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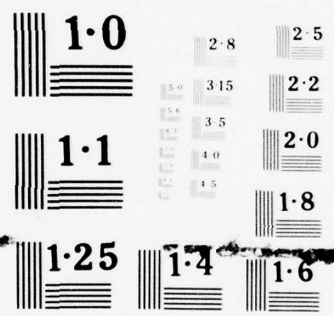

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ESTABLISHMENT OF NEW MAJOR PUBLIC AIRPORTS IN THE UNITED STATES

Report of the Secretary of Transportation to the United States Congress pursuant to Section 26 of the Airport and Airway Development Act Amendments of 1976 (P.L. 94-353)

U.S. DEPARTMENT OF TRANSPORTATION
Federal Aviation Administration
Washington, D.C. 20591
AUGUST 1977

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16. Abstract

This study was performed in response to Section 26(2) of the Airport and Airway Development Act Amendments of 1976 (Public Law 94-353) which directed the Secretary of Transportation to conduct a study on the establishment of new major public airports in the United States, including (a) identifying potential locations, (b) evaluating such locations, and (c) investigating alternative methods of financing the land acquisition and development costs necessary for such establishment.

The report assesses needs for major new airports in the United States through the year 2000. Potential airport locations, the general size requirement of new airports, financing, and airport development issues and problems are also analyzed under a variety of future conditions. The potential need for new major airports is highly sensitive to the future forecasted activity, extent of accommodation of general aviation, effectiveness of the upgraded third generation air traffic control system in increasing capacity, and peak spreading, in that order.

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THE SECRETARY OF TRANSPORTATION
WASHINGTON, D.C. 20590

SEP 5 1977

Honorable Thomas P. O'Neill, Jr.
Speaker of the House of Representatives
Washington, D.C. 20515

Dear Mr. Speaker:

I am pleased to transmit the "Establishment of New Major Public Airports in the United States" report. This report is submitted in accordance with Section 26(2) of Public Law 94-353 signed by the President on July 12, 1976.

The report assesses needs for major new airports in the United States through the year 2000. Potential airport locations, the general size requirement of new airports, financing, and airport development issues and problems are also analyzed under a variety of future conditions. The potential need for new major airports is highly sensitive to the future forecasted activity, extent of accommodation of general aviation, effectiveness of the upgraded third generation air traffic control system in increasing capacity, and peak spreading, in that order. Since the report does not attempt to say that an airport should or should not be built at a particular location, which is a highly complex decision, it should not be considered a final answer. Instead, the report should serve as a principal basis for further dialog on the subject.

A report has also been sent to the President of the Senate.

Sincerely,

Brock Adams

Enclosure

THE SECRETARY OF TRANSPORTATION
WASHINGTON, D.C. 20590

SEP 5 1977

Honorable Walter F. Mondale
President of the Senate
Washington, D.C. 20510

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EXECUTIVE SUMMARY

Through analysis of the runway capacity of 24 major air carrier airports under a variety of possible future conditions, the study concludes that the capability of major airport hubs to handle air traffic through the year 2000 is principally a function of:

- The extent to which forecast future traffic actually develops.
- The effectiveness of the Upgraded Third Generation Air Traffic Control System.
- The extent to which forecast future traffic can be dispersed from peak periods.
- The extent to which major air carrier airports experience, or do not experience, shifts in general aviation activity.

Under the most adverse conditions, up to 19 major air carrier airports may experience serious capacity deficits by the year 2000. Under the most favorable conditions, only two airports will experience such deficiencies.

Even with planned expansion of existing airports, construction of new major air carrier airports will be necessary in 1 to 10 hubs to handle forecast air carrier, commuter, and other air taxi activity alone by the year 2000. The cost is estimated at \$0.24 to \$2.58 billion. However, even with this construction hubs with major air carrier airports would on the average accommodate only 73 percent of general aviation traffic. At a few hubs, less than 15 percent of general aviation activity would be accommodated. In cases such as this, alternatives to additional major air carrier airports, such as use of new or existing reliever airports, would be less feasible.

The study relies principally on an analysis of runway capacity as a determinant of airport need. While other constraints, such as a terminal access problem at Los Angeles by 1995, are identified as being potential reasons for new major airport construction, the study does not analyze these problems in detail. Further, the study does not attempt to reconcile potentially valid differences between national and local perspectives of when a new major airport is necessary. Hence, the results should not be viewed as a warrant to build new airports or a denial of their need.

If Federal airport assistance continues at historic rates of participation, and if it is assumed that total Federal fund levels are adequate, airports will likely be able to arrange suitable revenue bond financing. If Federal assistance is limited, or curtailed entirely, financing problems become serious or prohibitive at a significant number of locations. Situations may also exist where new airport jurisdictions are created which are not currently eligible for Federal financing. While a single local jurisdiction is desirable, it might not always be possible.

No attempt is made to identify specific sites of new major airports except insofar as such sites are already identified or are under study by local communities. In many hubs potentially requiring airports, such sites are not identified.

It is presumed that a new airport is required when average annual runway delay exceeds 6 minutes. New airports are sized on the assumption that new airports will supplement and not replace existing airports and that delay at all airports at a hub will be reduced to an average of 4 minutes.

The study highlights the major influence of Upgraded Third Generation Air Traffic Control improvements on the potential need for new major airports. Because UG3RD is not yet installed and capacity increases from these improvements have not yet been demonstrated, the timing and effects upon capacity will need to be monitored closely.

Study assumptions tend to be somewhat conservative concerning:

- The possible limited accommodation of general aviation--which may be neither desirable nor practicable.

- The development of supplemental and not replacement airports--which may not always be feasible.

- A 6-minute average annual delay developing before a potential need is identified--which represents a highly congested condition.

As a result, the study estimate of potential need may also be conservative.

The study does not propose a definite course of Federal action. Instead, it forms a basis for further discussions regarding:

- Planning effectively for new airports so as to accommodate future traffic, recognizing future uncertainty.

- Methods of accommodating expected general aviation activity.

- Integrating Federal financial assistance for new major airports with other airport development needs.

- Encouraging a single airport financial jurisdiction for all air carrier hub airports, or providing Federal financial assistance to new airport authorities.

- Identifying and preserving needed airport sites.

Such discussions will form an important basis for developing an appropriate extension of the current Airport and Airway Development Act.

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CHAPTER 1. INTRODUCTION, SUMMARY, AND FINDINGS

This report has been developed in response to section 26 of the Airport and Airway Development Act Amendments of 1976 which directed the Secretary of Transportation to conduct a study on "the establishment of new major public airports in the United States, including (A) identifying potential locations, (B) evaluating such locations, and (C) investigating alternative methods of financing the land acquisition and development costs necessary for such establishment...."

INTRODUCTION

This report develops a national overview of potential needs for major new airports through the year 2000. Future needs for major public airports will depend upon many variables that cannot be predicted with a high degree of certainty. Among the more notable variables are various categories of airport activity; regulatory actions by Federal, state, and local jurisdictions; and expected capacity enhancement of airports and navigation and air traffic control systems. The analysis deals with the possible variations by developing sets of scenarios of future conditions to provide contexts for potential major airport needs. Potential need is assessed in terms of average delay and the cost of total delays. By developing airport needs in relationship to user delays, air carrier airport configurations are proposed which are designed to bring delays within reasonable bounds in a timely manner.

It should be recognized that the identification of a potential need at the national level for airport facilities will not necessarily correspond to what is perceived as a need at the local or regional level. Local and regional decisions on the need and configuration of major airports during the past decade have given substantial weight to both passenger convenience and concepts of the future development of their communities.

SCOPE

The findings of this study are predicated on several alternatives concerning future growth of air carrier traffic, increases in airport capacity attributable to improvements in air traffic control, and greater utilization of available airport capacity through spreading of peak period operations. The study findings derive from investigation of the following questions:

- How many new airports would be needed when existing airports reach perceived levels of congestion?
- What plausible site options exist for new airport locations in the metropolitan areas where a potential need is identified?
- What general sizes of new airports are required to accommodate the expected demands to be placed upon them?
- What are the likely costs of land acquisition and facilities development for new airports, and how can their investment costs be financed?
- What important airport development issues and problems are generally common among metropolitan areas, and what roles should the Federal Government play in assisting state and local agencies in mitigating them?

- Is it potentially feasible and practicable to completely relocate air carrier services and facilities from an existing airport to a new airport?

This study is concerned with the following hubs as given in Airport Activity Statistics:[1]

Atlanta	Minneapolis/St. Paul
Boston	Newark
Chicago	New Orleans
Cleveland	New York
Denver	Philadelphia/Camden
Detroit & Ann Arbor	Pittsburgh/Wheeling
Honolulu	St. Louis
Houston	San Diego
Las Vegas	San Francisco/Oakland
Los Angeles/Burbank/Long Beach	Seattle/Tacoma
Miami/Ft. Lauderdale	Tampa & St. Petersburg/ Clearwater & Lakeland

The above hubs are equivalent to the following (combinations of) Standard Metropolitan Statistical Areas (SMSA's):[2]

Atlanta	Minneapolis-St. Paul
Boston	New Orleans
Chicago	New York
Cleveland	Newark
Denver-Boulder	Philadelphia
Detroit-Ann Arbor	Pittsburgh and Wheeling
Honolulu	St. Louis
Houston	San Diego
Las Vegas	San Francisco-Oakland
Los Angeles-Long Beach	Seattle-Tacoma
Miami-Fort Lauderdale	Tampa-St. Petersburg and Lakeland-Winter Haven

All of these are single SMSA's with the exception of the Detroit, Miami, Pittsburgh, Seattle, and Tampa areas, which are combinations of two SMSA's. In addition, the Detroit, Miami, and Seattle areas are defined as Standard Consolidated Statistical Areas (SCSA's). All of these areas are referred to by the name of the principal city. The New York and Newark areas are treated as a single hub and referred to as New York.

[1]Civil Aeronautics Board and Federal Aviation Administration, Airport Activity Statistics of Certificated Route Air Carriers: 12 Months Ended June 30, 1976 (Washington: U.S. Government Printing Office, undated).

[2]Office of Management and Budget, Standard Metropolitan Statistical Areas (Washington: U.S. Government Printing Office, Revised Edition, 1975).

There are a total of 24 airports analyzed: New York includes La Guardia Airport (LGA) and Newark Airport (EWR) as well as John F. Kennedy International Airport (JFK), since each of the three airports would be, by itself, a large hub. Similarly, Ft. Lauderdale-Hollywood International Airport (FLL) is analyzed as well as Miami International Airport (MIA), since FLL by itself would be a medium hub and had 1,776,000 enplaned passengers in fiscal year 1975, which was 31 percent of the enplaned passengers at MIA.[3]

Given the calendar time and resources available for this study, it was not possible to analyze each airport to the level of detail found in a master plan, or even in a system plan. Fortunately, such detail is not necessary to meet the overall objective of this study, which is to address national problems which may be associated with the provision of major new airports. Consequently, the results of the study need be valid only for the hubs as a group and not necessarily for any particular hub. It is important that this report be reviewed carefully in this context.

The methodology for this study places great emphasis upon the existing literature on major airports. This has been supplemented only where essential by the collection of primary data, and supplemented only where feasible by additional analysis. This additional analysis is limited to the estimation of delay, the cost of delay, and the financial requirements due to new airports. Other matters, such as environmental concerns, are limited to the analysis found in the literature. The varying scope of that analysis implies that the general results of the study are somewhat subjective, especially in view of the greater range of possible future events that are considered as opposed to the range usually found in the literature. These possible future events are described by three sets of scenarios.

The first set of scenarios consists of low, middle, and high scenarios of airport activity as expressed in air carrier (including commuter and other air taxi) enplaned passengers and operations and in general aviation operations associated with a considerable need to use a major airport.

The air carrier operations and enplaned passengers in the middle airport activity scenario are the same as in the Upgraded Third Generation Air Traffic Control System (UG3RD) delay reduction study,[4] which represents an extension of the Terminal Area Forecast (TAF) methodology.[3] Through passengers are calculated using factors developed in another study.[5] The low and high scenarios represent variations around the TAF.

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[3]Federal Aviation Administration, Terminal Area Forecast: 1978-1988 (Washington: Federal Aviation Administration, January 1977).

[4]Robert A. Rogers, Vincent J. Drago, and Edward S. Cheaney, Estimation of UG3RD Delay Reduction (Washington: Federal Aviation Administration, January 1977).

[5]Juan F. Bellantoni, Helen M. Condell, Irwin Englander, Louis A. Fuertes, and Judith C. Schwenk, The Airport Performance Model - Extensions, Validation, and Applications (Cambridge: Transportation Systems Center, undated).

The second set of scenarios are low and high estimates of the effects upon capacity of the possibilities concerning implementation of UG3RD. To be sure of covering all possibilities the low scenario is no change in capacity, and the high scenario represents the capacity given full implementation of UG3RD.

The third set of scenarios are low and high estimates of the effects upon peak hour operations of such peak spreading alternatives as limits on peak hour operations with consequent quotas and greater fees during peak hours. Possibilities concerning implementation of such alternatives and their effects are captured by letting the low and high estimates of the reduction in peak hour operations be 0 percent and 30 percent, respectively, with a 6 percent floor on the ratio of peak hour to average day operations.

The three airport activity scenarios, the two air traffic control (ATC) scenarios, and the two peak spreading scenarios yield a total of 12 scenario combinations. The scenario years will be calendar years 1985, 1990, 1995, and 2000. Rather than estimating year-by-year capital costs, they are centered 3 years before the identified scenario year.

OVERVIEW OF METHODOLOGY

For each of the 24 airports and for each of the 12 scenarios, potential needs are assessed in terms of estimates of runway capacity surpluses or deficits. The study is in a context of a longstanding FAA guideline that an airport is considered to be approaching a congested state when delays average 4 minutes per aircraft. Average delay is allowed to rise to 6 minutes per aircraft before a potential need for a new airport is identified.[6] The 6-minute point is a congested state that will result in delays on the order of 30 minutes during peak hours. Beyond this point the percentage of passengers who perceive a substantial degradation of service reaches unacceptable levels. New airports are sized to result in average delays of 4 minutes or less.

The delay analyses are augmented by a synthesis of master plans, regional/state system plans, environmental impact reports, and the results of interviews at airports and regional planning commissions. Information was sought concerning land use compatibility, community and environmental impacts, access, and jurisdictional arrangements.

The planning data and results of the delay analyses are used as a basis for generally locating new airports in those scenario-specific instances where a potential need is identified. The capital costs of new airports are compared to the delay reduction benefits, and to operating surpluses to obtain estimates of the coverage for revenue bond financing. Common problems in developing new airports and a discussion of the practicability of shifting air carrier services from an existing airport to a new airport are based on the synthesis of available secondary information.

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[6] William R. Fromme and John M. Rodgers, Policy Analysis of the Upgraded Third Generation Air Traffic Control System (Washington: Federal Aviation Administration, January 1977).

INTERPRETING THE STUDY RESULTS

This report identifies future potential needs for major new airports predicated on a criterion of reaching passenger and aircraft delay times at a level that may not necessarily represent acceptable quality of service to the communities. Delay times for the 24 airports that were analyzed depend on the magnitudes of the scenario-specific traffic growth rates (especially on peak period operations) and on predicted capacity increases attributable to full implementation of UG3RD. The growth rates of aviation cannot be predicted with certainty nor can the capacity increases due to UG3RD be fully known until the systems are installed and evaluated. Indeed, it is because of these uncertainties that the decision was made to employ scenarios, and hence, conditional determinations of potential needs in this study. Therefore, it is emphasized that the potential needs for major new airports should be carefully interpreted with respect to the antecedent scenario conditions from which they derive. This care in interpretation is further amplified by the high sensitivity of the number of new airport potential needs to the alternative traffic growth scenarios, the impact of UG3RD on capacities at existing airports, and the 6-minute average aircraft delay deficiency criterion.

The reductions in delay costs associated with new airport developments are compared to the costs of new airport land acquisition and facilities construction. However, a final decision to build (or not to build) a new major airport follows from exhaustive assessments of demand and supply, site studies, land use and environmental impacts, need for and availability of financing, jurisdictional and institutional relationships, and socio-demographic and economic impacts. While interview information pertaining to these assessment factors was collected for this study, its principal purpose was to facilitate characterization of common problems impairing the ability of a community to locate and develop new airports. Evaluation of all of the benefits and costs of major new airports was beyond the scope of this investigation. Hence, the service-based potential needs identified in this study should not be interpreted as warrants for new airport development.

Several assumptions have been made in sizing and locating new airport services and facilities which significantly influence estimation of capital requirements. Most importantly, sizing of new airport needs is based on the assumption (treated in chapter 7) that future major new airports serving large metropolitan areas will supplement rather than replace the existing airport or airport system. Air carrier operations are assumed to be split between the existing and new airports in such a manner as to reduce average aircraft delays to a maximum of 4 minutes at each airport serving the hub. Stated alternatively, new airports are sized to provide that capacity needed to accommodate the incremental activity at the existing airport above the 4-minute delay design criterion. Where new airport potential needs and sizes are identified, new site locations have been determined mainly on the basis of information reported in the literature or in the interviews.

FINDINGS

Potential Major New Airport Needs

In identifying potential needs for new airports in the 21 hubs, findings are scenario-specific, that is, conditional statements of needs with respect to alternative combinations of assumptions about airport activity levels, UG3RD air traffic control system capacity increases, and reduction of capacity requirements through peak spreading. Of the 12 scenarios evaluated, 4 were determined to adequately represent the feasible range of alternatives. The findings are also dependent upon the assumptions embodied in the methodology. Given these conditions, key findings are:

- Using total operations (air carrier, commuter, other air taxi, and general aviation) in the four scenarios, 10 to 19 airports are expected to have an average delay exceeding 6 minutes by the year 2000. However, this assumes that general aviation will not be severely constrained at several of the airports with extensive general aviation activity. Similar analysis in the absence of general aviation indicates the number of airports exceeding the 6-minute criterion is from 2 to 12. Results are summarized in table 1-1. Realistically, it must be expected that general aviation operations will not be entirely eliminated from major air carrier airports. In fact, at a few hubs, less than 15 percent of general aviation activity would be accommodated at existing major air carrier airports without exceeding the delay criteria and without additional facilities for general aviation, with the average accommodation at existing and new airports being 60 to 84 percent, depending upon the scenario. However, general aviation cannot be expected to continue at high levels when air carrier airports approach congestion.

- At airports where general aviation activity increases the delay beyond the 6-minute criterion, general aviation activity averages 36 percent of total operations. For airports in the study where air carrier and air taxi activity alone results in an average delay of more than 6 minutes, general aviation averages 17 percent of total operations. Because of the high percentage of general aviation at many of those airports exceeding the delay criterion when total airport activity is considered, it appears to be appropriate to determine potential major new airport needs based upon air carrier, commuter, and other air taxi activity and determine the percentage of general aviation activity that could be accommodated.

- A detailed examination of methods (including incentives) for diverting general aviation to satellite airports should be the subject of further analysis.

- Anticipated potential needs for major airports in the range of four scenarios are shown in table 1-2 for air carrier and air taxi activity. Under the varying conditions, potential needs vary from a high of 10 airports to a low of 1 airport.

TABLE 1-1. AIRPORTS WHERE AVERAGE DELAY EXCEEDS 6 MINUTES IN 2000

	Scenario Combination			Operations	
	Airport Activity	UG3RD	Peak Spreading	Air Carrier, Air Taxi, and General Aviation	Air Carrier and Air Taxi
1.	Middle	No	No	19	12
2.	High	Yes	Yes	14	6
3.	Middle	Yes	Yes	10	3
4.	Low	No	Yes	10	2

TABLE 1-2. POTENTIAL MAJOR NEW AIRPORT NEEDS WITH AIR CARRIER AND AIR TAXI
(millions of 1976 dollars)

Scenario	1		2		3		4	
Airport Activity	Middle		High		Middle		Low	
UG3RD	No		Yes		Yes		No	
Peak Spreading	No		Yes		Yes		Yes	
Hub	Capacity Deficit	Total Cost	Capacity Deficit	Total Cost	Capacity Deficit	Total Cost	Capacity Deficit	Total Cost
Atlanta	1995	207.6						
Boston	1985	271.9	1995	271.9	2000	271.9		
Chicago	1985	212.7						
Denver	1995	194.7						
Minneapolis	2000	212.2						
New York	1985	346.7	1995	221.1	2000	221.1		
Philadelphia	1990	285.1	2000	285.1				
St. Louis	1990	216.9						
San Francisco	1985	392.3	1985	243.9	1990	243.9	1985	243.9
Seattle	2000	241.5						
Total		2,581.6		1,022.0		736.9		243.9

- In addition to airports required for airside capacity, Los Angeles is expected to reach a ground access limit of 40 million enplaned and deplaned passengers by 1995. If groundside access cannot be improved, other airport facilities will be required to handle excess passengers.

- Average runway delays are sensitive to airport activity, implementation of UG3RD, and peak spreading, in that order. An increase of 11 percent in airport activity (from middle to high levels) increases average delay by 73 percent, and a decrease of 24 percent in airport activity (from middle to low) decreases average delay by 74 percent. UG3RD reduces average delay by 76 percent, and peak spreading reduces average delay by 30 percent.

- The numbers of airports exceeding the delay criterion are also sensitive to airport activity, implementation of UG3RD, and peak spreading, in that order. An increase of 11 percent in airport activity (from middle to high levels) increases the numbers of airports with capacity deficits by 40 percent, and a decrease of 24 percent in airport activity (from middle to low) decreases the numbers of airports by 73 percent. UG3RD reduces the numbers of airports exceeding the delay criterion by 60 percent, and peak spreading implies a reduction of 26 percent.

- It appears likely that future major new airports will almost exclusively supplement, rather than replace, existing air carrier airports in the major metropolitan areas.

New Airport Costs and Their Financing

- New airport capital costs range from $0.2 billion to $2.6 billion in the four scenarios with the Federal share (as specified in existing legislation and with no ceiling on the absolute levels) ranging from $0.1 billion to $1.2 billion.

- It appears that revenue bond financing will probably continue to be a preferred method for raising capital for building new airports. If there is no ceiling on the absolute levels of the Federal share and we assume that a 125 percent ratio of the sum of the operating surpluses (at the existing airport(s) and the new airport at the levels of the first year of the new airport) to the bond payments is required for successful revenue bonds, revenue bond financing appears feasible with a few exceptions (table 1-3). If there were a $50 million ceiling on Federal aid to any one airport, revenue bond financing would still be generally feasible, but the exceptions would be more numerous, with most of the exceptions now requiring state or local funding instead of only lending or guarantees of bonds. If there were no Federal participation, the exceptions would be even more numerous and more serious. Some kind of assistance would be required more often than not, usually financing rather than merely guaranteeing or lending. A single airport financial jurisdiction for all air carrier hub airports should be encouraged or Federal financial assistance provided to new airport authorities.

TABLE 1-3. BOND COVERAGE[a]
(percent)

	Year	Federal Participation: 75 percent of eligible expenditures[b]	Limit of $50 million[c]	None
Scenario 1				
Atlanta	1995	407	309	235
Boston	1990	147	89*	72**
Chicago	1985	351	248	190
Denver	1995	192	153	114*
Minneapolis	2000	249	181	139
New York	1985	294	197	169
Philadelphia	1990	105*	63**	52**
St. Louis	1990	145	103*	79**
San Francisco	1985	99**	65**	57**
Seattle	2000	101*	68**	54**
Scenario 2				
Boston	2000	264	160	130
New York	1995	803	564	437
Philadelphia	2000	205	122*	101*
San Francisco	1990	240	166	132
Scenario 3				
New York	2000	720	506	392
San Francisco	1990	203	140	111*
Scenario 4				
San Francisco	1985	147	102*	81**

[a]Operating surpluses (at existing airport(s) and new airport at levels of the first year of the new airport) as percentage of equal annual payments for 25 years at 10 percent on a bond to finance the local share of new airport capital costs.

[b]Fifty percent of eligible terminal expenditures; eligibility as defined in P.L. 94-353 for large air carrier airports.

[c]Five years of construction at $10 million per year.

*Less than the amount required for a successful revenue bond; guarantees or lending required.

**Less than the amount required for bond payments; income required.

Impacts at Existing Airports

- Expansion of existing major air carrier airports is planned or judged to be possible at 13 of the 24 airports which were investigated in this study. These expansions include feasibility of land acquisition and new construction. However, in 9 of the 13 airports, expansion is judged to be feasible with major constraints stemming principally from land use incompatibilities.

- The principal impacts associated with expansion of existing airports concern noise and access/egress. Noise is cited as a major impact at 11 of the 24 airports. Access/egress congestion associated with airport expansion is cited as increasing in severity at 9 of the 24 airports.

Possible Actions for Improving the Planning Process

- Establishment of recommended standards to be applied by local jurisdictions and promotion of one common noise rating system.

- Promulgation of better citizen participation and public awareness programs.

- Evaluation of the long term benefits and costs of converting selected military air bases to air carrier airports.

Feasibility of Relocating Major Air Services

- Of the 10 hubs having a potential need for a new airport in the maximum need scenario, it appears feasible at only 4 locations to relocate, rather than supplement, existing major airports.

The principal advantages of relocation are:

- Ability to acquire sufficient land to meet long term needs at costs which are relatively low.

- Opportunity to influence the development of environmentally compatible land uses in the new airport impact zone.

- Ability to optimize facilities layout and construction with respect to long term needs.

- Provision for concomitant long term landside accessibility relatively free from competing ground transportation demands.

- Easier routing and scheduling for a single new airport in contrast to multiple hub airports.

The principal disadvantages of relocation are:

- Multijurisdictional issues of financing, land acquisition, land use control within the new airport environmental impact area, and ground transportation.

- Typical remoteness of new sites from users and employees.
- Disruption of airport-related or induced economic activity [illegible] or near the existing airport.

CHAPTER 2. METHODOLOGY

SECTION 1. IDENTIFICATION OF CAPACITY DEFICIENCIES

In order to form a common basis of evaluation, an aircraft runway delay analysis was performed on each airport in the study. This analysis consisted of using the various airport activity scenarios and the estimated runway capacities of various operational scenarios to determine average aircraft runway delays.

DELAY CRITERION

The function of an air carrier airport is to serve as a connecting point between the air transportation system and various forms of ground transportation. The primary service unit of an airport is its runway system which typically occupies the greatest percentage of the airport property, is the least flexible to change, has the greatest impact on airport operations, and consequently, is greatly impacted by land use patterns surrounding the airport. Although delays can occur at any point in the airport system (runways, gates, terminals, access roads), congestion of the runway system can generally serve as a primary measure for identifying a need for additional capacity at an airport. Therefore, the average runway delay per aircraft operation was selected as the primary measure for identifying a need at the various airports analyzed in this study. For FAA planning purposes, an airport runway(s) may generally be considered to be approaching a congested state when delays average 4 minutes. However, after discussions among the FAA and the study team, it was concluded that a somewhat higher average delay at existing airports would be used in identifying capacity deficits. Accordingly, a criterion of a 6-minute average annual runway delay per aircraft operation was established as the point at which a serious capacity problem would exist.[1] The 6-minute point was chosen based on the judgment that at this point, the level of service becomes unacceptable. A conventional rule of thumb is that peak hour average runway delays are on the order of five times annual average runway delays. Total peak hour average delays would be another multiple of peak hour average runway delays.

In this study, runway delay is defined as the time an aircraft must wait for a runway to become available for its use. The delay time does not include the service time of either the runway or the final approach airspace (that space traversed just before and during the final approach after an aircraft has been cleared for landing).

DELAY ANALYSIS

To accomplish the objectives of the delay analysis, it was necessary to develop a methodology capable of efficiently analyzing the delay situation for the airports and scenarios of interest. The methodology described below

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[1]William R. Fromme and John R. Rodgers, Policy Analysis of the Upgraded Third Generation Air Traffic Control System (Washington: Federal Aviation Administration, January 1977).

is based on a delay model developed for the FAA.[2] Adapting this model for use in this study facilitated achievement of the study objectives within the strict time and cost constraints imposed on this project and served as a common basis for analyzing the airports of interest.

Queuing Model Formulation

The primary computational tool used in the delay analysis was the Airport Integrated Design System (AIDS). AIDS is a computer program that uses queuing models to establish relationships between airport activity, capacity, and delay. The mathematical structure of these models is developed in the cited reference. It was determined at the outset of the study that it would be beyond the resource and time constraints of this project to make a separate AIDS run for each airport, year, and scenario of interest. Therefore, AIDS was used to develop an abbreviated estimation procedure.

The delay analysis discussed below is based on a generalized computer methodology that could be easily applied to the airports, years, and scenarios of interest. It must be realized that the method developed yields only approximate delay estimates, and its results should be considered in this light.

Aircraft Runway Delays

A similar approach for determining aircraft runway delays was taken for each scenario of interest. The runway system capacities used in this study are defined as the number of operations possible in 1 hour if there were always an aircraft waiting to use the runway system and are those capacities determined by the MITRE Corporation and used in its UG3RD analysis.[3] The MITRE study, however, did not include airport capacities for Fort Lauderdale or San Diego (SAN). For these two airports, surrogate runway system capacities were determined by matching the respective system configurations to similar airport configurations for which system capacities were known. (FLL was matched with La Guardia Airport and SAN was matched with Washington National Airport.)

For each airport, scenario, and year of interest, MITRE calculated eight capacities which it felt best typified the airport's mode of operation. The eight different capacity cases correspond to low and high capacities, Visual Flight Rules (VFR) versus Instrument Flight Rules (IFR) conditions, and whether or not the Wake Vortex Avoidance System (WVAS) is in use. These rates reflected forecasted runway improvements, aircraft mix, and in-trail separation standards.

AIDS was used to generate eight generalized delay curves. Each curve represents the average delay per aircraft operation as a function of the ratio of annual operations to runway hourly capacity. One set of four curves represents a low diurnal peaking factor of 6.0 percent, while the other set of four curves represents a high diurnal peaking factor of 10.65 percent. These low and high peaking factors represent the extremes that prevailed at the 30 airports investigated by MITRE. At this time slightly higher peaking

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[2]Battelle-Columbus Laboratories, Estimation of UG3RD Delay Reduction (Columbus: Battelle-Columbus Laboratories, July 1976).

[3]Arthur P. Smith, Estimation of UG3RD Capacity Impacts (Washington: The MITRE Corporation, May 1976).

factors exist at some airports. The four curves in each set represent different capacities: 50, 100, 125, and 150 operations per hour, respectively. Each of these curves was formulated under the assumption that the typical number of operations per day is the same for either a weekday or a weekend.

Once the annual aircraft demand is known, the delay per operation associated with each capacity can be found by interpolating between the low curves and the high curves on the basis of each airport's diurnal peaking factor and hourly capacity. Therefore, eight values of delay are calculated for each airport, scenario, and year. These eight values are then combined into a single weighted average of delays per operation. The weights used in calculating this average are the fractions of the time the airport is operating in each of the eight capacity situations.

Unbalanced Arrival/Departure Scheme

For a number of the airports considered, MITRE calculated the runway capacity based upon an unbalanced arrival/departure scheme, i.e., more departures than arrivals. In some cases, the ratio of departures to arrivals was as great as 3:1. Naturally, in a real world situation, this arrival/departure unbalance fluctuates throughout the day. The abbreviated procedure used in this analysis assumes that the runway capacity is constant throughout the day, and therefore, the MITRE capacity was assumed to apply throughout the day. The exact effect of this assumption on the delays estimated in this analysis is uncertain and would vary from airport to airport.

APPLICATION OF DELAY CRITERION

The delay analyses were performed for each airport, year, and scenario of interest. For each case in which a 6-minute or greater average aircraft delay was reached, a capacity deficiency was identified.

Possible Airside Expansion

For each airport where a capacity deficit was identified, the study team made a subjective determination as to whether sufficient land was potentially available for possible airside expansion. Such expansion was found not to be possible for any of the airports being considered, beyond the planned expansions already incorporated into the delay analyses.

Diversion to Other Air Carrier Airports

An investigation was made to determine if there were any other air carrier airports in the hub area to which traffic could be diverted. If enough airport activity could be diverted to reduce the aircraft delay below the 6-minute level, the airport could be removed from the deficit category. Such diversion was found not to be possible for any of the airports being considered.

Potential Need for a New Airport

Since after the above steps, the estimated average delay still remained at or above the 6-minute level, the hub was identified as having a potential need for a new air carrier airport. It is emphasized that the establishment of potential need is based strictly on capacity deficit vis-a-vis the 6-minute delay criterion and the quality of airport service implied by this criterion.

NEW AIRPORT SIZING

If a hub was identified as potentially needing a new airport, it was assumed that the new airport would be used in conjunction with, rather than completely replace, the present airport. The size of the new airport would be such that it would have sufficient capacity to insure no greater than a 4-minute average delay at both the new and current airports.

SITE LOCATION

In order to determine the cost of the new airports, the land cost and, therefore, the general location of new airport sites required identification. At hubs where new sites have already been identified, the land costs at such sites were used for this purpose. Where no new sites have been or could not be identified, the average land cost in the hub area exurban fringe (a distance of approximately 30 miles from the city center) was assumed.

SECTION 2. COSTS AND REVENUES

NEW AIRPORT CAPITAL COSTS

Land Acquisition

In most cases, land values are difficult to estimate for a hypothetical airport at an undetermined site inasmuch as land values are intrinsically site-specific. Order of magnitude land value estimates in terms of cost per acre were solicited from an airport planner or land use planner in each of the 10 hub areas. In certain cases, new sites have already been purchased, and better cost estimates were obviously available.

New Airport Design Size

The physical size of new airports which can handle traffic diverted in the year 2000 is developed from a combination of actual construction experience and information derived from existing literature. In addition to the guidance provided by the FAA Federal Aviation Regulations (FAR) and advisory circulars (AC), two other sources were of great value:

a. Horonjeff, R., Planning and Design of Airports (New York: McGraw-Hill, 1975).

b. Ralph M. Parsons Company, The Apron and Terminal Building Planning Manual (Washington: U.S. Department of Transportation, July 1975).

More specific design information is provided as follows:

a. Airfield: The general configuration is derived from Horonjeff and from FAA AC 150/5060-3A, Airport Capacity Criteria Used in Long Range Planning, instrument landing system and navigation aids criteria from AC 150/5300-2C, Airport Design Standards - Site Requirements for Terminal Navigational Facilities, typical runway length from AC 150/5325-4, Runway Length Requirements for Airport Design, taxiway design from AC 150/5335-1A, Airport Design Standards, Airports Served by Air Carriers - Taxiways, runway design from AC 150/5335-4, Airport Design Standards, Airports Served by Air Carriers - Runway Geometrics, and terminal apron size from Parsons.

b. Terminal complex: The passenger terminal gross building area is derived from the following sources:

(1) Horonjeff, p. 256-7, states that "typical peak-hour passenger" figures are in the range of 0.03 to 0.05 percent of the annual passenger volume. Total gross area (domestic) is approximated by 25,000 square feet per typical peak hour passenger.

(2) Parsons, figure 6-5, gives data for estimating terminal area per gate as a function of annual enplanements.

(3) Trends in new terminal area planning were extracted from data for existing airports summarized in Capacity/Demand Survey for Large Hub Airports, by D. E. Gentry, J. D. Howell, and N. K. Taneja for the FAA.

c. Access: Parsons provides a method for estimating terminal curbside length and parking requirements. Parking area is based on a figure of 2,000 employee and passenger parking spaces per one million annual enplanements.

Building and Construction Costs

Unit 1976 prices for construction costing were developed from the annual Dodge Manual for Building Construction Pricing and Scheduling of the McGraw-Hill Information Systems Company, the annual edition of Means Building Construction Cost Data of the Robert Snow Means Company, Inc., the March 24, 1977 issue of Engineering-News Record, as well as from past experience with construction estimating practices.

COMPARISON OF CAPITAL COSTS WITH DELAY REDUCTION BENEFITS

Since the airport system in a hub is assumed to be designed for an average delay of 4 minutes if there is a persistent capacity deficiency, and since no more traffic is assumed to be diverted than that traffic necessary to bring the existing airport down to an average delay of 4 minutes, the average delay at the new airport will be 4 minutes or less. It is assumed that the average delay will be 4 minutes at the new airport and consequently throughout the hub.

It is also assumed that the reduction in delay will be constant throughout the life of the new airport. The reduction in average delay is the difference between 4 minutes and the estimated average delay for the year of capacity deficiency. If the life of the new airport is 25 years, the value of the delay reduction over the entire airport life at a point 2.5 years before the year of capacity deficiency is 7.5 times the annual delay reduction, using the discount rate of 10 percent.[4] The point 2.5 years before the year of capacity deficiency and hence of airport opening is assumed to be the midpoint of construction.

The reduction in total aircraft delay is the reduction in average delay multiplied by the number of aircraft operations, and is valued at $700 per hour. The reduction in total passenger delay is the reduction in average delay multiplied by the number of passengers (including through passengers), and is valued

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[4] Office of Management and Budget, Discount Rates To Be Used in Evaluating Time-Distributed Costs and Benefits (Washington: Office of Management and Budget Circular No. A-94, Revised, March 1972).

at \$12.50 per hour.[5] It is then possible to compare the total value of delay reduction with the total capital cost of a new airport, sized to handle traffic diverted in the year 2000.

OPERATING SURPLUSES

Revenues by source vary widely from one airport to another. To a lesser extent, even the definition of cost and revenue varies; that is, a revenue at one airport might be a negative cost at another, or a cost at one airport might be a negative revenue at another. Because of this, and because the basic purpose of estimating operating costs and revenues is to determine to what extent operating surpluses will fund new airport construction, operating surpluses are estimated directly rather than first estimating operating costs and operating revenues by source.

Estimates are made of the sum of the operating surpluses at the present airport(s) studied plus a new airport in a given hub. These estimates are based upon a least squares regression developed for an HNTB master plan:[6]

$$S = 1.505\ E - 91{,}586$$

where S denotes operating surplus in 1971 dollars and E denotes enplaned passengers. This equation fits 89 percent of the variation in data for 92 air carrier airports.[7] Operating surpluses were put into 1971 dollars using the implicit price deflator of state and local government purchases of goods and services. According to the State and Government Branch of the Government Division of the Bureau of Economic Analysis, the 1971 and 1976 deflators are now 94.5 and 138.7, respectively, which can be used to put the equation into 1976 dollars:

$$S = 2.209\ E - 134{,}423$$

According to this equation, operating surplus is zero when enplaned passengers are approximately 61,000.

This relationship is applied to the airport activity scenarios to develop estimates of operating surpluses. Note that the estimates are not affected by the ATC or peak spreading scenarios. The peak spreading scenario with a reduction in peak hour operations may embody greater fees during peak hours. Consequently, the operating surplus estimate may be conservative for this scenario.

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[5] Federal Aviation Administration, Establishment Criteria for Category I Instrument Landing System (Washington: Federal Aviation Administration, December 1975).

[6] Howard, Needles, Tammen & Bergendoff, Burlington International Airport Master Plan: Technical Report (Burlington: City of Burlington, April 1975).

[7] Federal Aviation Administration, Economics of Airport Operation: Calendar Year 1972 (Washington: Federal Aviation Administration, April 1974).

BOND COVERAGE

The local share of the new airport capital costs are centered 2.5 years before the opening of the new airport. A bond is posited that covers the construction costs and grows at a given rate of interest for 2 years. The bond then is repaid in equal annual payments for a period equal to a given economic life of the new airport. If the operating surpluses devoted to the retirement of these bonds are assumed to remain constant for the economic life of the new airport, increases in the operating surpluses at both the old and new airports can then be devoted to capital replacement at the old airport(s). The coverage of the bond payments (the ratio of the operating surpluses to the bond payments) is compared to the 125 percent requirement for a successful revenue bond. The range of interest rates is from 1 to 20 percent and the range of airport economic lives is 10 years to 40 years.

From a local point of view, the financial considerations are basically how money for capital costs can be borrowed and how this money can be repaid. In this context, there are three possible outcomes of the preceding: the first is that operating surpluses are estimated to be generally sufficient for coverage on revenue bonds. In this case, the traditional revenue bond financing is feasible, and the operating surpluses will more than cover the bond payments.

The second possible outcome is that operating surpluses are estimated to be generally larger than the bond payments but not sufficient for the revenue bonds to be sold. The local alternative would be general obligation bonds, which might encounter local debt ceilings. Since debt ceilings are beyond the purview of this study, the recommendations in this case would concentrate upon mechanisms by which the Federal Government could induce the market to accept revenue bonds.

The third possible outcome is that operating surpluses would be less than bond payments. In this case, the recommendations would focus upon local capacity to finance the difference and perhaps greater Federal and state shares of costs as well as mechanisms to make revenue bonds more attractive.

SECTION 3. AIRPORT IMPACTS AND POSSIBLE FEDERAL ROLES

In addition to analyzing delays at each of the 24 airports in the 21 hubs under study, two equally important objectives of this study were first, to identify and characterize common environmental and community problems currently encountered during the expansion of the existing airports and/or during the selection of a location for a new airport site, and second, to identify areas for possible Federal actions designed to alleviate the impact of these problems. The threefold approach employed to accomplish these objectives is as follows:

a. Identification of relevant airport problems based on a literature review.

b. Identification and characterization of airport problems during interviews.

c. Synopsis of relevant airport problems and identification of possible roles for Federal action in the airport planning process.

Specific results of this study segment are presented in chapter 6, "Capacity Expansion Options", and in chapter 8, "Possible Roles for Federal Action."

AIRPORT PROBLEMS IN THE LITERATURE

At the outset of the study, airports and local planning agencies were contacted to inform them of the existence and nature of the study, to seek their cooperation in the study, and to procure current airport master plans, regional/state airport system plans, airport layout and area maps, urban transportation and land use studies, environmental impact reports, and other appropriate documents. All documents received from the agencies as well as those documents already available were subsequently reviewed and a draft profile paper was prepared for each airport hub. These profile papers included brief descriptions of the location and configuration of the existing airports, identified community and environmental impacts resulting from airport operations, and contained the status of airport expansion and/or airport planning activities to the extent that such existed. The draft profile papers also served as a basis for preparing a common list of specific topics to be discussed during the field interviews.

IDENTIFICATION OF AIRPORT PROBLEMS DURING INTERVIEWS

Following FAA protocol, interviews with the appropriate airport agency, A-95 review agency, and regional transportation authority were arranged. (A-95 agencies are areawide planning agencies designated under provisions of the Intergovernmental Cooperation Act of 1968 to coordinate federally assisted projects and to stimulate intergovernmental cooperation in planning and development activities.) A letter was mailed to each agency which included the draft profile paper and activity and delay projections for agency review prior to the scheduled interview.

SYNOPSIS OF AIRPORT PROBLEMS AND POSSIBLE FEDERAL ROLES IN THE AIRPORT PLANNING PROCESS

Upon completion of the field interviews, the draft hub profile papers were expanded and corrected as required. They were subsequently mailed to personnel at the respective airports for verification in order to insure that all information obtained during the field interviews had been correctly stated.

From the hub profiles and all other pertinent information acquired during the literature review and field interviews, a summary matrix of common environmental and community impacts of the major airports was prepared. The environmental and community impacts associated with both current airport operations (e.g., land use compatibility, noise exposure, traffic congestion, and air and water quality) as well as those similar impacts commonly experienced during airport expansion or new airport site selection are identified and discussed in chapter 6. An overview of the status of airport expansion programs and new air carrier airport planning by hub is also discussed and presented in a second matrix in chapter 6. The identified environmental and community factors are qualitatively assessed because of data unavailability and data inconsistencies. Additionally, the impacts at each hub are subjectively analyzed in relation to the severity and frequency of the impacts at all other hubs to reflect the severity of the identified impacts in a national context.

SECTION 4. RELOCATION OF MAJOR AIRPORTS

This task addresses the feasibility and practicability of shifting air carrier services and facilities from an existing airport to a new site. The output of this task consists of:

a. A broad general discussion of the factors influencing feasibility and practicability; in other words, a summary portrayal of advantages and disadvantages of relocation generally applicable to any metropolitan area.

b. Classification of metropolitan areas where potential new airport needs are related to relocation feasibility.

The distinguishing feature between this task and the preceding task is the explicit consideration of removal of major air carrier operations from an existing metropolitan airport in the present case. Both tasks entail summary assessment of a common set of factors (environment, land use, jurisdictional matters, etc.). Thus, the methodological approach to the relocation task closely parallels that of the preceding task. Specifically:

a. Using information reported in the hub profile papers and analyses of this information summarized in the impact matrices, a preliminary assessment of relocation feasibility was made for the 21 hubs.

b. To establish a factual empirical basis for refined examination of the relocation question, interviews were held with officials in Dallas/Ft. Worth, Kansas City, and Montreal for the purpose of documenting their experiences in the relocation actions that occurred in those cities.

c. Based on the findings of these steps, a general analysis of the advantages and disadvantages of airport relocation was prepared and is presented in chapter 7.

d. Finally, the hubs where potential new airport needs had been identified were classified with respect to relocation feasibility and practicability based on judgmental assessment of the advantages/disadvantages associated with expansion/new airport planning factors for the areas in question.

With respect to the second step in this task design on a realistic appraisal of the relative success of selected major airport relocations, two major research perspectives are presented. First, the analysis of airport relocations is based upon generalizations of findings drawn from three case studies.

a. In Kansas City in the early 1970's, scheduled air carrier service was transferred from a central city municipal airport to the new Kansas City International Airport located approximately 19 miles north of the city's center. This case study was chosen because it provides an example of an airport relocation where most steps in the process went smoothly, and only minor problems or disruptions were encountered.

b. The development of the new Dallas-Fort Worth International Airport was chosen as a case study characterized by a number of implementation problems, involving both local political jurisdictions as well as the new airport configuration and equipment.

c. The new Mirabel air facility in Montreal was chosen as an airport relocation that has been characterized by a great number of implementation problems.

By examining these somewhat divergent airport relocation processes, each with its own degree of success in specific areas, it was possible to identify some of the major factors that may facilitate or impede the relocation of other major metropolitan airports.

The second perspective deals with the major types of questions that were asked in the analysis. It was beyond the scope of this research to carry out an in-depth analysis of the plans for each of the airports, the specific facility development benchmarks accomplished, or to present a detailed financial and air operations evaluation of the relocation action. However, by focusing the research upon the general characteristics of the move, three basic questions have been explored:

a. First, in the case of each of the three airports noted above, the major reasons cited for causing a relocation were identified.

b. Second, the general characteristics of the relocation process were examined, including the identification of major problems that had been anticipated, but focusing on those which arose during the relocation process and had not been adequately foreseen.

c. Finally, an examination of the relative success of the new facility is presented, including an evaluation of the degree to which the new airport satisfies the objectives that led to the move. An important part of this third perspective is an examination of the activities that characterized the old airport, especially the roles of general aviation and air freight.

In chapter 8, the common role of planning and governmental agencies in the airport planning process at the local/regional and Federal levels is characterized; suggestions are made as to possible roles of Federal agencies and new opportunities for Federal involvement to alleviate and/or resolve the common airport planning problems identified in chapter 6.

CHAPTER 3. SCENARIO DEVELOPMENT

Three airport activity scenarios are combined with each of four operational scenarios to form 12 scenario combinations which are analyzed at 5-year increments from 1985 to 2000. As discussed in the previous chapter, the criterion for a potential runway capacity need is an average delay per aircraft operation of 6 minutes or greater.

SECTION 1. AIRPORT ACTIVITY SCENARIOS

The first set of scenarios consists of low, middle, and high scenarios of airport activity as expressed in general aviation operations and air carrier (including air taxi) enplaned passengers and operations. These scenarios are given in the appendix.

The air carrier operations and enplaned passengers in the middle airport activity scenario are the same as in the UG3RD delay reduction study, which represents an extension of the TAF methodology. The low and high scenarios represent variations around the TAF.

The general approach to the facility forecasts presented in the TAF is top-down. For each series, the national forecasts are distributed to the regions, states, and then the individual airports. For the top 30 air carrier airports, adjustments are made according to state population, state income, and tower forecasts. In addition, tower and market characteristics are used to modify the forecasts at these locations. Average aircraft size, the carriers serving the airport, their historic and present capacity in terms of frequency and aircraft type, the markets served, and the composition of future fleets of the relevant carriers are used to test the internal consistency of the air carrier forecasts. In addition, changes in carrier status from commuter to certificated carrier influence the forecasts.

Because the commuter and nonscheduled air taxi service seem to be the most volatile of the series projected, special consideration is given to these forecasts. By using the number of commuter or scheduled air taxi operators as an indicator, a growth rate for air taxi operations is determined individually for each airport served. Judgments made about both the strength of the carrier itself and the strength of market served are the basis of these rates. As airports reach a certain level of operations, aircraft will tend to use other nearby airports unless additional facilities are installed.

After the forecasts are generated and the adjustments made, the FAA regional planning offices are asked to comment on them. Updates of based aircraft and activity at nontowered airports are included in these regional comments. In addition, information is received on plans for new runways, on the possibility of new commuter service, and on airports expected to deviate from the national trends. These comments are incorporated in the TAF subject to the constraints imposed by the national forecasts.

SECTION 2. OPERATIONAL SCENARIOS

Four airport operating scenarios are considered: (1) a baseline scenario which assumes the airport's present mode of operation, (2) a peak spreading scenario which assumes that the airport has the same runway capacity as the baseline, but the operations are spread more evenly throughout the day, thus reducing the number of peak hour operations, (3) a UG3RD scenario which assumes the runway capacity benefits of UG3RD, and (4) a UG3RD and peak spreading scenario which assumes the runway capacity of UG3RD plus the benefits of peak spreading.

PEAK SPREADING

The shape and amplitude of the diurnal pattern (the pattern throughout the day) of aircraft arrivals and departures at an airport affects aircraft delays. It was beyond the scope of this study to include in the analysis a detailed description of each airport's diurnal pattern. However, one variable, the diurnal peaking factor, was chosen as the single variable that best represents the effects of the diurnal pattern on aircraft delay. The peaking factor is the ratio of the number of peak hour operations to the number of average daily operations. The higher the peaking factor, the higher will be the average aircraft runway delay. Typically peaking factors run between approximately 6 and 11 percent. The peaking factors used in this study are those that existed at each airport on November 7, 1975.[1]

The purpose of the peak spreading scenario is to show the effect on aircraft delay of reducing the peaking factor by spreading operations more evenly throughout the day. This is done by reducing the peaking factor to 0.7 of its original value, but never lower than the floor of 6 percent.

BASELINE AND UG3RD CHARACTERISTICS

In its analyses of the cost and benefits of UG3RD, the FAA defined five systems: a baseline system that contained no UG3RD advances and four groups containing various levels of UG3RD advances with group 4 being the most advanced. Associated with each system is a different level of runway capacity with the baseline having the lowest capacity and group 4 having the highest capacity. In this study, only the baseline and the group 4 systems are considered, and wherever UG3RD is indicated in this report, group 4 is implied. Group 4 is taken to represent full implementation of the UG3RD system.

There are nine major elements of UG3RD.[2] They are:

a. Discrete Address Beacon System

b. Airborne Separation Assurance System

c. Flight Service Stations

d. Upgraded ATC Automation (including Metering and Spacing)

e. Airport Surface Traffic Control

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[1]Federal Aviation Administration, Profiles of Scheduled Air Carrier Airport Operations: Top 100 U.S. Airports: November 7, 1975 (Washington: Federal Aviation Administration, February 1976).

[2]Arthur P. Smith, Estimation of UG3RD Capacity Impacts (Washington: The MITRE Corporation, May 1976).

f. Wake Vortex Avoidance System

g. Area Navigation

h. Microwave Landing System

i. Aeronautical Satellite

The various combinations of the above elements that could be implemented are numerous. A detailed discussion of the possible implementation options is given in the previously cited MITRE study.

Baseline Configuration

The baseline configuration assumes the existence of certain new items of air traffic control equipment, such as the completion of the Automated Radar Terminal System (ARTS) III program and highly probable additions to the airport facilities (e.g., instrument landing systems). The following assumptions characterize the baseline configuration:

a. The National Airspace System Stage A will be implemented at all en route centers.

b. ARTS III will be implemented at 63 terminals.

c. ARTS II will be implemented at 69 terminals.

d. Improved capability will be added to the Air Traffic Control Radar Beacon System.

e.. Extended Radar Advisory Service may be provided at additional terminals as permitted by existing regulations.

f. Ground proximity warning indicators will be installed on all air carrier aircraft.

UG3RD Groups

The groups are based on a progression of increased airport capacity and their most probable implementation dates. Group 1 is the current system with a Wake Vortex Avoidance System. This avoidance system is supplemented in group 2 by basic Metering and Spacing. Group 3 has a more sophisticated Wake Vortex Avoidance System and an improved surveillance system including automated controller aids in the form of digitized displays and computer generated alarms. Group 4 is the most sophisticated group which includes advanced Metering and Spacing, Discrete Address Beacon System, Microwave Landing System, and Area Navigation to aid the airside, and Airport Surface Traffic Control and high speed exits to ensure efficient movement on the taxiways and aprons.

Estimated Implementation Dates for UG3RD Groups

The particular combination of elements that comprise the groups discussed were chosen not only because of their potential for increasing airport capacity, but also because of their expected time of availability. Since there are risks involved in development programs, the estimates of the FAA as to when the groups will be fully operational at the first location is a range of years. These estimates are given in table 3-1. The optimistic, most likely, and pessimistic dates are based on accelerated, normal, and deferred budget, procurement, and implementation cycles. The most likely implementation dates are assumed to be the most appropriate dates on which to base the capacity estimates.

TABLE 3-1. ESTIMATED IMPLEMENTATION DATES OF FUTURE UG3RD GROUPS

		Implementation		
	Development	Optimistic	Most likely	Pessimistic
Group 1 -- Wake Vortex Avoidance System	1976	1979	1980	1982
Group 2 -- Wake Vortex Avoidance System; Basic Metering and Spacing	1977	1980	1982	1985
Group 3 -- Wake Vortex Avoidance System; Basic Metering and Spacing; Improved Surveillance	1978	1982	1985	1988
Group 4 -- Wake Vortex Avoidance System; Advanced Metering and Spacing; Discrete Address Beacon System; Microwave Landing System; Area Navigation; Airport Surface Traffic Control; High Speed Exits	1980	1984	1987	1990

Source: Federal Aviation Administration

CHAPTER 4. POTENTIAL NEEDS FOR MAJOR NEW AIRPORTS

The basic thrust of this chapter is the assessment of the airside capacities of each of the 24 study airports through the year 2000. Based upon this assessment, the potential needs for new airport facilities for the 21 hubs are identified. The airside capacities are assessed by applying the delay methodology and delay criterion described in chapter 2 to the airport activity and operational scenario combinations outlined in chapter 3.

SECTION 1. DELAY ANALYSES

DELAY ANALYSES

The analysis of each airport is based on the airport activity scenarios contained in the appendix and on the runway capacities developed by the MITRE Corporation.

Expanded Facilities

For three airports, the capacities represent estimates for presently planned or proposed expanded airside facilities. These three airports are Atlanta, Cleveland, and Pittsburgh.

At Atlanta, the layout plan shows a fourth parallel runway in the 9/27 direction. If this new runway were to prove environmentally acceptable, it would significantly reduce aircraft taxi time and gate congestion.

At Cleveland, an environmental impact assessment has already been prepared for a proposed major airside program which would entail the relocation of runway 5L/23R to a point 1,100 feet apart from runway 5R/23L, and the construction of a 710-foot extension on the south end of runway 18R/36L.

At Pittsburgh, plans call for the completion of a third runway (a new 10R/28L) in fiscal year 1979 if approval can be obtained for phase III funds in fiscal year 1977. Federal funds in the amount of $15 million have been requested to allow for the completion of this runway.

Delays with Air Carrier, Air Taxi, and General Aviation

The average aircraft delays with air carrier, air taxi, and general aviation operations for each airport, for each scenario combination, and for the years 1990 and 2000 are given in the appendix. The distribution of these delays for the year 2000 are summarized in table 4-1. The number of airports with average delays greater than 6 minutes ranges from 21 airports for the high airport activity, no UG3RD, and no peak spreading scenario combination to 2 airports (Miami and Minneapolis) for the scenario combination with low airport activity, UG3RD, and peak spreading. Changing the delay criterion by 2 minutes in the range from 2 to 10 minutes changes the number of airports with a capacity deficit only by an average of two.

In what might be called the most likely scenario combination (middle airport activity with UG3RD and peak spreading), there are 10 airports with average delays greater than 6 minutes. Assuming for the moment that it is not

TABLE 4-1. DELAY DISTRIBUTION BY SCENARIO COMBINATION
(Air carrier, air taxi, and general aviation in 2000)

Scenario combination			Airports where average delay exceeds, minutes				
Airport activity	UG3RD	Peak spreading	2	4	6	8	10
High	No	No	24	22	21	20	19
High	No	Yes	23	20	19	18	18
High	Yes	No	21	19	19	16	14
High	Yes	Yes	20	17	14	11	10
Middle	No	No	23	19	19	18	17
Middle	No	Yes	19	18	17	17	17
Middle	Yes	No	19	17	13	13	11
Middle	Yes	Yes	17	13	10	9	9
Low	No	No	19	15	13	10	9
Low	No	Yes	18	12	10	9	6
Low	Yes	No	13	10	6	3	2
Low	Yes	Yes	12	4	2	1	1
Average			19	16	14	12	11

possible to expand any of these airports to the extent necessary to bring average delays down to 6 minutes, it becomes necessary to divert traffic to another airport, or (if necessary) to a new airport. Since a higher percentage of general aviation could be diverted to a reliever or smaller airport, the mix of diverted operations would have a higher percentage of general aviation operations than the operations remaining at the major airport. Rather than attempt the difficult task of estimating the relative likelihoods of diverting general aviation versus air carrier and air taxi operations, the simplifying assumption was made that general aviation operations would be diverted before air carrier and air taxi operations. However, the percentage of general aviation operations that could be accommodated at new airports is estimated below.

Delays with Air Carrier and Air Taxi Operations

The average aircraft delays with air carrier and air taxi operations only are also given in the appendix for each airport, for each scenario combination, and for the years 1985, 1990, 1995, and 2000. The distributions of these delays for the year 2000 are summarized in table 4-2. The number of airports with average delays greater than 6 minutes ranges from 15 airports (6 less than when general aviation is included) for the high airport activity, no UG3RD, and no peak spreading scenario combination to no airports (a reduction of two) for the scenario combination with low airport activity, UG3RD, and peak spreading. Increasing the delay criterion from 6 minutes to 8 minutes or from 8 minutes to 10 minutes would decrease the number of airports with a capacity deficit by an average of only one. But decreasing the delay criterion from 6 minutes to 4 minutes would increase the number of airports with a capacity deficit by an average of two, and decreasing the delay criterion further to 2 minutes would further increase the number of airports with a capacity deficit by an average of four. Table 4-2 also gives the total aircraft delay at all of the airports in millions of minutes. The scenario combinations are ordered according to the total aircraft delay.

EFFECTS OF SCENARIOS UPON DELAYS

Table 4-3 rearranges the total aircraft delays with air carrier and air taxi operations only in the year 2000 at all airports by scenario to highlight the scenario effects. It is seen that peak spreading reduces delays by 30 percent overall and UG3RD reduces delay by 76 percent overall. The sum of total delays in the low airport activity scenarios is 80 percent less than in the middle airport activity scenarios, made up of a 24 percent decrease in operations and a 74 percent decrease in average delay. The sum of total delays in the high airport activity scenarios is 92 percent greater than in the middle airport activity scenarios, made up of an 11 percent increase in operations and a 73 percent increase in average delay.

SECTION 2. CAPACITY DEFICITS

CAPACITY DEFICITS BY AIRPORT

The number of airports with average delays greater than 6 minutes in the year 2000 is given in table 4-2 for each scenario combination. Table 4-4 expands upon this data by identifying the airports and also the first year in

TABLE 4-2. SCENARIO COMBINATION REDUCTION
(Air carrier and air taxi in 2000)

Scenario combination			Aircraft delay, millions of minutes	Airports where average delay exceeds, minutes				
Airport Activity	UG3RD	Peak spreading		2	4	6	8	10
High	No	No	418	20	16	15	13	12
High	No	Yes	307	17	14	12	12	12
Middle	No	No*	224	18	15	12	12	11
Middle	No	Yes	156	15	12	11	9	8
High	Yes	No	108	15	10	9	7	6
High	Yes	Yes*	68	14	9	6	4	3
Middle	Yes	No	55	15	8	4	4	2
Low	No	No	44	14	8	5	2	2
Middle	Yes	Yes*	34	9	5	3	2	2
Low	No	Yes*	29	11	5	2	2	2
Low	Yes	No	13	7	2	1	0	0
Low	Yes	Yes	9	3	0	0	0	0
Average			122	13	9	7	6	5

*Scenario combinations retained.

TABLE 4-3. INTERRELATIONSHIP OF AIRPORT ACTIVITY, UG3RD AND PEAK SPREADING ON TOTAL AIRCRAFT DELAY
(Air carrier and air taxi millions of minutes in 2000)

	No peak spreading	Peak spreading	Reduction due to peak spreading	
			Amount	Percent
Low airport activity				
No UG3RD	44	29	15	34
UG3RD	13	9	4	31
Reduction due to UG3RD				
Amount	31	20		
Percent	70	69		
Middle airport activity				
No UG3RD	224	156	68	30
UG3RD	55	34	21	38
Reduction due to UG3RD				
Amount	169	122		
Percent	75	78		
High airport activity				
No UG3RD	418	307	111	27
UG3RD	108	68	40	37
Reduction due to UG3RD				
Amount	310	239		
Percent	74	78		

Overall weighted* percentage decrease in total delay due to

UG3RD - 76 percent

Peak spreading - 30 percent

*Overall weighted percentage is obtained by averaging all percentage reduction figures for UG3RD and peak spreading, weighting each figure by its associated total delay.

TABLE 4-4. FIRST YEARS OF CAPACITY DEFICITS
(Air carrier and air taxi)

Scenario: Airport activity / UG3RD / Peak spreading	High No No	High No Yes	Middle No No	Middle No Yes	High Yes No	High Yes Yes	Middle Yes No	Low No No	Middle Yes Yes	Low No Yes	Low Yes No	Low Yes Yes
Airport												
Atlanta	1995	1995	1995	2000	--	--	--	--	--	--	--	--
Boston	1985	1985	1985	1990	1995	1995	1995	1995	2000	--	--	--
Chicago	1985	1985	1985	1985	1995	--	--	--	--	--	--	--
Cleveland	2000	--	--	--	--	--	--	--	--	--	--	--
Denver	1995	1995	1995	2000	--	--	--	--	--	--	--	--
Detroit	--	--	--	--	--	--	--	--	--	--	--	--
Honolulu	--	--	--	--	--	--	--	--	--	--	--	--
Houston	--	--	--	--	--	--	--	--	--	--	--	--
Las Vegas	--	--	--	--	--	--	--	--	--	--	--	--
Los Angeles	--	--	--	--	--	--	--	--	--	--	--	--
Miami (MIA)	2000	--	--	--	--	--	--	--	--	--	--	--
Miami (FLL)	--	--	--	--	--	--	--	--	--	--	--	--
Minneapolis	1995	2000	2000	2000	2000	--	--	--	--	--	--	--
New Orleans	2000	--	--	--	--	--	--	--	--	--	--	--
New York (JFK)	1985	1985	1985	1985	1985	1985	1985	1985	1990	1985	--	--
New York (LGA)	1985	1985	1985	1990	1995	2000	--	--	--	--	--	--
New York (EWR)	1990	1995	1990	1995	1995	2000	2000	--	--	--	--	--
Philadelphia	1985	1990	1990	1990	2000	2000	--	2000	--	--	--	--
Pittsburgh	--	--	--	--	--	--	--	--	--	--	--	--
St. Louis	1990	1995	1990	1995	2000	--	--	2000	--	--	--	--
San Diego	--	--	--	--	--	--	--	--	--	--	--	--
San Francisco	1985	1985	1985	1985	1985	1985	1985	1985	1990	1985	1990	--
Seattle	1995	2000	2000	--	--	--	--	--	--	--	--	--
Tampa	--	--	--	--	--	--	--	--	--	--	--	--
Airports with capacity deficits	15	12	12	11	9	6	4	5	3	2	1	0

which there is a capacity deficit. The scenario combinations are ordered as in table 4-2, that is, according to total aircraft delay at all the airports combined. There are a total of 80 airport-scenario combination cases with capacity deficits or 28 percent of the total number of cases. The high airport activity scenario combinations include 42 of these cases, the middle airport activity scenario combinations include 30, and the low airport activity scenario combinations include the remaining 8. The UG3RD scenario combinations have 23 of the capacity deficit cases, and the scenario combinations without UG3RD have the remaining 57. The peak spreading scenario combinations have 34 of the capacity deficit cases, and the scenario combinations without peak spreading have the remaining 46. These results parallel the scenario effects upon total aircraft delay.

REDUCTION IN SCENARIO COMBINATIONS

Table 4-2 indicates the four scenario combinations to be retained for further analysis. These four combinations were arrived at by the following reasoning. The two scenario combinations with the greatest total aircraft delays are both combinations with high airport activity but no UG3RD. These combinations were ruled out on the grounds that, given high growth, full implementation of UG3RD would be closer to what would actually happen than no UG3RD. The two scenario combinations with the lowest total aircraft delays both have low airport activity with full UG3RD. These two combinations were ruled out on similar grounds.

This reasoning left a set of eight scenario combinations. The highest and lowest of this set in terms of total aircraft delay were retained for further analysis. Of the two scenario combinations in the middle of this set of eight, the combination with high growth, UG3RD, and peak spreading has a total aircraft delay closer to the average of the highest and lowest total aircraft delays in the set of eight. Consequently, this middle combination was also retained. Finally, the combination with middle growth, UG3RD, and peak spreading is perhaps a likely scenario combination, and was retained for this reason. The four scenario combinations retained for further analysis will be referred to as scenarios 1, 2, 3, and 4, in order of descending total aircraft delay. These four scenarios can be summarized as follows:

a. Middle airport activity growth with neither peak spreading nor UG3RD. This scenario provides a baseline consisting of the impacts of expected growth on the existing airport system without operations improvements.

b. High airport activity growth with implementation of peak spreading and UG3RD. This scenario permits the examination of the greatest possible improvements under the most pressing demand situation.

c. Middle airport activity growth with UG3RD and peak spreading. This may be a likely case.

d. Low airport activity growth with implementation of peak spreading but not UG3RD. This scenario allows the examination of peak spreading alone in a situation of low airport activity.

CAPACITY DEFICITS BY HUB

In each of the four scenarios, one or more of the New York airports has a capacity deficit. In scenarios 1 and 2, all three New York airports have capacity deficits and alternatives clearly must be examined. In scenarios 3 and 4, the situation is less clear-cut, since only JFK has an average delay greater than 6 minutes. In such a case it is necessary to address whether a redistribution of traffic among the three airports could bring average delays at each of the airports under 6 minutes. In 1990 in scenario 3, this would clearly be possible, since the weighted average of the delays at the three airports is 4.7 minutes. But in 1995, the weighted average reaches 6.5 minutes. Even here, because of the nature of the relationship between delay and airport activity, it might be possible to redistribute traffic so that average delay would be less than 6 minutes at each airport. Consequently, the delay model was used to estimate by linear interpolation the numbers of operations at each New York airport that would result in a 6-minute average delay, given the combinations of UG3RD and peak spreading. The sums of these operations for the three airports are as follows: 1,239,000 operations with UG3RD and peak spreading, 1,115,000 operations with UG3RD alone, 986,000 operations with peak spreading alone, and 902,000 operations with neither peak spreading nor UG3RD. These sums were compared to the sums of airport activities at the three airports to result in the capacity deficits for the entire hub as shown in table 4-5. In scenario 2 the hub capacity deficit is 1995 as opposed to the first airport deficit, which is 1985 at JFK. In scenario 3, the weighted average of the airport delays of 6.5 minutes in 1995 turns out not to be binding; a hub deficit does not appear until 2000. And in scenario 4, a hub deficit never appears, even with a deficit at JFK in 1985.

SECTION 3. TRAFFIC DIVERSIONS

DIVERSIONS OF AIR CARRIER AND AIR TAXI

To determine whether or not operations which must be diverted can be handled at another airport in the hub (complete relocations are discussed in chapter 7), and to determine the approximate size of a new airport if diversion to another existing airport is not feasible, it is necessary to estimate the number of operations which must be diverted. For this purpose, it is then necessary to estimate the activity which could be accommodated at the existing airport without violating the design standard of 4 minutes of average delay, again using the delay model with linear interpolation. These estimates are given in table 4-5, along with the ensuing estimates of diverted operations and diverted enplanements and deplanements. The last estimates are calculated by assuming that enplanements and deplanements per diverted operation are the same as at the existing airport.

Based upon investigation of activity and capacity, it was determined that it would not be possible to accommodate diverted operations in the year 2000 in another air carrier airport in any of the hubs in the four scenarios. While it is recognized that some would argue that such accommodation would be possible at another air carrier airport or possibly at a general aviation airport with albeit substantial upgrading, it was decided as a consequence to formulate new airports in a somewhat Spartan fashion with somewhat reduced costs, thus striking something of a balance between the cost of a new airport and the cost of substantial upgrading and renovation of an existing nonmajor airport.

TABLE 4-5. HUB CAPACITY DEFICITS AND DIVERSIONS

Hub	Capacity Deficit	Air Carrier and Air Taxi: Operations, thousands: Resulting in 4-Minute Delay	Operations, thousands: Diversions 1985	Diversions 1990	Diversions 1995	Diversions 2000	Diversions of Enplanements and Deplanements, millions: 1985	1990	1995	2000
Scenario 1										
Atlanta	1995	645	--	--	54	100	--	--	4.6	9.3
Boston	1985	296	37	64	95	124	2.1	4.3	6.8	9.7
Chicago	1985	632	111	118	125	129	7.3	9.1	11.1	13.1
Denver	1995	345	--	--	46	97	--	--	3.2	6.8
Minneapolis	2000	241	--	--	--	63	--	--	--	3.7
New York	1985	819	226	303	378	442	15.4	22.4	29.7	36.8
Philadelphia	1990	293	--	55	84	115	--	2.8	5.1	7.6
St. Louis	1990	277	--	46	84	113	--	3.0	6.0	9.3
San Francisco	1985	289	128	187	210	233	8.3	13.0	16.8	20.5
Seattle	2000	235	--	--	--	60	--	--	--	3.3
Scenario 2										
Boston	1995	390	--	--	35	76	--	--	2.9	7.0
New York	1995	1,170	--	--	130	229	--	--	11.8	22.8
Philadelphia	2000	410	--	--	--	43	--	--	--	3.3
San Francisco	1985	400	35	107	142	179	2.4	8.2	13.1	18.5
Scenario 3										
Boston	2000	390	--	--	--	30	--	--	--	2.4
New York	2000	1,170	--	--	--	91	--	--	--	7.6
San Francisco	1990	400	--	76	99	122	--	5.3	7.9	10.8
Scenario 4										
San Francisco	1985	296	79	110	107	104	5.1	7.6	8.8	9.4

To determine the approximate size of a new airport, linear interpolation was used again with the delay model. In conjunction with the San Diego data, this produced the following estimates of activity at an airport with a single runway which would not violate the design standard of 4 minutes of average delay: 285,000 operations with UG3RD and peak spreading, 242,000 operations with peak spreading alone, and 212,000 operations with neither peak spreading nor UG3RD. These capacities comfortably accommodate the diverted operations in table 4-5 with the exceptions of New York and San Francisco in scenario 1. In these two cases it is necessary to posit two runways. Using data on Dallas-Fort Worth from the MITRE study, the activity which would not violate the design standard of 4 minutes of average delay was estimated as follows: 668,000 operations with UG3RD and peak spreading, 571,000 operations with peak spreading alone, and 505,000 operations with neither peak spreading nor UG3RD.

ACCOMMODATION OF GENERAL AVIATION

Table 4-6 demonstrates that overall 80 percent of general aviation operations in the year 2000 could be accommodated without exceeding the design standard of 4 minutes of average delay in hubs that provided an additional major new airport. This percentage ranges from 75 percent and 76 percent in scenarios 1 and 2, respectively, to 100 percent in scenarios 3 and 4. This accommodation is due to the lumpiness of capital investment in runways; that is, the number of additional runways must be one or two.

Tables 4-7 through 4-10 add similar calculations on the accommodation of general aviation in hubs without a major new airport, where the average delay criterion is 6 minutes rather than 4 minutes. Overall, 72 percent of general aviation operations could be accommodated in hubs without a major new airport, ranging from 51 percent in scenario 1, through 74 percent in scenarios 2 and 4, to 82 percent in scenario 3.

The percentage of general aviation operations accommodated in all hubs (both with and without a major new airport) would range as follows: 60 percent in scenario 1, 74 percent in scenario 2, 75 percent in scenario 4, and 84 percent in scenario 3, with the overall figure being 73 percent.

If advantage were taken of the construction of a major new airport to provide the necessary additional facilities for general aviation at much less cost per operation, the accommodation of general aviation would range from 70 percent in scenario 1, through 75 percent in scenario 4 and 78 percent in scenario 2, to 84 percent in scenario 3, with the overall figure being 77 percent. In scenario 1, 5 of the 10 new airports would require additional facilities to fully accommodate general aviation. In this case, 15 of the 21 hubs would fully accommodate general aviation while the remaining 6 hubs would accommodate 32 percent of general aviation activity. Hubs impacted would be Cleveland, Houston, Las Vegas, Miami, New Orleans, and San Diego. Of the general aviation activity not accommodated, 81 percent would be attributed to Cleveland, Miami, and New Orleans.

In scenario 2, one of the four new airports would require additional facilities to fully accommodate general aviation. In this case, 14 of the 21 hubs would fully accommodate general aviation while the remaining 7 hubs would accommodate 49 percent of general aviation activity. Hubs impacted would be

TABLE 4-6. ACCOMMODATION OF GENERAL AVIATION IN 2000 IN HUBS WITH NEW AIRPORTS

Operations, thousands

Hub	Resulting in 4-Minute Delay: Existing Airport(s)	Resulting in 4-Minute Delay: New Airport	Resulting in 4-Minute Delay: Total	Air Carrier and Air Taxi Activity	Surplus Capacity	General Aviation: Activity	General Aviation: Accommodated Number	General Aviation: Accommodated Percent
Scenario 1								
Atlanta	645	212	857	745	112	56	56	100
Boston	296	212	508	420	88	124	88	71
Chicago	632	212	844	761	83	50	50	100
Denver	345	212	557	442	115	166	115	69
Minneapolis	241	212	453	304	149	181	149	82
New York	819	505	1,324	1,261	63	186	63	34
Philadelphia	293	212	505	408	97	92	92	100
St. Louis	277	212	489	390	99	139	99	71
San Francisco	289	505	794	522	272	79	79	100
Seattle	235	212	447	295	152	55	55	100
Total	4,072	2,706	6,778	5,548	1,230	1,128	846	75
Scenario 2								
Boston	390	285	675	466	209	130	130	100
New York	1,170	285	1,455	1,399	56	209	56	27
Philadelphia	410	285	695	453	242	210	210	100
San Francisco	400	285	685	579	106	79	79	100
Total	2,370	1,140	3,510	2,897	613	628	475	76
Scenario 3								
Boston	390	285	675	420	255	124	124	100
New York	1,170	285	1,455	1,261	194	186	186	100
San Francisco	400	285	685	522	163	79	79	100
Total	1,960	855	2,815	2,203	612	389	389	100
Scenario 4								
San Francisco	296	242	538	400	138	43	43	100
Total	296	242	538	400	138	43	43	100
Grand Total	8,698	4,943	13,641	11,048	2,593	2,188	1,753	80

TABLE 4-7. ACCOMMODATION OF GENERAL AVIATION IN 2000 IN SCENARIO 1

Hub	Delay Criterion, minutes*	Operations, thousands					
		Resulting in Criterion Delay	Air Carrier and Air Taxi Activity	Surplus Capacity	General Aviation		
					Activity	Accommodated Number	Accommodated Percent
Atlanta	4	857	745	112	56	56	100
Boston	4	508	420	88	124	88	71
Chicago	4	844	761	83	50	50	100
Cleveland	6	284	275	9	181	9	5
Denver	4	557	442	115	166	115	69
Detroit	6		342		87	87	100
Honolulu	6		270		160	160	100
Houston	6	399	323	76	202	76	38
Las Vegas	6	381	220	161	169	161	95
Los Angeles	6		556		44	44	100
Miami	6	739	664	75	429	75	17
Minneapolis	4	453	304	149	181	149	82
New Orleans	6	249	230	19	219	19	9
New York	4	1,324	1,261	63	186	63	34
Philadelphia	4	505	408	97	92	92	100
Pittsburgh	6		460		60	60	100
St. Louis	4	489	390	99	139	99	71
San Diego	6	236	164	72	104	72	69
San Francisco	4	794	522	272	79	79	100
Seattle	4	447	295	152	55	55	100
Tampa	6		254		154	154	100
Subtotal	4		5,548		1,128	846	75
Subtotal	6		3,758		1,809	917	51
Total			9,306		2,937	1,763	60

*The delay criterion is 4 minutes for hubs with a new airport and 6 minutes for hubs without a new airport.

TABLE 4-8. ACCOMMODATION OF GENERAL AVIATION IN 2000 IN SCENARIO 2

Hub	Delay Criterion, minutes*	Operations, thousands: Resulting in Criterion Delay	Air Carrier and Air Taxi Activity	Surplus Capacity	General Aviation: Activity	Accommodated: Number	Accommodated: Percent
Atlanta	6		826		108	108	100
Boston	4	675	466	209	130	130	100
Chicago	6		842		50	50	100
Cleveland	6	465	305	160	181	160	88
Denver	6	612	489	123	166	123	74
Detroit	6		379		87	87	100
Honolulu	6		300		160	160	100
Houston	6		357		202	202	100
Las Vegas	6		245		283	283	100
Los Angeles	6		619		60	60	100
Miami	6	1,066	737	329	429	329	77
Minneapolis	6	348	337	11	287	11	4
New Orleans	6	300	255	45	219	45	21
New York	4	1,455	1,399	56	209	56	27
Philadelphia	4	695	453	242	210	210	100
Pittsburgh	6		511		169	169	100
St. Louis	6	438	433	5	165	5	3
San Diego	6		181		104	104	100
San Francisco	4	685	579	106	79	79	100
Seattle	6	416	328	88	113	88	78
Tampa	6		281		290	290	100
Subtotal	4		2,897		628	475	76
Subtotal	6		7,425		3,073	2,274	74
Total			10,322		3,701	2,749	74

*The delay criterion is 4 minutes for hubs with a new airport and 6 minutes for hubs without a new airport.

TABLE 4-9. ACCOMMODATION OF GENERAL AVIATION IN 2000 IN SCENARIO 3

Hub	Delay Criterion, minutes*	Operations, thousands: Resulting in Criterion Delay	Air Carrier and Air Taxi Activity	Surplus Capacity	General Aviation: Activity	General Aviation: Accommodated Number	General Aviation: Accommodated Percent
Atlanta	6		745		56	56	100
Boston	4	675	420	255	124	124	100
Chicago	6		761		50	50	100
Cleveland	6		275		181	181	100
Denver	6		442		166	166	100
Detroit	6		342		87	87	100
Honolulu	6		270		160	160	100
Houston	6		323		202	202	100
Las Vegas	6		220		169	169	100
Los Angeles	6		556		44	44	100
Miami	6	1,066	664	402	429	402	94
Minneapolis	6	348	304	44	181	44	24
New Orleans	6	300	230	70	219	70	32
New York	4	1,455	1,261	194	186	186	100
Philadelphia	6	439	408	31	92	31	34
Pittsburgh	6		460		60	60	100
St. Louis	6	438	390	48	139	48	35
San Diego	6		164		104	104	100
San Francisco	4	685	522	163	79	79	100
Seattle	6		295		55	55	100
Tampa	6		254		154	154	100
Subtotal	4		2,203		389	389	100
Subtotal	6		7,103		2,548	2,083	82
Total			9,306		2,937	2,472	84

*The delay criterion is 4 minutes for hubs with a new airport and 6 minutes for hubs without a new airport.

TABLE 4-10. ACCOMMODATION OF GENERAL AVIATION IN 2000 IN SCENARIO 4

Hub	Delay Criterion, minutes*	Operations, thousands: Resulting in Criterion Delay	Air Carrier and Air Taxi Activity	Surplus Capacity	General Aviation: Activity	General Aviation: Accommodated Number	General Aviation: Accommodated Percent
Atlanta	6		571		56	56	100
Boston	6	364	322	42	124	42	34
Chicago	6		582		50	50	100
Cleveland	6	329	211	118	181	118	65
Denver	6		338		65	65	100
Detroit	6		262		49	49	100
Honolulu	6		206		71	71	100
Houston	6		248		127	127	100
Las Vegas	6		167		169	169	100
Los Angeles	6		427		44	44	100
Miami	6	810	509	301	310	301	97
Minneapolis	6	293	232	61	181	61	34
New Orleans	6	283	176	107	109	107	98
New York	6	986	963	23	139	23	17
Philadelphia	6	324	312	12	92	12	13
Pittsburgh	6		351		60	60	100
St. Louis	6	312	298	14	120	14	12
San Diego	6		125		104	104	100
San Francisco	4	538	400	138	43	43	100
Seattle	6		226		55	55	100
Tampa	6		194		154	154	100
Subtotal	4		400		43	43	100
Subtotal	6		6,720		2,260	1,682	74
Total			7,120		2,303	1,725	75

*The delay criterion is 4 minutes for hubs with a new airport and 6 minutes for hubs without a new airport.

Cleveland, Denver, Miami, Minneapolis, New Orleans, St. Louis, and Seattle. Of the general aviation activity not accommodated, 76 percent would be associated with Minneapolis, New Orleans, and St. Louis.

In scenario 3, none of the three new airports would require additional facilities to fully accommodate general aviation. At 16 of the 21 hubs, general aviation would be fully accommodated while the remaining 5 hubs would accommodate 56 percent of general aviation activity. Hubs impacted would be Miami, Minneapolis, New Orleans, Philadelphia, and St. Louis. Of the general aviation activity not accommodated, 62 percent would be associated with Minneapolis and New Orleans.

In scenario 4, the single new airport would not require additional facilities to fully accommodate general aviation. At 13 of the 21 hubs, general aviation would be fully accommodated while the remaining 8 hubs would accommodate 54 percent of general aviation activity. Hubs impacted would be Boston, Cleveland, Miami, Minneapolis, New Orleans, New York, Philadelphia, and St. Louis. Of the general aviation activity not accommodated, 59 percent could be attributed to Minneapolis, New York, and St. Louis.

Including all general aviation operations would increase the number of hubs with capacity deficits in the year 2000 by five to eight, depending upon the scenario. Building an additional five to eight major new airports to accommodate general aviation activity to provide acceptable delays at the airports analyzed would not be prudent. An analysis of alternatives for accommodating general aviation activity at existing or new reliever airports should be accomplished prior to any firm decision to construct a major new airport.

CHAPTER 5. COSTS AND REVENUES

SECTION 1. NEW AIRPORT CAPITAL COSTS

DESIGN AIRPORTS

Utilization of Design Airports

In actual practice, development of a new major airport on a virgin site requires an enormous planning effort involving a vast amount of background data. Once this data has been collected, a number of alternative plans can be generated which will eventually result in the selection of a specific airport design, precisely tailored for the particular site in question. For the purposes of this study, however, such precise planning is not necessary in order to satisfy the objective of determining airport capital costs at the national level; it is sufficient to utilize design airports which can be developed to represent typical conditions and costs. This procedure will obviously introduce errors into the estimated cost of each hub airport, but it is safe to assume that these errors will substantially cancel out on the average in approximating the total cost of new airports in the hubs under study.

In selecting representative cost factors for the design airports, it is necessary to consider such site-dependent variables as access, site preparation, aircraft mix, atmospheric and wind conditions, and site altitude. Some of these variables are dependent on regional characteristics (i.e., aircraft mix) while others are a result of actual site selection, which in most hubs has not taken place. Therefore, unit costs are employed which will tend to compensate for all variables at a national level. For example, a long access road over difficult terrain at one airport would likely be balanced by a shorter simple access road at another site. Additionally, individual hub airport costs are refined by applying regional construction cost indices and land values.

The introduction of a design airport into any one of the hub areas will result in a major increase in that hub's air traffic capacity. In some areas, where introduction of a new airport would suddenly provide a great deal of surplus capacity, it could be argued that expansion of existing facilities would be a more cost-effective strategy. In this respect, the concept of a design airport represents an additional simplification. However, this simplification seems justified by the fact that capital costs associated with the expansion of existing facilities might very well approximate the costs of constructing a completely new facility.

Airport Configuration

The simplest type of airport configuration is the single runway, oriented to take advantage of prevailing winds for maximum operating efficiency. Since a large proportion of the potential new airport operations are air carrier, it was also deemed necessary to include a single parallel taxiway. This airfield configuration results in the capacity data provided in chapter 4 for a new single runway airport, as modified by the various scenarios. A runway length of 10,000 feet was selected, although in actual practice, take off runway length is determined by airport elevation, airport reference temperature, effective runway gradient, and gross takeoff weight of the design aircraft.

In order to substantially increase the capacity of a single runway airfield, it is necessary to add a second runway. This may result in several types of airport configurations, depending primarily on wind conditions and site limitations. In the absence of any specific site criteria, however, the most efficient design consists of double parallel runways separated by at least 5,000 feet to allow independent landings and take offs, again with parallel taxiways. The capacity data for this design is also given in chapter 4. It is, of course, entirely possible that crosswind conditions at some of the hub areas would dictate an airfield configuration different from this double parallel runway design. However, this divergence would not be likely to result in a serious loss in operating capacity nor would it have a significant impact on capital costs.

In addition to runways and taxiways, airfield design also includes provision for passenger and cargo terminal aprons and connecting taxiways. In the case of the single runway design, the terminal area is assumed to be located near the center of the runway, as close as possible to the main parallel taxiway. In the case of the double runway configuration, the terminal area is again situated near the center of the runways longitudinally, as well as being placed midway between runways in the transverse direction. This arrangement, being the most compact, offers the greatest efficiency in terms of pavement area and aircraft taxiing distance. The landside configuration of a design airport allows the planner a great deal more freedom of choice than the airside configuration, and for this reason development of a specific landside design is not considered practicable. The objective of a landside configuration is to provide a passenger and cargo capacity and an aircraft service capability which is at least adequate to prevent delay of aircraft operations on the airside. In the development of a new airport, this objective should normally be attainable, and, therefore, landside restrictions are not permitted to affect the operating capacity of design airports developed in this study. It is important to emphasize, however, that certain landside conditions can indeed impose severe stress on total airport capacity. These and other restraints, such as increased security precautions in passenger terminals and rising costs of building construction, will compete with airside restraints for priority in the evolution of new airport master plans.

Land Requirements

Once the basic airport configuration has been determined according to airport activity, it is possible to investigate the two major factors comprising capital costs. site development and construction costs. The first factor, site development, encompasses the processes of site selection, land acquisition, and basic site preparation, including grading and the provision of drainage. The initial task is obviously to determine the size of the site required for the design airports under consideration. In the early days of aviation, most airports were located near downtown areas, and site dimensions were determined directly by the operating characteristics of the airfield. The site boundaries included enough land for the terminal area, airfield, and space for clear zones and navigational aids adjacent to the runways. When an additional amount of land is added to allow for reasonable expansion, this area still gives us what might be considered the basic airport site. In the case of the single runway airport, this site is approximately 3,500 acres. However, due to the rapidly changing aircraft characteristics of the past 20 years, other constraints, particularly noise impacts, have greatly complicated the process of airport site planning. Federal legislation, in the form of the Airport and Airway Development Act of 1970 and the Environmental Policy Act of 1969, establishes requirements designed to protect the natural environment and local communities from the negative effects of airport development. These Federal requirements, coupled with local statutes and good planning practice, have led to the inclusion of buffer zones as part of the land requirements for all new major airports in the United States. An additional advantage of these buffer zones is that they allow airport authorities greater control over land use, a situation which has major benefits, for example in maintaining the obstruction clearances necessary for air navigation. In order to use airport property to the best advantage, it is sometimes possible to obtain revenue from these buffer zones by leasing out portions of the land for activities which are compatible with the airport environment.

A new airport can have serious impacts on air and water quality, ambient noise levels, and ecological processes. The master plan for each new airport site must address these environmental problems by identifying what the site-specific problems are, providing means to minimize or mitigate the adverse impacts, and preserving any outstanding ecological values of the site or beneficial impacts of the airport. To achieve this solution, each environmental factor must be studied in detail on a site-specific basis.

However, certain conclusions can be made about the effect of environmental values on airport size on a non-site-specific basis. Aircraft noise is usually the overriding environmental criterion for sizing an airport. The envelope of moderate residential noise impact for a large airport often covers 40 to 50 square miles. Severe noise impacts for such an airport can occur in areas of up to 20 square miles. Most other environmental criteria only affect relatively small areas. The only sure way to prevent incompatible land uses is for the major impact area to be within the airport site. Recent new airport plans have attempted to provide a buffer zone by including the area of severe noise impacts within the airport site boundaries. Examples of this type of solution are Dallas-Ft. Worth Airport which has an area of 17,500 acres, and Dulles Airport with 10,000 acres. An extreme case is the new Montreal Airport. In an attempt to both control noise impacts and land development it was necessary to use 90,000 acres for the site. Based on state-of-the-art noise data, the inclusion of the severe noise impact area within the airport boundaries requires a minimum total of about 8,000 acres for a single runway airport and about 12,000 acres for a dual runway airport. These figures can be modified on a site-specific basis by such factors as the presence of existing compatible land uses (i.e., waterways, industrial areas, etc.) that are not likely to change and, therefore, need not be purchased.

Another important environmental factor is water quality and domestic and industrial sewage. Water and waste treatment facilities may require land in areas that may not be within the noise impact area. For example, an on-site solid waste disposal site should be located away from flight paths to prevent safety problems with birds. Air pollution impacts are not as extensive as the noise impacts, and will usually be restricted to inside the area chosen on a noise criteria basis. However, individual sites must be analyzed to confirm this assumption.

The importance of a buffer zone extends beyond these specific environmental considerations. A buffer zone can act as a land bank for future compatible industrial land development, and produce revenues for the airport. It can act as a natural resource by providing areas of open space for recreation, wildlife, etc. In addition, the buffer zone can mitigate the sociological impacts of the airport by making the physical characteristics of the airport as unobtrusive as possible.

While environmental impact is the major element acting to increase airport land requirements, an opposite effect is exerted by the influence of rising land costs in the vicinity of major airports, which tends to limit airport size. At the same time, both of these factors also act in concert to propel airport sites away from urban centers into rural areas, where population is dispersed and hence noise impacts are minimized and assemblage of real estate becomes easier and less expensive. But this tendency is again counter-balanced by the inconvenience and costs associated with longer access routes from hub center to airport. All of these various factors form a complex web which can only be unravelled by exhaustive research and public discussion. Therefore, this study will not attempt more than a very preliminary assumption as to new airport site location and size, except for those hubs in which favored sites for new airports have already been identified. The general site areas which have been selected are 8,000 acres for a single runway design airport and 12,000 acres for a double runway design airport.

The site location is hypothetically set at 30 miles from the CBD, which in turn would entail an average of 10 miles of highway to connect with the existing road system. Total costs of airport access could result in somewhat higher figures than are used in this study, especially if rail rapid transit is developed as an alternate travel mode. However, through proper planning, the costs of airport access can be shared by other activities which benefit from increased transportation availability, thus reducing capital costs actually attributable to airport development.

In determining land area requirements for a new airport, the possibility of future expansion may indicate the advisability of purchasing an excess amount of property during initial development. This practice is particularly necessary at hubs where plans call for the existing airport eventually to be completely replaced by a new airport. Since none of the 10 hubs in question has actually adopted such a measure, however, this report will not attempt to anticipate future policy. The site areas selected permit a generous amount of space for expansion of facilities but do not extend into the realm of land banking. Of course, at certain hubs, preliminary site selection has already been made and these site areas are adopted intact. Refer to chapter 7 for a further discussion of existing airport relocation.

Two other factors which impact on site development costs are availability of utilities and geophysical obstacles to construction. As in the case of access costs, utility costs will be aggravated by the selection of a site remote from the existing urban infrastructure. A hypothetical distance of 10 miles was chosen for transmission of electric power, fuel, water, sewage disposal, etc.

Airport site selection is greatly dependent on the condition of the natural terrain. Not only must the vicinity be free of hazards to air navigation, but also sites which contain obstacles to construction, such as hills or swamp areas, should be avoided. In order to substantially reduce land acquisition costs and noise impacts, several of the hubs have considered proposals to build new airports over water. While this strategy may someday be economically feasible, it is not likely that such proposals will be acted upon before the year 2000. For the purposes of this study, it was assumed that a careful site selection process would eliminate the possibility of excessive site preparation costs.

NEW AIRPORT CAPITAL COSTS

Land Acquisition Costs

Since land acquisition costs account for the greatest fluctuation in new airport design costs, they will be discussed in further detail. A summary is provided in table 5-1.

a. Atlanta - The city of Atlanta purchased 10,000 acres with as yet undetermined boundaries out of a 40,000-acre site assembled and owned by Adelphi Corporation in July 1975. The city had 30 months to identify the precise parcel they wish to use. The land was purchased at the price of $987 per acre for a total of approximately $10 million.

b. Boston - Previous studies have identified four possible sites including an Air Force base which could probably be obtained at minimal cost. The extent of settlement in Massachusetts is such that the availability of an undeveloped tract of 5,000 to 10,000 acres is highly unlikely. It is likely that significant residential relocation would be required which would have a great impact on land acquisition costs. The bottom range of costs was estimated to be $5,000 to $10,000 per acre. The latter price is used based on the considerations noted above.

c. Chicago - Five years ago a number of potential sites were identified. One site was in Greengarden Township, Will County, Illinois. Rural land in Will County is now selling at $4,000 per acre.

d. Denver - Denver is actively considering the possibility of a new airport. No site has been selected. However, the best general location seems to be east of Denver in the dry land farming belt, well away from the mountains. No development pressures are expected east of Denver due to the inhospitality of the area. Maximum land costs would be in the range of $500 per acre.

e. Minneapolis - A site search area north of the Twin Cities has been identified. Land costs in this area are expected to be $3,000 per acre.

f. New York - Studies have highlighted the virtual impracticality of a new airport in the New York metropolitan area, primarily due to environmental considerations. This relief must be provided by increased use of outlying airports. Of these, Stewart Airport is considered to have the potential for providing at least a portion of this relief by virtue of its existing land availability and location with respect to projected regional growth.

g. Philadelphia - Philadelphia has no potential sites identified. Property values typical of outer Bucks and Chester Counties, which are about 30 miles from the CBD, are $10,000 per acre.

h. St. Louis - A new 18,650-acre site had been selected in Monroe County, Illinois. Land is expected to cost in the range of $900 to $1,500 per acre, with the latter value being used here.

TABLE 5-1. LAND ACQUISITION COSTS

Hub	Runways	Area, acres			Thousands of 1976 dollars	
		Total	Access road	Site	Price per acre	Total cost
Atlanta	1	10,250	250	10,000*	1.0	10,250
Boston	1	8,250	250	8,000	10.0	82,500
Chicago	1	8,250	250	8,000	4.0	33,000
Denver	1	8,250	250	8,000	0.5	4,125
Minneapolis	1	8,250	250	8,000	3.0	24,750
New York	2	12,000	--	1,500*	0.0	
				8,600*	4.2	
				1,900	5.0	45,620
	1	10,100	--	1,500*	0.0	
				8,600*	4.2	36,120
Philadelphia	1	8,250	250	8,000	10.0	82,500
St. Louis	1	18,900	250	18,650	1.5	28,350
San Francisco	2	12,000	--	12,000	5.0	60,000
	1	8,000	--	8,000	5.0	40,000
Seattle	1	8,250	250	8,000	5.0	41,250

*Acquired.

i. San Francisco - Marin County has applied to the U.S. General Services Administration to acquire Hamilton Air Force Base and intends to restrict it to commuter traffic for at least 5 years. Typical prices for land on the suburban fringe of the urban area are estimated at $3,000 to $5,000 per acre, with the latter value being used here.

j. Seattle - Seattle presently has no active plans for a new air carrier airport. Northeast King County was identified as a good hypothetical site for an airport. Typical land costs can be estimated at $5,000 per acre.

Construction Costs

Once a site has been acquired and basic site preparation (excavation, fill, grading) has been accomplished, actual construction can begin. The costs of airfield development are derived from the airfield configuration and associated navigational aids and are given in table 5-2. Runway and taxiway lengths were discussed in a preceding paragraph, while widths are determined by FAA regulations. The dimensions of terminal aprons are more flexible, being a product of aircraft mix and passenger and cargo processing concepts. A typical apron area can be approximated using a linear gate system with 20 to 25 gates and 15 to 20 remote parking positions accommodating Group II aircraft (DC-10, L-1011), doubling these figures for a double runway airfield. As aircraft mix varies, the number of gates will tend to increase while gate dimensions decrease. Navigational aids (airfield lighting, ILS, and air traffic control electronic equipment) are based on requirements for Category II flight operations.

There are several formulas available for estimating gross terminal building area, although in practice, wide variations exist depending on local conditions. The most important criterion is the number of "typical peak-hour passengers" which is normally a function of aircraft mix, flight scheduling, and the number of annual enplanements. Other considerations are the ratio between domestic and international traffic, the type of passenger-to-aircraft connection (loading bridge, passenger transfer vehicle, etc.), the amount of commercial space, and management's policy with regard to future expansion. While this study provides an indication of the number of annual enplanements at each new airport through the year 2000, the many variables mentioned above make an accurate prediction of individual hub terminal areas impractical. Instead, an overall average of annual enplanements, used with the formulas given in chapter 2 and adjusted for actual construction experience, provide an estimate of design terminal area. Design cargo terminal areas were arrived at in a similar manner.

Access costs at new airports are a function of such factors as modal choice, the passenger-visitor ratio, number of employees, and passenger volume. Modal choice describes the percentage of passengers utilizing the available transportation modes: bus, limousine, private auto, taxi, rental car, rapid transit, helicopter, etc. The private auto continues to be the primary transportation mode for airline passengers in the United States. This fact indicates a four-lane access highway to the airport with an additional four lanes provided at terminal curbs for originating passengers. Parking space requirements for passengers, visitors, and employees are determined according to the formulas given in chapter 2. Airport service roads comprise the final component of airport access costs.

A breakdown of airport utility elements is given in table 5-2 for both design airports. The primary capital costs of utility installation are those associated with long-distance transmission, as discussed above.

TABLE 5-2. DESIGN AIRPORT BUILDING AND CONSTRUCTION COSTS
(1976 dollars)

		Cost, thousands			Federal Participation			
					Rate, percent		Amount, thousands	
	Cost per Unit	Single Runway	Double Runway	Eligible Portion, percent	Of Eligible Portion	Of Total	Single Runway	Double Runway
Construction								
Runway	$4.75/sq. ft.	$ 9,500	$ 19,000	100	75	75	$ 7,125	$ 14,250
Runway shoulder	1.40/sq. ft.	700	1,400	100	75	75	525	1,050
Taxiway	4.75/sq. ft.	6,175	12,350	100	75	75	4,631	9,262
Taxiway shoulder	1.40/sq. ft.	1,400	2,800	100	75	75	1,050	2,100
Connecting taxiway	4.75/sq. ft.	475	2,850	100	75	75	356	2,138
Connecting taxiway shoulder	1.40/sq. ft.	126	700	100	75	75	94	525
Terminal apron	4.75/sq. ft.	14,250	28,500	100	75	75	10,688	21,375
Terminal apron shoulder	1.40/sq. ft.	280	560	100	75	75	210	420
Cargo apron	4.75/sq. ft.	712	1,425	100	75	75	534	1,069
Cargo apron shoulder	1.40/sq. ft.	42	84	100	75	75	32	63
Airfield lighting		3,000	5,000	100	75	75	2,250	3,750
Navaids and communications		4,000	4,500	100	75	75	3,000	3,375
Aircraft fuel system		1,720	1,900	0		0	0	0
Access road (4 lanes)	2,400,000/mi.	24,000	24,000	100	75	75	18,000	18,000
Public road (4 lanes)	1,600,000/mi.	1,600	2,400	100	75	75	1,200	1,800
Service road (2 lanes)	1,000,000/mi.	6,000	8,000	100	75	75	4,500	6,000
Automobile parking	3.15/sq. ft.	12,600	25,200	0		0	0	0
Landscaping and fencing		3,000	4,000	100	75	75	2,250	3,000
Power distribution		2,500	4,000	36	75	27	675	1,080
Water distribution		4,500	5,500	8	75	6	270	330
Sanitary collection		4,000	4,500	36	75	27	1,080	1,215
Telephone distribution		1,500	1,800	36	75	27	405	486
Total Construction		$102,080	$160,469				$58,875	$ 91,288
Buildings								
Control tower		4,000	4,000	100	100	100	4,000	4,000
Passenger terminal	110/sq. ft.	77,000	132,000	36	50	18	13,860	23,760
Cargo terminal	60/sq. ft.	6,000	12,000	0		0	0	0
Operation	60/sq. ft.	2,400	3,600	8	75	6	144	216
Fire, crash, and rescue	50/sq. ft.	1,000	1,000	100	75	75	750	750
Total Buildings		$ 90,400	$152,600				$18,754	$ 28,726
Total		$192,480	$313,069				$77,629	$120,014

As is usual in construction estimates, a contingency factor of 10 percent is applied to the basic construction cost total. To this figure is applied a 15 percent factor, which represents the costs of planning, design, engineering, and contract administration. Table 5-2 also gives the Federal participation in each kind of cost in the absence of the present limitation of $10 million annually to any one airport.

Total Costs by Hub

Table 5-3 uses regional cost indices to apply the design airport costs of table 5-2 to each hub. Also given in table 5-3 are the land costs and Federal participation in land costs at a rate of 75 percent. Total costs range from $2.6 billion in scenario 1 to $0.2 billion in scenario 4. Federal participation ranges from $1.2 billion in scenario 1 to $0.1 billion in scenario 4.

SECTION 2. COMPARISON OF CAPITAL COSTS WITH DELAY REDUCTION BENEFITS

Table 5-4 develops a comparison of capital costs with delay reduction benefits. Since the airport system in a hub is assumed to be designed for an average delay of 4 minutes if there is a persistent capacity deficiency, and since no more traffic is assumed to be diverted than that traffic necessary to bring the existing airport down to an average delay of 4 minutes, the average delay at the new airport will be 4 minutes or less. It is assumed that the average delay will be 4 minutes at the new airport and consequently throughout the hub.

It is also assumed that the reduction in delay will be constant throughout the life of the new airport. The reduction in average delay will be the difference between 4 minutes and the estimated average delay for the year of capacity deficiency. If the life of the new airport is 25 years, the value of the delay reduction over the entire airport life at a point 2.5 years before the year of capacity deficiency is 7.5 times the annual delay reduction, using the discount rate of 10 percent. The point 2.5 years before the year of capacity deficiency and hence of airport opening is assumed to be the midpoint of construction.

The reduction in total aircraft delay is the reduction in average delay multiplied by the number of aircraft operations, and is valued at $700 per hour. The reduction in total passenger delay is the reduction in average delay multiplied by the number of passengers (including through passengers), and is valued at $12.50 per hour. It is then possible to compare the total value of delay reduction with the total capital cost of a new airport.

Table 5-4 gives a break-even average delay, which is the average delay at the existing airport(s) without a new airport that equates the delay reduction benefit to capital costs. The last column of the table gives the ratio of the delay reduction benefit to the construction costs, which is algebraically equivalent to the difference between the estimated delay and 4 minutes divided by the difference between the break-even delay and 4 minutes.

The break-even delay was greater than the estimated delay in four cases, three of which were scenario 1 in Boston in 1985, scenario 2 in San Francisco in 1985, and scenario 2 in Boston in 1995. In these three cases the analysis was repeated for 5 years later, with the result that the break-even delay became less than the

TABLE 5-3. NEW AIRPORT CAPITAL COSTS BY HUB

Hub	Runways	Regional Cost Indices[a]		New Airport Capital Costs, millions of 1976 dollars							
				Construction		Buildings		Land		Total	
		Construction	Buildings	Total	Federal	Total	Federal	Total	Federal[b]	Total	Federal
Scenario 1											
Atlanta	1	239	222	107.0	61.7	90.4	18.8	10.2	7.6	207.6	88.1
Boston	1	222	221	99.4	57.3	90.0	18.7	82.5	61.9	271.9	137.9
Chicago	1	214	206	95.8	55.3	83.9	17.4	33.0	24.8	212.7	97.5
Denver	1	222	224	99.4	57.3	91.2	18.9	4.1	3.1	194.7	79.3
Minneapolis	1	222	216	99.4	57.3	88.0	18.2	24.8	18.6	212.2	94.1
New York	2	214	219	150.6	85.7	150.5	28.3	45.6	34.2	346.7	148.2
Philadelphia	1	247	226	110.6	63.8	92.0	19.1	82.5	61.9	285.1	144.8
St. Louis	1	230	210	103.0	59.4	85.5	17.7	28.4	21.3	216.9	98.4
San Francisco	2	228	250	160.5	91.3	171.8	32.3	60.0	45.0	392.3	168.6
Seattle	1	238	230	106.6	61.5	93.7	19.4	41.2	30.9	241.5	111.8
Total		228[c]	222[c]	1,132.3	650.6	1,037.0	208.8	412.3	309.3	2,581.6	1,168.7
Scenario 2											
Boston	1	222	221	99.4	57.3	90.0	18.7	82.5	61.9	271.9	137.9
New York	1	214	219	95.8	55.3	89.2	18.5	36.1	27.1	221.1	100.9
Philadelphia	1	247	226	110.6	63.8	92.0	19.1	82.5	61.9	285.1	144.8
San Francisco	1	228	250	102.1	58.9	101.8	21.1	40.0	30.0	243.9	110.0
Total		228[c]	222[c]	407.9	235.3	373.0	77.4	241.1	180.9	1,022.0	493.6
Scenario 3											
Boston	1	222	221	99.4	57.3	90.0	18.7	82.5	61.9	271.9	137.9
New York	1	214	219	95.8	55.3	89.2	18.5	36.1	27.1	221.1	100.9
San Francisco	1	228	250	102.1	58.9	101.8	21.1	40.0	30.0	243.9	110.0
Total		228[c]	222[c]	297.3	171.5	281.0	58.3	158.6	119.0	736.9	348.8
Scenario 4											
San Francisco	1	228	250	102.1	58.9	101.8	21.1	40.0	30.0	243.9	110.0
Total		228[c]	222[c]	102.1	58.9	101.8	21.1	40.0	30.0	243.9	110.0

[a]Indices for March 1977 from 25 March 1977 issue of Engineering News Record, p. 68-69.

[b]75 percent of total.

[c]Average of the indices for the 10 hubs.

TABLE 5-4. COMPARISON OF CAPITAL COSTS WITH DELAY REDUCTION BENEFITS

Hub	Capacity deficit	New airport capital cost, millions of 1976 dollars	Air carrier and air taxi: Operations, thousands	Air carrier and air taxi: Enplanements and deplanements, millions	Through passengers as percent of total	Average delay, minutes: Break-even[a]	Average delay, minutes: Estimated	Ratio of delay reduction benefit[b] to capital costs
Scenario 1								
New York	1985	346.7	1,045	71	3	5.7	24.7	12.2
Chicago	1985	212.7	743	49	4	5.5	12.4	5.6
San Francisco	1985	392.3	417	27	4	8.9	25.7	4.4
Atlanta	1995	207.6	699	59	4	5.3	7.6	2.8
Boston	1990[c]	271.9	360	24	4	7.9	12.5	2.2
Minneapolis	2000	212.2	304	18	5	7.8	11.4	1.9
Seattle	2000	241.5	295	16	8	8.6	10.0	1.3
Denver	1995	194.7	391	27	8	6.4	7.0	1.2
Philadelphia	1990	285.1	348	18	9	8.6	9.7	1.2
St. Louis	1990	216.9	323	21	11	7.3	7.6	1.1
Total		2,581.6						3.8
Scenario 2								
New York	1995	221.1	1,300	117	3	4.7	10.9	9.9
San Francisco	1990[c]	243.9	507	39	4	6.3	15.2	4.9
Boston	2000[c]	271.9	466	43	4	6.5	11.6	3.0
Philadelphia	2000	285.1	453	35	9	6.9	6.9	1.0
Total		1,022.0						4.4
Scenario 3								
New York	2000	221.1	1,261	105	3	4.8	8.2	5.2
San Francisco	1990	243.9	476	33	4	6.6	10.5	2.5
Boston	2000	271.9	420	33	4	7.0	6.4	0.8
Total[d]		465.0						3.8
Scenario 4								
San Francisco	1985	243.9	375	24	4	7.4	10.5	1.9
Total		243.9						1.9

[a]Average delay at which delay reduction benefit[b] equals capital costs.
[b]Value at midpoint of construction of reduction in annual delay costs. See text for specific assumptions.
[c]Ratio of delay reduction benefit[b] to capital costs is less than one, five years earlier.
[d]Excludes Boston.

estimated delay. In the case of scenario 3 in Boston in 2000, it was not possible to shift the analysis 5 years later, with the result that this case was dropped from the totals and excluded from further analysis.

SECTION 3. AIRPORT FINANCING

Undertaking construction of a major new airport or substantially enlarging an existing airport is a capital-intensive effort requiring a relatively long lead time. Not only must the project be adequately planned, but adequate funds to finance the project are mandatory.

The analysis in section 1 indicates that if the percentage of Federal participation in airport projects now legislated continues into the period when major new airports are constructed, well over half of the cost burden will be placed upon local sponsors and states.

Private capital has been the primary lender for civil airport development in the past, accounting for approximately 43 percent of funds raised from all sources for large airports. For the most part, these funds are raised through the sale of general obligation and revenue bonds.

General obligation bonds carry the full faith and credit of the issuer. Revenues to service a general obligation bond issue come from all the taxes and income of the local government. This results in lower interest rates (tax-exempt to investors).

General obligation bonds become part of the outstanding debt of the local community, and this has several ramifications. First, there is usually a statutory debt limit which the local government cannot exceed. A common limitation is that debt cannot exceed a given percentage, say 2, 5, or 10 percent, of the valuation of taxable property in the community.

If statutory limits have been reached, or governments desire to reserve any remaining margin for other local public works, general obligation bond financing of airport projects is precluded. If the debt ceiling is raised to accommodate additional airport bond issues, the credit rating of the government may be affected, resulting in higher interest costs. Because fiscal pressures on local governments for all types of activities have been increasing, debt ceilings and priorities of other public work projects probably constitute the most significant problem for general obligation bond financing. However, there are also several forms of psychological limitations such as adverse taxpayer reaction to more public debt. When general obligation bonds became less popular, the concept of revenue bonds was developed.

Revenue bonds for airport development do not constitute a debt of the local government. They are sold in the private capital market on the premise that revenues from the airport will be sufficient to cover interest and capital repayment of the bond over the period of the loan. Because they do not require pledge of the faith and credit of the state or municipality, revenue bonds do not normally impinge on local statutory debt limitations. Generally, the only limitations are economic ones, that is, how large a debt revenues will support. Large-scale financing through revenue bonds may also have problems in the future. A past record of proven earnings and good management is the best basis for selling revenue bonds. This limitation is either in the form of unmarketability or high interest rates, or both. Another limiting factor can be the ability of the airlines to guarantee revenues for revenue bonds. While this has been a common practice in the past, the current financial posture of the airlines casts some doubt on their future ability to continue the practice.

One possibility in this regard is for the Federal Government to guarantee revenue bonds. This would reduce the liability of the airlines and reduce interest rates somewhat. On the other hand, the Federal role would become more pronounced, and probably only specific items of development would be eligible for funding with federally guaranteed bonds.

Any discussion of this source of capital immediately raises the issue of the capability of state and local government to raise funds for airport development. Available information indicates that air carrier airports are generally unable to generate sufficient operating revenues to meet operating expenses and support moderate capital improvements unless annual enplanements exceed 275,000. The cost of major airport development cannot usually be met by revenues at airports with less than 2 million annual enplanements.

Significant amounts of funds might not be available from revenues from existing airports to fund new large airports. One exception to this could be the establishment of a head tax or ad valorem tax at an existing airport(s) to help fund a new airport. Even at a very busy airport with 10 million annual enplanements, a $1 tax would require 10 years to generate $100 million.

One unexplored area is the ability and willingness of states to assist in establishing new airports. At the present time, state budgets for airport development vary from nothing at all to several million dollars annually. It appears that one way states could help is through the existing revenue sharing program authorized by the State and Local Fiscal Assistance Act of 1972 (P.L.93-512). This Act is funded through a specially created trust fund, which is authorized to be allocated among the states for "priority expenditures." One of the priority expenditures listed in the Act is public transportation, presumably including airports.

Several options for Federal assistance are possible. Some of these are:

Federal Grant-in-Aid Program

If up to $2 billion were required for new airports in the next 20 years and the Federal Government provided 75 percent of that cost through a separate program for large airports, the required average Federal level of funding would be $75 million per year.

Federal Loans

Federal funds, either from the general fund or the trust fund, could be used to grant loans to airport operators to construct major new airports. These loans would be similar to and replace general obligation or revenue bonds. This method may be attractive if private investors cannot be convinced that revenues from new airports will become available within a reasonable time. Federal loans could possibly be paid off either from airport revenues or by applying future grants against them.

Federal Grants for Debt Service

Large amounts of private capital could be made available if the Federal Government were to make grants to pay the debt service on the loans. The attractiveness of this proposal is that it permits a large amount of construction for a relatively small expenditure. On the other hand, this technique commits the Federal Government to a long term obligation.

Loan Guarantees

General obligation and/or revenue bonds could be made more marketable by the Federal Government guaranteeing payment. A precedent for this option exists in the aircraft loan guarantee program. Unless airport operators defaulted on bond payment obligations, this option would not require any increase in Federal taxes.

SECTION 4. OPERATING SURPLUSES AND BOND COVERAGE

Table 5-5 includes estimates of the sum of the operating surpluses at the present airport(s) studied plus a new airport in a given hub. These estimates are based upon a least squares regression developed for an HNTB master plan:[1]

$$S = 1.505\ E - 91{,}586$$

where S denotes operating surplus in 1971 dollars and E denotes enplaned passengers. This equation fits 89 percent of the variation in data for 92 air carrier airports. Operating surpluses were put into 1971 dollars using the implicit price deflator of state and local government purchases of goods and services. According to the Bureau of Economic Analysis, the 1971 and 1976 deflators are now 94.5 and 138.7, respectively, which can be used to put the equation into 1976 dollars:

$$S = 2.209\ E - 134{,}423$$

According to this equation, operating surplus is zero when enplaned passengers are approximately 61,000. This equation implies that operating surplus per enplaned passenger increases as the number of enplaned passengers increase.

An operating surplus in table 5-5 is the estimate for the year given. Also shown in the table is the local share of the new airport capital costs. These costs are centered 2.5 years before the opening of the new airport. A bond is posited that covers the capital costs and grows at a given rate of interest for 2 years. The bond then is repaid in equal annual payments for a period equal to a given economic life of the new airport. The bond payments for the case of 10 percent interest and an airport economic life of 25 years are given in table 5-5. If the operating surpluses devoted to the retirement of these bonds are assumed to remain constant for the economic life of the new airport, the coverages of the bond payments (the ratio of the operating surpluses to the bond payments) are as given in the table. Increases in the operating surpluses at both the old and new airports can then be devoted to capital replacement at the old airport(s).

[1]Howard, Needles, Tammen & Bergendoff, Burlington International Airport Master Plan: Technical Report (Burlington: City of Burlington, April 1975).

TABLE 5-5. BOND COVERAGE

Hub	Year	Local share of new airport capital costs, millions of 1976 dollars	Existing airport(s) studied plus new airport: Operating surpluses, Millions of 1976 dollars	Operating surpluses, As percent of bond payments*	Bond payments,* millions of 1976 dollars
Scenario 1					
New York	1985	198.5	77.9	294	26.5
Chicago	1985	115.2	53.9	351	15.4
San Francisco	1985	223.7	29.6	99	29.8
Atlanta	1995	119.5	64.9	407	15.9
Boston	1990	134.0	26.2	147	17.9
Minneapolis	2000	59.0**	19.6	249	7.9
Seattle	2000	129.7	17.4	101	17.3
Denver	1995	115.4	29.6	192	15.4
Philadelphia	1990	140.3	19.6	105	18.7
St. Louis	1990	118.5	22.9	145	15.8
Total			361.5	200	180.5
Scenario 2					
New York	1995	120.2	128.7	803	16.0
San Francisco	1990	133.9	42.8	240	17.8
Boston	2000	134.0	47.2	264	17.9
Philadelphia	2000	140.3	38.4	205	18.7
Total			257.1	365	70.4
Scenario 3					
New York	2000	120.2	115.4	720	16.0
San Francisco	1990	133.9	36.2	203	17.8
Total			151.6	448	33.9
Scenario 4					
San Francisco	1985	133.9	26.2	147	17.8
Total			26.2	147	17.8

* Equal annual payments for 25 years at 10 percent on a bond to finance the local share of new airport capital costs.

** State pays one-half of non-Federal share.

Table 5-5 estimates that for all hubs in a given scenario, the coverage is well above the 125 percent requirement for a successful revenue bond. The only exceptions to this are San Francisco, Seattle, and Philadelphia in scenario 1. Table 5-6 gives the coverages for all hubs combined in scenarios 1 through 4. The range of interest rates is from 2 to 20 percent and the range of airport economic lives is 10 years to 40 years. The pattern indicates that, in scenario 1, coverage is greater than 125 percent for any interest rate less than 12 percent. In scenarios 2 and 3, every coverage calculated is greater than 125 percent. In scenario 4, where the only new airport is in San Francisco, the coverage is greater than 125 percent for interest rates less than 8 percent.

While the Federal share (table 5-3) is never more than the amount in the trust fund that is estimated to be in excess of the requirements of existing programs, it is of interest to examine the case where there is a $10 million limitation on annual Federal aid to any one airport. If it is assumed that airport construction takes place over 5 years and that the Federal share is the maximum of $10 million every year, tables 5-7 and 5-8 present the corresponding estimates for this case. The coverages in table 5-7 (25 years and 10 percent) are still generally greater than 125 percent, but with more exceptions, especially scenario 4, where the only new airport is in San Francisco. Table 5-8 indicates that the coverage for all hubs combined in scenario 1 would be less than 125 percent for very short airport lives, except for equally low interest rates. Otherwise, the results are generally the same.

If there were no Federal participation, the corresponding estimates are given in tables 5-9 and 5-10. The coverages in table 5-9 (25 years and 10 percent) are still often greater than 125 percent, but the exceptions are even more numerous and more serious. Table 5-10 indicates that the coverage for all hubs combined in scenarios 1 or 4 would be less than 125 percent unless interest rates were relatively low.

If there were no limitation on Federal participation at the rates given in table 5-2, revenue bond financing would be feasible with a few exceptions. If there were a $10 million limitation on annual Federal participation, the exceptions would be more numerous. In some instances, guarantees of the bonds would suffice. But in more instances, what would be required would be more financing (as opposed to merely guaranteeing or lending) from the state and/or the local governments. If there were no Federal participation, the exceptions would be even more numerous and more serious. Some kind of assistance would be required more often than not, usually financing rather than merely guaranteeing or lending.

TABLE 5-6. BOND COVERAGE (PERCENT) BY INTEREST RATE AND AIRPORT LIFE

Rate of interest, percent	Airport life, years						
	10	15	20	25	30	35	40
Scenario 1							
2	231	330	420	501	575	642	702
4	200	275	336	386	427	461	489
6	175	231	273	304	327	345	358
8	154	196	225	244	258	267	273
10	136	168	188	200	208	213	216
12	120	145	159	167	171	174	175
14	107	126	136	141	144	145	146
16	96	111	118	121	123	123	124
18	86	98	103	105	106	106	106
20	78	87	90	92	92	93	93
Scenario 2							
2	420	601	765	913	1047	1169	1279
4	365	500	611	703	778	840	890
6	319	421	497	554	596	628	652
8	280	357	410	445	470	486	497
10	247	306	342	365	379	388	393
12	219	264	290	304	312	317	320
14	195	230	248	257	262	265	266
16	175	202	214	220	223	225	225
18	157	178	187	191	193	194	194
20	142	158	165	167	168	169	169
Scenario 3							
2	515	737	938	1120	1284	1434	1569
4	447	613	750	862	954	1030	1092
6	391	516	609	679	731	770	799
8	343	438	502	546	576	596	610
10	303	375	420	448	465	476	482
12	269	324	355	373	383	389	392
14	239	282	304	316	322	325	326
16	214	247	263	270	274	276	276
18	193	218	229	234	236	237	238
20	174	194	202	205	206	207	207
Scenario 4							
2	169	242	308	368	422	471	515
4	147	201	246	283	313	338	359
6	128	169	200	223	240	253	262
8	113	144	165	179	189	196	200
10	100	123	138	147	153	156	158
12	88	106	117	123	126	128	129
14	79	93	100	104	106	107	107
16	70	81	86	89	90	91	91
18	63	72	75	77	78	78	78
20	57	64	66	67	68	68	68

TABLE 5-7. BOND COVERAGE WITH FEDERAL LIMITATION
(Limit of $10 million on annual Federal participation)

Hub	Year	Local share of new airport capital costs, millions of 1976 dollars	Existing airport(s) studied plus new airport: Operating surpluses, Millions of 1976 dollars	Operating surpluses, As percent of bond payments*	Bond payments,* millions of 1976 dollars
Scenario 1					
New York	1985	296.7	77.9	197	39.6
Chicago	1985	162.7	53.9	248	21.7
San Francisco	1985	342.3	29.6	65	45.6
Atlanta	1995	157.6	64.9	309	21.0
Boston	1990	221.9	26.2	89	29.6
Minneapolis	2000	81.1**	19.6	181	10.8
Seattle	2000	191.5	17.4	68	25.5
Denver	1995	144.7	29.6	153	19.3
Philadelphia	1990	235.1	19.6	63	31.3
St. Louis	1990	166.9	22.9	103	22.2
Total			361.5	136	266.7
Scenario 2					
New York	1995	171.1	128.7	564	22.8
San Francisco	1990	193.9	42.8	166	25.8
Boston	2000	221.9	47.2	160	29.6
Philadelphia	2000	235.1	38.4	122	31.3
Total			257.1	235	109.6
Scenario 3					
New York	2000	171.1	115.4	506	22.8
San Francisco	1990	193.9	36.2	140	25.8
Total			151.6	312	48.7
Scenario 4					
San Francisco	1985	193.9	26.2	102	25.8
Total			26.2	102	25.8

* Equal annual payments for 25 years at 10 percent on a bond to finance the local share of new airport capital costs.

** State pays one-half of non-Federal share.

TABLE 5-8. BOND COVERAGE (PERCENT) BY INTEREST RATE AND AIRPORT LIFE WITH FEDERAL LIMITATION
(Limit of $10 million on annual Federal participation)

Rate of interest, percent	Airport life, years						
	10	15	20	25	30	35	40
Scenario 1							
2	156	223	284	339	389	434	475
4	136	186	227	261	289	312	331
6	118	156	184	206	221	233	242
8	104	133	152	165	174	181	185
10	92	114	127	136	141	144	146
12	81	98	108	113	116	118	119
14	73	85	92	96	97	98	99
16	65	75	80	82	83	83	84
18	58	66	69	71	72	72	72
20	53	59	61	62	62	63	63
Scenario 2							
2	270	386	492	587	673	752	822
4	235	322	393	452	500	540	572
6	205	270	319	356	383	404	419
8	180	230	263	286	302	313	320
10	159	197	220	235	244	249	253
12	141	170	186	196	201	204	206
14	126	148	159	165	169	170	171
16	112	130	138	142	144	144	145
18	101	114	120	123	124	124	125
20	91	102	106	107	108	108	109
Scenario 3							
2	359	513	653	779	894	998	1092
4	311	427	522	600	664	717	760
6	272	359	424	473	509	536	556
8	239	305	350	380	401	415	425
10	211	261	292	312	324	331	336
12	187	226	247	260	267	271	273
14	167	196	212	220	224	226	227
16	149	172	183	188	191	192	192
18	134	152	160	163	165	165	166
20	121	135	140	143	144	144	144
Scenario 4							
2	117	167	213	254	291	325	356
4	101	139	170	195	216	234	248
6	89	117	138	154	166	175	181
8	78	99	114	124	131	135	138
10	69	85	95	102	105	108	109
12	61	73	81	85	87	88	89
14	54	64	69	72	73	74	74
16	49	56	60	61	62	63	63
18	44	49	52	53	54	54	54
20	39	44	46	46	47	47	47

TABLE 5-9. BOND COVERAGE WITH NO FEDERAL PARTICIPATION

Hub	Year	Local share of new airport capital costs, millions of 1976 dollars	Existing airport(s) studied plus new airport: Operating surpluses, Millions of 1976 dollars	Existing airport(s) studied plus new airport: Operating surpluses, As percent of bond payments*	Existing airport(s) studied plus new airport: Bond payments,* millions of 1976 dollars
Scenario 1					
New York	1985	346.7	77.9	169	46.2
Chicago	1985	212.7	53.9	190	28.4
San Francisco	1985	392.3	29.6	57	52.3
Atlanta	1995	207.6	64.9	235	27.7
Boston	1990	271.9	26.2	72	36.2
Minneapolis	2000	106.1**	19.6	139	14.1
Seattle	2000	241.5	17.4	54	32.2
Denver	1995	194.7	29.6	114	26.0
Philadelphia	1990	285.1	19.6	52	38.0
St. Louis	1990	216.9	22.9	79	28.9
Total			361.5	110	330.0
Scenario 2					
New York	1995	221.1	128.7	437	29.5
San Francisco	1990	243.9	42.8	132	32.5
Boston	2000	271.9	47.2	130	36.2
Philadelphia	2000	285.1	38.4	101	38.0
Total			257.1	189	136.2
Scenario 3					
New York	2000	221.1	115.4	392	29.5
San Francisco	1990	243.9	36.2	111	32.5
Total			151.6	245	62.0
Scenario 4					
San Francisco	1985	243.9	26.2	81	32.5
Total			26.2	81	32.5

* Equal annual payments for 25 years at 10 percent on a bond to finance the local share of new airport capital costs.

** State pays one-half of non-Federal share.

TABLE 5-10. BOND COVERAGE (PERCENT) BY INTEREST RATE AND AIRPORT LIFE WITH NO FEDERAL PARTICIPATION

Rate of interest, percent	Airport life, years						
	10	15	20	25	30	35	40
Scenario 1							
2	126	180	230	274	314	351	384
4	110	150	184	211	233	252	267
6	96	126	149	166	179	188	196
8	84	107	123	134	141	146	149
10	74	92	103	110	114	116	118
12	66	79	87	91	94	95	96
14	59	69	74	77	79	79	80
16	52	61	64	66	67	67	68
18	47	53	56	57	58	58	58
20	43	47	49	50	50	51	51
Scenario 2							
2	217	311	395	472	542	604	661
4	189	259	316	363	402	434	460
6	165	217	257	286	308	325	337
8	145	185	212	230	243	251	257
10	128	158	177	189	196	201	203
12	113	137	150	157	162	164	165
14	101	119	128	133	136	137	138
16	90	104	111	114	115	116	117
18	81	92	97	99	100	100	100
20	73	82	85	86	87	87	87
Scenario 3							
2	281	403	512	612	702	783	857
4	245	335	410	471	521	563	597
6	214	282	333	371	399	421	437
8	188	239	274	298	315	326	333
10	166	205	229	245	254	260	264
12	147	177	194	204	209	213	214
14	131	154	166	172	176	177	178
16	117	135	144	148	150	151	151
18	105	119	125	128	129	130	130
20	95	106	110	112	113	113	113
Scenario 4							
2	93	133	169	202	232	258	283
4	81	111	135	155	172	186	197
6	70	93	110	122	132	139	144
8	62	79	91	98	104	107	110
10	55	68	76	81	84	86	87
12	48	58	64	67	69	70	71
14	43	51	55	57	58	59	59
16	39	45	47	49	49	50	50
18	35	39	41	42	43	43	43
20	31	35	36	37	37	37	37

CHAPTER 6. CAPACITY EXPANSION OPTIONS

While conflicting interpretations with respect to the timing of capacity-based needs of major hub airports will undoubtedly persist, virtually all airport operators are coping, or will eventually cope, with the prospects of capacity expansion. Recently reduced rates of growth of passengers has only postponed the time when major hub airport operators will be compelled to examine alternative options for expansion of capacity. Greater use of wide-bodied aircraft and higher load factors may also delay this time, at least in terms of most airside improvements. Even in these cases, airport operators must respond to the need for landside expansion and, therefore, must confront the environmental, financial, and jurisdictional problems associated with such actions.

This chapter focuses on the practicability of alternative airport capacity expansion options. The analysis extracts from the recent experience of the 21 major hubs covered in this study, a composite picture of the major opportunities and constraints associated with four approaches to capacity expansion: first, expansion within current airport boundaries; second, expansion through land acquisition; third, expansion by means of diverting general aviation and/or commercial traffic to reliever airports; and fourth, expansion by relocation of all or a portion of air carrier traffic to a new location. To begin, a brief overview of the nature of these options is presented. Next, a synopsis of impacts resulting from current operations at the 24 airports is presented, that summarizes the type, extent, and severity of common airport expansion issues. A qualitative assessment of each problem is provided and then used to draw a number of generalizations on the relative importance of each. Finally, some distinctions are drawn between the expansion in situ versus the new airport option for each of the major identified problem areas. A major purpose of the chapter 7 review of the Dallas-Fort Worth, Kansas City, and Montreal experiences is to provide empirical verification of some of the generalizations derived in this chapter.

TYPES OF CAPACITY EXPANSION OPTIONS

Four general approaches to expanding capacity at major airports are currently practiced or contemplated by airport operators. First, capacity expansion may be achieved within the physical boundaries of the existing facility. This approach includes improvements in operational procedures as well as terminal/landside improvements. For example, increased airport capacity may be achieved by peak spreading or the adoption of UG3RD to increase the acceptance rate of aircraft. Capacity increase without additional land requirements may also be achieved by terminal and landside improvements such as the addition of gates, parking facilities, and improvements to the airport road system.

A second approach to capacity expansion involves land acquisition to improve either airside or landside facilities, although the former is most typical. (Not all land acquisition programs, it should be noted, are capacity-oriented, such as the purchase of land or easements as buffer zones to abate noise exposure.) Land acquistion programs may be implemented in conjunction with, or in lieu of, adjustments in operating procedures. In general, however, operational adjustments with little or no land acquisition are preferred by airport operators since the numerous social and environmental issues associated with land purchases are circumvented.

When a large-scale land acquisition program is required, an airport operator typically requests a condemnation ordinance from the appropriate jurisdiction and, once approved, proceeds to negotiate the specific terms of transfer with individual property owners. The experience of a majority of airport operators is that only 10 to 20 percent of such cases require judicial settlement; i.e., the most serious opposition to property expansion is resolved prior to the condemnation action. In cases where few properties are involved, airport operators generally negotiate the terms of transfer with individual property holders without the direct intervention of the municipal or county government.

The third approach to capacity expansion encompasses all actions intended to divert operations from a major air carrier airport to either existing or planned reliever airports. Operations which are prime candidates for diversion may include military, general aviation, air cargo, and air taxi. General aviation and military operations at the 24 airports studied range from 6 percent at Chicago to 72 percent at Fort Lauderdale. At six airports (Cleveland, Denver, Fort Lauderdale, Honolulu, San Diego, and Tampa), general aviation and military operations account for 40 percent or more of all operations. When general aviation traffic represents a significant proportion of total operations, airport operators typically look toward diversionary tactics to relieve actual or anticipated congestion at major airports. Since FAA regulations disallow outright prohibition of general aviation traffic at air carrier airports, the most common proposed tactic is to increase landing fees as a disincentive to general aviation traffic. At present, however, this approach to traffic diversion remains in the discussion stage and invariably provokes an adverse response from the general aviation community.

Traffic diversion measures aimed at expanding air carrier operations at major airports may take the form of shifting civil and military training operations to alternative sites. In the case of Miami, for example, a major portion of all airline training missions utilize the Dade-Collier training runway. In other hubs where training operations are of significance to the overall traffic levels, a similar assignment can contribute to the reduction of airside congestion. It is worth noting, however, that the growing use of flight simulators for training purposes reduces the potential impact of this activity.

The fourth capacity expansion option is the relocation of all or a portion of air carrier traffic to a new airport site. Recent examples of relocating all air carrier traffic to a new airport site include Dallas-Fort Worth and Kansas City. The relocation of all versus a portion of air carrier traffic is treated in chapter 7.

In summary, current trends suggest airport operators will continue to maintain the cautious posture that has characterized decisionmaking in recent years. Operational improvements in the form of upgraded instrumentation, coupled with relatively modest programs of land acquisition for runway and/or landside improvements, appear to be the preferred option for airport capacity expansion. In the next section, the community impacts of these types of activities are examined in detail.

COMMUNITY IMPACTS OF CAPACITY EXPANSION

Proposed capacity expansion of any type, whether it occurs at existing airports or at new sites, generates numerous community impacts that affect the practicability of such action. Increased passenger enplanements, for example, may cause ground access congestion even if the level of operations is held constant through the introduction of wide-bodied aircraft. Noise levels at existing airports may be reduced with the introduction of curfews, changes in landing and departure procedures, and quiet engine aircraft; yet noise exposure may simultaneously increase. This would occur in cases where ineffective zoning controls in adjacent areas permit the addition of noise sensitive land uses (schools, hospitals, and residences) in exposed areas. Thus, the degree of community impacts attributable to airport capacity expansion depends upon a mix of variables reflecting the volume of increased capacity, the method by which the expansion is realized, and the concurrent physical and legal environments that govern land development in the adjacent areas.

In this section, a summary of the degree of the major community and environmental impacts associated with present airport operations and proposed airport capacity expansion are presented. A summary of the findings, by airport and major impact, are presented in tables 6-1 and 6-2. As supplementary material, these tables also list the size and year of initial air passenger service for each hub, an assessment of the community attitudes toward airport operations, and qualitative estimates of the feasibility of land acquisition and airport relocation.

Land Use Compatibility

A review of table 6-1 reveals 7 airports with major land use incompatibilities in the airport vicinity, 12 with limited incompatibilities, and 5 airports with no significant problems.

In general, open space as well as industrial and recreational land uses are regarded as most compatible with an airport environment, whereas institutional and residential land uses are deemed most incompatible. Typically, as in the cases of St. Louis and San Diego, major land use incompatibilities evolved from both locational and land use control sources. Both airports are located relatively close to their respective central business districts and have gradually been encircled by residential and commercial development over a period of three decades. Both hubs illustrate the need for, and absence of, stringent land use controls by county and municipal governments to ensure land use compatibility. The experience of these hubs, as well as that of other older airports such as New York and Miami, suggests that the willingness of local governments to adopt and enforce necessary land use controls varies at least in part with the nature of the land at stake. Where the airport vicinity includes accessible yet costly urban land, zoning controls are less likely to be adopted and rigidly enforced.

In contrast to those airports with major land use incompatibilities, half of the major airports studied experience only limited incompatibilities. As exemplified by Atlanta and San Francisco, airport authorities have dealt with the presence of noise sensitive uses by implementing abatement procedures that effectively utilize existing physical or manmade features in the airport vicinity. In San Francisco, bayside landings and departures reduce noise exposure

TABLE 6-1. CURRENT COMMUNITY IMPACTS OF MAJOR AIRPORTS

Airport	(Approximate) Year commercial operations began	Size, acres[a]	Distance from CBD, miles	Compatibility of adjacent land uses[b]	Localized adverse impacts[c]				Community attitudes[d]
					Noise	Air	Water	Access	
Atlanta	1930	3,750	8	LI	MO	NP	MO	MO	SP
Boston	1933	2,300	3	MI	SF	NP	NP	SF	UN
Chicago	1959	7,000	19	LI	MO	NP	NP	SF	SP
Cleveland	1925	1,600	12	LI	MO	NP	NP	MO	SP
Denver	1929	4,651	7	MI	SF	MO	NP	SF	SP
Detroit	1955	3,700	15	NP	NP	NP	NP	NP	IN
Honolulu	1927	4,811	10	NP	MO	NP	NP	MO	SP
Houston	1969	8,000	17	NP	MO	NP	NP	MO	SP
Las Vegas	1948	1,700	7	LI	MO	MO	NP	MO	SP
Los Angeles	1928	3,500	17	MI	MO	NP	NP	MO	UN
Miami(MIA)	1929	3,230	5	LI	MO	NP	MO	MO	IN
Miami(FLL)	1953	1,160	4	LI	MO	NP	NP	SF	SP
Minneapolis	1920	3,000	10	NP	NP	NP	NP	SF	IN
New Orleans	1946	1,700	12	LI	MO	NP	MO	MO	IN
New York(JFK)	1948	4,930	15	MI	SF	NP	NP	SF	UN
New York(LGA)	1939	650	8	MI	SF	NP	NP	SF	UN
New York(EWR)	1928	2,300	14	LI	MO	NP	NP	SF	UN
Philadelphia	1940	2,500	7	LI	MO	NP	NP	MO	IN
Pittsburgh	1952	10,000	17	NP	MO	NP	NP	SF	SP
St. Louis	1942	2,011	10	MI	SF	MO	NP	SF	SP
San Diego	1928	487	2	MI	SF	NP	NP	SF	SP
San Francisco	1926	5,207	15	LI	MO	NP	NP	MO	IN
Seattle	1942	2,200	15	LI	MO	NP	NP	NP	SP
Tampa	1927	3,300	6	LI	NP	NP	NP	NP	SP

[a]As of March 1977.

[b]Refers to uses generally within the airport's zone of high noise exposure (greater than Noise Exposure Forecast 30).

[c]Refers only to impacts within the airport boundary and the immediate vicinity. Air quality, for example, may be significantly impacted locally, but not at the metropolitan or regional level.

[d]Refers to the environmentally impacted populations.

Keys:

Adjacent land Uses	Impacts	Community Attitudes
NP - No significant problem	NP - No significant problem	SP - Supportive
LI - Limited incompatibilities	MO - Moderate and/or occasional problems	IN - Indifferent
MI - Major incompatibilities	SF - Severe and/or frequent problems	UN - Unsupportive

TABLE 6-2. FEASIBILITY AND IMPACTS OF EXPANSION AT EXISTING AIRPORT AND STATUS OF NEW AIRPORT SITE SELECTION

	Expansion of existing airport					New airport site selection					
	Feasibility of proposed land acquisition	Major localized impacts[a]				Capacity deficiency in scenario				Status of new site selection	Feasibility of relocation[b]
Airport		Noise	Air	Water	Access	1	2	3	4		
Atlanta	C	B	-	-	A	X	-	-	-	SA	L
Boston	N	A	-	-	A	X	X	X	-	NS	-
Chicago	N	A	A	-	B	X	-	-	-	NS	-
Cleveland	C	B	-	-	-	-	-	-	-	US	-
Denver	C	B	A	-	A	X	-	-	-	PS	-
Detroit	F	A	-	-	-	-	-	-	-	NS	-
Honolulu	C	-	-	-	-	-	-	-	-	NS	-
Houston	F	B	-	-	A	-	-	-	-	NS	-
Las Vegas	C	A	A	-	-	-	-	-	-	PS	-
Los Angeles	C	B	-	-	B	-	-	-	-	SA	-
Miami(MIA)	N	B	-	-	A	-	-	-	-	CS	N
Miami(FLL)	N	A	-	-	A	-	-	-	-	CS	N
Minneapolis	F	B	-	-	-	X	-	-	-	CS	N
New Orleans	C	-	-	A	-	-	-	-	-	CS	N
New York(JFK)	N	A	-	-	A	X	X	X	X	US	N
New York(LGA)	N	A	-	-	A	X	X	-	-	US	N
New York(EWR)	N	A	-	-	-	X	X	-	-	US	N
Philadelphia	N	B	-	-	-	X	X	-	-	NS	-
Pittsburgh	F	B	-	B	-	-	-	-	-	NS	-
St. Louis	N	A	A	-	-	X	-	-	-	CS	F
San Diego	N	A	-	-	-	-	-	-	-	CS	L
San Francisco	N	A	-	-	A	X	X	X	X	US	L
Seattle	C	B	-	-	B	X	-	-	-	NS	-
Tampa	C	-	-	-	-	-	-	-	-	NS	-

[a]Associated with operations expansion and/or growth of the impacted population, 1985 to 2000.

[b]Based on land availability, accessibility, physiographic conditions, and environmental impacts.

Keys:

Land Acquisition
- F - Feasible
- C - Feasible with major constraints
- N - Not feasible

Impacts
- A - Adverse impact
- B - Beneficial impact

New Site Selection
- NS - No study proposed
- PS - Proposed study
- US - Under study
- CS - Completed study
- SA - Site acquired

Relocation
- F - Negligible limitations
- L - Few limitations
- N - Major limitations

levels over residential communities to the west of the airport. In Atlanta, flight paths that follow the interstate highway system have proved effective in noise abatement. Local physiographic features in San Diego and Boston (despite coastal locations) disallow or render ineffectual this type of abatement measure.

Land use incompatibilities in the vicinity of major airports result in part from fragmented jurisdictional control over land use in the airport environs. Zoning authority is frequently vested in county or various municipal government agencies other than the government agency that owns and operates the airport. Rational land use planning and effective zoning controls are weakened by this discrepancy in authority. However, Seattle and Houston have shown that such obstacles are not insurmountable. In what will be perhaps the best example of comprehensive land use planning, the Port of Seattle and King County have jointly designed a multifaceted program (the Sea-Tac Communities Plan) to ensure future land use compatibility in the airport environs. Although the program is still in the design stage, it is noteworthy for its methodological innovations and comprehensive approach to promoting land use compatibility. A combination of land acquisition, purchase guarantees, and shared costs of insulation of noise sensitive structures is intended to eliminate the most glaring incompatible and noise sensitive uses. These measures will be supplemented by property advisory services to all owners who seek such assistance. A distinct advantage enjoyed by the Port of Seattle in making the plan operational is that, relative to other cities, few jurisdictions are involved in the land use decisions affecting the airport environment.

Noise Exposure

The magnitude of Federal and local concern over noise exposure levels at major airports is reflected in the number of research studies and congressional hearings devoted to the topic, FAA and proposed Environmental Protection Agency (EPA) regulations to reduce noise exposure, and the number of past and pending lawsuits involving noise issues. As indicated in table 6-1, noise from airport operations is the preponderant environmental issue at the present time and is expected to remain so at least through 1995, despite the replacement of older aircraft by aircraft with quieter engines.

Noise measurement remains an inexact science, and although the Noise Exposure Forecast (NEF) is the most common indicator of noise levels, it is neither universally used nor accepted. Alternative noise rating measures include the Perceived Noise Level (PNL), A-weighted Sound Pressure Level (dBA), and Speech Interference Level (SIL). Most noise measures are intercorrelated, and all purport to provide an indication of the level of annoyance and/or speech interference. The advantage of NEF is that, unlike the alternatives, it provides an overall (albeit conservative) indicator of the extent of potential adverse community response to the noise from airport operations. A list of the most important variables in deriving NEF contours illustrates this point:

a. The total number of operations per day.

b. The ratio of daytime to nighttime flights.

c. The projected runway utilization.

d. The assumed aircraft mix.

e. Aircraft operating procedures.

f. Aircraft noise.

The State of California has adopted the Community Noise Equivalent Level (CNEL). CNEL values represent the average noise level at a given position on the ground during a 24-hour period, adjusted to account for the lower tolerance of people to noise during the evening and nighttime hours.

Whereas a divergence of opinion persists over the most accurate measure of noise exposure, there is a clear-cut consensus among both airport operators and community officials that the noise problem requires immediate mitigating measures. The extent and intensity of adverse noise impacts across hubs is depicted in table 6-1. In only three airports is noise judged to be an insignificant problem. In six airports (Boston, Denver, Kennedy, La Guardia, St. Louis, and San Diego) noise exposure is classified as severe and/or frequent. In the remaining hubs, moderate and/or occasional noise problems exist, although several (e.g., Chicago, Los Angeles, and Miami) are clearly borderline cases.

The FAA and local airport operators have adopted numerous measures to reduce noise impacts in the vicinity of major airports. Most significant among these measures is the imposition of FAR Part 36 aircraft standards and, at the local level, various airport operational procedures such as nighttime curfews and schedule adjustments (although the authority to impose such measures has not been tested in the courts). Other mitigating measures such as preferential approach departure, and runway usage patterns are operational at most hubs. The authority to exercise such controls, however, falls within the purview of FAA Air Traffic Control and Flight Standards Regulations. Consequently, although airport operators must assume the responsibility for coping with adverse community reactions to noise impacts, the authority to implement noise mitigating measures is largely beyond the scope of their legal authority.

Effective action to combat noise impacts is complicated by other factors as well. First, while absolute noise levels may be reduced over time (an anticipated trend in every hub), noise exposure may concurrently increase. This, for example, is the forecast for St. Louis, where urban growth in the airport vicinity will result in more persons exposed to NEF 30 (or greater) noise levels in 1985 than at present. This will occur despite the increased use of aircraft with quieter engines and it is testimony to the indispensability of effective land use controls in dealing with airport environmental impacts.

Second, noise standards, whether Federal or state, lack standardization and an unambiguous assignment of authority to jurisdictions in noise issues. Both conditions make the implementation of control measures an uncertain and potentially wasteful activity since the ultimate authority to engage in and enforce such action lacks unequivocal legal definition. Legal actions against airport operators for damages suffered from noise exposure continue to be settled on an individual basis, generally resulting in an award to cover the costs of insulation or other remedial measures. In any case, the uncertain legal basis for imposing noise standards means that an airport operator runs the risk of complying with one set of standards and, sometime in the future, finding the airport subjected to a different set of standards which are either more or less stringent.

Third, in the case of some airports, resurfacing poses a difficult problem. A temporary diversion of traffic to a less than optimal landing and/or departure runway creates both safety and environmental consequences. Noise exposure, in particular, may affect for the duration of the repairs communities that are otherwise free of such impacts.

To summarize, noise abatement procedures require, and frequently lack, a coordinated effort on the part of the FAA, the airport operator, and the jurisdictions responsible for land use control in the airport vicinity. Without such collaboration, the efforts of one participant in the abatement process may be negated by the inaction of another.

Air Quality, Water Quality, and Ecological Impacts

In addition to the noise impacts discussed above, air quality, water quality, and ecological impacts resulting from airport operations were also examined. In general, few significant air, water, and ecological impacts were identified that are attributable to air carrier airport operations at the 24 airports covered in this study (table 6-1). However, Federal air quality standards are expressed in terms of concentration of a particular pollutant from all sources, including aircraft. While aircraft operations alone may not exceed Federal air quality standards, aircraft operations along with airport related emissions activity, such as automobile traffic, contribute to the violations of Federal air quality standards at a limited number of airports.

Air pollution emissions generated in the airport environ are primarily comprised of carbon monoxide, hydrocarbons, nitrogen and sulfur oxides, and particulate emissions from aircraft and automobile engines. Except for Honolulu, Miami, Ft. Lauderdale, and New Orleans, each airport studied is located within a metropolitan area that has been designated as an Air Quality Maintenance Area (AQMA), and local air pollution control agencies frequently monitor ambient air quality in the airport environs. Although the estimated total quantities of the various air pollutants generated within the airport environs were significant, no direct adverse air quality impacts on areas adjacent to any of the 24 airports were identified and airport air pollutants were found to comprise a very small proportion (at most 1 or 2 percent) of the total air pollution emissions within any AQMA.

The primary water quality impacts associated with airport operations include the pollution and/or lowering of ground water tables and the diminished quality of nearby surface water bodies resulting from airport runoff discharges. Occasional water quality problems were identified, such as erosion and sedimentation during airport construction programs. However, no continuing deterioration of the quality of any surface or subsurface water body which resulted from airport runoff was identified. Airport infrastructures were found to include adequate and well-maintained storm and sanitary sewerage systems, and emergency control measures designed to control accidental fuel spills were noted at each airport.

Although airport construction activities destroy existing wildlife habitats, airport operations as such were not found to impose any significant adverse impacts on the remaining air, fauna, or flora communities. Instead, depending upon individual airport management practices, the airport environs (including buffer and clear zones) were often found to provide a protected large open space in the metropolitan area conducive to such wildlife communities. Therefore, no assessment of ecological impacts was included in table 6-1 since no significant adverse impacts were identified.

Land Acquisition: Feasibility and Impacts

This section presents an overview of the extent of land acquisition programs at the 24 airports studied and the attendant environmental impacts such programs will create. Programs of land acquisition serve two major purposes. First, land acquisition is one means of expanding capacity at existing airports. The most typical capacity motive for acquiring contiguous land is runway improvement or addition. Airport operators also engage in land acquisition for purposes of assembling large tracts in order to insure adequate space for future airport sites. Examples of the latter type include New York, Atlanta, which owns two 10,000-acre tracts, and Los Angeles, where the Palmdale acquisition program is more than 80 percent complete. (The Los Angeles Department of Airports is the only major airport operator that is currently involved in a large-scale land acquisition program.)

As indicated in table 6-2, land acquisition at the existing airport is not feasible for nearly half of the airports examined. The reasons for this are both economic and environmental. A majority of airports are hemmed in by high density, intensive land uses whose value exceeds the resources of most airport authorities. Large-scale land acquisition in the vicinity of Logan, O'Hare, Miami, and La Guardia, for example, would require an expenditure of resources that would be prohibitive. Ironically, the high cost of land itself is partly attributable to the commercial advantages of an airport location, an advantage which ultimately imposes severe constraints on the capacity of airport operators to physically expand airport boundaries.

Environmental concerns also affect the feasibility of land acquisition. Whereas many communities are prepared to accept an increased volume of traffic made possible by improved instrumentation and/or operational procedures, physical expansion of the airport for the same purposes generally stimulates community opposition and requires a comprehensive environmental review. The exception to this sequence is when land acquisition in contiguous areas is aimed at creating a buffer zone to abate noise exposure.

At four airports listed in table 6-2, land acquisition is judged to be feasible. Not surprisingly, however, these airports (Detroit, Houston, Minneapolis, and Pittsburgh) are among the less congested airports.

The degree of environmental impact associated with land acquisition depends upon the objectives of the acquisition. If capacity expansion is the objective (as assumed in table 6-2), then the usual environmental impacts, especially noise exposure, will ensue. As in the above analysis, capacity expansion will generate negligible air and water quality impacts at virtually all airports. In contrast, if the creation of buffer zones is the objective of land acquisition (as in the case of Philadelphia and Houston) and upgraded environmental condition will result.

Finally, land acquisition for purposes of land banking is an ongoing activity only in Los Angeles. Acquisition at the Palmdale location, which ultimately will include 17,500 acres situated 60 miles from the CBD, is now 80 percent complete. The land requirements for a possible new jetport forced the City of Los Angeles to settle on the relatively remote Palmdale site. Similarly, in the case of Atlanta, the two 10,000-acre sites purchased for possible future development are located approximately 45 miles from the CBD. Thus, while land requirements by definition dictate a remote location for a new airport, the same locational attribute makes the acceptance and utilization of such a site (by both the airlines and the user population) commensurately more difficult.

Access Impacts

Access to 11 airports, particularly those situated close to their respective CBD's, is currently inadequate, and expansion of airside activity will further exacerbate this situation. For example, in Boston, Chicago, Ft. Lauderdale, and the three New York airports, airport access is severely and/or frequently impaired due to inadequate surface transportation. Typically, peak air traffic periods roughly coincide with morning and evening rush hour commuting. The coincidence of peak hour surface and peak airport transportation produces congestion on local arterial streets and freeways that provide airport access. One spillover effect of this congestion includes temporary deterioration of air quality in adjacent communities. In only 3 airports does ground access present no significant problem (see table 6-1); at 10 airports (e.g. Atlanta, Honolulu, Las Vegas, and New Orleans) access is a moderate and/or occasional problem for local communities and users.

As in the cases of other significant impacts examined above, the ability of airport operators to take concerted steps to improve ground access is handicapped by the fragmentation of authority. In addition to the airport operator, other levels of government are involved in the provision of surface transportation: the city (or county) transportation department and perhaps the state transportation department. Effective comprehensive surface transportation planning for airport traffic necessitates the coordination of at least two agencies.

To cope with deficiencies in surface transportation, several hubs are looking to rapid transit systems. Of the 21 hubs studied, only Boston and Cleveland offer direct rapid transit service. Philadelphia is presently constructing a rapid transit system to include airport service. Numerous cities (including Miami, New Orleans, Honolulu, San Francisco, and New York) have developed plans for construction of special airport-CBD rapid rail lines to alleviate traffic congestion. While this approach to improving ground access is widely recognized, its effectiveness in attracting more than 20 percent of total airport users remains to be proven. This explains why Chicago, where landside capacity is less than passenger volume, has remained hesitant to invest in a rapid transit link between O'Hare and the CBD.

In the case of new airports, accessibility presents an equally important, though somewhat different type of problem. The construction of new air carrier airports at distances of 25 or more miles from the CBD translates into average trip times of at least 45 minutes. Although much of the uncertainty, congestion, and pollutant emissions are eliminated, average trip time is increased. Public willingness to make this trade-off has yet to be proven. Furthermore, a rapid transit link to a relatively remote site is less workable than in the case of a centrally located airport.

Jurisdictional Considerations

The impact of jurisdictional fragmentation on capacity expansion has been noted at several points in the above discussion. It may be recalled that overlapping and/or ill-defined legal authority in airport matters impinges upon the feasibility of capacity expansion in various ways. The authority to implement changes in operational procedures is shared between the airport operator and the FAA, although several aspects of this authority remain untested in the courts. Similarly, noise standards vary across states, and between states and the Federal Government, thereby creating a distinctive element of uncertainty with respect to abatement measures and compliance. Land use planning and zoning responsibilities are usually spread over a multiplicity of jurisdictions, a situation that hinders the ability of airport authorities to ensure compatible land uses in the airport vicinity. Finally, solutions to the access problem at many hubs is complicated by the division of authority among the airport operator and the city, county, and state transportation departments.

In short, a fundamental issue in airport expansion is the coordination or *realinement of existing* authorities in order to integrate the individual roles of each into a rational mechanism for the planning and implementation of capacity expansion programs. Specific recommendations, as well as extended examination of existing coordinating bodies such as the A-95 agencies, are deferred until chapter 8. However, there is little reason to expect that such coordination is likely to evolve without the creation of attractive incentives by the Federal Government. One finding to emerge from the interviews conducted during this study is that a strong sense of jurisdictional parochialism (e.g. city versus county) prevails among many airport operators, especially among the larger, financially independent airports which depend least heavily on Federal monies to support their operations and capital improvement programs.

Finance Issues

The major airports examined in this study are financially solvent. No hubs face financial difficulties in covering either operating expenses or in financing improvements programs. Several actually generate an operating surplus large enough to permit (should they so choose) a significant degree of financial independence from both Federal and state funding agencies. In no case has expansion of an existing hub airport been seriously or consistently hindered by lack of matching local funds for facility improvements.

Several reasons for this generally favorable financial status may be cited. First, airports rely for financial assistance upon numerous matching funds sources that collectively provide a reliable pool of resources. Federal participation in airport development is based upon the Airport and Airway Development Program (ADAP) of 1970 (as amended in 1976). The ADAP program provides financial assistance for acquisition of airport land and for facilities needed for safe and dependable use of aircraft. The 1976 Amendments make several new types of projects eligible for development grants, including acquisition of snow removal equipment and noise suppression equipment, the construction of physical barriers and landscaping for the purpose of diminishing the effects of aircraft noise, the acquisition of land to insure that it is used only for purposes which are compatible with the noise levels of the operation of a public airport, and terminal development, including multimodal terminal development, in non-revenue producing public-use areas. The Amendments to the 1970 Act, among other changes, increased the Federal share of airport development projects from 50 percent to 75 percent for large airports, except for terminal development. There are limitations on Federal participation.

Federal grants are the prime, but not the only, source of revenues for capital improvements. Most states, through their departments of aviation or transportation, grant funds to airport operators for capital improvements. In some cases, state agencies receive Federal funds for regional or systems planning that incorporates analyses of major air carrier airports. State agencies traditionally have been active in the development of general aviation airports.

A third source of revenues is revenue generated by activities at the airports. At airports with more than 2 million enplaned passengers, key revenue generators are concessions (44 percent), airfield area (28 percent), terminal area (13 percent), hangar and building area (11 percent), and systems and services (4 percent).[2]

In summary, financial constraints historically have been a relatively minor obstacle to existing airport expansion. Generous Federal support supplemented by state contributions and operating revenues have collectively created a perceived situation of financial security among airport operators.

Despite the existence of millage authority to tax area residences by many airport operators, local political reality has prevented the exploitation of this potentially lucrative revenue source. To date, this has not created serious pressures on airport operators because of the number of alternative funding sources. However, should these alternatives become less accessible, local authorities may be compelled to reevaluate their hesitancy to use the tax levy.

EXPANSION AT EXISTING AIRPORTS VERSUS NEW SITES

Portions of the above discussion have alluded to the community and environmental impacts of airport relocation. In this section, these issues are addressed explicitly. The objective of this analysis is to evaluate the comparative advantages and disadvantages of the expansion versus relocation options. A review of the feasibility and anticipated impacts of the airport expansion *in situ* is presented. Next, new site needs and the status of new site selection for the various hubs are discussed. Finally, a number of generalizations are offered with respect to the practicability of relocation from the standpoint of land availability and environmental constraints. An overview of these issues is presented in table 6-2, which summarizes the basic data from which the following analysis is derived.

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[2]Federal Aviation Administration, *Economics of Airport Operation: Calendar Year 1972* (Washington: Federal Aviation Administration, April 1974).

Feasibility of Land Acquisition and Related Impacts

Table 6-2 reveals that for nearly half the airports examined in this study, additional land acquisition at the existing site is not a feasible alternative. The rationale for this assessment is based upon both economic and environmental considerations. In almost all cases, infeasibility is associated with centrally located airports hemmed in by high density residential, commercial, and industrial growth: a condition that translates into exorbitantly high aquisition costs for airport operators. The typical evolution of urban development in these areas is characterized by the original airport and subsequent expansion, concurrent commercial and industrial growth of airport-related activities, and additional, though modest, airport land acquisition. Thus, much of the commercial and industrial activity in the vicinity of major airports is there because of the airport. Acquisition of these properties cannot be considered a viable approach to accommodating traffic needs in the long run.

Some airports view land acquisition as a means of creating buffer zones. In these instances, beneficial impacts are noted in the appropriate cells in table 6-2, indicating that noise exposure would be reduced. Otherwise, land acquisition programs are designed with the intent of expanding the physical plant of the airport in order to increase capacity. This is the most common motivation, and adverse impacts are anticipated for most cities. Constraints in these cases refer to both the availability and cost of surrounding land as well as the likelihood that strong environmental obstacles would emerge to any proposed major acquisition program.

With respect to air quality and water quality, the few significant impacts are generally associated with already existing problems, e.g., air pollution in Denver, Las Vegas, and St. Louis, and water quality deterioration in New Orleans.

Finally, the ground access impacts associated with land acquisition are generally adverse in nature, once again owing to the orientation of most airport operators to view acquisition as a means of expanding airside capacity. With the exceptions of Los Angeles and Seattle, land acquisition will generally adversely affect already congested arterial streets, freeways, and interstate highways in the airport vicinity.

New Site Needs and Status of Selection

Different scenarios previously presented in the study indicate that by the year 2000, between 1 and 10 hubs may experience excessive delays and will be compelled to divert a portion of their air carrier traffic to new sites.

To meet these anticipated needs, a backlog of site selection studies in various stages of preparation has emerged. In Cleveland, Denver, Las Vegas, New York, and San Francisco, studies are either proposed or underway. In Miami, Minneapolis, New Orleans, St. Louis, and San Diego, comprehensive relocation studies have been completed. In New York, Atlanta, and Los Angeles, new site acquisition is completed or near completion. Finally, in cities such as Boston and Philadelphia, relocation studies are not contemplated.

From a review of the experience of the major hubs that have at least considered new air carrier airport sites, a generalization may be drawn. Despite the emphasis on environmental concerns in the selection of new sites, other considerations have ultimately determined the outcome of the expansion/relocation decision. The recent cases of San Diego and St. Louis are exemplary. The case against continuation of operations at Lindbergh Field from an environmental standpoint was clear-cut. Capacity expansion possibilities at Lindbergh are limited, and the few feasible alternatives that do exist will intensify adverse noise and ground access impacts. A number of alternatives to the retention of Lindbergh were suggested in the San Diego Region Alternative Air Transportation Plan (1975), all of which would have reduced the impacts associated with Lindbergh operations. The April 1976 decision to retain Lindbergh in its current configuration for an indefinite period may be interpreted as a public willingness to accept adverse environmental impacts as a cost of preserving the accessibility and economic stimulus of a centrally located air carrier airport.

The case of St. Louis also reveals the fundamental determinants of an expansion versus relocation decision. Operations at Lambert will continue to create high levels of noise exposure despite the increased use of aircraft with quieter engines. (See the earlier discussion of noise impacts.) In spite of this, however, there is widespread public support for retaining Lambert even though a site for a replacement airport is available. This suggests that, at least in this instance, the local community places less emphasis on environmental considerations than on economic and other considerations (e.g., accessibility to CBD). Whether or not such a determination would result at other locations, however, must await the future experience of cities contemplating airport relocations.

CONCLUSIONS

This chapter has examined the alternative types of capacity expansion options, the community impacts of existing airports, the feasibility and impacts of expansion *in situ*, and the status of new airport site selection. The major conclusions of this analysis may be summarized as follows:

a. Among the four major types of capacity expansion, the most commonly adopted option is one which relies upon improved operational procedures within current airport boundaries. This preference derives from environmental, economic, and accessibility considerations.

b. Noise exposure is, and will continue to be, the major community impact associated with airport operations for at least a decade. The responsibility and authority to legislate and finance abatement procedures lacks a clear-cut legal basis. This situation is common to many elements of airport planning and operations and hinders the implementation of effective control measures.

c. The financial position of major airports is secure, owing to the mix of revenue sources and disposition of public agencies to promote airport development. However, this may not be necessarily true for new major air carrier airports such as Kansas City and Dallas-Fort Worth.

d. Although environmental concerns tend to dominate the public debate over the expansion/relocation issue, considerations of accessibility and finances exert more influence in the decision to retain or relocate a major airport.

In chapter 7, three airport relocation decisions are examined in detail in order to provide some insights into the background, implementation, and subsequent operational problems that are likely to accompany such decisions.

CHAPTER 7. RELOCATION OF MAJOR AIRPORTS

SECTION 1. INTRODUCTION

The purpose of this chapter is to examine the general characteristics of the relocation process associated with the shifts in scheduled air carrier service from an existing metropolitan airport to a new facility. In particular, those factors are described which shape the feasibility and practicability of relocation actions. The chapter includes an examination of the major causes that led to the establishment of major new airports in selected American cities, an overview of the steps and general types of actions which characterize the relocation process, and an evaluation of how successful the relocations have been. This is an important task for a number of reasons.

First, the current relevance of relocation is underscored by the fact that a number of major hubs in the United States are contemplating relocations (for example, Cleveland and Miami). Further, because many observers have related the development of the new Atlanta airport in the midsixties with the growth of the southeast (and even relate the new Dallas-Fort Worth air complex to the general economic well-being of Texas), the construction of major new airports has also emerged as a major regional development strategy.

Second, an analysis of the moves that have characterized selected major airports serves to identify, and place in a more proper perspective, a number of critical planning factors that were not adequately considered when the programs were initiated.

Third, by examining the events that characterize the airport relocations, it is possible to draw conclusions concerning the general feasibility of the establishment of major new air facilities in the future.

Finally, as this overview clearly indicates, several of the assumptions which led to the establishment of new airports have not proven to be entirely accurate, and, consequently, benefits of relocation primarily associated with regional economic stimuli were less than anticipated.

RESEARCH STRATEGY

In order to present a realistic appraisal of the relative success of selected major airport relocations, two major perspectives have provided the overall frame of reference for this chapter. First, the analysis of airport relocations is based upon generalizations of findings drawn from three case studies.

a. In Kansas City in the early 1970's, scheduled air carrier service was transferred from a central city municipal airport to the new Kansas City International Airport located approximately 19 miles north of the city's center. This case study was chosen because it provides an example of an airport relocation which proceeded without major problems.

b. The development of the new Dallas-Fort Worth International Airport was chosen as a case study characterized by a number of implementation problems, involving both local political jurisdictions as well as the new airport configuration and equipment.

c. The new Mirabel Airport in Montreal was chosen as an airport relocation that has been characterized by numerous implementation problems.

By examining these somewhat divergent airport relocation processes, each with its own degree of success in specific areas, it is possible to identify some of the major factors that may facilitate or impede the relocation of other major airports.

The second perspective deals with the major types of questions that are asked in the analysis. It is beyond the scope of this research to carry out an in-depth analysis of the plans for each of the airports, the specific architectural and engineering work accomplished, or to present a detailed financial and air operations evaluation of the move. However, by focusing the research upon the general characteristics of the relocation, three basic questions are explored.

a. First, in the case of each of the three airports noted above, the major reasons cited for prompting a relocation are identified.

b. Second, the general characteristics of the relocation process are examined, including the identification of major problems that had been anticipated, but focusing on those that arose during the relocation process and had not been adequately foreseen.

c. Finally, an examination of the relative success of the new facility is presented, including an evaluation of the degree to which the new airport satisfies the objectives that led to the move. An important part of this third perspective is an examination of the activities that characterized the old airport, especially the roles of general aviation and air freight.

ORGANIZATION OF THE CHAPTER

In the discussion which follows, four major topics are examined in detail:

a. Review of the major causes for relocation.

b. Problems and characteristics of the relocation process.

c. Current status and relative success of the new facilities.

d. General conclusions; i.e., are major airport relocations feasible today?

SECTION 2. MAJOR CAUSES OF AIRPORT RELOCATIONS

Based upon an examination of the factors that led to the relocation of airports in Montreal, Dallas-Fort Worth, and Kansas City, it is possible to identify a number of causal factors that were common to these communities. Furthermore, many of these same factors have appeared to be critical in stimulating feasibility studies and plans for new airports in other cities such as

St. Louis, Cleveland, and Miami, and were observed in communities that recently have completed major airport expansion programs such as Tampa and Honolulu. That is, in each of these cases, certain critical indicators emerged as the major stimuli for relocation or redevelopment. These factors may be related to three major groups:

a. Problems with the quality and capacity of existing facilities. The first group of factors leading to airport relocations involves considerations of the quality and capacity of existing airport facilities. These factors include:

(1) Lack of room for airside expansion, including a shortage of space for runways (both increased length and additional runways), the parking of aircraft, and required new buildings.

(2) Lack of room for landside expansion, including a lack of space for expanded terminal facilities, air traffic control facilities, parking, air freight, related office space, and areas for industrial and service use.

(3) Shortages of space and limited expansion potential in contiguous areas, especially related to traffic, parking, public transportation, and related problems. In most cases, expansion at the old airport was severely limited by cost considerations, as well as the possibility of conflicts with activities associated with the surrounding areas.

(4) Potential safety problems related to runway length and orientation (especially in summer months), and potential obstacles to airport use resulting from the rapid buildup of contiguous areas.

(5) Reductions in the quantity and quality of air service including problems of excessive delays, reduced passenger and cargo loadings due to deficient runways, and general passenger dissatisfaction with the overall layout of facilities.

(6) Needs for major renovations for old facilities, and requirements for updated baggage handling and passenger routing systems.

(7) Land use conflicts, especially numerous lawsuits related to excessive noise impacts on surrounding residential areas.

(8) Conflicts in competition with general aviation activities and certain types of fixed base operators. Strong recommendations and orders by the Civil Aeronautics Board (CAB) and the Federal Aviation Administration designed to reduce undesirable competition between airports.

(9) Plans for major changes in types of air service, such as planning for the "age of the jumbo jet" and the attraction of international routes.

b. Regional growth considerations. The second major type of factor underlying airport relocations may be described as symbols of regional economic prosperity. In other words, the new airports were viewed as being symbolic necessities in that they tended to present evidence of a region's economic strengths, viability, and potential growth. They were seen as absolute necessities for major regional economic development programs. The presence of a regional airport was regarded as an essential step in attracting a wide range of headquarters activities, manufacturing activities, services, financial institutions, international travelers, and a host of other business benefits.

c. Projections of demand. Perhaps the most important cause of all is the fact that the planning activities associated with the new airports in the cities noted above all had prepared sets of projections that indicated rapid growth in the demand for air travel in their areas. In retrospect, if these projections had been more conservative, many of the problem areas noted above might have been handled by operational improvements such as peak spreading, or by concerted growth programs designed to expand into contiguous areas. However, given acceptance of high growth forecasts for the three areas studied that generally stated the experience of the 1960's would continue throughout the forecast period, the development of entirely new airports seemed the only rational alternative.

DISCUSSION OF INDIVIDUAL CAUSES

As the outline presented above suggests, it is possible to identify a number of causes for the airport relocation; however, whether or not these would have actually led to the creation of an entirely new facility -- without the presence of high growth projections for air service demand -- is an entirely different question. In the discussion that follows, the nature of these major causal factors are discussed in greater detail.

Space for Expansion

In the case of all three airports noted above, the need for space for expansion is mentioned most often and most strongly as the reason for new airport construction. There are at least four dimensions to this expansion question that should be noted. First, in each of the airports there was a significant need for expansion space in regard to airside activities. For example, the Kansas City Municipal Airport consisted of a little over 50 acres. The facility was so tight in terms of space, that major problems of congestion were encountered in parking aircraft, and it was often necessary to shuttle empty equipment to other fields for service and storage. In a number of cases, due to the compactness of airside facilities, aircraft which had just landed had quite long waits in order to reach gates, and other problems related to maneuvering on the airfield itself were encountered. The airfield was so small that it was not possible to plan seriously for the construction of new hangars.

A lack of space for expansion in regard to landside activities was also a major causal factor. For example, in the case of Kansas City, the old Municipal Airport had a maximum capacity of 1,000 vehicular parking spaces. There was no satellite parking, and there was no room for the expansion of terminal facilities or air freight facilities. In the case of Love Field in Dallas, while that airport accounts for almost 1,300 acres, space was simply not available for any type of increased air carrier operations, general aviation operations, or the expansion of passenger and traffic control facilities.

In this context, each of the airports demonstrated major problems in terms of expanding the airport boundary into contiguous areas. The Kansas City airport was bounded on at least three sides by the Missouri River, and on the fourth by a highway system. More typical is the situation found in Montreal and Dallas. In these cities the areas surrounding the airport became highly built up with commercial, industrial, and residential land uses. Not only was the surrounding area characterized by a high incidence of vehicular congestion, but land prices were high; acreage for commercial and industrial use in each case exceeded $50,000 per acre. Further, due to a growing sensitivity on the part of local residents and merchants, any type of airport expansion into the neighboring areas was likely to have been strongly opposed. In many cases, residents and businessmen in the area indicated that any type of airport expansion would adversely affect their businesses and the quality of life -- even though most of the economic activities in the area were clearly airport related.

Airside and Landside Situations

The question of the relative importance of airside versus landside activities in stimulating airport expansion is one where professionals often tend to disagree. For example, some feel that landside problems of saturation are easier to deal with than are airside problems. However, in this analysis landside activities in the views of citizens, city planners, and businessmen appear to have been considered to be more significant in limiting growth. For example, in the case of Montreal, local airport planners indicate that even with relatively high demand projections, airside related capacities at Dorval were certainly adequate through 1985. However, landside operations were characterized by exceptionally high levels of congestion, and their peak saturation point was considered passed in 1973.

Operational Safety Factors

The question of air operations safety is another factor that should be noted in this context because it is closely related to expansion potential. For example, the old Kansas City Municipal Airport had a main runway length of only 7,000 feet, which presented some major problems for aircraft operations in inclement weather and influenced capacities during summer months. Also, in Kansas City and to a lesser extent in Montreal and Dallas, the surrounding area was characterized by a number of dangerous obstacles such as radio and television towers, high rise apartments, large retail signs, and other urban features that presented safety hazards.

Quality of Service

Another group of considerations that led to airport relocations are related to the quantity and quality of air service. In each of the three airports, due to limitations on the scale of operations and especially the number and length of runways, a number of flights were characterized by relatively long delays. For example, in the case of Love Field, there were several hours each day with runway delays of 20 to 30 minutes. At the same time, parking, traffic, baggage handling, and similar types of problems exacerbated the situation and led to significant passenger dissatisfaction. Also, in the case of Kansas City's 7,000-foot runway, in the hottest summer months the number of passengers and amount of air cargo had to be reduced in order to assure certain safety minimums.

The air carriers themselves were very sensitive to the extent of passenger dissatisfaction at these locations, and this could have been one of the major factors in ensuring their support for the new airports.

Similarly, in all three communities, the terminals themselves were outmoded to varying degrees. These facilities were initially constructed in the 1940's and 1950's, and despite significant improvements over time they tended to be too small, to have outmoded baggage handling equipment, and to use poor passenger routings; in some cases (such as Love Field), a series of incremental improvements only served to lengthen the walk from passenger lounges to the aircraft. In short, delays to aircraft, congestion, and turmoil in passenger related activities, and the general age of the facilities all suggested that major improvement programs would be required.

Environmental and Land Use Concerns

A number of land use questions contributed to the eventual decision to relocate. Each of the airports experienced over a decade of complaints regarding the impact of noise on contiguous areas. By the late 1960's and early 1970's, these complaints had become quite common and had evolved from angry phone calls to acrimonious lawsuits. Further, a number of citizen groups began to emerge in the late 1960's organized primarily to fight airport expansion in these communities on environmental, economic, and other grounds. Because of these types of conflicts with surrounding areas, and including the problems in regard to expansion noted above, a number of airport planners in the three metropolitan areas felt that it was not feasible to expand locally.

Role of General Aviation

Although it was not a major consideration, a number of planners who were involved in the relocation decision were concerned about potential conflicts with general aviation activity. In the case of each airport examined, competition for airspace as well as landside facilities had caused certain types of confrontations between general aviation groups and the scheduled air carriers. Consequently, although it was not a strong consideration, the possibility of improving general aviation conditions through relocation was one consideration in the planning process.

Regulatory Pressures

In order to obtain a more rational distribution of regional airport facilities, direct intervention by the CAB and FAA in several cases stimulated the relocation decision. For example, the withdrawal of Federal funds for either planning or construction until Dallas and Fort Worth ended their intense competition was a prime factor in solidifying plans for a major new regional airport. To an even greater extent in the case of Montreal, direct Federal intervention was a critical factor leading to the decision that an existing airport would not be adequate despite any type of renovation or expansion program.

Trends in Air Transportation

The airlines, as well as the airport planners, were also influenced in their relocation decision by perceptions of evolving trends in air transportation. For example, from the mid-1960's onward, the belief was widely held that by the mid-1970's the jumbo jet of the 747 variety would be common; some observers suggested that by 1985 aircraft significantly larger than a 747 would be commonplace. In other words, it was held that, due to technological changes in equipment, the old airports with their limited runways and support facilities would simply be outmoded. Similarly, by the early 1960's, a number of schemes had reached the planning stages for highly automated and computerized baggage and passenger transfer systems, and it was felt that most existing terminals could not accommodate this new technology. This shift to reliance upon very large aircraft in each of these three cases was also accompanied by the assumption that international travel would increase greatly, requiring facilities that were not available. In short, the decision to relocate was also stimulated by a number of assumptions concerning shifts in airline equipment and certain types of operations which would have made existing facilities obsolete.

Airports as Economic Multipliers

The new airports in Montreal, Dallas-Fort Worth, and Kansas City all were built with the idea that they would present a major stimulus for economic growth. In the case of Dallas-Fort Worth, the new airport was seen as a gateway that would attract a large number of new jobs and new businesses to the area, some of which would be related to the airport, but many of which would be attracted by the symbol of wealth, power, and forward thinking that would reflect very favorably upon the area. More specifically, businessmen in the Dallas-Fort Worth area felt that the airport would make the "metroplex" region a major banking and financial center, a major center of international trade, and even lead to the development of a massive research and development complex. Both psychological and economic multipliers were used as justification for the magnitude of the Dallas-Fort Worth facility, and local mass media suggested that "the impact of the new Dallas-Fort Worth airport on the landlocked metroplex can be calculated only in billions of dollars."[1] It was also stated that "the effects of the Dallas-Fort Worth airport will unwittingly touch every man, woman, and child in the metroplex -- the total direct and indirect impact of the airport in 1975 is estimated to be $637 million spread into virtually every industry sector."

In the case of Kansas City, similar sentiments were expressed for building an entirely new facility, and a confidential report prepared for the City Council stated that "Kansas City must place highest priority on obtaining the rapid and orderly development of KCI to ensure the future role of the city against possible stagnation and deterioration as a place to live and work."[2] On a visit to Kansas City, the president of Braniff Airlines stated "There is no doubt that Kansas City will become a new international gateway to the world's major cities."

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[1] Jay D. Starling, et al., Technology and Politics: The Regional Airport Experience (Dallas: Southern Methodist University, 1976), chapter 2.

[2] Ibid., chapter 3.

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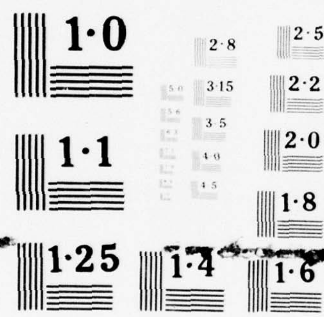
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In short, because of factors related to regional development, and a strong desire to develop symbols of metropolitan wealth and power, key decisionmakers in these communities were almost forced to think in terms of major airport relocation as opposed to expansion or improved air traffic control procedures that would have significantly extended the utility of existing facilities.

Problem of Demand Projections

Each of the airports had carried out quite comprehensive projections of demand for air traffic, including both passengers and freight. For the most part, these projection programs were based upon trends that were prevalent in the late 1950's and throughout the decade of the 1960's, a period of rapid growth in the demand for air traffic services. In the case of these three airports, most existing studies indicated that demand was growing so rapidly that conditions would likely become intolerable by the mid-1970's. As will be discussed in greater detail in the final section of this chapter, experiences clearly indicated that these projections have proven to be high.

SECTION 3. CHARACTERISTICS OF THE RELOCATION PROCESS

During the actual relocation process, at each of the three airports a number of unanticipated problems arose which varied widely in terms of their overall significance for the success of the airport relocation. In each community, initial airport planning had begun in the 1950's. Ground was acquired and construction started in the 1960's, and operations were initiated in the early 1970's.

In each of the three airports studied, a number of common problems arose during the planning and implementation process associated with the airport relocation. In the following discussion, these problem areas are grouped according to the severity and frequency of occurrence.

Areas with Few Problems

Several areas related to the airport relocations presented no significant problems, and generally had been fully anticipated. These included:

a. The basic architectural and engineering studies carried out in relation to the terminal, runways, appropriate hangar and related structures, and the overall airport configuration.

b. Initial land acquisition.

c. The attraction of hotels, motels, rental car agencies, and other ancillary services.

d. The floating of revenue bonds and obtaining financing.

e. Most types of air operations equipment.

f. Utilities, such as water, sewer, and energy resources (for these three activities, no major environmental problems were encountered).

g. Overall community support.

Areas with Unanticipated Problems

In some areas, problems related to relocation did arise, and they did have some type of negative impact on the conduct of construction as well as on the actual relocation process. These types of problems included:

a. The design and completion of access roads, especially freeway interchanges.

b. Obtaining additional land for expansion (at reasonable cost).

c. The development of anti-airport sentiment by some citizens.

d. Considerable public confusion over terminal layout, signs, services, and other passenger features.

e. Public confusion concerning transportation within the airport area, especially involving shuttle service between airlines.

f. The attraction of industrial and service activities to develop revenue.

g. Adequate training and preparation of airline personnel for the actual transfer of activities.

h. Some problems encountered in the area of fixed base operations designed to serve general aviation interests.

i. The reluctance of all scheduled carriers and especially air taxi services to transfer operations.

Areas with Severe Problems

In some cases, very severe problems were encountered that caused adverse impacts on operations and costs. These included the following:

a. The provision of dependable and economic ground transportation services -- especially important in the case of remote facilities.

b. Serious labor problems related to escalating costs, strikes, and conflicts over jurisdiction.

c. Implementation of sophisticated passenger, baggage, and freight handling systems.

AREAS WITH FEW PROBLEMS

In most respects, the actual relocation processes that characterized the Dallas-Fort Worth, Kansas City, and Montreal airports have been relatively smooth. That is, from that time when a firm decision to relocate was made until scheduled air service was actually transferred, relatively few major barriers to operations and relocation were encountered.

In the area of architectural, engineering, and other airport consulting services, the planning process proceeded without significant problems. For the most part, designs utilized at the new airports borrowed heavily from techniques that were relatively well-proven in other new U.S. facilities. The only extraordinary planning expenses stemmed from situations where the air carriers raised their estimates of the utilization of jumbo jets; this caused some minor redesign expenditures. Although a number of people have been critical of the exceptionally large scale of the Dallas-Fort Worth and Mirabel efforts, these tended to reflect the high growth rates in the demand forecasts rather than any architectural and engineering shortcomings.

In regard to land acquisition, few major hurdles were encountered. In the case of Montreal, the problem was solved by government expropriation of 17,000 acres directly related to air operations, as well as an additional 71,000 acres to be controlled by a special municipality. In most cases, initial land acquisition began when prices were quite low (for example, $350 per acre in the case of Kansas City), and prices did escalate as the program progressed. Still, the most rapid increases in land prices were not encountered until the development was fairly far along and did not present major hurdles. Similarly, no problems were encountered in attracting a number of hotels, motels, rental car activities, and other appropriate ancillary services to the Dallas-Fort Worth and Kansas City International airports; however, because of its isolation, this movement is slower in Montreal. In regard to revenue bonds, few problems were encountered in floating the entire issues. This reflected the fact that the communities involved aggressively supported the overall development program through official actions, through public relations programs, and even to the point of underwriting and guaranteeing certain expenditures. Perhaps more important is the fact that loan guarantees made by the individual air carriers made these bonds exceptionally safe investments, so no problems were encountered in their sale.

In the area of air operations, the relocations also encountered few problems. Only a few practice take offs and landings were required to familiarize pilots with the new facilities, and most airlines prepared detailed guidelines and training programs to facilitate the actual shift of equipment and personnel. With the exception of the very complex baggage and people-mover systems at Dallas-Fort Worth, the worst impacts of the relocation were only several days of confusion on the parts of both passengers and airline employees.

In the cases of Dallas-Fort Worth and Kansas City (and to a much lesser extent in Montreal), community support was especially strong for the airport throughout most of the relocation process. Citizens had been well briefed on the nature of the operations, and the many economic benefits which were attributed to the new facilities had been quite prominent in the local press for many years. Consequently, no major problems concerning local support occurred during this phase. In fact, when the sophisticated baggage and passenger handling capabilities of Dallas-Fort Worth were proven somewhat ineffective, the community disappointment that characterized many local residents is often assumed to be a reflection of just how much the facility had been oversold and how high the local residents' expectations had become.

AREAS WITH UNANTICIPATED PROBLEMS

During the actual relocations, a number of problems arose that resulted in unanticipated expenditures of time and, in many cases, funds.

These new regional airports were designed around traffic patterns that necessitated a number of new limited access highways and interchanges. In each of these three cases, airport planners proceeded to lay out proposed special access highways with little detailed coordinated planning involving official transportation agencies. That is, required roads were laid out in feasibility plans, but these sometimes differed from actual transportation routes that had been planned and funded. In the case of existing limited access highways (and those authorized and funded), the new airport plans involved the construction of new interchanges, but in some cases these were not adequately coordinated with transportation agencies. While a satisfactory set of interchanges and access roads was produced at each airport, these patterns were often realized only after a number of meetings with transportation officials, many of which were less than pleasant.

As the airport development evolved, in Kansas City and to a lesser extent in Dallas-Fort Worth, it became clear that additional land for expansion would be required. Contiguous landowners had become aware of the potential value of their parcels, and prices rose precipitously. For example, even though it is a rural area, land that was selling for $350 an acre when KCI was laid out initially in 1965, was selling for almost $5,000 an acre by 1971. These costs, and the reluctance on the part of some landowners to sell also presented some temporary barriers to development. Furthermore, as construction progressed around each of the airports a certain degree of anti-airport sentiment developed among citizen groups. By the early 1970's, this anti-airport feeling was manifested most strongly in complaints concerning noise pollution, air pollution, loss of agricultural land, and other related complaints (factors that relocation was to ameliorate).

A number of problems were encountered around the time of the new facilities' formal openings. For example, considerable public confusion over terminal layouts, signs, services, public transportation, and other passenger features was observed. This reflected the availability of the services, the placement of signs, and the generally new layout of the facilities. Especially significant was public confusion concerning transportation within the airport area, primarily as it involved shuttle service between airlines and terminals. It is important to point out that the greatest percentage of derogatory comments about Dallas-Fort Worth, and complaints by passengers, involved the people-mover and baggage handling system (Airtrans), and these comments are still being made. However, in all three airports, planners recognized that the vociferous nature of these complaints is a direct reflection of the degree to which the innovative advances at these facilities may have been oversold before they were adequately proven and tested.

In the case of Dallas-Fort Worth, and to a lesser extent at the other airports, adequate training and preparation of airline personnel for the actual transfer of activities presented problems. While manuals and guidelines had been prepared in order to facilitate the transfer, it is clear that many employees did not receive adequate briefings. The unfamiliarity of employees with new facilities and equipment, coupled with regular breakdowns of baggage handling and people-moving equipment, led to considerable confusion surrounding the airport opening.

Finally, and potentially most serious, was the reluctance of certain scheduled air carriers and especially air taxi services to transfer operations. With the possible exception of Kansas City International, each of the airports encountered situations where a major carrier did not want to transfer all of its operations at one particular time. This led to considerable confusion on the part of some carriers. Similarly, a number of problems were encountered in the area of fixed base operations designed to serve general aviation interests, and several weeks were required to sort out the availability of services required to serve this aviation component.

In essence, most of these shortrun problems presented relatively minor inconveniences for the airport operator and have been overcome. However, if these new airports were to be built today, problems of new roads, land for expansion, and anti-airport sentiment probably would be much more serious.

AREAS WHERE SEVERE PROBLEMS WERE ENCOUNTERED

In terms of the actual relocation process, relatively few severe problems were encountered. For the most part, these fall into three main groups.

First, the provision of dependable and reasonably priced ground transportation services has been a problem at Kansas City International and Mirabel. At both of these airports, a number of schemes involving special contracts with taxi firms, airport limousine services, buses operated by public and quasi-public boards, and other methods for moving passengers to the airports have been adopted, with limited success. The distances and costs involved have presented major barriers to the satisfactory use of the new airport. In these cases, a direct tendency has been observed for private vehicles to be utilized, presenting major cash flow problems for the public transportation operators. On the other hand, business and recreation travelers who do not have privately owned vehicles available complain about the adequacy of the public transportation service and related costs. In Dallas-Fort Worth, just the opposite situation has been encountered. Here, Surtrans, the public transportation activity, has proven exceptionally popular from Dallas to the airport, less so from Fort Worth, but has been generally accepted to the point that privately owned vehicles have not been utilized extensively for airport access. This has meant that revenues from parking lots have failed to reach projected magnitudes. In fact, the demand for parking spaces at Dallas-Fort Worth is so low that a multistory parking garage has not been formally opened.

Second, serious labor disputes were encountered at each airport. While these varied in intensity, competition between various labor organizations caused a number of other disruptions.

Third, it is clear that at least in the case of Dallas-Fort Worth some types of equipment which were built into the new airport complex had not been well tested and proven. For example, the Airtrans people-mover and baggage handling apparatus and certain other types of equipment were not adequately perfected for Dallas-Fort Worth. This has resulted in a high degree of passenger dissatisfaction with the Dallas-Fort Worth Airport. Since the Airtrans system at Dallas-Fort Worth is carrying only a small portion of the passenger, baggage, and other items that it was designed to serve, alternative means of transportation and transport must be utilized. Further, the system has proven undependable, and a number of attendants are assigned to operate individual vehicles (or at least to assist passengers when the system breaks down), greatly increasing the cost of operation.

SECTION 4. EVALUATION OF THE RELOCATIONS

In most respects, the airport relocations described above have been successful. Overall, many of the problems that developed were worked out within several months following the actual transfer of scheduled air service. However, certain issues still are presenting problems for the airports:

a. Passenger service is generally higher than before; however, the costs to the air carriers have also risen above anticipated levels.

b. Major ground transportation problems still exist in moving passengers between terminals and between metropolitan areas and airports.

c. Increasing pressure is felt from contiguous land uses in such forms as exceptionally high prices for expansion space and complaints over noise.

d. Revenues from airport operations are below projections.

Beneficial aspects of the moves include:

a. The relocation of scheduled air service has resulted in a rapid expansion of general aviation activities in the old airports.

b. The effective utilization of abandoned central city terminals (in retailing, recreation, and business and personal services) are producing important sources of funds for the municipalities involved.

c. Space for larger facilities if needed.

d. Fewer persons exposed to airport environmental impacts.

With few exceptions, the airlines, as well as officials of the airports, feel that the new facilities represent a significant improvement over the old airports. While both Dallas and Kansas City experienced a leveling off of passenger demand immediately after the relocation, total enplanements (although less than had been forecasted) soon surpassed previous levels, and growth in total air passenger service has continued at the facilities. Detailed evaluation of the slight reduction in demand indicated that there were certain groups of travelers in each metropolitan area that reacted unfavorably to the additional drive to the new airport. In most cases, these were passengers traveling relatively short distances who determined that it was worth their time (and money) to simply drive to destinations up to 100 miles away, as opposed to driving some additional distance to an airport and then boarding an aircraft. Consequently, the overall impact on passenger service has been substantial.

In terms of costs, the relocation has presented a number of problems for the airlines themselves. In the case of Dallas-Fort Worth, landing fees are more than three times what they were before relocation, and they are between 25 to 35 percent higher than they were projected to be at the new facility. Due to the cost overruns that were encountered at the airports, other types of operational costs have been passed on to the airlines and have presented some major problems. This is especially important for this analysis because this is one of the major reasons why it will be difficult to get airlines to underwrite major new airports in the future. Similarly, this is one of the reasons that major air carriers will be reluctant to underwrite and guarantee various types of bond issues.

Major ground transportation problems still exist in moving passengers between terminals, and between metropolitan areas and the airports. As suggested above, the airports have not worked out entirely adequate systems for moving passengers between cities and the air terminals, and programs involving contracts of taxicabs, limousine services, and scheduled bus services have generally lost money. The only exception has been Dallas-Fort Worth, where so many people have been using Surtrans that parking revenues have been significantly reduced. While passengers generally like the general layout of new terminals, it is clear that the necessity for them to use shuttle cars or buses between terminals has presented a problem. The projections of the airlines in this regard have been inaccurate. For example, it was anticipated that relatively few transfers would occur in Dallas-Fort Worth and in Kansas City; however, in both of these airports the transfer rate has greatly exceeded expectations, causing problems in moving passengers and baggage between terminals and between airlines. This problem may be one of success, reflecting the attractiveness of the airports and their scheduled services for connecting flights.

In terms of land use, the relocations have not proven as acceptable as anticipated. In the case of Montreal, the development of an extensive buffer has tended to eliminate many problems related to complaints, pressure of contiguous land uses, and other factors, although this isolation has been achieved with a number of tradeoffs in the area of surface transportation and passenger contentment. At both Dallas-Fort Worth and Kansas City, increasing pressure is being felt from contiguous activities in forms such as exceptionally high prices for surrounding land, increasing complaints concerning noise, and other factors. In other words, the growth of commercial, industrial, and to a lesser extent residential activity around the airport, which was so desirable in initial planning, has led quite early to a resumption of complaints.

One of the most serious problems encountered at the new airports studied is the fact that revenues have not reached anticipated magnitudes. In its first full year of operation, Dallas-Fort Worth incurred an operating deficit of approximately $5 million. Between 1972 and 1976, Kansas City International had accumulated an operating deficit of well over $1 million. These revenue shortfalls indicate that demand for air service has not matched projected payback levels, and that a number of revenue generating mechanisms associated with the airport (such as parking, rents from ancillary activities, and others) have failed to provide an operating surplus.

One of the most significant side benefits of the airport relocations has been the impact on general aviation. In the case of Love Field in Dallas, the growth in general aviation activities and the expansion of fixed base operations have been dramatic. For example, in 1974 Dallas ranked 48th among all cities in terms of general aviation activities; in 1976 it had risen to 8th place. The old Kansas City Municipal Airport has also experienced major growth in general aviation and fixed base operations; take offs and landings are almost 100 percent greater than was the case when scheduled air service was there. The increase in general aviation activities has also proven to be a valuable source of revenue for these cities.

At Love Field, the old terminal and field has been converted to a variety of other uses as well, including a major recreation center, office space, theaters, as well as a number of airport related activities. In Kansas City, the old terminal has been converted to a major wholesale trade mart for apparel manufacturers, with three major convention halls for various types of programs and numerous restaurants, and has experienced significant growth in airport related activities such as repair parts for aircraft, distribution activities, repair services for avionics, and the development of several air taxi firms. Thus, a positive cash flow is generated by these facilities; both Dallas and Kansas City have developed moneymaking activities at their old terminals.

In this context, it is important to point out that one of the major sources of contention between the cities of Dallas and Fort Worth involved the use of Love Field for intrastate transportation. In 1976, Southwest Airlines handled almost 700,000 passengers from Love Field and contributed significant revenues to the City of Dallas (not to the Dallas-Fort Worth Airport) for the use of this field. When this income is added to other sources of revenues being generated at Love Field, it is clear that this is emerging as a major source of income for the City of Dallas.

SECTION 5. REVENUES FROM DISPOSAL OF EXISTING AIRPORTS

If entirely new airports are constructed in response to identified airport capacity requirements, there is potential for conversion of the existing airport to other uses. Generally speaking, a replaced airport represents a source of prime industrial land. Significant revenues can be realized from the sale or lease of the existing airport facilities which would be replaced. A number of factors must be considered in determining the possible value of airports which are replaced. Obviously, each airport is unique and must be evaluated by itself. The factors which must be considered include:

a. The airport's size and location.

b. The nature of surrounding land use.

c. The site's accessibility to important transportation facilities including railroads and waterways.

d. The facilities present onsite including infrastructure, utilities, buildings, and other structures.

e. The demand for and value of industrial land in the urban area.

Each site considered for reuse should be evaluated in a number of ways. Property assessors dealing in industrial properties should be consulted to estimate the reuse or salvage value of the existing facilities. Local real estate firms should be consulted to make use of their detailed local knowledge. Finally, case studies of other airports which have been replaced and reused should be performed. This applies to a number of major airports. For example, Willow Run was replaced by Detroit Metropolitan Airport and has been converted to a number of industrial uses.

Due to the wide variations in location, size, and facilities of existing airports, it is impossible to arrive at a typical disposal revenue, such as the typical cost established for construction of a hypothetical new airport. However, the total cost of relocation would also involve the construction of a new primary airport for the hub, and the capital cost of this facility can be estimated to be in the range of $600 million, exclusive of land acquisition. New land acquisition on the urban fringe is likely to be more than compensated for by disposal of existing facilities, although the area of new sites would be on the order of two to three times larger than existing sites. In summary, it is relatively safe to assume that relocation would always cost money, and in many cases the total cost would be on the order of a half billion dollars.

SECTION 6. FUTURE AIRPORT RELOCATIONS

Based upon the discussion of the factors noted above and a review of the changes that have taken place at the individual airports, it is appropriate to raise the question as to whether or not it is generally feasible today to relocate a major air facility. Based upon the interviews conducted with airport managers and air carrier executives, the review of case studies, and discussions with government officials, the answer is that relocations would be difficult. This conclusion is based upon the following:

a. Land -- it would be exceptionally difficult to pull together one parcel of several thousand acres at a reasonable price.

b. Ground-based transportation -- at this time, no workable and economic solution exists, and it would be extremely difficult to have a functioning air facility that is more than 15 or 20 miles from a metropolitan area and still provide dependable public transportation.

c. Funding -- in the past, most bonds have been supported by guarantees by individual air carriers or municipal agencies; this is less likely to be the case in the future.

d. Improvements in air traffic control and peak scheduling in many cases may remove the need for a new airport.

POTENTIAL RELOCATIONS OF AIRPORTS IN THE 21 HUBS

As described in detail in the other chapters, 10 of the 21 hubs examined in this research demonstrate a capacity deficit in scenario 1. Based upon considerations such as anticipated impacts of noise, air quality, water quality, access, and site selection procedures that have been completed, it is possible to rate the 10 airports according to the degree to which total relocations of scheduled air services are feasible (refer to table 6-2). As noted in table 7-1, relocations appear feasible in terms of four airports (Atlanta, Chicago, Denver, and Seattle). However, relocations are doubtful in Minneapolis, Philadelphia, St. Louis, and San Francisco and are clearly not feasible in Boston and New York.

TABLE 7-1. FEASIBILITY OF MAJOR AIRPORT RELOCATIONS IN SELECTED CITIES

	Feasible	Doubtful	Not Feasible
Atlanta	X		
Boston			X
Chicago	X		
Denver	X		
Minneapolis		X	
New York			X
Philadelphia		X	
St. Louis		X	
San Francisco		X	
Seattle	X		

SECTION 7. CONCLUSIONS

The analysis of airport relocations presented above provides a number of conclusions to guide future decisions of this type. Among the most important of these are:

a. Overall, the level of expertise available in the architectural and engineering side of airport design is quite well developed. Two basic structures have received considerable attention: a terminal between runways (such as Kansas City International) and the single landside facility with transport to loading areas (Montreal and Dulles). Airport planners have been able to build upon proven techniques so that, in the future, this aspect of airport relocation should present no major problem.

b. In the area of site selection, it is clear that no totally acceptable methodology is available at present. Airport site selection involves accepting a very high number of tradeoffs that leave no one satisfied. The site selection process involves airline executives, airport managers, departments of transportation, environmental groups, local political officials, union officials, and others and will arrive at a site that appears to alienate the fewest number of people. However, it is clear that this type of thinking tends to result in new airport locations far removed from the major passenger sources, and these eventually leave the airlines, management, and especially the passengers totally dissatisfied. Further, the effort to achieve consensus through remoteness is leading to increased problems (and costs) in arriving at satisfactory solutions to providing passenger transportation to the airport from surrounding metropolitan areas.

c. New regional airports in themselves may not significantly stimulate regional economic development. An examination of the new facilities at Kansas City, Dallas-Fort Worth, and other cities suggests that the overall growth potential of a region dictates the economic expansion of a particular area. In the airports studied, it was not possible to demonstrate that the new airport facilities themselves have attracted any new industry, and in some cases (such as the motels surrounding Kansas City) the lack of growth potential is providing considerable local alarm. It is appropriate to point out that Atlanta, which has been used as a case study of the situation where a new airport (completed in the midsixties) led to significant growth, has been exceptionally hard hit in the recession of the early 1970's; most regional planners attribute its growth over the last decade to excellent highway and rail transportation.

d. In too many cases, the new airports purchased and attempted to implement various types of people and cargo handling equipment that was not at the point of feasible use. For example, in regard to the Airtrans system at Dallas-Fort Worth, only two of the system's six functions are working, and the airport has incurred enormous cost overruns and expenses related to this program. It is now clear that while the general technology for Airtrans was well developed, the actual hardware and the implementation of this system had not been sufficiently proven. However, it is also important to recognize that Airtrans was conceived to some extent in symbolic terms, where the sophistication of the system played as important a role in proclaiming the modernity of Dallas-Fort Worth as it did in actually handling passengers and baggage. In other words, airport planners in Dallas-Fort Worth were interested in having one of the world's most sophisticated and complex baggage and people-mover systems. One airport planner stated that when sophisticated technology begins to serve a symbolic role, it often results in physical and technical excess and increases the possibility that both designers and users will expect much more from the system than it can provide.

e. The airport planners involved in these facilities have misread trends in air transportation: in their conception of their airports as gateway cities, the planners for these facilities had counted on greatly increased numbers of international flights, which have not been forthcoming. In the cases of Dallas-Fort Worth and Kansas City, connections to the Orient and to Europe have not materialized; they have instead had to depend upon only minor connections to Mexico. Even in regard to Montreal, there is some evidence that Mirabel has not evolved as the focal point for international traffic in eastern Canada. Further, plans for accepting the Concorde at Dallas-Fort Worth and plans in Kansas City for dealing with aircraft substantially larger than 747's have not materialized. In short, the airports misread trends in these areas as well as other critical factors such as trends in transfer patterns of passengers.

f. In terms of financial consequences, the history of the new airports is not good. At Dallas-Fort Worth, large amounts of money have been expended in trying to get the Airtrans and baggage handling systems operational (additional costs have been incurred in busing, trucks, and manpower to compensate), and parking related revenues have declined significantly. As a result, landing fees have increased very rapidly at that airport, increasing from $0.65 per 1,000 pounds in the early 1970's to $0.90 per 1,000 pounds in 1975: fees generally higher than incurred in other airports. Similarly, unit costs at Kansas City, Montreal, and other new airports have been higher than expected, reflecting the fact that anticipated demand has not materialized. This is unfortunate from a number of perspectives, not the least of which is the fact that costs are often passed on to the air carriers themselves, making them more reluctant in the future to expend funds directly for airport improvements or to guarantee revenue bonds.

g. The impacts on general aviation have generally been very good. For example, as noted above, the general aviation activity at Love Field caused that airport to go from 48th place in the United States to 8th place in terms of general aviation activity since scheduled service was transferred. General aviation activity in Kansas City is substantially higher than it was before the airport transfer.

h. The movement toward airport consolidation has a number of favorable and unfavorable aspects. From the point of view of the airlines, the wholesale and immediate transfer of all scheduled activity appears to be the most effective method of shifting service. In those cases when all scheduled services have not been transferred, as in the case of Southwest Airlines at Love Field and in the case of Mirabel and Dorval in Montreal, there is considerable passenger confusion and a splitting of costs that increases total costs. Further, in the case of Dallas-Fort Worth, the landing fees accruing to Dallas as a result of the use of Love Field are emerging as a major source of conflict between Dallas and Fort Worth. The movement toward consolidation has increased the number of flight options but reduced the number of airport options, which has significantly increased access problems.

CHAPTER 8. POSSIBLE ROLES FOR FEDERAL ACTION

The number and scope of airport planning elements and the intensity of community impacts resulting from airport operations have increased substantially over the past decade. New planning issues (e.g., citizen participation), planning procedures (e.g., environmental impact statements), and airport operating procedures (e.g., noise abatement measures) have come of age in airport expansion programs and new airport location studies. These new airport planning issues are now being incorporated with traditional airport planning issues, such as the physical infrastructure and the political balance of costs and benefits between users and nonusers of airports. The lack of available land for new airports in some regions of the nation has also emerged as a prominent airport planning consideration. The number and intensity of noise, accessibility, and other adverse community and environmental impacts from operations at air carrier airports have also increased over the last decade as a result of both the physical expansion of airports and the simultaneous urban development of open space lands in the vicinity of the airports.

Although new airport planning programs have been restructured to accommodate the myriad of planning factors noted above, the airport planning process has not kept pace with the complexity of emerging planning issues. As noted in chapters 6 and 7, this lag in maintaining the effectiveness of the airport planning process in major metropolitan areas of the United States over the last few years has significantly impaired the ability of communities to provide timely additional capacity at new or existing airports. Only one new major airport (Dallas-Fort Worth) has been constructed since the 1960's. Several existing major hub airports are approaching maximum capacity with no feasible options for expansion. In particular, expansion options are becoming increasingly limited because of lack of available land, environmental constraints, and soaring land and construction costs. These conditions have led some airport planners to agree with critics who have suggested that there may never be another major new air carrier airport built in the United States.

In this chapter, a number of possible areas for Federal action to alleviate some common airport planning problems are explored. These are approached by:

a. Characterization of common airport planning problems of national significance which might effectively be resolved by Federal action.

b. Description of present governmental roles and relationships in the airport planning process.

c. Identification of areas where Federal roles in the airport planning process may be appropriate.

The objective of this component of the study was only to identify possible Federal actions. The scope and time frame of the study did not permit evaluation of:

a. The host of legal and institutional issues related to the exercise of Federal authority in airport planning.

b. The procedures that would be required for effective implementation of any of the possible Federal actions.

c. Other ramifications that may directly impact the overall effectiveness of the various actions.

Therefore, the Federal actions outlined in this chapter require a more comprehensive examination before actual implementation is contemplated.

SECTION 1. COMMON AIRPORT PLANNING PROBLEMS

Several common issues of national significance that result from airport operations and current airport planning processes were identified in previous chapters. These issues, which are briefly characterized in the following paragraphs, include:

a. Lack of integrated airside/landside versus access/egress planning.

b. Multijurisdictional conflicts and coordination.

c. Community relations and increased citizen participation in the airport planning process.

d. Land availability for expansion or new airport development.

AIRSIDE/LANDSIDE VERSUS ACCESS/EGRESS PLANNING

At several of the 24 major hub airports studied, different local agencies have responsibility for the airside/landside facilities and the access/egress system. The airport facility is owned and operated by an airport commission while the responsibility for access/egress systems is under the jurisdiction of a city or county department of streets and public works. Similarly, the authority for mass transit system planning often falls under the jurisdiction of a regional planning or transportation authority. As a result of piecemeal planning by various agencies, development plans usually do not address the airport environ as a system. Consequently, the capacity of airside and terminal facilities may not be fully used until the ground access system is upgraded, which often takes several years.

MULTIJURISDICTIONAL CONFLICTS AND COORDINATION

Multijurisdictional conflict and coordination problems are frequently encountered if the expansion of an existing airport or construction of a new airport entails land acquisition in more than one municipality. Multijurisdictional conflicts also arise when spillover effects from airport operations occur. No mechanisms currently exist to effectively incorporate regional planning and implementation agencies into airport master planning programs. Rivalry between political units, lack of a regional authority responsible for areawide airport planning and implementation, and the power of local governmental units to halt a proposed airport development which may be in the best interest of the region are other common major multijurisdictional issues that must be addressed in airport planning programs.

COMMUNITY RELATIONS AND CITIZEN PARTICIPATION

When a major airport construction program is contemplated, community relations efforts frequently concentrate on responding to adverse publicity. Mechanisms for effectively incorporating citizen participation into the airport planning process before formal public hearings have also been lacking. Public opinion is influenced by the clarity with which information is brought to its attention. The identification of citizen groups, the design and organization of projects to effectively incorporate community values, and mechanisms for relating social values of citizen groups to a proposed airport project are important elements which must be incorporated into the airport planning process.

LAND FOR EXPANSION OR NEW AIRPORT DEVELOPMENT

As a major regional transportation facility, a major air carrier airport induces development in open spaces in the vicinity of the airport but not owned by the airport. To provide adequate levels of service for projected passengers and to minimize adverse impacts on surrounding communities resulting from technological innovations, generally airports must also expand outward into surrounding communities. Most hub airports are now generally faced with no room for expansion and/or conflicting land use patterns which exist at the airport/community interface even though open space lands, buffer areas, and land for all anticipated future airport expansion plans were set aside more than 15 years ago. Zoning ordinances and other forms of land use controls generally have not been effective in retaining contiguous land areas for future airport expansion programs, nor in protecting the enormous public investment in airport facilities from the development of surrounding incompatible land use patterns. Also, metropolitan growth in the form of suburbanization has been so intensive in some hub regions (particularly in the northeastern United States) that no environmentally acceptable and topographically usable land areas of sufficient size remain in relative proximity (less than 50 miles from the CBD) for possible development as new hub airport sites.

SECTION 2. GOVERNMENTAL ROLES IN THE AIRPORT PLANNING PROCESS

Planning for major air carrier airports in the United States primarily occurs at four levels of government. The four levels of planning, which are briefly described below, are:

a. National Airport Systems Plans undertaken at the Federal level by the Federal Aviation Administration.

b. State Airport Systems Plans usually undertaken by an aeronautics commission with the state department of transportation.

c. Regional (substate) and Metropolitan Airport Systems Plans for each hub undertaken by a regional transportation planning agency.

d. Master Plans for each airport undertaken by the local governmental agency that owns and operates the airport.

Additionally, airline planning and local governmental land use and surface transportation planning are also important components in the airport planning process.

The National Airport Systems Plan (NASP) is a 10-year planning program whose basic objective is to provide adequate capacity at public airports. This planning program seeks to provide long-range guidance for the integration of local and regional air transportation subsystems into a rational and efficient national air transportation system.

State airport systems plans include all aviation facilities required to meet the immediate and future air transportation needs of a particular state. State airport systems plans also show the timing and estimated cost of airport expansion and development. Although most state airport systems plans are primarily oriented to general aviation facilities, they normally include expansion programs at existing air carrier airports and recommendations for the general location of new airports.

Regional and metropolitan area airport system plans encompass both commercial and general aviation facilities required to meet existing and projected air transportation demands for a given Standard Metropolitan Statistical Area or a state planning region or district. Regional and metropolitan area airport system plans contain specific recommendations as to the extent, type, general location, estimated cost, and timing of all anticipated airport developments within a designated planning period.

Master plans are periodically written for airport owners/operators to reflect the current development and operations of an existing airport and to present planned modernization and expansion of existing airports and/or site selection and planning for new airports.

Throughout the planning process, a host of issues must be considered, including air safety and airspace regulations promulgated by the FAA, EPA water and air standards, and the impact of aircraft noise. Federal agencies that in some way regulate or affect airports and their operations include the Departments of Commerce, Defense, Housing and Urban Development, and Justice, the Environmental Protection Agency, and agencies in the Department of Transportation. In addition to airport proprietors, airlines, and regulatory agencies, the airport planning process must also take into account other interest groups made up of various combinations of the numerous subgroups of users and nonusers. Although most of the funding for airport planning studies is provided via Federal/local sharing grants administered through the planning grant program (PGP), no mechanism exists to ensure an integrated planning process that comprehensively incorporates desires of all interest groups; uses the same time frame, assumptions, and data inputs; or provides for a continuous updating of the contents of resulting plans.

SECTION 3. SUGGESTED FEDERAL ROLES IN THE AIRPORT PLANNING PROCESS

The Federal role is defined as those policies, programs, and practices that Federal agencies should pursue to facilitate the air carrier airport planning process in the national interest. The following suggestions as to the appropriate Federal roles in the airport planning process are based upon opinions and ideas solicited from individual airport managers, consultants, and planners as well as local and regional transportation and planning agency personnel. They are also based upon the common problems identified above.

Since the airport planning process is ever changing in terms of regulatory procedures and the implications of technological advancements, specific Federal roles could be modified accordingly. Improvements to Federal agency roles are identified, in the following discussion, to further promote coordination among the four airport systems planning programs and among all local planning agencies and programs affecting the airport environ (airside, landside, access/egress, and surrounding land use), to alleviate national implications of local control policies and procedures, and to promote assessments of the benefits and costs of using military airfields for civilian use.

Integration of Airport Systems Plans

The present four-level airport systems planning (national, state, regional or metropolitan, and master plan) are sometimes inconsistent, especially when state and local boundaries are transcended. Air traffic originates from the entire hub service area, not only from within the confines of the jurisdiction which may own and operate the major airport. A particular need for airport system planning on a multistate level exists in the Northeastern United States where large tracts of open spaces are not generally available for new airport locations. The most logical place to ensure consistency among the four airport systems planning programs is at the national level. Once planning overlaps or omissions are identified, efforts could be made at an early stage to rectify emerging problems.

Airport Planning Period

Another aspect of the present airport planning process that could be addressed is the planning period. Currently, the planning period is from 5 to 10 years for capital improvement and airline passenger planning projections. More generally, longer-range airport expansion programs are sometimes identified in airport master plans. This planning period is seemingly appropriate given the status of technological innovation, population changes, and economic conditions upon which the need for new airport facilities is based.

However, the airport planners interviewed estimated the time frame after the initial decision is made to construct a new airport to be at least 15 years (without substantial court action) to complete the site selection process, environmental reviews, land acquisition, airport design and master planning, and construction. Therefore airport planning programs must allow early identification of the need for a new airport facility so that the facility can be constructed and become operational when required.

As one means of ensuring continuity among the airport systems planning studies, the FAA could annually establish and distribute a set of comprehensive planning guidelines and 20-year traffic projections based on a common set of demographic, economic, and technological assumptions.

Integration of Airport Environ Planning

The integration of airside, landside, access/egress, and land use planning within the general airport environ is a two-sided problem that includes: first, the outward airport expansion to accommodate anticipated air travel, and second, the control of incompatible land use adjacent to the airport. As characterized earlier in this chapter, several different local agencies have authority over land use and ground transportation facilities near airports. Land use and ground transportation systems planning programs must incorporate long-range airport requirements.

Presently, most A-95 agencies in the hub regions studied merely review and comment upon federally assisted airport programs. Increased coordination among agencies at all levels (which can total as many as 50 agencies) is required during the entire planning process, not just during the planning review stage.

Existing federally coordinated planning programs for metropolitan areas could be improved or modified as appropriate to elicit the direct cooperation and involvement of all levels of government in airport planning programs.

Technical Planning Assistance

By virtue of its overview position, and because of its responsibility to carry out the Federal airport grant-in-aid and surplus property programs, the FAA is in a position to observe what is occurring nationwide, study current airport issues, and to systematically promulgate pertinent information. The obvious benefits of this are more uniform approaches to airport planning throughout the country and a greater amount of knowledge available to airport planners. Examples of what has been done in the past include guidance on performing airport master and system planning, airport dimensional design standards, and guidance on such specific issues as airport terminal design and environmental assessment of airport development. Further research could be performed dealing with current questions such as potential airport capacity increases available through implementation of noncapital innovations such as hourly quotas or peak hour pricing, and the development of a long term planning process to establish future major new airports.

Mitigation of Nationally Significant Impacts

Anticipated state and local airport planning and operational decisions that have national impacts must be addressed at the earliest possible stage. The national implications of the various noise abatement control strategies being imposed and planned is the most significant issue of this type to require timely and decisive Federal action today. The Department of Transportation could encourage the use of one common noise rating system. The desirability of action along these lines was mentioned by many airport operators.

Citizen Participation and Public Awareness

The FAA could expand its present efforts to provide guidance for citizen involvement in the airport planning process. A program could be designed to educate the general public on airport impacts (both positive and adverse) so as to reveal the significance of an airport to community welfare. While conflicts between interest groups may be irreconcilable, areas of disagreement might be decreased. Public educational programs might subsequently lessen community opposition to proposed and future airport expansion programs by permitting the programs to stand on their own merits. Since airports require large public investments which pay off over a long period of time, and costs are generally more conspicuous than benefits, political and community leaders should be involved at the outset of the airport planning program and throughout the planning process.

Use of Military Bases as Air Carrier Airports

An option to new site development frequently cited by airport planners was the use of an existing military airfield and installation facilities for air carrier operations, especially in metropolitan areas in which undeveloped land for a new airport is not available. Often military airfields are relatively close to metropolitan areas, have established airport operation impact zones, and have established ground access routes. Both the joint civilian/military use and total acquisition of installations being closed have been suggested.

Therefore, airport system planning programs should include detailed assessments of the benefits and costs of the potential utilization of military airfields for civilian use.

The airport planning process is a dynamic process, and airport planning and operating agencies must accordingly be flexible. The planning process for major air carrier airports could include changes in existing Federal roles to address identified common airport planning problems and emerging issues of national significance in order to ensure adequate air transportation facilities in metropolitan areas of the United States. Several possible Federal actions were discussed in this chapter; however, these possible actions require further evaluation to determine the feasibility of their implementation.

APPENDIX. AIRPORT ACTIVITY AND DELAYS

This section gives the airport activity scenarios and consequent average delays for each of the 24 study airports. For each airport, low, middle, and high activity scenarios are given. Each scenario gives aircraft operations and passenger enplanements for the years 1985, 1990, 1995, and 2000. The average annual growth rates for air carrier and air taxi operations and enplanements associated with these three scenarios are given in table A-1.

TABLE A-1. ANNUAL GROWTH RATES OF AIR CARRIER AND AIR TAXI OPERATIONS AND ENPLANEMENTS

Airport activity scenario	(Percent)	
	Operations	Enplanements
High	2.7	5.3
Middle	2.2	4.1
Low	1.2	3.1

TABLE A-2. AIRPORT ACTIVITY AND DELAYS AT ATLANTA

		Airport Activity Scenario											
		Low				Middle				High			
		1985	1990	1995	2000	1985	1990	1995	2000	1985	1990	1995	2000
Air Carrier and Air Taxi													
Enplanements and deplanements, millions*		36	43	48	54	40	50	59	69	45	59	73	90
Operations, thousands*		535	547	565	571	595	642	699	745	620	683	759	826
Average Aircraft Delay Without General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no	1.7	2.0	2.4	2.7	2.5	3.8	7.6	13.9	2.9	5.7	13.5	30.6
no	yes	1.2	1.3	1.6	1.8	1.6	2.3	4.2	8.0	1.8	3.1	7.8	17.5
yes	no	0.7	0.7	0.8	0.8	0.9	1.2	1.6	2.2	1.0	1.5	2.3	3.8
yes	yes	0.6	0.6	0.6	0.6	0.6	0.8	1.0	1.3	0.7	0.9	1.3	2.1
General Aviation													
Operations, thousands*			55		56		55		56		93		108
Average Aircraft Delay With General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no		2.5		3.8		5.3		22.1		11.2		67.8
no	yes		1.6		2.3		3.0		11.6		5.6		47.3
yes	no		0.9		1.1		1.5		3.0		2.3		8.0
yes	yes		0.7		0.8		1.0		1.7		1.4		3.7

*Federal Aviation Administration

TABLE A-3. AIRPORT ACTIVITY AND DELAYS AT BOSTON

		Airport Activity Scenario											
		Low				Middle				High			
		1985	1990	1995	2000	1985	1990	1995	2000	1985	1990	1995	2000
Air Carrier and Air Taxi													
Enplanements and deplanements, millions*		17	21	23	26	19	24	28	33	21	28	35	43
Operations, thousands*		300	307	316	322	333	360	391	420	347	383	425	466
Average Aircraft Delay Without General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no	4.2	5.1	6.2	7.6	7.8	12.5	19.0	27.5	10.0	16.9	27.1	39.8
no	yes	2.5	3.0	3.6	4.3	4.5	8.0	13.8	21.6	6.0	11.9	21.2	32.5
yes	no	1.7	1.9	2.1	2.3	2.7	4.2	6.6	9.6	3.3	5.9	10.1	15.7
yes	yes	1.2	1.3	1.4	1.5	1.7	2.4	4.0	6.4	2.0	3.4	6.8	11.6
General Aviation													
Operations, thousands*			81		124		81		124		113		130
Average Aircraft Delay With General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no		8.2		15.5		18.0		47.1		27.1		68.6
no	yes		4.7		9.3		12.1		34.6		19.3		52.9
yes	no		2.9		4.6		6.2		15.9		9.8		25.4
yes	yes		1.8		2.6		3.6		10.7		6.2		17.7

*Federal Aviation Administration

TABLE A-4. AIRPORT ACTIVITY AND DELAYS AT CHICAGO

		Airport Activity Scenario											
		Low				Middle				High			
		1985	1990	1995	2000	1985	1990	1995	2000	1985	1990	1995	2000
Air Carrier and Air Taxi													
Enplanements and deplanements, millions*		44	50	55	60	49	58	67	77	55	68	83	101
Operations, thousands*		668	639	611	582	743	750	757	761	774	797	821	842
Average Aircraft Delay Without General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no	6.0	5.3	4.5	3.7	12.4	15.4	19.4	23.3	16.5	25.8	37.7	51.0
no	yes	3.6	3.2	2.7	2.3	7.3	8.9	10.7	12.4	9.6	14.2	22.3	33.2
yes	no	1.9	1.6	1.3	1.1	3.3	3.6	3.8	4.0	4.2	5.2	6.2	7.4
yes	yes	1.2	1.0	0.9	0.8	1.9	2.1	2.3	2.3	2.5	3.2	3.9	4.6
General Aviation													
Operations, thousands*			50		50		50		50		50		50
Average Aircraft Delay With General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no		7.6		5.5		26.1		38.0		40.1		72.3
no	yes		4.3		3.2		14.1		22.0		23.6		52.5
yes	no		2.0		1.5		4.7		5.2		6.7		10.0
yes	yes		1.3		1.0		2.7		3.0		3.9		5.8

*Federal Aviation Administration

TABLE A-5. AIRPORT ACTIVITY AND DELAYS AT CLEVELAND

	Airport Activity Scenario											
	Low				Middle				High			
	1985	1990	1995	2000	1985	1990	1995	2000	1985	1990	1995	2000
Air Carrier and Air Taxi												
Enplanements and deplanements, millions*	9	11	12	14	10	13	15	18	11	15	19	24
Operations, thousands*	182	193	202	211	202	226	250	275	211	241	272	305
Average Aircraft Delay Without General Aviation, Minutes												
UG3RD / Peak Spreading												
no / no	1.5	1.7	2.0	2.3	1.8	2.5	3.3	5.0	2.0	2.8	4.5	8.3
no / yes	1.1	1.3	1.5	1.7	1.4	1.8	2.3	3.3	1.5	2.0	3.0	5.1
yes / no	0.9	1.0	1.1	1.3	1.1	1.5	1.9	2.4	1.2	1.7	2.3	3.5
yes / yes	0.7	0.8	0.9	1.0	0.8	1.1	1.4	1.7	0.9	1.2	1.6	2.3
General Aviation												
Operations, thousands*		162		181		162		181		162		181
Average Aircraft Delay With General Aviation, Minutes												
UG3RD / Peak Spreading												
no / no		7.1		14.4		10.7		42.5		13.3		68.7
no / yes		4.5		8.4		6.5		22.6		7.8		37.5
yes / no		3.1		4.5		4.3		9.0		5.0		13.7
yes / yes		2.1		2.9		2.7		5.3		3.1		7.7

*Federal Aviation Administration

TABLE A-6. AIRPORT ACTIVITY AND DELAYS AT DENVER

		Airport Activity Scenario											
		Low				Middle				High			
		1985	1990	1995	2000	1985	1990	1995	2000	1985	1990	1995	2000
Air Carrier and Air Taxi													
Enplanements and deplanements, millions*		16	19	22	24	18	22	27	31	20	26	34	41
Operations, thousands*		278	299	316	338	309	351	391	442	322	373	424	489
Average Aircraft Delay Without General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no	1.5	1.9	2.6	4.1	2.0	3.8	7.0	13.3	2.3	5.2	9.7	20.6
no	yes	1.0	1.3	1.7	2.4	1.3	2.2	4.3	9.0	1.5	3.0	6.4	13.8
yes	no	0.9	1.0	1.1	1.3	1.0	1.4	1.9	3.3	1.1	1.6	2.7	5.1
yes	yes	0.7	0.7	0.8	0.9	0.8	1.0	1.3	1.9	0.8	1.1	1.6	2.9
General Aviation													
Operations, thousands*			96		65		170		166		170		166
Average Aircraft Delay With General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no		4.0		6.5		14.3		64.6		19.1		96.1
no	yes		2.3		3.7		7.2		34.9		9.6		62.3
yes	no		1.7		1.9		4.4		12.1		5.5		21.4
yes	yes		1.2		1.3		2.4		5.7		2.8		9.6

*Federal Aviation Administration

TABLE A-7. AIRPORT ACTIVITY AND DELAYS AT DETROIT

		Airport Activity Scenario											
		Low				Middle				High			
		1985	1990	1995	2000	1985	1990	1995	2000	1985	1990	1995	2000
Air Carrier and Air Taxi													
Enplanements and deplanements, millions*		13	16	17	20	14	18	21	25	16	21	26	33
Operations, thousands*		228	242	254	262	254	284	314	342	265	302	341	379
Average Aircraft Delay Without General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no	0.5	0.5	0.6	0.7	0.6	0.7	0.8	1.0	0.6	0.8	1.0	1.3
no	yes	0.4	0.5	0.5	0.5	0.5	0.6	0.7	0.7	0.5	0.6	0.7	0.9
yes	no	0.3	0.3	0.3	0.4	0.3	0.4	0.5	0.6	0.4	0.5	0.6	0.7
yes	yes	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.3	0.4	0.4	0.5
General Aviation													
Operations, thousands*			56		49		85		87		85		87
Average Aircraft Delay With General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no		0.7		0.8		1.0		1.7		1.2		2.3
no	yes		0.6		0.7		0.8		1.1		0.9		1.4
yes	no		0.4		0.5		0.6		0.8		0.7		0.9
yes	yes		0.3		0.4		0.5		0.6		0.5		0.7

*Federal Aviation Administration

TABLE A-8. AIRPORT ACTIVITY AND DELAYS AT HONOLULU

		Airport Activity Scenario											
		Low				Middle				High			
		1985	1990	1995	2000	1985	1990	1995	2000	1985	1990	1995	2000
Air Carrier and Air Taxi													
Enplanements and deplanements, millions*		15	16	19	22	16	19	23	28	18	22	29	37
Operations, thousands*		185	195	201	206	206	229	249	270	215	244	271	300
Average Aircraft Delay Without General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no	0.4	0.5	0.5	0.6	0.6	0.7	0.8	0.9	0.6	0.7	0.9	1.0
no	yes	0.4	0.4	0.4	0.5	0.5	0.5	0.6	0.7	0.5	0.6	0.7	0.8
yes	no	0.3	0.3	0.3	0.4	0.3	0.4	0.5	0.6	0.4	0.5	0.6	0.7
yes	yes	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.3	0.4	0.5	0.6
General Aviation													
Operations, thousands*			99		71		160		160		160		160
Average Aircraft Delay With General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no		1.0		0.9		1.8		2.7		2.1		3.4
no	yes		0.8		0.7		1.3		1.7		1.4		2.1
yes	no		0.7		0.6		1.1		1.4		1.2		1.7
yes	yes		0.5		0.5		0.8		1.0		0.9		1.1

*Federal Aviation Administration

TABLE A-9. AIRPORT ACTIVITY AND DELAYS AT HOUSTON

		Airport Activity Scenario											
		Low				Middle				High			
		1985	1990	1995	2000	1985	1990	1995	2000	1985	1990	1995	2000
Air Carrier and Air Taxi													
Enplanements and deplanements, millions*		9	10	12	13	10	12	15	17	11	14	19	22
Operations, thousands*		204	227	238	248	227	266	294	323	236	282	318	357
Average Aircraft Delay Without General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no	0.8	0.9	1.1	1.2	0.9	1.2	1.6	2.2	1.0	1.4	2.0	2.9
no	yes	0.7	0.8	1.0	1.1	0.8	1.1	1.4	1.8	0.9	1.2	1.6	2.3
yes	no	0.5	0.6	0.7	0.7	0.6	0.8	0.9	1.1	0.6	0.8	1.0	1.3
yes	yes	0.5	0.5	0.6	0.6	0.5	0.7	0.8	0.9	0.6	0.7	0.9	1.1
General Aviation													
Operations, thousands*			84		127		104		202		104		202
Average Aircraft Delay With General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no		1.6		3.2		2.6		20.4		2.9		32.4
no	yes		1.4		2.5		2.0		13.4		2.3		22.9
yes	no		0.9		1.5		1.3		4.9		1.5		7.1
yes	yes		0.8		1.2		1.1		3.4		1.2		4.6

*Federal Aviation Administration

TABLE A-10. AIRPORT ACTIVITY AND DELAYS AT LAS VEGAS

		Airport Activity Scenario											
		Low				Middle				High			
		1985	1990	1995	2000	1985	1990	1995	2000	1985	1990	1995	2000
Air Carrier and Air Taxi													
Enplanements and deplanements, millions*		8	9	11	12	9	11	13	15	10	13	16	20
Operations, thousands*		135	147	158	167	151	174	197	220	158	186	215	245
Average Aircraft Delay Without General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no	0.5	0.6	0.8	0.9	0.6	0.8	1.1	1.4	0.7	0.9	1.2	1.6
no	yes	0.4	0.5	0.6	0.7	0.5	0.6	0.8	1.1	0.5	0.7	1.0	1.2
yes	no	0.2	0.3	0.4	0.4	0.3	0.5	0.6	0.7	0.4	0.5	0.7	0.9
yes	yes	0.2	0.3	0.3	0.4	0.3	0.4	0.5	0.6	0.3	0.4	0.6	0.7
General Aviation													
Operations, thousands*			152		169		152		169		233		283
Average Aircraft Delay With General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no		2.1		3.9		2.8		6.4		6.8		48.0
no	yes		1.5		2.5		1.9		3.8		3.9		22.9
yes	no		1.1		1.6		1.4		2.4		2.9		8.7
yes	yes		0.9		1.1		1.0		1.6		1.8		4.4

*Federal Aviation Administration

TABLE A-11. AIRPORT ACTIVITY AND DELAYS AT LOS ANGELES

		Airport Activity Scenario											
		Low				Middle				High			
		1985	1990	1995	2000	1985	1990	1995	2000	1985	1990	1995	2000
Air Carrier and Air Taxi													
Enplanements and deplanements, millions*		33	33	33	34	36	38	40	43	40	45	50	56
Operations, thousands*		474	461	444	427	527	540	548	556	550	576	597	619
Average Aircraft Delay Without General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no	1.1	1.1	1.0	1.0	1.6	1.9	2.1	2.3	1.9	2.6	3.4	4.7
no	yes	0.9	0.9	0.9	0.8	1.3	1.5	1.6	1.7	1.5	1.9	2.4	3.1
yes	no	0.4	0.3	0.3	0.3	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.7
yes	yes	0.3	0.3	0.3	0.2	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.6
General Aviation													
Operations, thousands*			32		44		32		44		60		60
Average Aircraft Delay With General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no		1.2		1.1		2.1		2.8		3.3		5.9
no	yes		1.0		0.9		1.6		2.0		2.3		3.9
yes	no		0.4		0.3		0.5		0.6		0.6		0.7
yes	yes		0.3		0.3		0.5		0.5		0.5		0.6

*Federal Aviation Administration

TABLE A-12. AIRPORT ACTIVITY AND DELAYS AT MIAMI (MIA)

		Airport Activity Scenario											
		Low				Middle				High			
		1985	1990	1995	2000	1985	1990	1995	2000	1985	1990	1995	2000
Air Carrier and Air Taxi													
Enplanements and deplanements, millions*		18	22	25	28	20	25	30	36	22	29	37	47
Operations, thousands*		322	345	363	379	358	405	449	495	374	432	489	550
Average Aircraft Delay Without General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no	1.1	1.3	1.5	1.7	1.4	2.0	3.1	4.3	1.6	2.7	4.1	7.2
no	yes	0.9	1.0	1.1	1.2	1.0	1.4	2.0	2.6	1.2	1.7	2.5	4.0
yes	no	0.8	0.9	0.9	1.0	0.9	1.2	1.6	2.3	1.0	1.4	2.2	3.4
yes	yes	0.6	0.7	0.7	0.8	0.7	0.9	1.1	1.5	0.7	1.0	1.4	2.0
General Aviation													
Operations, thousands*			60		60		146		179		146		179
Average Aircraft Delay With General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no		2.0		2.9		6.9		31.9		9.0		61.2
no	yes		1.4		1.8		3.9		14.9		4.8		30.2
yes	no		1.2		1.5		3.4		9.0		3.9		16.3
yes	yes		0.9		1.0		2.0		4.6		2.3		7.9

*Federal Aviation Administration

TABLE A-13. AIRPORT ACTIVITY AND DELAYS AT MIAMI (FLL)

		Airport Activity Scenario											
		Low				Middle				High			
		1985	1990	1995	2000	1985	1990	1995	2000	1985	1990	1995	2000
Air Carrier and Air Taxi													
Enplanements and deplanements, millions*		5	7	8	9	6	8	10	11	7	9	12	14
Operations, thousands*		105	115	123	130	117	135	152	169	122	144	165	187
Average Aircraft Delay Without General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no	0.7	0.9	1.1	1.2	0.9	1.2	1.5	1.9	0.9	1.4	1.8	2.2
no	yes	0.6	0.7	0.8	1.0	0.7	1.0	1.2	1.4	0.8	1.1	1.3	1.7
yes	no	0.4	0.5	0.6	0.7	0.5	0.7	1.0	1.2	0.6	0.9	1.1	1.4
yes	yes	0.3	0.4	0.5	0.6	0.4	0.6	0.8	0.9	0.5	0.7	0.9	1.1
General Aviation													
Operations, thousands*			250		250		250		250		250		250
Average Aircraft Delay With General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no		19.5		31.6		27.8		66.4		32.5		85.5
no	yes		11.7		18.4		16.3		37.7		18.8		49.8
yes	no		7.7		10.1		9.7		17.9		10.8		23.7
yes	yes		4.9		6.3		6.0		10.5		6.6		13.7

*Federal Aviation Administration

TABLE A-14. AIRPORT ACTIVITY AND DELAYS AT MINNEAPOLIS

		Airport Activity Scenario											
		Low				Middle				High			
		1985	1990	1995	2000	1985	1990	1995	2000	1985	1990	1995	2000
Air Carrier and Air Taxi													
Enplanements and deplanements, millions*		9	11	13	14	10	13	16	18	11	15	20	24
Operations, thousands*		187	202	217	232	208	237	269	304	217	252	292	337
Average Aircraft Delay Without General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no	1.8	2.3	3.0	3.7	2.5	3.7	5.9	11.4	2.8	4.4	8.7	22.3
no	yes	1.4	1.7	2.1	2.5	1.8	2.5	3.7	6.6	2.0	2.9	5.2	12.1
yes	no	1.1	1.4	1.6	1.9	1.4	2.0	3.0	4.3	1.6	2.4	3.7	6.9
yes	yes	0.9	1.0	1.2	1.4	1.1	1.5	2.0	2.8	1.2	1.7	2.4	4.1
General Aviation													
Operations, thousands*			159		181		159		181		225		287
Average Aircraft Delay With General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no		32.4		62.0		49.3		110.7		100.9		212.9
no	yes		18.1		44.2		32.5		88.2		80.9		182.5
yes	no		12.1		31.0		23.4		63.0		60.2		141.5
yes	yes		6.7		17.1		12.3		45.3		42.8		119.7

*Federal Aviation Administration

TABLE A-15. AIRPORT ACTIVITY AND DELAYS AT NEW ORLEANS

	Airport Activity Scenario											
	Low				Middle				High			
	1985	1990	1995	2000	1985	1990	1995	2000	1985	1990	1995	2000
Air Carrier and Air Taxi												
Enplanements and deplanements, millions*	7	9	10	11	8	10	12	14	9	12	15	18
Operations, thousands*	146	156	166	176	162	183	206	230	169	195	224	255
Average Aircraft Delay Without General Aviation, Minutes												
UG3RD / Peak Spreading												
no / no	1.5	1.7	2.0	2.3	1.8	2.3	3.2	4.6	1.9	2.7	4.1	6.4
no / yes	1.2	1.3	1.5	1.7	1.4	1.8	2.3	3.2	1.5	2.0	2.9	4.2
yes / no	1.1	1.2	1.3	1.5	1.2	1.5	1.9	2.4	1.3	1.7	2.3	3.3
yes / yes	0.8	0.9	1.0	1.1	1.0	1.2	1.4	1.8	1.0	1.3	1.7	2.3
General Aviation												
Operations, thousands*		85		109		114		219		114		219
Average Aircraft Delay With General Aviation, Minutes												
UG3RD / Peak Spreading												
no / no		4.8		10.0		11.1		126.3		13.7		153.2
no / yes		3.2		6.1		6.6		92.2		7.9		117.0
yes / no		2.8		4.6		5.2		56.2		6.2		72.8
yes / yes		2.0		3.0		3.4		34.9		3.9		47.8

*Federal Aviation Administration

TABLE A-16. AIRPORT ACTIVITY AND DELAYS AT NEW YORK (JFK)

		Airport Activity Scenario											
		Low				Middle				High			
		1985	1990	1995	2000	1985	1990	1995	2000	1985	1990	1995	2000
Air Carrier and Air Taxi													
Enplanements and deplanements, millions*		30	33	35	36	33	38	42	46	37	45	52	60
Operations, thousands*		425	433	435	428	473	509	539	560	493	542	586	622
Average Aircraft Delay Without General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no	25.9	31.7	33.6	34.0	46.8	78.9	105.0	130.4	60.8	105.4	146.0	192.8
no	yes	15.8	19.8	21.2	21.6	29.3	49.6	71.2	94.1	37.3	71.6	108.8	154.3
yes	no	5.1	5.6	5.7	5.0	8.9	13.9	19.5	24.0	11.5	20.3	33.1	45.8
yes	yes	2.9	3.1	3.2	2.9	4.8	7.3	10.4	13.0	6.1	10.9	18.5	26.1
General Aviation													
Operations, thousands*			30		30		30		30		30		30
Average Aircraft Delay With General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no		43.2		46.8		101.1		158.9		128.5		222.4
no	yes		25.5		27.8		67.4		121.3		91.9		183.0
yes	no		6.9		6.2		17.8		32.2		26.6		61.0
yes	yes		3.7		3.4		9.2		16.9		13.8		34.8

*Federal Aviation Administration

TABLE A-17. AIRPORT ACTIVITY AND DELAYS AT NEW YORK (LGA)

		Airport Activity Scenario											
		Low				Middle				High			
		1985	1990	1995	2000	1985	1990	1995	2000	1985	1990	1995	2000
Air Carrier and Air Taxi													
Enplanements and deplanements, millions*		23	25	27	29	25	29	33	37	28	34	41	49
Operations, thousands*		296	288	281	272	330	339	349	357	344	361	379	396
Average Aircraft Delay Without General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no	5.2	5.2	5.0	4.8	8.1	10.7	13.9	17.2	10.1	15.4	22.6	32.5
no	yes	3.6	3.6	3.5	3.4	5.3	6.7	8.6	10.7	6.4	9.5	14.4	20.9
yes	no	2.7	2.6	2.5	2.4	3.8	4.4	5.1	5.9	4.4	5.6	7.4	10.2
yes	yes	2.0	2.0	1.9	1.8	2.7	3.0	3.4	3.9	3.0	3.7	4.7	6.2
General Aviation													
Operations, thousands*			51		43		60		60		83		83
Average Aircraft Delay With General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no		9.0		7.5		24.5		41.6		50.7		92.5
no	yes		5.8		5.0		14.0		24.9		31.6		69.6
yes	no		4.0		3.5		8.0		11.8		14.9		31.2
yes	yes		2.8		2.5		5.0		7.0		8.4		17.5

*Federal Aviation Administration

TABLE A-18. AIRPORT ACTIVITY AND DELAYS AT NEW YORK (EWR)

		Airport Activity Scenario											
		Low				Middle				High			
		1985	1990	1995	2000	1985	1990	1995	2000	1985	1990	1995	2000
Air Carrier and Air Taxi													
Enplanements and deplanements, millions*		12	14	16	17	13	16	19	22	14	19	24	29
Operations, thousands*		217	233	249	263	242	274	309	344	252	291	335	381
Average Aircraft Delay Without General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no	3.1	3.8	5.1	5.9	4.1	6.6	14.4	26.0	4.6	8.8	23.4	46.9
no	yes	2.2	2.6	3.4	3.8	2.8	4.1	7.8	14.0	3.1	5.1	12.6	28.7
yes	no	1.8	2.1	2.7	3.1	2.4	3.4	5.3	8.6	2.7	4.0	7.7	15.8
yes	yes	1.4	1.6	1.9	2.1	1.7	2.3	3.3	4.8	1.9	2.6	4.4	8.2
General Aviation													
Operations, thousands*			66		66		80		96		80		96
Average Aircraft Delay With General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no		9.0		16.9		25.3		87.8		33.4		125.0
no	yes		5.2		8.9		13.3		62.6		18.1		94.4
yes	no		4.2		6.5		9.3		37.8		12.2		57.0
yes	yes		2.7		3.8		5.1		22.0		6.4		38.0

*Federal Aviation Administration

TABLE A-19. AIRPORT ACTIVITY AND DELAYS AT PHILADELPHIA

		Airport Activity Scenario											
		Low				Middle				High			
		1985	1990	1995	2000	1985	1990	1995	2000	1985	1990	1995	2000
Air Carrier and Air Taxi													
Enplanements and deplanements, millions*		13	16	19	21	14	18	23	27	16	21	29	35
Operations, thousands*		284	296	304	312	316	348	377	408	330	371	410	453
Average Aircraft Delay Without General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no	4.0	4.7	5.5	6.6	5.7	9.7	16.8	29.5	6.9	13.9	27.4	57.6
no	yes	3.0	3.5	4.0	4.8	4.1	6.6	11.6	21.0	4.9	9.4	19.4	42.3
yes	no	1.7	1.9	2.1	2.3	2.3	3.1	4.1	5.9	2.6	3.8	5.8	10.5
yes	yes	1.4	1.6	1.7	1.9	1.8	2.3	3.0	4.1	2.0	2.8	4.0	6.9
General Aviation													
Operations, thousands*			102		92		102		92		210		210
Average Aircraft Delay With General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no		16.0		22.8		39.5		92.3		157.6		267.7
no	yes		10.2		14.1		25.3		74.2		138.5		246.8
yes	no		4.7		5.3		8.4		18.9		55.9		121.3
yes	yes		3.3		3.7		5.5		11.3		40.5		103.1

*Federal Aviation Administration

TABLE A-20. AIRPORT ACTIVITY AND DELAYS AT PITTSBURGH

		Airport Activity Scenario											
		Low				Middle				High			
		1985	1990	1995	2000	1985	1990	1995	2000	1985	1990	1995	2000
Air Carrier and Air Taxi													
Enplanements and deplanements, millions*		12	15	17	19	13	17	21	24	14	20	26	31
Operations, thousands*		293	324	338	351	327	382	420	460	341	407	457	511
Average Aircraft Delay Without General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no	0.6	0.7	0.8	0.8	0.7	0.9	1.2	1.6	0.7	1.0	1.5	2.3
no	yes	0.4	0.5	0.6	0.6	0.5	0.7	0.8	1.0	0.6	0.8	1.0	1.4
yes	no	0.4	0.4	0.5	0.5	0.4	0.6	0.7	0.9	0.5	0.6	0.8	1.1
yes	yes	0.3	0.3	0.3	0.4	0.3	0.4	0.5	0.6	0.3	0.5	0.6	0.7
General Aviation													
Operations, thousands*			60		60		60		60		169		169
Average Aircraft Delay With General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no		0.8		1.1		1.2		2.2		2.6		6.5
no	yes		0.7		0.8		0.8		1.3		1.5		3.1
yes	no		0.5		0.6		0.7		1.0		1.2		2.4
yes	yes		0.4		0.5		0.5		0.7		0.8		1.3

*Federal Aviation Administration

TABLE A-21. AIRPORT ACTIVITY AND DELAYS AT ST. LOUIS

		Airport Activity Scenario											
		Low				Middle				High			
		1985	1990	1995	2000	1985	1990	1995	2000	1985	1990	1995	2000
Air Carrier and Air Taxi													
Enplanements and deplanements, millions*		14	18	21	25	15	21	26	32	17	25	32	42
Operations, thousands*		253	275	291	298	282	323	361	390	294	344	393	433
Average Aircraft Delay Without General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no	2.9	4.2	5.6	6.7	4.2	7.6	15.9	28.8	4.9	10.6	26.1	56.5
no	yes	2.1	2.8	3.5	4.1	2.8	4.5	8.7	16.3	3.1	5.9	14.7	32.7
yes	no	1.5	1.8	2.1	2.4	1.9	2.9	4.2	5.9	2.1	3.5	5.8	10.0
yes	yes	1.1	1.3	1.5	1.7	1.4	1.9	2.6	3.4	1.5	2.2	3.4	5.3
General Aviation													
Operations, thousands*			120		120		136		139		165		165
Average Aircraft Delay With General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no		18.7		41.1		54.1		143.1		94.3		219.7
no	yes		9.4		20.0		27.2		109.7		62.4		184.2
yes	no		5.4		7.9		11.9		40.4		26.5		83.4
yes	yes		3.2		4.3		5.9		19.0		11.6		53.4

*Federal Aviation Administration

TABLE A-22. AIRPORT ACTIVITY AND DELAYS AT SAN DIEGO

		Airport Activity Scenario											
		Low				Middle				High			
		1985	1990	1995	2000	1985	1990	1995	2000	1985	1990	1995	2000
Air Carrier and Air Taxi													
Enplanements and deplanements, millions*		4	4	6	6	4	5	7	8	4	6	9	10
Operations, thousands*		104	111	119	125	116	131	148	164	121	139	160	181
Average Aircraft Delay Without General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no	1.0	1.1	1.3	1.4	1.2	1.5	1.8	2.2	1.3	1.6	2.0	2.7
no	yes	0.8	0.9	1.0	1.1	1.0	1.2	1.4	1.7	1.0	1.3	1.6	2.0
yes	no	0.7	0.8	1.0	1.0	0.9	1.1	1.3	1.6	1.0	1.2	1.5	1.8
yes	yes	0.6	0.7	0.8	0.8	0.7	0.9	1.1	1.2	0.8	1.0	1.2	1.4
General Aviation													
Operations, thousands*			104		104		104		104		104		104
Average Aircraft Delay With General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no		4.2		5.2		5.3		9.6		5.9		12.8
no	yes		2.9		3.4		3.5		5.7		3.8		7.2
yes	no		2.8		3.3		3.5		5.0		3.8		6.2
yes	yes		2.0		2.3		2.4		3.2		2.6		3.9

*Federal Aviation Administration

TABLE A-23. AIRPORT ACTIVITY AND DELAYS AT SAN FRANCISCO

			Airport Activity Scenario											
			Low				Middle				High			
			1985	1990	1995	2000	1985	1990	1995	2000	1985	1990	1995	2000
Air Carrier and Air Taxi														
Enplanements and deplanements, millions*			24	28	33	36	27	33	40	46	30	39	50	60
Operations, thousands*			375	406	403	400	417	476	499	522	435	507	542	579
Average Aircraft Delay Without General Aviation, Minutes	UG3RD	Peak Spreading												
	no	no	14.8	23.3	23.7	23.9	25.7	56.5	76.3	99.3	31.9	78.5	111.5	156.3
	no	yes	10.5	17.0	17.2	17.3	18.7	39.7	56.2	77.6	23.1	58.2	89.0	133.0
	yes	no	4.4	6.6	6.5	6.3	7.5	15.5	20.9	28.7	9.4	22.4	34.4	53.6
	yes	yes	2.9	4.2	4.1	4.0	4.8	10.5	14.1	19.3	6.2	15.2	23.1	37.0
General Aviation														
Operations, thousands*				43		43		67		79		67		79
Average Aircraft Delay With General Aviation, Minutes	UG3RD	Peak Spreading												
	no	no		37.2		38.9		104.5		177.0		136.5		237.1
	no	yes		24.6		25.4		82.1		153.4		113.5		212.3
	yes	no		9.4		9.1		30.2		62.5		45.2		102.5
	yes	yes		5.9		5.6		18.7		42.7		29.1		80.0

*Federal Aviation Administration

TABLE A-24. AIRPORT ACTIVITY AND DELAYS AT SEATTLE

		Airport Activity Scenario											
		Low				Middle				High			
		1985	1990	1995	2000	1985	1990	1995	2000	1985	1990	1995	2000
Air Carrier and Air Taxi													
Enplanements and deplanements, millions*		8	9	11	13	9	11	13	16	10	13	16	21
Operations, thousands*		176	194	211	226	196	228	261	295	205	243	284	328
Average Aircraft Delay Without General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no	1.9	2.3	3.0	3.7	2.3	3.5	5.8	10.0	2.6	4.3	7.8	18.3
no	yes	1.4	1.7	2.2	2.6	1.7	2.5	3.7	5.9	1.9	2.9	4.8	10.1
yes	no	1.0	1.1	1.3	1.5	1.1	1.5	1.9	2.7	1.2	1.6	2.4	3.8
yes	yes	0.8	0.9	1.0	1.1	0.9	1.1	1.4	1.9	1.0	1.2	1.7	2.5
General Aviation													
Operations, thousands*			40		55		40		55		81		113
Average Aircraft Delay With General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no		3.7		7.0		5.5		22.5		11.4		93.1
no	yes		2.6		4.4		3.6		11.9		6.6		59.9
yes	no		1.5		2.3		2.0		4.6		3.5		14.0
yes	yes		1.2		1.7		1.5		2.9		2.3		7.2

*Federal Aviation Administration

TABLE A-25. AIRPORT ACTIVITY AND DELAYS AT TAMPA

		Airport Activity Scenario											
		Low				Middle				High			
		1985	1990	1995	2000	1985	1990	1995	2000	1985	1990	1995	2000
Air Carrier and Air Taxi													
Enplanements and deplanements, millions*		7	9	11	12	8	11	13	15	9	13	16	20
Operations, thousands*		152	168	182	194	170	198	226	254	177	210	245	281
Average Aircraft Delay Without General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no	0.3	0.4	0.5	0.5	0.4	0.5	0.7	0.9	0.4	0.6	0.8	1.1
no	yes	0.3	0.3	0.4	0.5	0.3	0.5	0.6	0.7	0.4	0.5	0.6	0.8
yes	no	0.2	0.2	0.3	0.3	0.2	0.3	0.4	0.5	0.3	0.4	0.5	0.7
yes	yes	0.2	0.2	0.3	0.3	0.2	0.3	0.4	0.5	0.3	0.3	0.4	0.5
General Aviation													
Operations, thousands*			126		154		126		154		205		290
Average Aircraft Delay With General Aviation, Minutes													
UG3RD	Peak Spreading												
no	no		1.0		1.4		1.2		2.3		2.3		8.9
no	yes		0.8		1.0		0.9		1.5		1.5		4.6
yes	no		0.7		0.9		0.8		1.2		1.3		3.7
yes	yes		0.5		0.7		0.6		0.9		0.9		2.1

*Federal Aviation Administration