited for the largest aircraft, with the greatest satellite prospects indicated for propeller-driven and smaller turbine airplanes.

5. Military airfields are particularly attractive satellite airport candidates because many of them are already configured for operation by larger aircraft. There are 38 military airfields in the 25 large hub areas which appear to offer some potential for satellite use. The Department of Defense indicates, however, that joint use is acceptable at only eight of these facilities.

5.0 Conclusions

This report examined a finite set of constraints to expanded use of satellite airports. Based on an assessment of these constraints, it is concluded that satellite airports have the potential for relieving a significant amount of air traffic delay at the primary large hub airports. As Figure 4.1 indicates, maximum utilization of the 365 satellite facilities identified in this report could maintain air traffic congestion at the primary large hub airports at or below 1975 levels for up to 15 years.

It is important to note that the findings of this report do not constitute an action plan for air traffic diversion; nor are they a forecast. Only the potential for developing satellite airports in major metropolitan areas has been estimated here. While capacity is available at satellite airports, there are insufficient incentives at present for air traffic to use these facilities. Without additional motivation, large scale diversion to satellite airports is unlikely.

APPENDIX A

SATELLITE AIRPORT CANDIDATES

CHICAGO, ILLINOIS, HUB

Satellite Airport	Airport Category 1/
Aurora	D
Chicagoland	E
Meigs Field	D
Midway	B
Pal-Waukee	C
Howell	D
Dupage County	D
Hammond	D
Schaumberg	D
Brookeridge	E
Elgin	D
Haley AAF	D
Frankfort	D
Glenview NAS	B
Joliet	D
Lewis-Lockport	D
Langer	E
Napier-Aero	D
Gear	D
Lenox-Howell	D
Hedler	E
Clow International	D
Wakeegan	D
Gary	B
Griffith	E
Hobart	D
Lemont Aero	D

1/ Refer to Table 3.2

NEW YORK, NEW YORK, HUB

Satellite Airport	Airport Category 1/
Somerset Hills	E
Caldwell-Wright	D+
E. Brunswick	E
Raceway Park	D
Hanover	E
Lakewood	NA
Lincoln Park	D
Linden	D+
Preston	D+
Teterboro	B
McGuire AFB	A
Zahn's	D
Grumman-Bethpage	B
Westchester County	B
Republic	B
Flushing	D
Suffolk County	NA
Morristown Muni	D+
Ramapo Valley	E

ATLANTA, GEORGIA, HUB

Fulton County	C
DeKalb-Peachtree	C
Covington Muni	D
S. Fulton Skyport	D
Bear Creek	D
S. Expressway	D
Gwinette County	E
McCollum	D
Berry Hill	D
Stone Mountain	D
Dobbins AFB	A

1/ Refer to Table 3.2

LOS ANGELES, CALIFORNIA, HUB

Satellite Airport	Airport Category 1/
Agua Dulce	D
Hollywood-Burbank	B
Shepherd Field	D
Compton	D
Stony Bridge Ranch	E
Hughes	B
El Monte	D
El Toro MCAS	A
Fullerton	D
Hawthorne	C
Meadow Lark	E
Santa Monica	C
Santa Suzanna	E
Torrace	C
Prackett Field	D
Long Field	A
Los Alimitos	B
Whiteman	D
Van Nuys	B
Ontario	A
Palmdale	A
San Fernando	D
Orange County	

DALLAS-FT. WORTH, TEXAS, HUB

Arlington	D+
Red Bird	C
Addison	B
Love Field	B
Dallas NAS Hensley Field	B
Meecham Field	B
Mangham Field	D
Ft. Worth Water District Levee	D
Luck Field	E
Oak Grove	D
Carswell AFB	A
Blue Mound	E
Saginaw	D
E-Systems	D
Grand Prairie	NA
Grand Prairie Muni	D
Air Park - Dallas	D

1/ Refer to Table 3.2

WASHINGTON, D.C., HUB

Satellite Airport	Airport Category 1/
Lee	D
Martin Marietta	B
Baltimore	A
Beltsville	A
Andrews AFB	B+
Hyde	E
College Park	D
Tipton AAF	D
PG	D
Montgomery County	D
Maryland	D
Suburban	E
Davis	E
Freeway	E
Patuxent NAS	A
Davidson AAF	D
Woodbridge	E
Manassas	E

MIAMI, FLORIDA, HUB

Boca Raton	C
Ft. Lauderdale-Hollywood	B
Ft. Lauderdale Executive	D
North Perry	D
Homestead AFB	A
New Tamaimi	C
Opa Locka West	D
Dade-Collier	A
Opa Locka	B
Pompano Beach	D+
Palm Beach	

1/ Refer to Table 3.2

SAN FRANCISCO, CALIFORNIA, HUB

Satellite Airport	Airport Category 1/
Alameda NAS	B
Antioch	D
Buchanan	C
Travis AFB	A
Fremont	E+
Half Moon Bay	C
Haywood	C
Livermore	D
Moffett Field	B+
Napa County	C
Gnoss	D
Oakland	A
Palo Alto	D
San Carlos	D
Reid-Hillview	D
South County	E
Smith Ranch	E
Hamilton AFB	B
San Jose	B+

DENVER, COLORADO, HUB

Lowrey AFB	NA
Boulder Muni	D
Brighton Van Air Estates	D
Sky Ranch	C
Jeffco	B
Buckley ANGB	A
Arapahoe County	C+
Marshdale	E
Ft. Collins	B
Flying D	E
Skyline	C
Longmount	D

1/ Refer to Table 3.2

BOSTON, MASSACHUSETTS, HUB

Satellite Airport	Airport Category 1/
Worcester	B
Hanscom Field	B
Beverly Muni	C
Otis AFB	B+
Haverhill	E
Hopedale-Daper	D
Lawrence Muni	C
Mansfield Muni	D+
Marshfield	D
Middleboro	D
Norfolk	D
Norwood	D
S. Weymouth NAS	B
Tew-Mac	D
Grenier Field-Manchester Muni	B
Pease AFB	A
Theodore Francis Green State (Providence, R.I.)	B

HONOLULU, HAWAII, HUB

Bellows AAE	B
Barbers' Point NAS	B
Ford Island ALF	D+
Kaneohe Bay MCAS	B
Wheeler AFB	C

1/ Refer to Table 3.2

DETROIT, MICHIGAN, HUB

Satellite Airport	Airport Category 1/
Selfridge ANGB	B+
Ann Arbor Muni	D
Grand Prix	E
BYNE	D
Custer	D
Detroit City	C
Grosse Isle	C
Willow Run	B
Bishop (Flint)	B
McKinley	D
New Hudson	D
Mettetal	D
Oakland-Orion	E
Oakland-Pontiac	C
Romeo	D
Salem	D
Berz-McComb	D+
Toledo Express	B
Toledo Muni	D+
Big Beaver	E

PITTSBURGH, PENNSYLVANIA, HUB

Beaver County	D+
Campbell	D
Butler-Graham	D+
Butler-Show-Roe	D
Glade Mill	E
Bandel	E
Pittsburgh-Boquet	D
Latrobe	C
Restraver	E
Pittsburgh-Monroeville	E
Allegheny County	B
Remich	D
Washington County	D+
Zelienople Muni	D+
Herron	E

1/ Refer to Table 3.2

PHILADELPHIA, PENNSYLVANIA, HUB

Satellite Airport	Airport Category 1/
Wilmington	B
NAFEC	A
Bridgeport	E
Mercer County	C+
Red Lion	D
Cross Keys	E
Hammonton	D
Burlington County	E+
McGuire AFB	A
3-M	D
Perkiomen Valley	E
Bughl Field	D
Montgomeryville	D
Wings Field	D
North Philadelphia	B
Turner Field	E
Warminister NAF	B
Willow Grove NAS	B

NEWARK, NEW JERSEY, HUB

Somerset Hills	E
Caldwell Airport	D+
E. Brunswick	E
Raceway Park	D
Hanover	E
Lincoln Park	D
Linden	D+
Preston	D+
Morristown Muni	D+
Ramapo Valley	E
Teterboro	B
McGuire AFB	A
Grumman-Bethpage	B
Flushing	D
Kupper	D
Nairobi	E
Islip	B

1/ Refer to Table 3.2

ST. LOUIS, MISSOURI, HUB

Satellite Airport	Airport Category 1/
Illinois	
Civic Memorial	B
Scott AFB	B
Bi-State Parks	C
Missouri	
Festus Memorial	E+
St. Charles	D
St. Charles-Smart	D
Arrowhead	D
Creve Couer	E
Weiss	D
Spirit of St. Louis	C

MINNEAPOLIS-ST. PAUL, MINNESOTA, HUB

Airlake	C
Crystal	D
Flying Cloud	D
Anoka County	D+
Koch Refining	E
Lake Elmo	D
St. Paul Downtown Holman Field	C
South St. Paul	D

1/ Refer to Table 3.2

HOUSTON, TEXAS, HUB

Satellite Airport	Airport Category 1/
Humphrey	D
Clear Lake	D
Express	D
Genoa	E
Andrau Air Park	D+
Clover Field	D
Ellington AFB	B+
Collier	D
Hull Field	D
Lakeside	D
Hobby	B
Hooks Memorial	C
La Porte Muni	D
Spaceland	C
Pearland	E
Southside	D
Hooks Ranch	D

CLEVELAND, OHIO, HUB

Wingfoot Lake	?
Bosworth	E
Chagrin Falls	E
Cuyahoga County	C
Burke Lakefront	C
Elyria	D
Patton	?
Lorian County	D
Forepaugh	D
Concord	D
Casement	D
Strongsville	D
Thompson	D
Lost Nation	C
Freedom Field	D+

1/ Refer to Table 3.2

SEATTLE-TACOMA, WASHINGTON, HUB

Satellite Airport	Airport Category 1/
Bellevue	E
Kitsap Sounty	C
Snohomish County	B
Gray AAF	C
Crest	D
Cedar Grove	E
Port Orchard	D
Puyallup	D
Renton	C
King County	A
Spanaway	D
McChord AFB	A
S. Tacoma	D
Tacoma Industrial	C

LAS VEGAS, NEVADA, HUB

Boulder City	D
Voc-Tech	E
Jean	D
Nellis AFB	A
N. Las Vegas	C
Henderson Sky Harbor	C

TAMPA-ST. PETERSBURG, FLORIDA, HUB

Bartow	C
Hernando County	B
Clearwater Executive	D
Lakeland	C+
Tampa Downs	E
Plant City	D
Albert Witted	D
St. Petersburg-Clearwater	B
Vandenberg	D
McDill AFB	A
Peter O. Knight	D
Zypher Hills Municipal	C

1/ Refer to Table 3.2

NEW ORLEANS, LOUISIANA, HUB

Satellite Airport	Airport Category 1/
Callendar Field	B
Lakefront	C
Slydell	D
Westwego	E+

KANSAS CITY, MISSOURI, HUB

Kansas City Suburban Airpark	E+
Gardner Muni	D
Fairfax Muni	B
Sherman AAF	C
Johnson County Industrial	B
Johnson County Executive	D
Hillside	E
Excelsior Springs Memorial	E
E. Kansas City	D
Richards Gebaur AFB	B+
Independence Memorial	B
Sky Line Airpark	B
Like Winnebago	D
Kansas City Muni	B
McComas	E+
Mitchell	E
Missouri City	E
Roscranz Memorial	B
Noah's Ark	D

1/ Refer to Table 3.2

SAN JUAN, PUERTO RICO, HUB

Satellite Airport	Airport Category 1/
Dorado	D
Isla Grande	C

PHOENIX, ARIZONA, HUB

Stellar City	D
Williams AFB	A
Chandler	D
Luke AFB	A
Glendale	E
Phoenix-Litchfield	B
Estrella	D
Falcon Field	D
Deer Valley	D
Scottsdale	D+

1/ Refer to Table 3.2

Nicholas P. Krull

APPENDIX B

SUMMARY OF LARGE HUB SURVEY OF MARKET CONSTRAINTS TO SATELLITE AIRPORT DEVELOPMENT

In this section five selected large hub areas are examined in order to identify the marketing factors which impact the development of satellite airport operations. These five were selected on the basis that they are highly developed air traffic centers and represent the full spectrum of conditions which might be expected to exist at any given major hub area. In all five hub areas there has been some attempt to develop a satellite airport system and in four of the five, some form of satellite airport operation is now in existence. The degree of success in each case varies with the existing conditions in the particular hub area.

B.1 Chicago

The Chicago hub is by far the largest hub with more than 16 million enplaned passengers annually and more than 8 percent of all the commercial traffic in this country. 1/ It is also a recent example of an attempt to establish a viable satellite airport operation. Judging from the results, however, it must be concluded that the traveling public has rejected the satellite and the operation has nearly ceased to exist. In restrospect the failure of Midway airport to develop as a satellite was predictable and offers several clues not only to the cause of the failure, but to the criteria necessary to select a potentially successful satellite airport.

Chicago is currently served by three airports: O'Hare International, Midway, and Meigs Field. Even though O'Hare is operating at nearly 130 percent 2/ of what the FAA considers to be its practical annual capacity it still has

1/ U.S. Department of Transportation, Federal Aviation Administration, Airport Activity Statistics of Certificated Route Air Carriers, 12 Months Ended December 31, 1974.

2/ Reference Table 2.

more than 97 percent 3/ of the total commercial air traffic in the metropolitan area. While Midway and Meigs Field handle a relatively large volume of general aviation, neither has sufficient commercial air traffic to provide any relief to the congestion at O'Hare. Neither is an operating satellite in the context of this study. There was a serious attempt to establish a satellite operation at Midway. Under considerable pressure from the city and the airport authority 4/ Midway had 3.0 percent of the commercial flight departures from Chicago in 1974. However, passenger enplanements were only 0.8 percent of the annual total and by June of 1975 only three arriving and three departing commercial flights per day were listed in the Official Airline Guide. 5/

Since Midway is only half as far from the central business district as O'Hare and had once been not only Chicago's primary airport but also the busiest commercial airport in the world, it would seem to be the logical site to establish a satellite or reliever airport. On closer inspection of the conditions at both O'Hare and Midway, Midway may have been a poor choice.

First, Chicago is a major transportation interchange and transfer point in the mid-section of the country. According to 1972 CAB statistics and calculations by the FAA more than 51 percent 6/ of the enplaned passengers were either through passengers or were transferring from one flight to another. With more than 97 percent of the scheduled flights serving O'Hare at least 50 percent of all the enplaned passengers

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3/ U.S. Department of Transportation, Federal Aviation Administration, Airport Activity Statistics of Certificated Route Air Carriers, 12 Months Ended December 31, 1974.

4/ Batchelder, James Henry IV, "Market Area Analysis of Parallel Air Service Between Two Regions", Unpublished Masters Thesis, Department of Civil Engineering, Massachusetts Institute of Technology, February 1972.

5/ Official Airline Guide, North American Edition, June 15, 1975.

6/ Reference Table 3.

must schedule their departure from O'Hare or accept the cost, delay, and inconvenience of transferring between airports. At the present time there are both air service and limousine service between airports. The one-way air fare is $14.00 and the limousine fare is $3.00. 7/ Transferring by air adds not only the flight time but also the combined total of connecting times at both airports. The nominal 50 minute minimum connecting time at O'Hare is thereby extended on the average to 1 hour and 33 minutes. The minimum connecting time which the airlines will accept if ground service is used is 2 hours and 40 minutes. 7/ In addition to the cost and time delay the transferring passenger is subjected to the added inconvenience of claiming, transporting, and rechecking baggage. If ground transportation is used he must also exit from the terminal, be subjected to a high concentration of exhaust emissions and possible inclement weather, and finally check in again at the departure terminal and reprocess through security inspections. Trends have shown that neither mode of transfer is acceptable to the traveling public if there is any reasonable alternative.

Physical limitations further reduce the market available at Midway. A maximum runway length of 6500 ft., nearby obstructions and airline flight procedures combine to limit the types of aircraft which can be operated. Airlines are therefore limited to scheduling only short and medium range aircraft. While this would not be as serious in a predominantly short haul market, it is a detriment in the Chicago market. More than half (52 percent) of all the scheduled operations from Chicago are on flights to points greater than 400 miles distant. 8/ The inability to offer flights to approximately half of the originating passengers is further compounded by the previously mentioned high percentage of transfer passengers. It is assumed that at least one and possibly both segments of the transfer passenger's journey involves a medium or longe range flight. Midway is unable to offer service to a large portion of the total Chicago market while O'Hare is able to accommodate short, medium and long range flights or any combination for the transfer passenger.

7/ Official Airline Guide, North American Edition, June 15, 1975.

8/ U.S. Department of Transportation, Federal Aviation Administration, Profiles of Scheduled Air Carrier Operations by Stage Length, Federal Aviation Administration Regions'

With the exception of holiday periods passengers are usually able to make reservations to their desired destinations at or near their desired time and seat availability has not generally been a constraint in the Chicago market. There have, however, been massive schedule disruptions which result in extensive periods with aircraft in holding patterns or "stacks" and airport congestion awaiting the arrival or departure of delayed flights. In some situations such as weather disruptions or airline labor disputes a satellite would be expected to be equally affected and offer no relief. In other cases where the disruption is localized (i.e., runway repair, or ATC delays) all traffic is delayed and to be effective a reliever airport must be able to accommodate all types of aircraft. With O'Hare operation at 130 percent of its practical annual capacity it must be assumed that flight frequencies will become a constraint, and as load factors increase, seat availability will impact the preferences of the traveling public.

The accessibility and conveniences at Midway or lack thereof have also discouraged its acceptance by the public. While Midway is only about half as far from the central business district as O'Hare, the actual travel times are nearly equal (40 minutes) to Midway and 45 minutes to O'Hare by limousine). 9/ Since motor transportation is essentially the only means of reaching either airport, O'Hare has the decided advantage of being located adjacent to the intersections of at least two major expressways and an interstate toll-road. O'Hare is actually closer to the residential growth areas on the north and west sides of the city and, as Gelerman 10/ pointed out, a significant percentage of passengers either originate or terminate their trips from their place of residence. An on airport hotel, parking

9/ *Official Airline Guide*, North American Edition, June 15, 1975.

10/ Gelerman, Walter, "Airline Competitive Games and Airport Utilization," Unpublished Masters Thesis, Department of Civil Engineering, Massachusetts Institute of Technology, May 1972.

facilities, and nearby hotels and convention facilities further enhance O'Hare's relative attractiveness. Conversely, Midway is close to only one major expressway and can only be reached by passing through an area characterized by a high crime rate. Concern for personal safety is a definite consideration.

Price differentiation has not been experienced in the Chicago market unless one considers transfer costs and in that case it is a disincentive to use the satellite airport. In view of the other considerations and the availability of discount fares at the primary airport it is unlikely that price differentiation would become a major incentive in the Chicago market.

B.2 New York

The New York air travel market is comprised of three distinct market segments. There is a short-range market concentrated in the eastern seaboard with little transfer traffic, a medium-range market connecting with the mid-section of the country and involving a moderate percentage of transfer passengers, and a long-range market with a relatively high percentage of transfer passengers. The metropolitan area is currently served by three major airports and two small airports. Of the three major airports J. F. Kennedy International (JFK) would normally be considered the primary airport. In 1974, however, La Guardia (LGA) exceeded JFK both in enplaned passengers and in aircraft departures. 11/ The third large airport, Newark (EWR) with approximately half as many enplaned passengers as either of the other two, is located across a state boundary and is statistically considered as a separate large hub. The two small airports located at Islip (ISP) and White Plains (HPN) are quite small and together account for less than 1.0 percent of the commercial traffic in the metropolitan area.

11/ U.S. Department of Transportation, Federal Aviation Administration, Airport Activity Statistics of Certificated Route Air Carriers, 12 Months Ended December 31, 1974.

Whether or not LaGuardia is considered the primary airport, it must be acknowledged to be the preferred airport. Only 8 miles from the Manhattan business district, LGA is easily accessible by taxi or by limousine from the East Side Terminal. It is also readily accessible from the so-called "bedroom" communities or residential areas north of Manhattan. LaGuardia has a 7000 ft. unobstructed runway which permits flights as distant as Houston (1416 miles). One of the design criteria for both the DC-10 and L-1011 wide-bodied aircraft was to be able to operate from LaGuardia to Chicago. LaGuardia is thus capable of handling both the short and medium range segments of the metropolitan market. LGA is limited by runway length, pier loading, and taxi space between gates so that Boeing 707 and 747 aircraft cannot be used. The long range, transcontinental and transatlantic flights must use another airport. Nonetheless, LGA is operating at or above its practical annual capacity.

J. F. Kennedy is considerably less accessible from the central business district and the residential areas north of Manhattan, but it does not have the physical limitations noted at LGA. Kennedy has one of the longest runways (14,000 ft.) of any of the large hub airports and serves most of the long-range market. 49 percent of the departures from JFK are on flight segments in excess of 1000 miles. The high percentage of transfer passengers (48 percent) associated with the long-haul market attracts about an equal number of short- and medium-range flights in order to provide connecting service. While Kennedy handled about the same number of enplaned passengers in 1974, the flight departures were only 85 percent as many as at LaGuardia primarily due to the use of larger aircraft. According to FAA preliminary calculations, JFK is operating at about 73 percent of its practical annual capacity.

The third large airport, Newark competes with both LaGuardia and Kennedy for a share of all three market segments. Newark's runways are stressed to handle aircraft up to the size of the Boeing 747 and are long enough (9800 ft.) to support flights to the U.S. west coast or the nearer European cities. Newark is also approximately the same distance from the central business district as LaGuardia, but it is further from the residential areas north of Manhattan and on Long Island. Newark also suffers both from image and accessibility problems. Because of its location in New Jersey, the traveling public does not associate Newark Airport with New York City and jurisdictional problems impede ready access by taxicab. Cab fares from midtown to Newark may be as much as $20 compared to $8.50 from midtown to LaGuardia including tip. Ground transportation is generally acknowledged 13/ to be a major obstacle to acceptance. Preliminary FAA calculations indicate that Newark is operating at 70 percent of its practical annual capacity and the airline industry generally agrees that Newark Airport is only at about 50 percent of its commercial airline potential and the other general aviation traffic could be relocated to another airport. With the increasing congestion at LaGuardia, Newark could provide significant relief if the image and accessibility problems can be resolved.

B.3 Los Angeles

The Los Angeles air travel market is highly concentrated in the short- (under 400 miles) and long-range (over 1000 miles) market segments because of its geographical location. The long-range market constituting approximately 27 percent of the total departures is almost completely concentrated at the primary airport, Los Angeles International (LAX), and transfer passengers account for 32 percent of the enplaned passengers. In addition to the primary airport, the Los Angeles metropolitan area is served by four satellite airports. These include: the Orange County Airport at Santa Ana (SNA), the Hollywood-Burbank Airport (BUR), the Long Beach Airport (LGB), and Ontario International Airport (ONT). According to CAB statistics, the satellite airports account for 6.8 percent of the enplaned passengers and 11.7 percent of the total departures. These statistics do not, however, include intrastate carriers and a review of the scheduled air carrier operations based on the Official Airline Guide 14/ would indicate that the satellite airports actually account for more than 22.4 percent of the scheduled departures.

13/ "Low Utilization, High Cost Haunt Newark," Aviation Week and Space Technology, August 11, 1975.

14/ U. S. Department of Transportation, Federal Aviation Administration, Profiles of Scheduled Air Carrier Operations by Stage Length, Federal Aviation Administration Regions' Top 100 U. S. Airports November 1, 1974, May 1975.

One of the most distinctive features about the Los Angeles hub is that satellite airports have been able to attract a significant segment of the travel market even though the primary airport has not been constrained by physical or regulatory limitations. It is generally accepted that intrastate carriers offering lower fares and greater convenience are primarily responsible for this development. Intrastate fares which are not subject to CAB regulation generally vary from 20 percent to 50 percent below the CAB regulated fares. 15/

Los Angeles International has adequate runways (12,100 ft.) to accommodate the long-haul market and is operating at 99 percent of its practical annual capacity. Heavy fog occasionally closes the airport and forces aircraft to divert to other airports. It is located within 12 miles of the central business district and is accessible via an extensive network of freeways, but the metropolitan area is geographically dispersed and ground access becomes extremely congested in the vicinity of the airport during the afternoon peak departure hours.

Hollywood-Burbank Airport is located approximately 12 miles north of the central business district in a valley which is somewhat separated from the Los Angeles basin area. Although the runway length (6900 ft.) precludes long-range flights, its proximity to a localized market and the attraction of intrastate fares allow it to compete effectively in the short-haul market. Burbank accounted for 6.6 percent of the scheduled air carrier departures from the Los Angeles hub area.

Ontario International Airport is fully capable of supporting long-range flights and is often the alternate airport used when LAX is closed by fog. Even though it has adequate runways (10,000 ft.) and is accessible by an extensive network of freeways, Ontario has not developed as a satellite airport serving the long-range market. Its distance from the central business district (37 miles) and from the primary airport (47 miles) is probably the primary deterrent although it has developed a short-range market because of its proximity to the Pomona, Ontario, and San Bernardino metropolitan areas. Transfer of the charter and international flights from LAX to Ontario by certification or regulatory limitations could be expected to increase the market share from the current 6.3 percent to approximately 10 percent (at least 4 percent of LAX traffic is international and charter flights) and the related flights to accommodate transfer passengers would probably increase the total to more than 14 percent excluding the intrastate segment of the travel market.

15/ Official Airline Guide, North American Edition, June 15, 1975

Orange County, like Burbank, is limited by its short runways (5700 ft. max.) to competing exclusively in the short-haul market. Although it is approximately 35 miles from the central business district, its accessibility to a local market and the congestion at the primary airport has allowed Orange County Airport to attract 2.7 percent 16/ of the CAB certificated air carrier flights and 7.9 percent 17/ of the total scheduled air carrier departures. Once again, intrastate carriers offering price differentiation significantly increase the viability of this airport operation.

Long Beach Airport, while capable of supporting both short- and long-haul traffic, has essentially no CAB certificated air carrier operations. While it does support a limited number of intrastate operations, the airport operates primarily as a production flight test and general aviation facility. Current operations far exceed (321 percent) its practical annual capacity and its location between LAX and Orange County Airports severely limits the ability of this airport to compete for a localized segment of the air travel market.

In summary, satellite airports already account for more than 22 percent of the total air carrier departures from the Los Angeles hub area and airport-specific certification or regulatory restraint on the use of the primary airport by international and charter flights could increase this to 26 percent and the associated connecting flights diverted could increase the total to 30 percent. While it can be argued that once the primary airport reaches saturation all growth in air traffic would be diverted to satellite airports, it must also be assumed that larger aircraft and technological advances will continue to increase the practical capacity of the primary airport. It is, therefore, conservatively estimated that traffic at satellite airports could continue to increase up to a maximum of about 40 percent. The combination of airport-specific certification and preferential fares might also be effectively used to divert traffic at other large hubs where there is a significant short-haul market.

16/ U. S. Department of Transportation, Federal Aviation Administration, Airport Activity Statistics of Certificated Route Air Carriers, 12 Months Ended December 31, 1974.

17/ U. S. Department of Transportation, Federal Aviation Administration, Profiles of Scheduled Air Carrier Operations by Stage Length, Federal Aviation Administration Regions' Top 100 U.S. Airports November 1, 1974, May 1975.

B.4 Dallas-Ft. Worth

The Dallas Ft.-Worth metropolitan area is unique in several aspects. First as the name implies it encompasses two separate central business districts. Like Chicago it is a major transportation interchange and transfer point located in the mid-section of the country. Here too, a high percentage (53 percent) of the enplaned passengers are transfers, and a similar percentage (53 percent) of the departures fall in the category of medium and long haul flights. Unlike Chicago, the primary airport, Dallas-Ft. Worth Regional (DFW), is very large and quite new. Although it has more than 96 percent of the departure operations it is only operating at 67 percent of its practical annual capacity. The former primary airport, Love Field (DAL), is able to support long range flights and is located considerably closer to the Dallas central business district (7 vs. 17 miles [18/] and is only one mile further from the Ft. Worth CBD. Since Love Field was quite recently the primary airport and is midway between the new primary airport and the Dallas CBD, it still has better accessibility and conveniences.

While all the CAB certificated carriers have been moved to the primary airport, one intrastate carrier continues to operate from Love Field.

In two of the three city-pair markets where this carrier operates the intrastate carrier offers an average of 30 percent [19/] of the departure frequencies and carries an estimated 40 percent of the enplaned passengers. The relative success of this intrastate carrier can be attributed to operating in a protected market. The CAB certificated carriers are not permitted to operate from the more convenient Love Field and the intrastate carrier offers fares 47 percent to 58 percent [19/] below the CAB regulated fares. Were these same conditions to exist in all of the markets under 400 miles distant, a protected carrier with preferential fares could be expected to capture up to 40 percent of the short haul market (which is 47 percent of the total market) or nearly 20 percent of the total departure market.

18/ *Official Airline Guide*, North American Edition, June 15, 1975.

19/ *Official Airline Guide*, North American Edition, June 15, 1975.

B.5 Washington, D.C.

The Washington-Baltimore air traffic market is highly concentrated in the short and medium range markets. Nearly two-thirds of the flight departures are on flights of less than 400 miles and long range flights account for less than 8 percent of the total market. The percentage of transfer passengers is considerably higher than would be expected with a limited long range market but approximately equal to the percentage of flight segments exceeding 400 miles. The metropolitan area is served by three major commercial airports. Two of these, Washington National (DCA) and Dulles International (IAD) primarily serve Washington and the third, Baltimore-Washington International serves both the Washington and Baltimore metropolitan areas.

The primary airport, Washington National, is very close to the Washington central business district. Driving time is less than 15 minutes and both taxi and limousine fares are quite reasonable. Heavy ground congestion does occur in the vicinity of the airport during peak traffic periods and parking space is limited. National currently handles 60 percent of the total scheduled air carrier departure operations for the area and 68 percent of the enplaned passengers. Because equipment is limited to two and three engine jets and flights are generally limited to segments under 650 miles 20/, flight segments of less than 400 miles account for 70 percent of the total departures by scheduled air carriers. The remaining 30 percent of all departures by scheduled air carriers are between 400 and 1000 miles. Transfer passengers account for 31 percent of the total enplanements. Airlines are allocated "slots" based on their historical usage and unused allocations are reassigned to other airlines. Maintaining these allocations is therefore one of the limiting criteria used by airline marketing departments in developing system-wide schedules. With the limitations described above, National is currently operating at or above its calculated practical annual capacity. Efforts to close Washington National Airport have met with strong public and political objections.

20/ Note: A few exceptions were granted on the basis of flight schedules in effect before this limitation was imposed.

Dulles International Airport, like Washington National is operated by the Federal Government. It is generally considered one of the most technically advanced airports in the world. Capable of handling the largest known commercial aircraft, Dulles has nearly 80 percent of the long range departures from the Washington metropolitan area. These, however, account for only slightly more than 7 percent of the total departures and Dulles has less than 15 percent of the total scheduled air carrier departures from the metropolitan area. Operations at Dulles are calculated to be at 48 percent 21/ of the practical annual capacity, but a check on daily schedules indicates that scheduled air carrier operations account for only 16 percent 21/ of the capacity. The principal deterrents to passenger acceptance at Dulles are its relative inaccessibility, and lack of flight frequencies. Located 26 miles from the central business district, the normal access time is in excess of one hour and because of jurisdictional limitations, cab fare will generally exceed $15. While several airlines maintain operations at Dulles, they are reluctant to schedule additional flight frequencies until there is additional demand. Unfortunately, the development of any satellite airport sufficiently accessible to attract traffic from National would tend to further inhibit the growth of traffic at Dulles.

Baltimore-Washington Airport (BWI), competes with both National and Dulles International airports. Located within 10 22/ miles of the Baltimore central business district it has a market base on which to develop flight frequencies and although it is 32 23/ miles from the Washington business district, it is as accessible as Dulles from those residential communities which are located north of the District. While BWI does offer long range flights in competition with Dulles, the majority of the scheduled flights match very closely with the market served by National Airport. Since BWI is located closer to, and is considered as the Baltimore airport, there is a fare differential to such cities as Boston and New York. This differential is

21/ Reference Table 2.

22/ *Official Airline Guide*, North American Edition, June 15, 1975.

23/ *Official Airline Guide*, North American Edition, June 15, 1975.

small (less than 10 percent) and would have little effect on passenger preference with respect to National, but it tends to minimize the accessibility differences when compared to Dulles. BWI currently offers more than 20 percent of the departures and enplanes more than 18 percent 24/ of the passengers in the combined Washington-Baltimore metropolitan area. The calculated percentage of practical annual capacity is nearly 90 percent, but once again the scheduled air carrier operations utilize less than 45 percent of the practical capacity 25/.

In analyzing the Washington metropolitan air travel market it becomes apparent that differences in access time are magnified in a predominately short haul market where total flight times are generally less than two hours. In extreme cases the difference in access times may even make a one-stop flight from a nearby airport more attractive than a non-stop flight from a more distant airport. It can then be concluded that any satellite airport which would attract the voluntary patronage of the short haul market must be as accessible or nearly as accessible as National Airport.

24/ U.S. Department of Transportation, Federal Aviation Administration, Airport Activity Statistics of Certificated Route Air Carriers, 12 Months Ended December 31, 1974.

25/ Reference Table 2.

APPENDIX C

TABLE C.1

SUMMARY DATA SUPPORTING THE ANALYSIS OF MARKET CONSTRAINTS

	Practical 1/ Annual Capacity (1000's)	Opns. as a 2/ % of Annual Capacity	Daily 3/ Scheduled Air Carrier Operations	Scheduled 4/ Air Carrier Opns. as a % of Capacity
Chicago (Total)			1920	
O'Hare Intl.	525	130%	1870	130%
Midway	330	54%	50	6%
Meigs Field	215	31%	-	-
New York (Total			1996	63%
Kennedy Intl.	525	73%	789	55%
La Guardia	310	109%	760	89%
Newark Intl.	315	70%	447	52%
Atlanta	450	112%	1157	94%

1/ U.S. Department of Transportation, Federal Aviation Administration Advisory Circular 1500/5060-3A.

2/ U.S. Department of Transportation, Federal Aviation Administration, Terminal Area Forecast, 1976 - 1986, September 1974.

3/ U.S. Department of Transportation, Federal Aviation Administration, Profiles Of Scheduled Air Carrier Operations by Stage Length, Federal Aviation Administration Regions' Top 100 U.S. Airports November 1, 1974, May 1975.

4/ Calculated from columns 1 and 3.

APPENDIX C (continuation)

TABLE C.1

SUMMARY DATA SUPPORTING THE ANALYSIS OF MARKET CONSTRAINTS

	Practical 1/ Annual Capacity (1000's)	Opns. as a 2/ % of Annual Capacity	Daily 3/ Scheduled Air Carrier Operations	Scheduled 4/ Air Carrier Opns. as a % of Capacity
Los Angeles (Total)			1470	
Los Angeles Intl.	473	99%	1141	88%
Burbank	195	109%	97	18%
Ontario Intl.	190	72%	116	22%
Orange County	-	-	116	-
Long Beach	170	321	-	-
Dallas-Fort Worth	525	29*	959	67%
Washington, D.C. (Total)			1186	46%
National	310	105%	712	84%
Dulles Intl.	390	48%	172	16%
Friendship Intl.	247	89%	302	45%
Miami-Ft. Lauderdale			782	
Miami Intl.	375	87%	586	57%
Hollywood Intl.	430	69%	196	17%
San Francisco	1060		1089	37%
San Francisco Intl.	280	121%	790	103%
Oakland Metro Intl.	450	75%	140	11%
San Jose	330	123%	159	18%

* When the original figures of operations as a percentage of capacity were compiled, the transition from the former airport had not been completed.

APPENDIX C (continuation)

TABLE C.1

SUMMARY DATA SUPPORTING THE ANALYSIS OF MARKET CONSTRAINTS

	Practical 1/ Annual Capacity (1000's)	Opns. as a 2/ % of Annual Capacity	Daily 3/ Scheduled Air Carrier Operations	Scheduled 4/ Air Carrier Opns. as a % of Capacity
Denver	280	135%	593	77%
Boston	308	96%	646	77%
Honolulu Intl.	280	109%	261	34%
Detroit	465	55%	490	38%
Pittsburgh	365	73%	636	64%
Philadelphia	280	113%	642	84%
Newark	315	70%	447	52%
St. Louis	465	72%	572	45%
Minneapolis-St. Paul	430	57%	413	50%
Houston Intercontinental	340	56%	469	50%
Cleveland	365	70%	390	39%
Seattle-Tacoma Intl.	280	56%	407	53%
Las Vegas McCarran Intl.	175	146%	272	57%
Tampa Intl.	390	50%	343	31%
New Orleans Intl.	310	50%	316	36%
Kansas City Intl.	310	57%	415	49%

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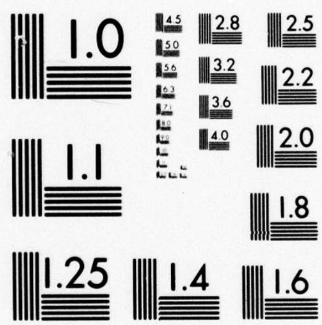

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

APPENDIX C

TABLE C.2

SUMMARY DATA SUPPORTING THE ANALYSIS OF MARKET CONSTRAINTS

	% of Flts 1/ by Segment Length Under 400 Mi.		Over 1000 Mi.	Transfer 2/ Psngrs as a % of Ttl Psngrs	Airport 3/ Location from CBD	Runway 4/ Length Limited
Chicago (Total)	48%	35%	17%	51%		
O'Hare Intl.	47%	36	17	52	16 NW	No
Midway	84	16	0	31	9 SW	Yes
Meigs Field	-	-	-	7	2 SE	Yes
New York (Total)	49	24	28	32		
Kennedy Intl.	39	12	49	48	12 SE	No
La Guardia	53	34	12	28	8.5 NE	Yes
Newark Intl.	57	26	17	16	8.5 W	No
Atlanta	48	50	3	73	8 S	No

1/ Calculated from U.S. Department of Transportation, Federal Aviation Administration, Profiles of Scheduled Air Carrier Operations by Stage Length, Federal Aviation Administration Regions' Top 100 U.S. Airports November 1, 1974, May 1975.

2/ Based on U.S. Civil Aeronautics Board, Airport Activity Statistics, December 21, 1972, Tables 3 and 4, and Origin - Destination Survey of Airline Passenger Traffic. Volume V-4-1, Fourth Quarterly 1972, Table 1.

3/ Official Airline Guide, North American Edition, June 15, 1975 and U.S. Department of Commerce, Sectional Aeronautical Charts - Effective Between June 19, 1975 and July 17, 1975.

4/ U.S. Department of Commerce, Sectional Aeronautical Charts - Effective Between June 19, 1975 and July 17, 1975. Primary airports are considered to be runway length limited if the length of the longest runway is insufficient to support long range commercial.

APPENDIX C (continuation)

TABLE C.2

SUMMARY DATA SUPPORTING THE ANALYSIS OF MARKET CONSTRAINTS

	% of Flts 1/ by Segment Length Under 400 Mi.		Over 1000 Mi.	Transfer 2/ Psngrs as a % of Ttl Psngrs	Airport 3/ Location from CBD	Runway 4/ Length Limited
Los Angeles (Total)	64	9	27			
Los Angeles Intl.	55	10	34	32	12 SW	No
Burbank	97	3	0		11 NW	Yes
Ontario Intl.	90	5	5		37 E	No
Orange County	99	1	0		35 SE	Yes
Long Beach					17.5 SE	No
Dallas-Fort Worth	47	34	19	53	9 N	No
Washington, D.C. (Total)	67	26	7	32		
National	70	30	0	31	3 S	Yes
Dulles Intl.	51	10	39	36	23 W	No
Friendship Intl.	69	25	6		28 NE	No
Miami-Ft. Lauderdale	36	22	42	25		
Miami Intl.	35	23	42		12 SW	No
Hollywood Intl.	38	20	42		8.5 N	No
San Francisco	63	17	20			
San Francisco Intl.	55	20	25	30	12.5 S	No
Oakland Metro Intl.	84	8	8	16	8 SE	No
San Jose	86	11	3		37 SE	

APPENDIX C (continuation)

TABLE C.2

SUMMARY DATA SUPPORTING THE ANALYSIS OF MARKET CONSTRAINTS

	% of Flts 1/ by Segment Length Under 400 Mi.		Over 1000 Mi.	Transfer 2/ Psngrs as a % of Ttl Psngrs	Airport 3/ Location from CBD	Runway 4/ Length Limited
Denver	35	55	10	49	7 E	No
Boston	73	15	12	26	2.5 E	No
Honolulu Intl.	62	0	38	53	4 W	No
Detroit	61	31	8	25	6.5 SE	No
Pittsburgh	86	11	3	44	12 NW	No
Philadelphia	71	20	9	22	8 SW	No
Newark	57	26	17	16	3 S	No
St. Louis	65	27	9	41	12.5 NW	No
Minneapolis-St. Paul	62	21	17	32	5.5 S	No
Houston Intentl.	68%	21%	11%	25%	20 NE	No
Cleveland	65	25	10	29	10 SW	No
Seattle-Tacoma Intl.	60	15	25	32	14 S	No
Las Vegas McCarran Intl.	64	16	20	30	6.5 S	No
Tampas Intl.	52	32	15	24	10.5 NW	No
New Orleans Intl.	54	34	12	37	12.5 NW	No
Kansas City Intl.	66	26	8	32	15.5 NW	No

APPENDIX D

FORMAT OF ISSUES (QUESTIONS) FOR DISCUSSIONS WITH LOCAL AIRPORT PLANNING AUTHORITIES

I. Local Legislative Constraints

A. Zoning ordinances, law, etc., which affect (limit) airport operations (e.g., noise, hours of operation, aircraft type)

1. Current
2. Contemplated

B. Other legal impediments/advantages

1. Eminent domain power
2. Restrictive covenants in
   a) airport deeds/grants
   b) surrounding deeds/grants

C. Zoning and ownership of contiguous property

II. Local Political Activity/Constraints

A. Zoning activity (recent)

1. More restrictive
2. Less restrictive

B. Nuisance lawsuits

1. Noise
2. Pollution (air, water, etc.)
3. Other

C. Nature of nearby growth

1. Residential
2. Commercial
3. Industrial
4. Recreational

D. <u>Community relationships (opposition to operation)</u>

1. Past
2. Present
3. Anticipated

E. <u>Community receptivity to expanded use</u>

1. With changing nature of operations
2. With upgraded operations (i.e., larger planes)
3. Commercial operations

F. <u>For military airports</u> (political aspects only)

1. Potential for civilian operations
2. Potential for joint use
3. Potential for conversion to exclusively civilian operations
4. Review constraints as above for civilian airports

III. <u>Financial Constraints</u>

A. <u>Public airports</u>

1. Current financial health/condition
   a) profit making
   b) non-profit making
      1) nature of subsidy (operations, etc.)
      2) source of subsidy
      3) amount of subsidy
      4) attitude of subsidizing group (city, county, etc.) toward continued/increased subsidy
2. Financing sources (bonding power)
3. Response to last bond issue
   a) timing
   b) amount
   c) what for
   d) speed of sale
   e) expected response to a bond issued now

4. Political situation regarding airport ownership and stability of owning authority

5. Financial ability to handle additional operations
   a) without new capital
      1) current revenue mix
      2) modified revenue mix; i.e., upgrade operations (level C to level B, etc.)
   b) with new capital
      1) current revenue mix
      2) modified revenue mix

B. <u>Private airports</u>

1. Financial health (satisfactory profits)
2. Ability to expand (embraces zoning, finances, etc.)
3. Desire to expand (owner's attitude)
4. Capital sources
   a) internally generated
   b) private
   c) public
5. Receptivity to sale to public agency
6. Financial ability to handle more traffic
   a) without new capital
      1) current revenue mix
      2) modified revenue mix
   b) with some new capital
      1) current revenue mix
      2) modified revenue mix

C. <u>Military airports</u>

1. FAA joint use military study
2. If airport is a candidate for civilian operations, the public/private financial questions become important

IV. <u>Other Constraints</u>

A. <u>What improvements would have maximum impact on capacity?</u> e.g.,

1. Terminal configuration
2. FBO facilities
3. Ramps and aprons
4. Runways
5. Navigation aids

B. <u>What improvements (cost) would be necessary for commercial service?</u>

APPENDIX E

OFFICIALS CONTACTED FOR SATELLITE AIRPORT FEASIBILITY ANALYSIS

1. FAA Officials Contacted

HUB AREA	INDIVIDUAL CONTACTED
San Francisco	W. Bruce Chambers
Seattle-Tacoma	George Buhley
Phoenix	W. Bruce Chambers
Las Vegas	W. Bruce Chambers
Cleveland	Donald Rice
Minneapolis-St. Paul	Owen Burkhart
Washington, DC.	Carl Steinhauer
Houston	Stanley Lou
New Orleans	Stanley Lou
Atlanta	Mac Ackerman
Dallas-Ft. Worth	Roland Lewis
Los Angeles	W. Bruce Chambers
Pittsburgh	Dan Cassidy
St. Louis (Illinois side)	George Brock
St. Louis (Missouri side)	William Knoefle
Kansas City	William Knoefle
Philadelphia	Dan Cassidy
Honolulu	William Bliss
New York	John Moretta, Otto Cerani
Tampa-St. Petersburg	Ray Peach, Frank Tavaras
San Juan	Ray Peach, Frank Tavaras
Miami	Ray Peach, Frank Tavaras
Newark	John Moretta, Otto Cerani
Boston	Vincent Arago
Denver	Robert Finley
Chicago	George Brody

APPENDIX E (continuation)

2. Metropolitan Planning Organization (MPO) Representatives Contacted

ORGANIZATION	INDIVIDUAL CONTACTED
Atlanta Regional Commission	Joel Stone Ray Fletcher
Washington, D.C.-- Washington Metro. Council of Governments	Phil Clark Walter Scheiber
Tri-State Regional Planning Committee (New Jersey)	Robert Wood Joseph Lener
Florida Department of Transportation	Robert Frye
Public Service Committee of Nevada	Robert L. Crowell
South California Association of Governments	Richard Block
State Department of Highways & Transportation-Michigan	Edmund A. Mellman
North Central Texas COG	Michael A. Shelton
Lake Erie Regional Transportation Authority	Jack C. Yemell
Chicago Area Transportation Study	David Newmyer
Office of Aviation Development (Georgia DOT)	Jack Joiner
Metro Dade County Planning Department	R.R. Walters

APPENDIX E (continuationn)

2. **Metropolitan Planning Organization (MPO) Representatives Contacted (cont'd.)**

ORGANIZATION	INDIVIDUAL CONTACTED
S.W. Pennsylvania Regional Planning Department	R. B. Froehlick
East-West Gateway Coordinating Council	Alan C. Richter
Twin Cities Metro Council	Johney Case
Ohio State DOT	Norm Crabtree Dr. Cameron Smith
Regional Planning Committee for Jefferson, Orleans and St. Bernard and La-mont Parishes	Leroy Dautries
Mid-American Regional Council (Kansas City)	Norman A. Schenmer
Pennsylvania DOT	

APPENDIX E (continuation)

3. Local Airport Contacted

NAME OF AIRPORT	LOCATION
DuPage Airport	Illinois
Boulder City Airport	Nevade
McDill AFB	Florida
Grosse Isle Muni	Michigan
McKinley	Frazier, Michigan
Oakland-Pontiac	Michigan
Islip-MacArthur Field	Islip, New York
Berry Hill	Georgia
Arlington Muni	Texas
E-Systems	Garland, Texas
Gear	New Lenox, Illinois
Kansas City Muni	Kansas City, Missouri
Perkiomen Valley	Collegeville, Penna.
Montgomeryville	Montgomeryville, Penna.
Roscranz Memorial	Elwood, Missouri
Brulington County	Mount Holly, New Jersey
Hammonton Muni	Hammonton, New Jersey
Red Lion	Vincentown, New Jersey
Mercer County	Trenton, New Jersey
Bridgeport	Bridgeport, New Jersey
Thompson Drag Strip- dirt Strip	Ohio
Stellar City	Arizona
Berke Lakefront	Ohio
Cross Keys	Doylestown, Penna.
Wings Field	Ambler, Penna
Warminister NAF	Warminister, Penna.
Willow Grove NAS-ATC Division Officer Opns.	Willow Grove, Penna.
NAFEC	Atlantic City, New Jersey
3-M	Bristol, Penna.
Buehl Field	Langhorne, Penna.
Toledo Muni	Toledo, Ohio
Lenox-Howell	New Lenox, Illinois
Martin-Marietta	Baltimore, Maryland
Los Alimitos NAS	Long Beach, California
Aero Valley A.P.	Roanoke, Texas
O'Brien Field	Red Oak, Texas

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APPENDIX G

POTENTIAL CAPACITY AT SATELLITE AIRPORTS FOR ADDITIONAL TRAFFIC

Additional operations that Satellite Airports could accept.

Metropolitan Area: Atlanta

Year	Potential Additional Operations by Aircraft Type (000)			
	A	B	C	D
1975	1568.	35.	0.	0.
1980	1305.	90.	65.	0.
1985	1141.	80.	65.	0.
1990	961.	69.	65.	0.
1995	826.	65.	65.	0.
2000	710.	65.	65.	0.

Metropolitan Area: Boston

Year	Potential Additional Operations by Aircraft Type (000)			
	A	B	C	D
1975	1681.	149.	106.	0.
1980	1497.	178.	76.	0.
1985	1363.	143.	47.	0.
1990	1234.	126.	37.	0.
1995	1082.	108.	29.	0.
2000	914.	88.	19.	0.

Metropolitan Area: Chicago

	Potential Additional Operations by Aircraft Type (000)			
	A	B	C	D
1975	2389.	173.	[illegible]45.	0.
1980	1973.	249.	171.	39.
1985	1604.	221.	157.	39.
1990	1337.	188.	139.	39.
1995	1127.	174.	137.	39.
2000	895.	159.	137.	39.

Metropolitan Area: Cleveland

Year	Potential Additional Operations by Aircraft Type (000)			
	A	B	C	D
1975	2189.	69.	0.	0.
1980	1922.	127.	66.	0.
1985	1777.	118.	66.	0.
1990	1611.	109.	66.	0.
1995	1440.	100.	66.	0.
2000	1234.	90.	66.	0.

Metropolitan Area: Dallas-Ft. Worth

Year	Potential Additional Operations by Aircraft Type (000)			
	A	B	C	D
1975	1332.	36.	19.	0.
1980	1126.	126.	2.	0.
1985	1070.	123.	0.	0.
1990	1004.	121.	0.	0.
1995	923.	120.	0.	0.
2000	858.	118.	0.	0.

Metropolitan Area: Denver

Year	Potential Additional Operations by Aircraft Type (000)			
	A	B	C	D
1975	752.	109.	94.	0
1980	635.	112.	80.	0
1985	519.	89.	63.	0.
1990	417.	80.	59.	0.
1995	377.	80.	59.	0.
2000	353.	80.	59.	0.

Metropolitan Area: Detroit

Year	Potential Additional Operations by Aircraft Type (000)			
	A	B	C	D
1975	1478.	231.	178.	0.
1980	1259.	162.	168.	72.
1985	1074.	115.	127.	72.
1990	904.	87.	109.	72.
1995	813.	72.	94.	72.
2000	715.	64.	86.	72.

Metropolitan Area: Honolulu

Year	Potential Additional Operations by Aircraft Type (000)			
	A	B	C	D
1975	30.	0.	0.	0.
1980	0.	0.	0.	0.
1985	0.	0.	0.	0.
1990	0.	0.	0.	0.
1995	0.	0.	0.	0.
2000	0.	0.	0.	0.

Metropolitan Area: Houston

Year	Potential Additional Operations by Aircraft Type (000)			
	A	B	C	D
1975	2154.	217.	119.	0.
1980	2007.	238.	100.	0.
1985	1880.	210.	78.	0.
1990	1726.	178.	52.	0.
1995	1568.	159.	41.	0.
2000	1382.	137.	29.	0.

Metropolitan Area: Kansas City

Year	Potential Additional Operations by Aircraft Type (000)			
	A	B	C	D
1975	2279.	326.	290.	0.
1980	2121.	229.	314.	101.
1985	1960.	207.	293.	101.
1990	1818.	181.	269.	101.
1995	1658.	157.	247.	101.
2000	1484.	140.	232.	101.

Metropolitan Area: Las Vegas

Year	Potential Additional Operations by Aircraft Type (000)			
	A	B	C	D
1975	671.	27.	0.	0.
1980	583.	66.	42.	0.
1985	579.	61.	42.	0.
1990	574.	61.	42.	0.
1995	568.	60.	42.	0.
2000	561.	59.	42.	0.

Metropolitan Area: Los Angeles

Year	Potential Additional Operations by Aircraft Type (000)			
	A	B	C	D
1975	1095.	37.	17.	52.
1980	1011.	26.	6.	19.
1985	921.	20.	0.	0.
1990	812.	20.	0.	0.
1995	706.	20.	0.	0.
2000	633.	20.	0.	0.

Metropolitan Area: Miami

Year	Potential Additional Operations by Aircraft Type (000)			
	A	B	C	D
1975	542.	65.	40.	0.
1980	383.	33.	70.	25.
1985	275.	7.	49.	25.
1990	183.	0.	49.	25.
1995	142.	0.	49.	25.
2000	139.	0.	49.	25.

Metropolitan Area: Minneapolis

Year	Potential Additional Operations by Aircraft Type (000)			
	A	B	C	D
1975	1017.	111.	0.	0.
1980	650.	170.	150.	19.
1985	548.	154.	150.	19.
1990	428.	136.	150.	19.
1995	311.	118.	150.	19.
2000	237.	103.	150.	19.

Metropolitan Area: New Orleans

Year	Potential Additional Operations by Aircraft Type (000) A	B	C	D
1975	519.	13.	0.	0.
1980	444.	29.	0.	0.
1985	378.	23.	0.	0.
1990	360.	22.	0.	0.
1995	349.	22.	0.	0.
2000	337.	22.	0.	0.

Metropolitan Area: New York

Year	Potential Additional Operations by Aircraft Type (000) A	B	C	D
1975	873.	112.	90.	0.
1980	751.	103.	65.	0.
1985	674.	83.	49.	0.
1990	631.	80.	47.	0.
1995	578.	76.	46.	0.
2000	513.	71.	44.	0.

Metropolitan Area: Newark

Year	Potential Additional Operations by Aircraft Type (000) A	B	C	D
1975	1269.	86.	65.	0.
1980	1139.	109.	50.	0.
1985	1083.	104.	49.	0.
1990	1039.	101.	47.	0.
1995	986.	97.	46.	0.
2000	922.	93.	44.	0.

Metropolitan Area: Philadelphia

Year	Potential Additional Operations by Aircraft Type (000)			
	A	B	C	D
1975	1958.	168.	131.	87.
1980	1813.	138.	80.	185.
1985	1720.	119.	62.	167.
1990	1607.	95.	40.	146.
1995	1500.	66.	13.	120.
2000	1397.	50.	0.	112.

Metropolitan Area: Phoenix

Year	Potential Additional Operations by Aircraft Type (000)			
	A	B	C	D
1975	1069.	62.	12.	0.
1980	939.	92.	2.	0.
1985	846.	86.	0.	0.
1990	759.	84.	0.	0.
1995	673.	84.	0.	0.
2000	646.	83.	0.	0.

Metropolitan Area: Pittsburgh

Year	Potential Additional Operations by Aircraft Type (000)			
	A	B	C	D
1975	2242.	143.	35.	0.
1980	1950.	224.	135.	0.
1985	1870.	205.	120.	0.
1990	1788.	192.	113.	0.
1995	1700.	186.	113.	0.
2000	1593.	179.	113.	0.

Metropolitan Area: St. Louis

Year	Potential Additional Operations by Aircraft Type (000)			
	A	B	C	D
1975	1332.	43.	14.	0.
1980	720.	290.	264.	0.
1985	618.	283.	260.	0.
1990	541.	278.	260.	0.
1995	462.	273.	260.	0.
2000	367.	267.	260.	0.

Metropolitan Area: San Francisco

Year	Potential Additional Operations by Aircraft Type (000)			
	A	B	C	D
1975	1065.	93.	83.	134.
1980	860.	132.	48.	107.
1985	740.	112.	28.	85.
1990	650.	102.	22.	66.
1995	609.	94.	15.	44.
2000	559.	83.	6.	18.

Metropolitan Area: Seattle-Tacoma

Year	Potential Additional Operations by Aircraft Type (000)			
	A	B	C	D
1975	856.	49.	9.	0.
1980	614.	72.	81.	40.
1985	539.	66.	81.	40.
1990	479.	63.	81.	40.
1995	406.	58.	81.	40.
2000	331.	53.	81.	40.

Metropolitan Area: Tampa-St. Petersburg

Year	Potential Additional Operations by Aircraft Type (000)			
	A	B	C	D
1975	1809.	238.	95.	0.
1980	1201.	304.	323.	183.
1985	1084.	291.	321.	183.
1990	979.	276.	318.	183.
1995	868.	258.	315.	183.
2000	732.	237.	311.	183.

Metropolitan Area: Washington, D.C.

Year	Potential Additional Operations by Aircraft Type (000)			
	A	B	C	D
1975	1316.	104.	109.	126.
1980	960.	200.	175.	156.
1985	816.	190.	165.	126.
1990	640.	178.	152.	90.
1995	456.	168.	143.	60.
2000	302.	168.	143.	60.

APPENDIX H

FORECAST OF KEY ECONOMIC INDICATORS

The assumptions and forecast economic variables for the econometric models introduced in Section 3.4 relate to those variables used by the Council of Economic Advisors. The factors discussed here include forecasts of several of these key economic indicators. 1/

First, the Nation's gross national product (GNP) in constant 1958 dollars is forecast to increase from $784 billion (est) in 1975 to $1,169 billion in 1985, an average growth rate of 4.0 percent per year. GNP is estimated to reach $1,870 billion by the year 2000 at an average growth rate of 3.2 percent per year. See Figure H.1. Population is expected to grow at the rate of 1 percent per year.

Total personal consumption expenditures are expected to increase from $533 billion (est) in constant 1958 dollars in 1975 to $770 billion in 1985 and $1,201 billion in 2000. See Figure H.2.

It is anticipated that the inflation rate will decrease from 10.1 percent (est) in 1975 to an average of 7.1 percent per year until 1980, then 5.5 percent per year from 1980 to 1985, and then 5 percent per year from 1985 until 2000.

Finally, real personal disposable income (RDI) is expected to grow at an annual average rate of 4.5 percent for the period 1975 through 1986, the rate of growth (about 5.2 percent) increasing for the 1987 through 1990 period and slowing (about 3.4 percent) for 1991 through 2000. The assumed increase in RDI's rate of growth for 1987 through 1990 is based upon the expectation of continued strong expansionary fiscal policies and large catch-up wage gains after a prolonged drop in real wages. The relatively slower rate of growth over the 1990 through 2000 period is attributed to expected moderation in wage demands, constraints placed upon Government expansionary policy due to increased tax burden, rekindled inflationary pressures stemming partly from earlier wage gains and partly from energy shortages and expected capacity bottlenecks impacting on employment.

1/ Provided by UG3RD Baseline and Implementation Scenario, FAA Policy Development Division, November 20, 1975.

FIGURE H.1
PROJECTED GROSS NATIONAL PRODUCT
(1958 DOLLARS)

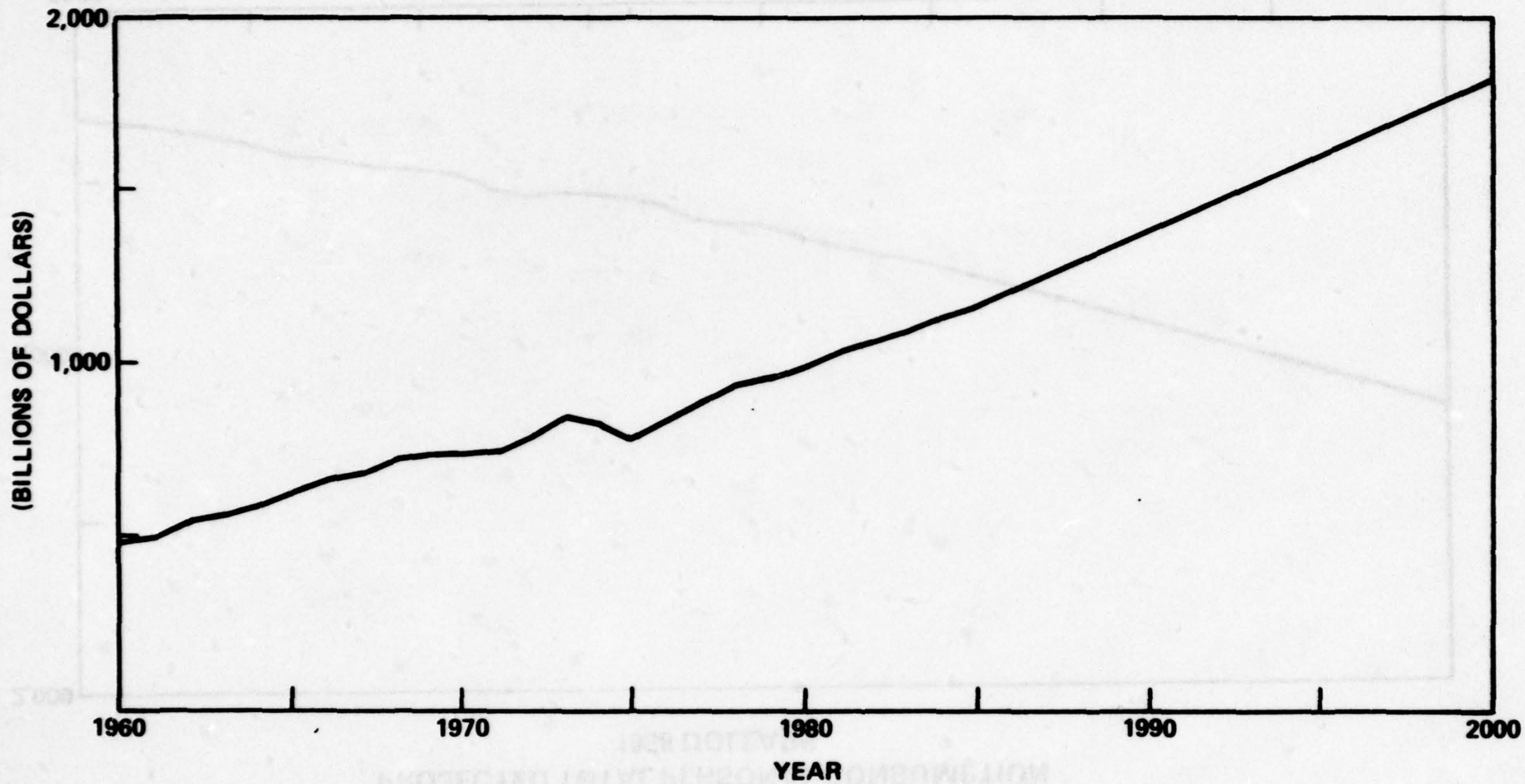
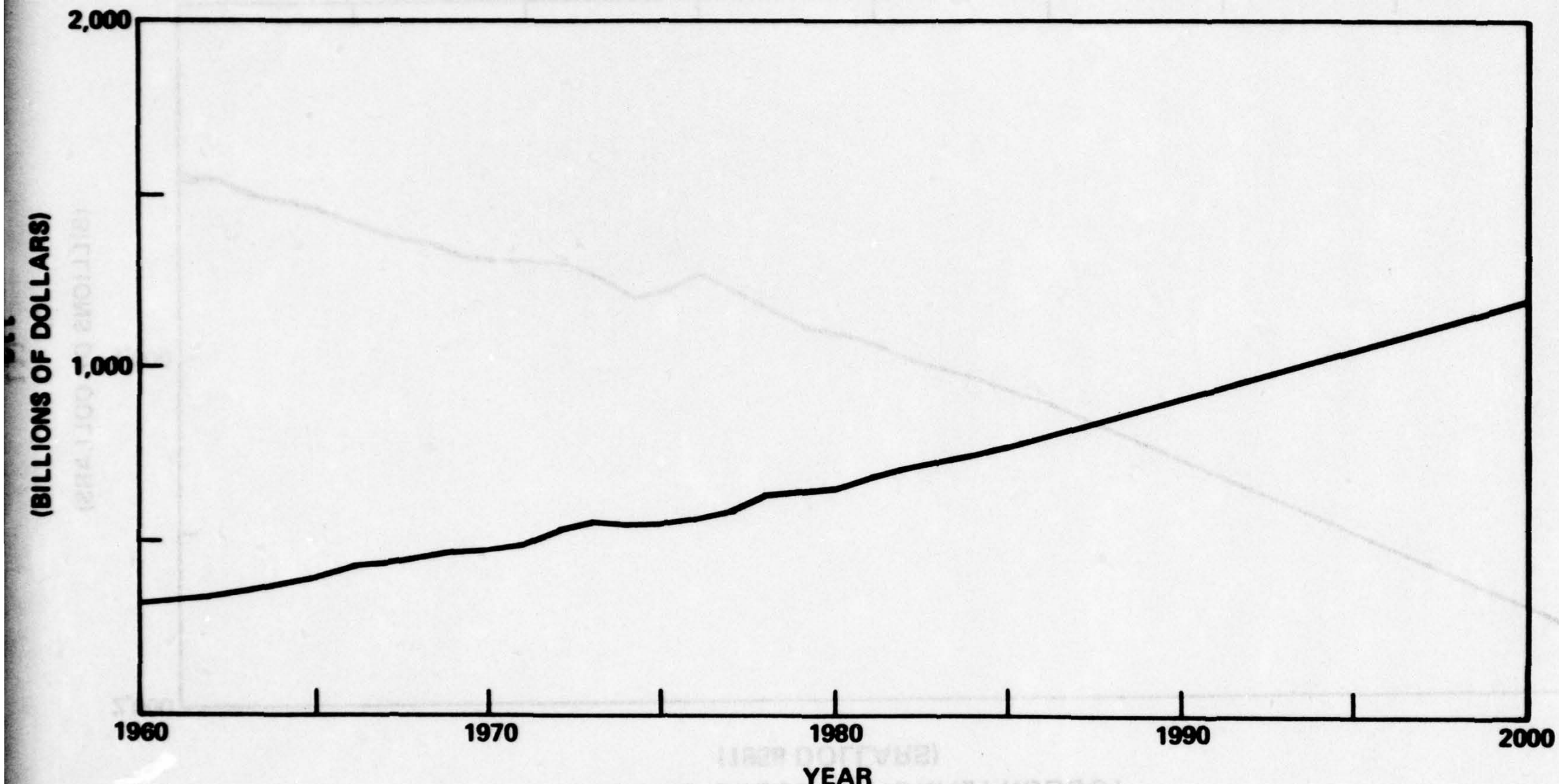


FIGURE H.2
PROJECTED TOTAL PERSONAL CONSUMPTION
1958 DOLLARS



APPENDIX I

TECHNICAL DISCUSSION OF DELAY MODELS

The theoretical model presented here is based on the earlier work of Koopman 1/ and is quite straightforward extension of that work to the case of multiple servers (i.e., multiple runway airports). This section provides an intuitive explanation of the basic rationale, the assumptions used, and the limitations of the models fundamental to the Handbook of Airport Delays. More rigorous treatment of the theoretical questions are provided in the literature. 2/

The model considers an airport as a set of independent, parallel servers (the runways). A schematic representation of this system is shown in Figure I.1.

It is assumed that the total demand at the airport--that is, the sum of the demands for landing and for takeoffs--is a Poisson process with a time-dependent average demand rate, given by $\lambda(t)$. The Poisson assumption for airport demand is consistent with actual observations at several major airports and has been used extensively in the literature. 3/

By contrast, the form of the probability law describing the duration of a service at the runways is still a matter for speculation. 4/ The duration of the period during which a runway is busy with an aircraft depends on such diverse factors as type of operation being conducted, weather, aircraft mix, runway configuration in use, runway surface conditions, location of runway exists, air traffic control equipment, requirements for minimum separations between aircraft, pilot and air traffic controllers performance, etc.

1/ "Air Terminal Queues Under Time-Dependent Conditions," B. O. Koopman, Operations Research, Vol. 20, 1972 pages 1089-1114.

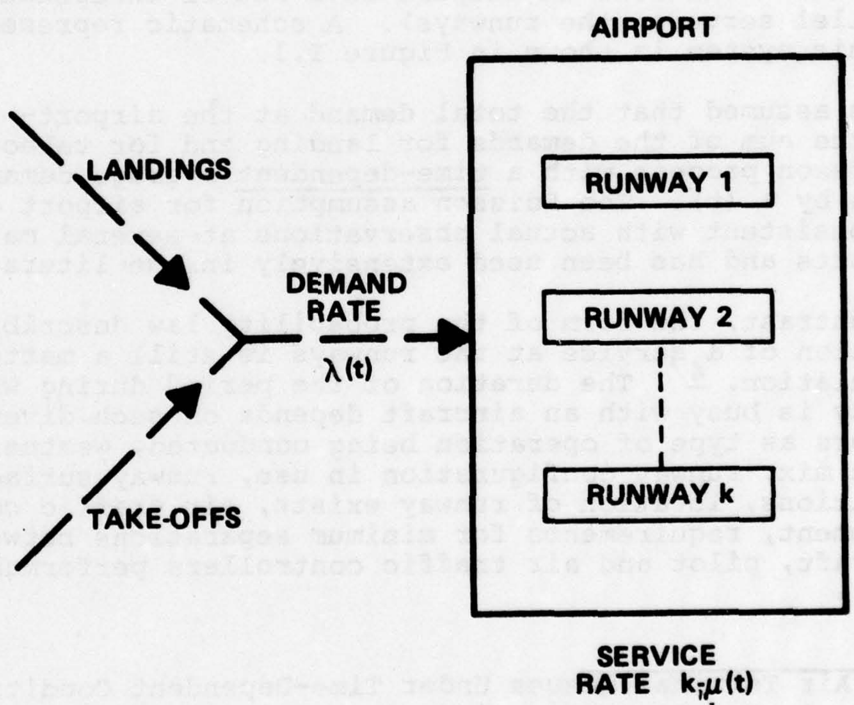
2/ Op. Cit.

3/ Models For Runway Capacity Analysis R. M. Harris, Report MITRE, The MITRE Corporation, McLean, Virginia, December 1972, also Analysis of a Capacity Concept for Runway and Final Approach Path Airspace, U.S. National Bureau of Standards, Report No. NBS-10111, AD-698-521, November 1969.

4/ An Analytic Investigation of Air Traffic in the Vicinity of Terminal Areas, A. R. Odoni, Operations Research Center, Massachusetts, Institute of Technology, Cambridge, 1969.

FIGURE I.1

SCHEMATIC REPRESENTATION OF THE QUEUING MODEL



Following the example of Koopman, it is observed that the duration of the service time must be "less random" than the perfect randomness described by the negative exponential probability density function and "less regular" than the perfect regularity described by deterministic service times.

The last point is a crucial one as it drives the approach to the problem: obtain upper and lower bounds on congestion-related statistics by noting that a worst cast is provided by the negative exponential service assumption M/M/K and a best case by the deterministic service assumption M/D/K. The rationale, of course, is that, if--for the set of parameter values prevalent at the airports under consideration--the upper and lower bounds turn out to be reasonably weighted combination of the two can be used as a good approximation of the actual statistics desired.

Here, then is the strategy to be followed: given an airport with k independent runways each of which has a time-dependent average service rate λ (t), solve iteratively and for the desired period of time two systems of equations, one describing a M/M/K queuing system and the other a M/D/K queuing system. 5/ The actual values of interest will then be bounded from above and below by the values obtained from these two queuing models. This whole approach is dictated by the fact that the differential equations describing a M/G/K (arbitrary) queuing system--a more realistic model for the base of interest--are unwieldy even for the purpose of obtaining numerical solutions.

Assumptions in the Model

To complete the description of queuing models which are fundamental to the airport delay calculations, the assumptions which were made are identified here. The most important of these, from a practical viewpoint, is the assumption of the existence of a single queue of aircraft awaiting use of the runways on a strictly first-come, first-served basis. Thus, there is no distinction between landing and departing aircraft. While, in practice, the average service times (and the probability distributions) for landings and takeoffs are different, a single weighted average service time for both kinds of operations is used.

Another assumption is that all active runways (or, all the parallel servers in Figure 3.1) operate independently and are identical. In practice, runways often cannot be operated independently, since operations at one may affect those on

5/ I. bid.

another, due to airport geometry. Again, from the practical viewpoint, this assumption is not too restrictive since dependencies among the servers, if they exist, can be accounted for by adjusting the service rates accordingly. As an example, consider an airport with a single runway which can handle, say, 50 aircraft movements per hour, i.e., the average service time in 72 seconds. Suppose now that operations are begun at a second runway which intersects the first one. Then the overall airport capacity might increase to, say 80 operations per hour, and not to 100 as it would if the two runways were independent. To account for this in our model, we would then assume the existence of a single independent server, with an average service time of 45 seconds, for an overall airport capacity of 80 movements per hour.

Obviously, the number of state-transition equations, describing the queuing models and being iteratively solved by the computer, must be finite. Since the number of such equations is equal to the number of states in the queuing model, it must be assumed that the queuing system of Figure 3.4 can accommodate up to a maximum of m aircraft (including the ones in service at the k servers). The variable m can be selected large enough to make it highly unlikely than the number of aircraft in the terminal area at any given instant will be equal to m.

Finally, it is assumed that successive service times are statistically independent. This is substantially true in reality, as little attempt is made, under today's air traffic control regime, to sequence operations in anything but a first-come, first-served way. Successive service times are, therefore, randomly mixed according to the mix of aircraft with little or no interdependence among them.

APPENDIX J

PRIMARY AIR CARRIER AIRPORT CAPACITY ESTIMATES

Illustrations of the concept of airport quotas typically assume a single airport capacity. Actually, airports have up to four or more capacities operating at different times. The most basic split is between the VFR capacity and the more limited capacities under IFR conditions. The other split is between operations using the normal duty runways and operations using runways designed for occasional use when wind direction and speed prohibit the usual airport configuration. Under IFR conditions and with unfavorable winds the capacity can be half that of the VFR fair wind conditions.

By way of example, the case of Boston's Logan Airport can be examined. Under existing conditions the capacities are:

	IFR	VFR
NORMAL	53.9	111.3
CROSSWINDS	50.3	89.8

The operating percentages are approximately:

	IFR	VFR
NORMAL	8%	63%
CROSSWINDS	8%	21%

In like manner, each of the airports in this appendix are identified by four capacity estimates for each forecast year.

APPENDIX J

AIRPORT CAPACITY ESTIMATES 1/

Throughput Rates
Airport: Atlanta (ATL)

Year	IFR Capacity 16% IFR Standard	Crosswind	VFR Capacity 84% VFR Standard	Crosswind
1975	107.8	107.8	129.8	129.8
1980	107.3	107.3	129.0	129.0
1985	112.8	112.8	142.6	142.6
1990	111.4	111.4	140.7	140.7
1995	109.4	109.4	137.7	137.7
2000	107.5	107.5	134.5	134.5

1/ Source: The MITRE Corporation

APPENDIX J

AIRPORT CAPACITY ESTIMATES 1/

Throughput Rates
Airport: Boston (BOS)

Year	IFR Capacity 15% IFR Standard/Crosswind		VFR Capacity 85% VFR Standard/Crosswind	
1975	51.8	56.8	91.8	117.7
1980	51.2	55.9	89.6	115.6
1985	51.1	55.9	89.4	115.1
1990	50.8	55.5	88.4	113.9
1995	50.7	55.1	87.5	113.3
2000	50.3	53.9	84.8	111.3

1/ Source: The MITRE Corporation

APPENDIX J

AIRPORT CAPACITY ESTIMATES 1/

Throughput Rates
Airport: Chicago (ORD)

Year	IFR Capacity 15% IFR Standard/Crosswind		VFR Capacity 85% VFR Standard/Crosswind	
1975	102.0	134.5	136.9	136.9
1980	101.5	133.1	135.0	135.0
1985	101.1	131.7	133.3	133.3
1990	100.4	128.8	130.1	130.1
1995	100.0	126.7	127.5	127.5
2000	99.8	125.0	125.2	125.2

1/ Source: The MITRE Corporation

APPENDIX J

AIRPORT CAPACITY ESTIMATES 1/

Throughput Rates
Airport: Cleveland (CLE)

Year	IFR Capacity 15% IFR Standard/Crosswind		VFR Capacity 85% VFR Standard/Crosswind	
1975	51.8	51.8	73.3	73.3
1980	51.5	51.5	72.6	72.6
1985	51.2	51.2	71.6	71.6
1990	50.9	50.9	70.3	70.3
1995	50.6	50.6	69.1	69.1
2000	50.3	50.3	67.5	67.5

1/ Source: The MITRE Corporation

APPENDIX J

AIRPORT CAPACITY ESTIMATES 1/

Throughput Rates
Airport: Denver (DEN)

Year	IFR Capacity 5% IFR Standard	IFR Capacity 5% IFR Crosswind	VFR Capacity 95% VFR Standard	VFR Capacity 95% VFR Crosswind
1975	52.0	59.6	59.6	106.2
1980	58.2	60.1	94.0	107.2
1985	57.4	59.8	92.2	103.3
1990	56.1	58.9	89.7	00.5
1995	55.3	58.2	87.9	98.4
2000	54.2	57.3	85.6	94.2

1/ Source: The MITRE Corporation

APPENDIX J

AIRPORT CAPACITY ESTIMATES 1/

Throughput Rates
Airport: Dallas/Ft. Worth (DFW)

Year	IFR Capacity 9% IFR Standard/Crosswind		VFR Capacity 91% VFR Standard/Crosswind	
1975	103.8	156.9	118.4	171.5
1980	103.7	156.8	118.1	171.1
1985	103.3	155.6	117.5	169.8
1990	102.5	153.3	116.7	167.5
1995	101.5	151.3	115.9	165.5
2000	101.1	149.2	115.2	163.3

1/ Source: The MITRE Corporation

APPENDIX J

AIRPORT CAPACITY ESTIMATES 1/

Throughput Rates
Airport: Detroit (DTW)

Year	IFR Capacity 14% IFR Standard/Crosswind		IFR Capacity 86% VFR Standard/Crosswind	
1975	78.9	78.9	117.2	117.2
1980	105.9	105.9	127.6	127.6
1985	105.0	105.0	126.1	126.1
1990	104.4	104.4	125.1	125.1
1995	103.4	103.4	123.6	123.6
2000	102.5	102.5	121.9	121.9

1/ Source: The MITRE Corporation

APPENDIX J

AIRPORT CAPACITY ESTIMATES 1/

Throughput Rates
Airport: Newark (EWR)

Year	IFR Capacity 15% IFR Standard	/Crosswind	VFR Capacity 85% VFR Standard	/Crosswind
1975	51.3	56.2	58.7	78.7
1980	51.3	56.8	58.5	78.7
1985	50.9	55.7	58.0	75.5
1990	50.7	55.1	57.7	77.7
1995	50.2	51.6	56.9	71.9
2000	50.1	53.5	57.1	75.5

1/ Source: The MITRE Corporation

APPENDIX J

AIRPORT CAPACITY ESTIMATES 1/

Throughput Rates
Airport: Honolulu (HNL)

Year	IFR Capacity 1% IFR Standard	Crosswind	VFR Capacity 99% VFR Standard	Crosswind
1975	52.0	52.0	57.0	57.0
1980	52.6	52.6	65.1	65.1
1985	52.3	52.3	64.3	64.3
1990	52.1	52.1	63.8	63.8
1995	51.9	51.9	63.4	63.4
2000	51.7	51.7	62.8	62.8

1/ Source: The MITRE Corporation

APPENDIX J

AIRPORT CAPACITY ESTIMATES 1/

Throughput Rates
Airport: Houston (IAH)

Year	IFR Capacity 15% IFR Standard	IFR Capacity 15% IFR Crosswind	VFR Capacity 85% VFR Standard	VFR Capacity 85% VFR Crosswind
1975	83.2	83.2	93.7	99.7
1980	82.3	82.3	92.7	99.2
1985	80.5	80.5	90.7	98.2
1990	79.6	79.6	89.7	97.7
1995	77.3	77.3	87.1	96.4
2000	76.0	76.0	85.8	95.7

1/ Source: The MITRE Corporation

APPENDIX J

AIRPORT CAPACITY ESTIMATES 1/

Throughput Rates
Airport: Kennedy (JFK)

Year	IFR Capacity 15% IFR Standard	Crosswind	VFR Capacity 85% VFR Standard	Crosswind
1975	59.3	72.2	81.3	81.3
1980	59.0	71.9	81.1	81.1
1985	58.4	71.3	80.4	80.4
1990	57.4	70.2	79.1	79.1
1995	57.0	69.9	78.8	78.8
2000	55.8	68.8	77.6	77.6

1/ Source: The MITRE Corporation

APPENDIX J

AIRPORT CAPACITY ESTIMATES 1/

Throughput Rates
Airport: (LAS)

Year	IFR Capacity 2% IFR Standard	Crosswind	VFR Capacity 98% VFR Standard	Crosswind
1975	80.9	80.9	91.2	91.2
1980	80.5	80.5	90.7	90.7
1985	79.6	79.6	89.7	89.7
1990	78.4	78.4	88.4	88.4
1995	76.3	76.3	85.9	85.9
2000	74.4	74.4	83.9	83.9

1/ Source: The MITRE Corporation

APPENDIX J

AIRPORT CAPACITY ESTIMATES 1/

Throughput Rates
Airport: Los Angeles (LAX)

Year	IFR Capacity 25% IFR Standard	IFR Capacity 25% IFR Crosswind	VFR Capacity 75% VFR Standard	VFR Capacity 75% VFR Crosswind
1975	106.6	106.6	167.0	167.0
1980	106.5	106.5	166.5	166.5
1985	105.6	105.6	164.2	164.2
1990	104.7	104.7	161.6	161.6
1995	104.0	104.0	159.4	159.4
2000	84.4	84.4	131.0	131.0

1/ Source: The MITRE Corporation

APPENDIX J

AIRPORT CAPACITY ESTIMATES 1/

Throughput Rates
Airport: LaGuardia (LGA)

Year	IFR Capacity 15% IFR Standard/Crosswind		VFR Capacity 85% VFR Standard/Crosswind	
1975	59.3	61.5	73.1	78.0
1980	57.9	59.8	71.3	75.8
1985	56.5	58.3	69.7	73.8
1990	55.3	56.9	68.2	72.0
1995	54.6	56.1	67.3	71.0
2000	53.9	55.3	66.3	69.7

1/ The MITRE Corporation

APPENDIX J

AIRPORT CAPACITY ESTIMATES 1/

Throughput Rates
Airport: Kansas City (MCI)

Year	IFR Capacity 10% IFR Standard/Crosswind		VFR Capacity 90% VFR Standard/Crosswind	
1975	88.6	88.6	99.6	102.9
1980	88.2	88.2	99.3	102.6
1985	87.8	87.8	99.1	102.3
1990	86.0	86.0	97.0	101.3
1995	84.9	84.9	95.7	100.7
2000	83.3	83.3	93.9	99.8

1/ Source: The MITRE Corporation

APPENDIX J

AIRPORT CAPACITY ESTIMATES 1/

Throughput Rates
Airport: Miami (MIA)

Year	IFR Capacity 1% IFR Standard/Crosswind		VFR Capacity 99% VFR Standard/Crosswind	
1975	101.4	101.4	115.8	115.8
1980	100.8	100.8	115.1	115.1
1985	100.5	100.5	114.6	114.6
1990	100.2	100.2	114.3	114.3
1995	100.0	100.0	113.9	113.9
2000	99.7	99.7	113.6	113.6

1/ Source: The MITRE Corporation

APPENDIX J

AIRPORT CAPACITY ESTIMATES 1/

Throughput Rates
Airport: Minneapolis/St. Paul (MSP)

Year	IFR Capacity 12% IFR Standard	IFR Capacity 12% IFR Crosswind	VFR Capacity 88% VFR Standard	VFR Capacity 88% VFR Crosswind
1975	57.8	57.8	59.3	118.7
1980	56.7	56.7	58.6	117.2
1985	55.9	55.9	58.1	116.1
1990	55.1	55.1	57.7	115.5
1995	54.4	54.4	57.5	114.9
2000	53.8	53.8	57.2	114.5

1/ Source: The MITRE Corporation

APPENDIX J

AIRPORT CAPACITY ESTIMATES 1/

Throughput Rates
Airport: New Orleans (MSY)

Year	IFR Capacity 11% IFR Standard	IFR Capacity 11% IFR Crosswind	VFR Capacity 89% VFR Standard	VFR Capacity 89% VFR Crosswind
1975	55.5	57.2	58.8	70.7
1980	55.5	57.3	58.7	70.6
1985	55.3	57.1	58.5	70.3
1990	54.5	56.1	58.1	69.1
1995	53.6	55.1	57.7	67.7
2000	52.9	54.2	57.4	66.5

1/ Source: The MITRE Corporation

APPENDIX J

AIRPORT CAPACITY ESTIMATES 1/

Throughput Rates
Airport: Philadelphia (PHL)

Year	IFR Capacity 15% IFR Standard/Crosswind		VFR Capacity 85% VFR Standard/Crosswind	
1975	57.3	57.3	73.4	73.4
1980	57.8	57.8	73.6	73.6
1985	57.4	57.4	72.7	72.7
1990	56.9	56.9	72.0	72.0
1995	56.1	56.1	71.0	71.0
2000	55.3	55.3	69.7	69.7

1/ Source: The MITRE Corporation

APPENDIX J

AIRPORT CAPACITY ESTIMATES 1/

Throughput Rates
Airport: Pittsburgh (PIT)

Year	IFR Capacity 17% IFR Standard	IFR Capacity 17% IFR Crosswind	VFR Capacity 83% VFR Standard	VFR Capacity 83% VFR Crosswind
1975	87.9	87.9	101.4	101.4
1980	87.5	89.0	100.8	100.8
1985	84.9	87.6	99.8	99.8
1990	82.8	87.1	99.3	99.3
1995	80.9	86.7	98.9	98.9
2000	79.2	86.4	98.5	98.5

1/ Source: The MITRE Corporation

APPENDIX J

AIRPORT CAPACITY ESTIMATES 1/

Throughput Rates
Airport: Seattle (SEA)

Year	IFR Capacity 16% IFR Standard/Crosswind		VFR Capacity 84% VFR Standard/Crosswind	
	Standard	Crosswind	Standard	Crosswind
1975	53.8	53.8	67.5	67.5
1980	53.6	53.6	67.0	67.0
1985	53.6	53.6	67.0	67.0
1990	53.1	53.1	66.1	66.1
1995	52.7	52.7	65.3	65.3
2000	52.2	52.2	64.2	64.2

1/ Source: The MITRE Corporation

APPENDIX J

AIRPORT CAPACITY ESTIMATES 1/

Throughput Rates
Airport: San Francisco (SFO)

Year	IFR Capacity 10% IFR Standard/Crosswind		VFR Capacity 90% VFR Standard/Crosswind	
1975	52.4	54.3	76.7	76.7
1980	52.2	54.1	76.3	76.3
1985	51.9	53.6	75.7	75.7
1990	51.6	53.1	74.9	74.9
1995	51.2	52.6	74.1	74.1
2000	51.0	52.1	73.3	73.3

1/ Source: The MITRE Corporation

APPENDIX J

AIRPORT CAPACITY ESTIMATES 1/

Throughput Rates
Airport: St. Louis (STL)

Year	IFR Capacity 12% IFR Standard/Crosswind		VFR Capacity 88% VFR Standard/Crosswind	
1975	59.4	59.4	75.6	75.6
1980	59.0	59.0	74.9	74.9
1985	58.0	58.0	73.5	73.5
1990	56.9	56.9	72.0	72.0
1995	55.7	55.7	70.3	70.3
2000	54.5	54.5	68.6	68.6

1/ Source: The MITRE Corporation

APPENDIX J

AIRPORT CAPACITY ESTIMATES 1/

Throughput Rates
Airport: Tampa (TPA)

Year	IFR Capacity 7% IFR Standard	IFR Capacity 7% IFR Crosswind	VFR Capacity 93% VFR Standard	VFR Capacity 93% VFR Crosswind
1975	82.3	82.3	117.6	117.6
1980	80.5	80.5	116.7	116.7
1985	78.8	78.8	115.9	115.9
1990	77.3	77.3	115.3	115.3
1995	76.3	76.3	114.9	114.9
2000	75.0	75.0	114.5	114.5

1/ Source: The MITRE Corporation

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