Airport System Development

August 1984

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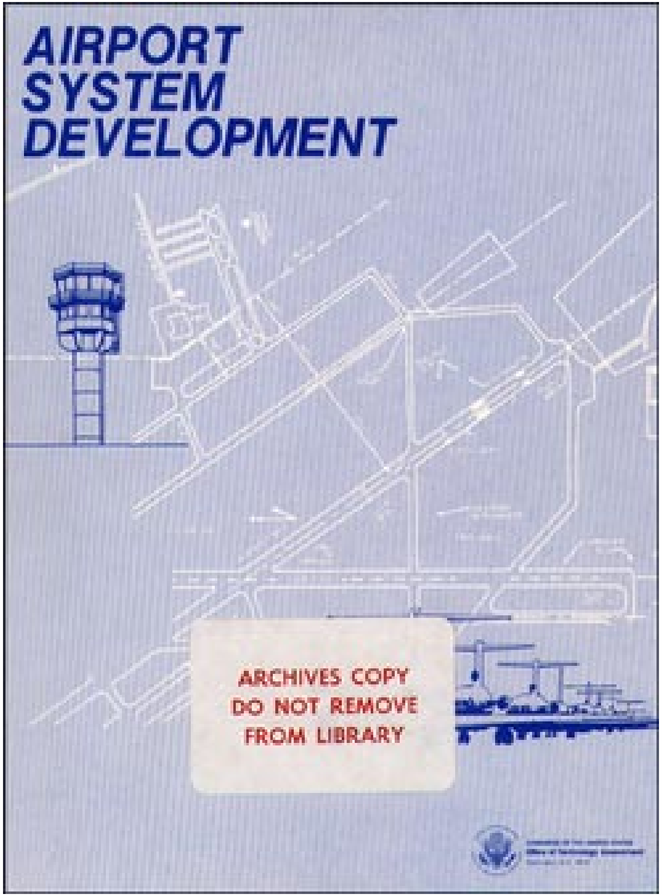

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Foreword

The United States has the largest and most technologically advanced system of airports in the world. These airports support an air transportation network that links all parts of the Nation to the rest of the world and enables over 300 million passengers each year to undertake journeys—many of great length—with ease, comfort, and safety. One measure of the excellence of this system is that over 98 percent of all airline flights arrive within 15 minutes of schedule.

Still, there is cause for concern about the future adequacy of the airport system. On one hand, there is need to accommodate expected growth in air travel demand at major airports, several of which are now experiencing severe congestion at periods of peak use. On the other, there is also need to assure access to airport facilities by private and business aircraft operators, who are fast becoming the predominant users of airports and the most active sector of civil aviation. Community concern about noise and land use limit the ability of airport planners and managers to provide additional facilities or, in some cases, to accommodate more traffic at existing facilities.

Undertaken at the request of the House Committee on Public Works and Transportation, this study examines present conditions and future needs of the Nation's airports, with emphasis on possible solutions to problems of operational capacity and air travel delay. The range of remedial actions considered includes improved airport and air traffic control technology, revised procedures for airport and airspace use, economic and regulatory measures to reduce demand during peak periods, and managerial approaches to make more efficient use of existing airport facilities. Special attention is given to issues of airport planning and funding methods at Federal, State, and local levels.

OTA was assisted in this assessment by an advisory panel reflecting a broad range of interests and expertise, ably chaired by Dr. Don E. Kash of the University of Oklahoma. OTA is greatly indebted to the advisory panel and to many others in the aviation community for their generous contributions. Their participation does not necessarily constitute consensus or endorsement of the content of the report, for which OTA bears sole responsibility.

One notable feature of this assessment is that it is a cooperative effort by the Office of Technology Assessment and the Congressional Budget Office, in which CBO provided detailed analysis of airport financial management, funding methods, and capital investment.

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OTA appreciates the valuable assistance and thoughtful comments provided by advisory panel members at many points during the assessment. OTA, however, accepts sole responsibility for the views expressed in this report.

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This assessment is a cooperative effort by the Office of Technology Assessment and the Congressional Budget Office. CBO'S work, which forms an integral part of this study has also been published by them in ***Financing U.S. Airports in the 1980s,*** April ***1984.*** OTA is particularly indebted to David Lewis, Richard R. Mudge, and Suzanne Schneider of CBO for their participation in this assessment.

'Through September]983
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THE AIRPORT SYSTEM

Photo credit: Dorn McGrath, Jr.

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Chapter 1
THE AIRPORT SYSTEM

INTRODUCTION

The system of airports in the United States is the largest and most complex in the world. As of the end of 1982, there were 15,831 airports on record with the Federal Aviation Administration (FAA) -4,805 publicly owned airports, 1,970 privately owned fields open to public use, and 9,056 reserved for private use only. This constitutes almost half of the world's total. These airports range in size from small unpaved strips used by a handful of private flyers to gigantic air transportation hubs such as Chicago O'Hare and Atlanta Hartsfield, each handling more than 500,000 operations (takeoffs and landings) per year.

The number of airports alone, however, does not adequately reflect the extent and volume of aviation activity in this country in comparison with other parts of the world. The United States has half of the world's airports, but two-thirds of the world's 400 busiest airports (in terms of passenger enplanements). Collectively, U.S. airports handled over 309 million passenger enplanements (domestic and international) and 3.6 million tons of mail and cargo in 1982—over three-quarters of the world totals, outside the Soviet bloc. ' Table 1 presents additional data on the size of the U.S. airport and air transportation system.

Because of the sheer number of airports and the variety of size and function, the term "airport system" has little meaning when applied to all the airports and landing fields in the United States as a whole. Many—in fact, most—of these airports exist only for the convenience of a few aircraft owners and operators and play no substantial part in public air transportation. For this reason, FAA has identified a smaller group of airports that serve public air transportation either directly or indirectly and can be deemed of national importance and eligible for Federal aid.

Since *1970,* FAA has published a list of such airports, classified by size and function, in a planning document known as the National Airport System Plan (NASP). Under the Airport and Air-

Table 1 .—U.S. Airport and Air Transportation Activity, 1982

Aircraft facilities:[a]	
Airports	12,596
Heliports	2,712
STOLports	65
Seaplane bases	458
	15,831
Airport ownership and use:[a]	
Publicly owned	*4,805*
Private, open to public	1,970
Private	9,056
	15,831
Domestic passenger enplanements (millions):	
Air carrier:	
Domestic	272.8
International	19.7
Commuter	17.1
	309.6
Domestic revenue passenger miles (billions):	
Air carrier	*207.8*
Commuter	*2.3*
	210.1
Civil aircraft fleet:	
Air carrier[b]	4,074
General aviation	209,799
	213,873
Aircraft operations (millions):	
Air carrier	9.1
Commuter and air taxi	5.1
General aviation	34.1
Military	2.3
	50.6
Hours flown (millions):	
Air carrier	*6.7*
Commuter	1.7
General aviation	*36.4*
	44.8
Air cargo (million tons):[c]	
Mail	1.2
Freight	2.4
	3.6

[a]Excludes Puerto Rico, Virgin Islands, and Pacific Territories.
[b]Includes commuter, air taxi, air travel clubs, and all-cargo service.
[c]1981 data.

SOURCE: Federal Aviation Administration and Civil Aeronautics Board data

'Airport Operators Council International, ***Worldwide Airport Traffic Report, Calendar Year*** 1982 (Washington, DC: AOC1, May 1983).

way Improvement Act of 1982 (Public Law 97-248), FAA was charged with preparing a new version of this plan, to be called the National Plan of Integrated Airport Systems (NPIAS), which is scheduled for issue in September 1984. As part of this planning effort, FAA has recently revised the method of classifying airports and now lists them in four major categories:[2]

1. Primary. -Public-use commercial service airports enplaning at least 0.01 percent of all passengers enplaned annually at U.S. airports.[3]
2. ***Commercial service.*** —Other public-use airports receiving scheduled passenger service and enplaning at least 2,500 passengers annually.
3. ***General aviation.*** —Those airports with fewer than 2,500 annual enplaned passengers and those used exclusively by private and business aircraft not providing common-carrier passenger service.
4. ***Reliever.—A*** subset of general aviation airports, which have the function of relieving congestion at primary commercial service airports and providing more access for general aviation to the overall community.

Table 2 lists the number of airports in each category as of the beginning of 1984 and those projected for inclusion in the NPIAS in 1994.[4]

Table 2.— Federal-Aid Airports by Service Level

Service level	Existing[a] (1984)	Projected[b] (1994)
Primary	281	284
Commercial service	279	346
General aviation	2,424	2,723
Reliever	219	286
Total	3,203	3,639

[a]As of February 1984.
[b]Very few of the projected additions will be new airports; most will be existing airports that qualify for Federal aid because of increased traffic volume.
SOURCE: Federal Aviation Administration.

Primary Airports

This category of airports, comprising 281 locations or less than 2 percent of all airports in the United States, handles virtually all of the airline passengers. Even within this small group, however, the range of airport size and activity level is very wide, and the distribution of passenger enplanements is highly skewed. About half of the primary airports (130) handle very little traffic, and collectively they account for only 3 percent of annual enplanements. At the larger primary airports, which handle the preponderance of passengers, there is a pattern of progressively higher concentration of traffic at fewer and fewer airports. For instance, the top 24 airports account for almost two-thirds of all enplanements, and the top 10 account for 40 percent. Perhaps the most telling fact is that one-quarter of all airline passengers board their flights at one of just five airports (Atlanta Hartsfield, Chicago O'Hare, New York Kennedy, Los Angeles, and Dallas-Fort Worth).[5]

Because several metropolitan areas are served by more than one primary airport, FAA measures aviation traffic by standard metropolitan statistical area (SMSA) as well as by individual airport. These metropolitan areas, called hubs by FAA, are divided into four classes according to percentage of total passenger enplanements: large, medium, small, and nonhub (table 3).

As with individual airports, the distribution of passenger enplanements is highly concentrated in a relatively few air traffic hubs. Figure 1 shows, for example, that 24 large hubs handle 70 percent of all traffic and, of these, the top 10 handle almost half.

Commercial Service Airports

Excluding primary airports, the remaining commercial service airports are typically small and located in communities with a population of under

[2]*First Annual Report of Accomplishments Under the Airport Improvement Plan, Fiscal Year 1982* (Washington, DC: Federal Aviation Administration, May 1983).

[3]In 1982, 0.01 percent was equivalent to about 31,000 enplaned passengers.

[4]Before 1983, FAA used a different classification scheme for larger airports, categorizing them according to the type of commercial service provided: air carriers and commuter airlines. The 1980 edition of the NASP listed 780 airports (635 air carrier and 145 commuter). The NPIAS classification reduces the total to 560 (281 primary and 279 commercial service), with the remaining very small commercial service airports (fewer than 2,500 annual enplanements) shifted to the general aviation category.

[5]Statistical ***Handbook of Aviation, Calendar Year 1982*** (Washington, DC: Federal Aviation Administration, December 1982).

Table 3.-FAA Classification of Air Traffic Hubs

Hub classification	Percent of total enplaned passengers	Number of hubs (1981)
Large	1,00 or more	24
Medium	0.25 to 0.99	39
Small	0.05 to 0.24	61
Nonhub	less than 0.05	425[a]

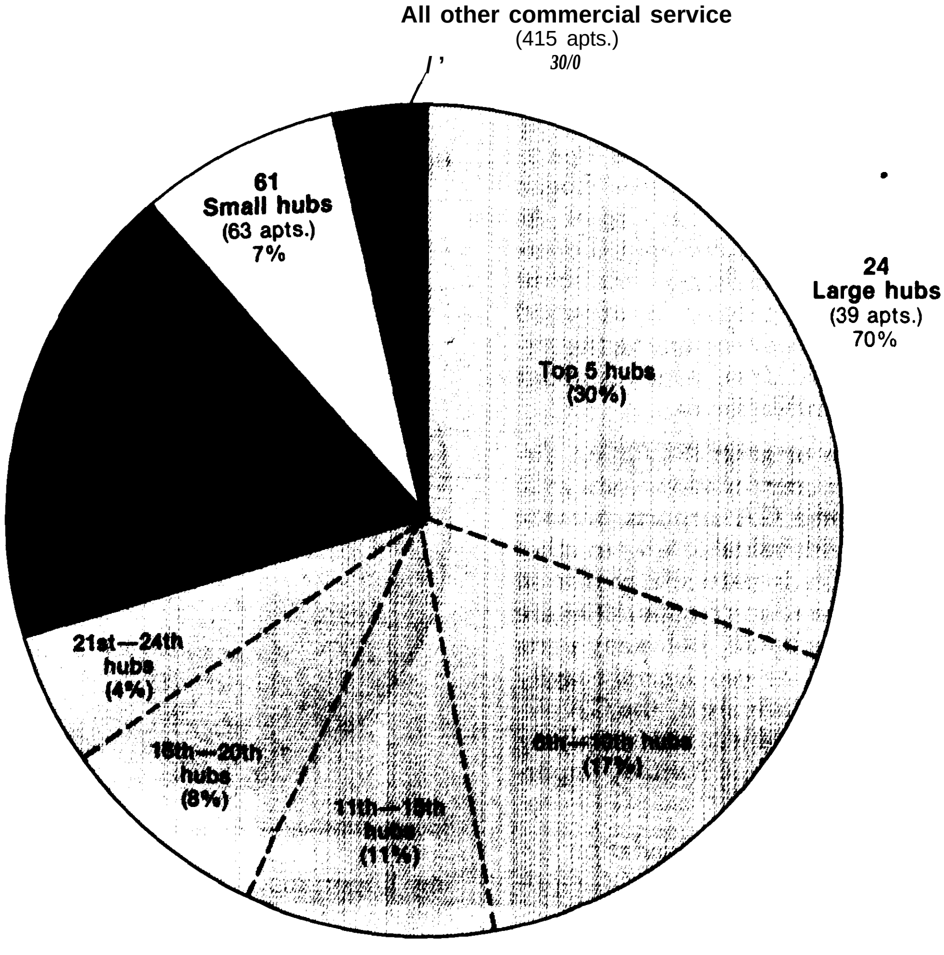
SOURCE: *Statistical Handbook of Aviation, Calendar Year 1982* **(IVashington, DC Federal Aviation Administration, December 1982).**

100,000. They handle a low volume of passenger traffic, 2,500 to 5,000 enplanements per year. Service is usually provided by commuter airlines, offering a few flights per day to nearby major hubs, and by air taxi operators. A large share of the activity at these airports is general aviation (GA), privately owned aircraft used for business and personal flying. The major concern of airports in this category is not adequate capacity but keeping the airport in operation so as to provide essential air service for the community and a base for general aviation.

General Aviation Airports

Over 90 percent of the airports available to the public are used exclusively by GA aircraft. General aviation is a broad and disparate category that includes aircraft used for business purposes, various types of aerial work, and flight instruc-

Figure I.—Distribution of Passenger Enplanements by Hub Size, 1982



SOURCE: *FAA Statistical Handbook of Aviation, Calendar Year 1982* tion, as well as those used for purely personal and recreational purposes (see fig. 2). The types of aircraft operated cover a wide spectrum: small piston-engine aircraft, advanced turboprops and turbojets, rotorcraft, gliders, balloons, and dirigibles.

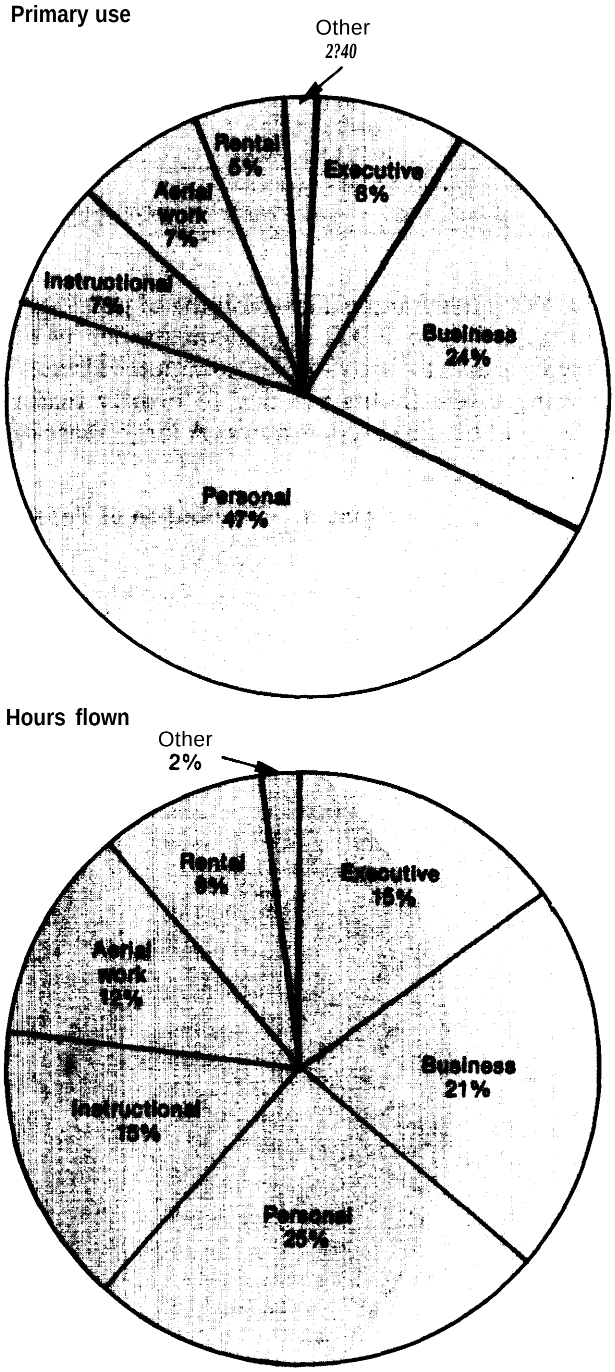
The airports serving general aviation are likewise varied. Typically, they are small, usually with a single runway and only minimal navigation aids. They serve primarily as a base for a few aircraft. There are notable exceptions, however. A few GA airports located in major metropolitan areas handle extremely high volumes of traffic (particularly business and executive aircraft) and are busier and more congested than all but the largest commercial airports. Table 4 lists the Nation's 10 busiest general aviation airports.

For comparison, the busiest GA airport, Van Nuys, CA, handled about 7 percent more operations in 1982 than Los Angeles International, the third-ranking air carrier airport in the United States (509,758 v. 478,892). Melbourne, FL, the 10th-ranking GA airport, had 229,138 operations—only slightly fewer than Boston Logan (244,748), the 10th-ranking air carrier airport. As additional perspective, the 301,363 annual operations at Tamiami Airport in Florida, the sixth-ranking GA airport, are equivalent to about so takeoffs or landings per hour (assuming the airport is open 16 hours per day), which is about the same as Washington National.

An important aspect of general aviation airports is that they serve many functions for a wide variety of aircraft. Some GA airports provide isolated communities with valuable links to other population centers. This is particularly true in areas of northern Alaska where communities are often unreachable except by air, but many parts of the Western United States also depend heavily on air transportation. In such areas, the GA airport is sometimes the only means of supplying communities with necessities and is vitally important in emergency situations.

The principal function of general aviation airports, however, is to provide facilities for privately owned aircraft used for business and personal activities. The role of GA airports in providing facilities for business aircraft is of growing importance. The business aircraft fleet is largely made up of twin-engine propeller or jet aircraft, typically equipped with sophisticated avionic devices comparable to those of commer-

Figure 2.-Profile of General Aviation Fleet, 1982



SOURCE: *FAA Statistical Handbook of Aviation, Calendar Year 1982.*

Table 4.—The 10 Most Active General Aviation Airports[a]

Airport	Annual operations
1. Van Nuys, CA	590,758
2. Long Beach, CA	461,287
3. Santa Ana, CA	396,029
4. Seattle-Boeing Field, WA.	362,524
5. Oakland, CA[b]	334,557
6. Tamiami, FL	301,363
7. Opa Locka, FL	295,215
8. San Jose, CA[b]	264,936
9. Pontiac, MI	238,532
10. Melbourne, FL[b]	229,138

[a]Ranked by number of operations (takeoffs and landings) by general aviation aircraft in 1982.
[b]Also receives commercial service; air carrier operations not included in total.

SOURCE: Airport Operators Council International, *Worldwide Airport Traffic Report, Calendar Year 1982* (Washington, DC: AOCI, May 1983).

cial airliners. General aviation airports serving business aviation play an important role by providing facilities comparable to those at major air carrier airports, thereby permitting diversion of some GA traffic from congested hubs.

Reliever Airports

Reliever airports are a special category of general aviation airports. They are located in the vicinity of major air carrier airports and are specifically designated by FAA as "general aviation type airports which provide relief to congested major airports." To be classified by FAA as a reliever, an airport must handle 25,000 itinerant operations or 35,000 local operations annually, either at present or within the last 2 years.[b] The reliever airport must also be located in an SMSA with a population of at least 500,000 or where passenger enplanements reach at least 250,000 annually. As the name suggests, reliever airports are intended to draw traffic away from crowded air carrier airports by providing facilities of similar quality and convenience to those available at air carrier airports.

In recent years, FAA and Congress have encouraged development of reliever airports as a means of reducing delays at the larger hub airports. This is reflected in the Airport and Airway Improvement Act of 1982 (Public Law 97-248), which specifies that 10 percent of airport aid funds be used for development of reliever airports.

[b]Local operations are aircraft flights that originate and terminate at the same airport. An itinerant operation originates at one airport and terminates at another.

Photo credit" Federal Aviation Administration

Reliever airport for general aviation

THE AIRPORT CAPACITY PROBLEM

The term "capacity" refers to the overall ability of an airport to accommodate demand for service. Often, this is expressed as the number of aircraft operations (takeoffs and landings) that can be handled on an hourly, daily, or annual basis. In the broadest sense, however, aircraft operations are not the only aspect of demand that must be considered. This ability of the terminal building to handle passenger flow and the volume of vehicular traffic that can be accommodated on airport circulation and access roads are also important. For aircraft operations, this rate of service is determined by several factors—chiefly the layout of runways, taxiways, and aprons, the paths through the airspace leading to and from the airport, the rules and procedures for controlling air traffic, the conditions of wind and weather, and the mix of aircraft using the airport. Within the terminal building and on the landside approaches to the airport, the service rate (throughput) is similarly affected by the basic design of facilities and by the characteristics of passenger traffic (ratio of origin-destination passengers to transfers, mode of surface access, etc.). Restrictions of vehicle movement on access roads and at the curbside and bottlenecks at ticket counters, check-in points, baggage handling facilities, and gates all create passenger delay and impinge on the efficiency of airport operation. Since all of these factors vary over time at a given airport, capacity is not a single, fixed amount but an average figure that represents the typical rate at which demand can be accommodated.

Since demand for airport service is not uniform and constant but highly variable from time to time and place to place, the root of the airport capacity problem is how to handle fluctuations in demand without unacceptable delay. This is not a general systemwide problem, it occurs at only a few airports at periods of peak demand. Most airports, including many large and busy airports in major

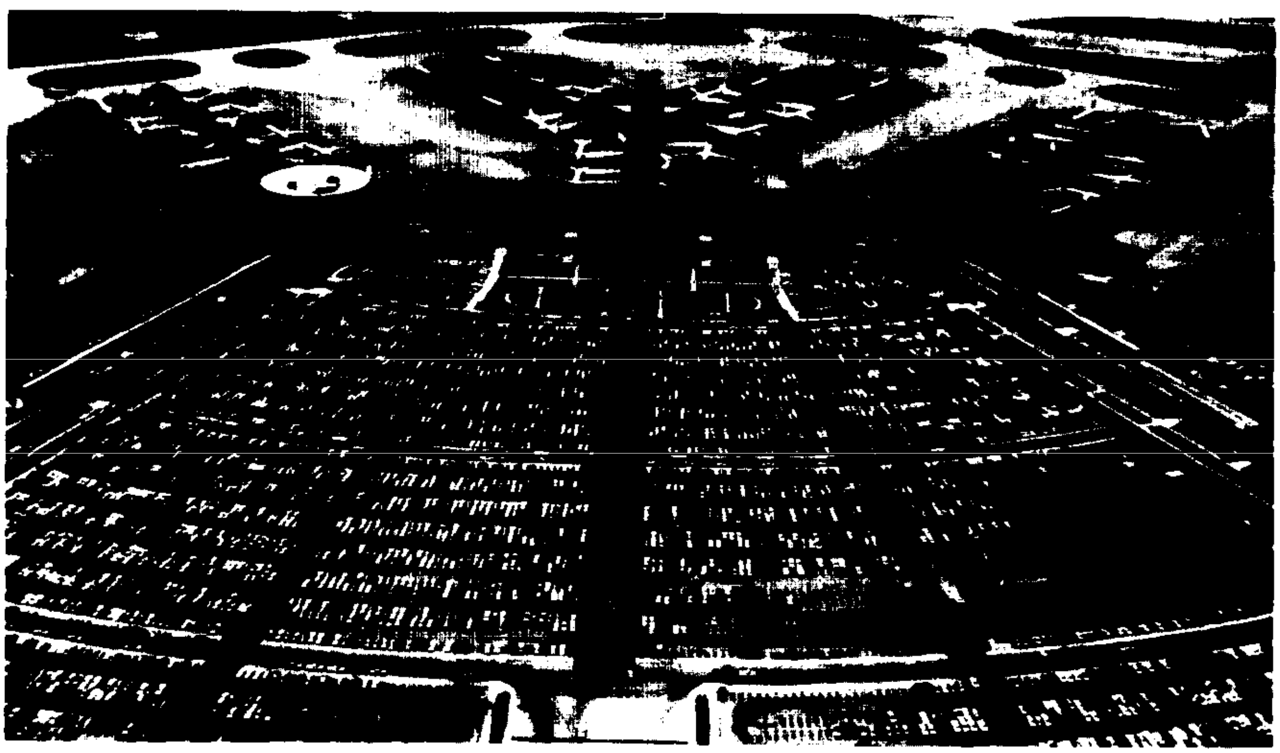


Photo credit' US. Department of Transportation

Airside and landside

metropolitan areas, have the capacity to handle present demand and projected growth for many years to come. Nor is the lack of capacity necessarily related to the size of the airport or the absolute volume of traffic. Some of the airports experiencing congestion and delay (or expected to in the future) are rather small, but they have high traffic density at certain times.

In general, however, delay tends to occur at those few airports serving the majority of airline passengers and so inconveniences **a** large number of travelers. Further, delay has a ripple effect throughout the system. Congestion at a few hub airports causes delay in connecting flights to and from other airports and, in the extreme, can affect the air traffic of a major region or the entire country.

FAA estimates that 14 airports (10 commercial and 4 general aviation) now experience significant problems of capacity and delay. If demand grows as FAA projects and if no remedial action is taken, the number of airports affected might reach 61 commercial airports—almost all large and many medium hubs—and 44 general aviation airports by the end of the century (see table 5).

The consequences of such congestion could be severe. Recent FAA estimates have placed the cost of delay for airlines in 1980 at $1.0 billion to $1.4 billion in extra crew time and wasted fuel, primarily the latter. This also represents an aggregate loss of ***60*** million hours of time for airline passengers.[7 8 9] If FAA's growth projections are realized, the delay costs to airlines could reach $2.7 billion by 1991 and perhaps twice that figure by 2000.

A number of alternatives have been suggested to alleviate airport capacity problems and to reduce delay. Very few of these solutions, however, are universally applicable, and none is a panacea. These alternatives can be divided into four categories. The first is to build new airports, although it is widely recognized that finding suitable large tracts of land and developing them as airport sites are becoming increasingly difficult. FAA has speculated that no more than one or two major air carrier airports will be built in the next decade. **10** A second alternative is to expand existing airport facilities. This has been done at several airports, but growing community resistance, particularly because of noise, may make expansion more difficult in the future. Application of new technology, however, has led to quieter aircraft that may make airport expansion less objectionable to those concerned about noise.

A third alternative is to make more efficient use of existing airport capacity. This includes improvements in technologies that would facilitate the movement of aircraft, both in the air and on the ground, and procedural changes such as reducing the longitudinal spacing between aircraft on final approach. A fourth alternative is to manage airport demand so that aircraft activity is more evenly distributed by time of day and among airports. The two most commonly mentioned demand-management techniques are economic measures, such as marginal-cost pricing, and regulatory actions, such as slot restrictions.

Because of the difficulties in building or expanding airports, there appears to be growing sentiment that other solutions should be explored. FAA has suggested that the "high capital costs and local resistance to large-scale airport construction in metropolitan areas-mandate that a critical need for additional capacity be evident before new major airport proposals are advanced.'"]

Table 5.—Airports Forecasted to Have Airside Congestion[a]

Commercial service	General aviation
1981	1981
Chicago O'Hare (IL)	Fort Worth Meachum (TX)
Denver Stapleton (CO)	Teterboro (NJ)
Detroit Metro (MI)	Van Nuys (CA)
Los Angeles International (CA)	By 1985
Philadelphia International (PA)	Baltimore Glenn L. Martin (MD)
San Francisco International (CA)	Farmingdale Republic (NY)
St. Louis Lambert (MO)	Kansas City Downtown (MO)
Washington National (DC)	Scottsdale Municipal (AZ)
By 1985	By 1990
Long Beach Dougherty (CA)	Anchorage Lake Hood (AK)
Santa Ana John Wayne (CA)	Everett Snohomish County (WA)
Palm Beach International (FL)	Houston Lakeside (TX)
By 1990	Killeen Municipal (TX)
Anchorage International (AK)	Manassas Municipal (VA)
Atlanta Hartsfield (GA)	Mesa Falon (AZ)
Baltimore-Washington International (MD)	Morristown Municipal (NJ)
Birmingham Municipal (AL)	Novato Gnoss (CA)
Boston Logan (MA)	Torrance Municipal (CA)
Dallas-Fort Worth (TX)	Vero Beach Municipal (FL)
Houston Hobby (TX)	By 2000
Houston Intercontinental (TX)	Anchorage Merrill (AK)
Las Vegas McCarran (NV)	Aurora State (OR)
New York Kennedy (NY)	Beverly Municipal (MA)
New York La Guardia (NY)	Carlsbad Palomar (CA)
Prescott Municipal (AZ)	Chicago Palwaukee (IL)
Raleigh-Durham (NC)	Dallas Addison (TX)
By 2000	Denver Arapahoe County (CO)
Burbank Glendale Pasadena (CA)	El Monte (CA)
Charlotte Douglas Municipal (NC)	Fort Lauderdale Executive (FL)
Eugene Mahlon-Sweet (OR)	Fullerton Municipal (CA)
Daytona Beach (FL)	Goodyear Phoenix-Litchfield (AZ)
Greensboro High Point-Winston-Salem (NC)	Greeley Weld County Municipal (CO)
Indianapolis International (IN)	Hayward Air Terminal (CA)
Lafayette Regional (LA)	Hartford Brainard (CT)
Memphis International (TN)	Hillsboro-Portland (OR)
Norfolk International (VA)	Houma Terrebonne (LA)
Oakland Metropolitan (CA)	Livermore Municipal (CA)
Orlando International (FL)	Miami New Tamiami (FL)
Oxnard (CA)	Minneapolis Crystal (MN)
Phoenix Sky Harbor (AZ)	New Orleans Lakefront (LA)
Providence T. F. Green (RI)	Norwood Memorial (MA)
Reno Cannon International (NV)	Palo Alto (CA)
San Antonio International (TX)	Philadelphia North (PA)
San Diego Lindbergh (CA)	Phoenix Deer Valley Municipal (AZ)
San Jose Municipal (CA)	Riverside Municipal (CA)
Sarasota Bradenton (FL)	San Carlos (CA)
Tucson International (AZ)	Santa Rosa Sonora County (CA)
White Plains Westchester County (NY)	Seattle King County (WA)
	Waukegan Memorial (IL)

[a]FAA considers an airport to be congested when traffic reaches 160 percent of Practical Annual Capacity or when significant constraints are expected because of physical limitations on airport use.

SOURCE: Federal Aviation Administration.

ORIGIN OF THE STUDY

Concern about the future adequacy of the airport system and possible strategies that might be adopted to deal with capacity and delay problems led the House Public Works and Transportation Committee to request that OTA assess future airport capacity and its implications in terms of public policy. The committee asked that four major subjects be examined in the study:

1, the present and future extent of airport capacity problems, their causes, and geographic distribution;
2. the extent to which these capacity problems will act as a critical constraint on aviation demand and the impact the capacity problems could have on the various aviation user groups, related industries, and local economies;
3. prospective technological solutions to airport capacity problems, including analysis of the extent to which future capacity problems are solvable by application of advanced technologies; and
4. past and current financing mechanisms (local or State funding, bonding, Federal grants, and various airport rents and user fees), the extent to which they have been relied on at various airport sizes and types, and the extent to which they can be depended on in the near future, including analysis of the extent to which future capacity problems are solvable by financial means.

This assessment addresses these questions by describing the existing state of the airport system and outlining technological and economic measures for dealing with airport capacity problems.

AREAS OF INTEREST

Various aviation organizations have called for increased Federal effort to provide technological improvements to increase capacity or to make more effective use of existing capacity. Chief among these are wake vortex detection and avoidance systems, improved air traffic control, and advanced landing systems. These groups have also advocated procedural changes to make more efficient use of airspace and runways, e.g., reduced longitudinal separation on final approach and closer lateral spacing for aircraft using parallel runways. Finally, they seek added facilities at some sites, notably separate runways for commuter and general aviation aircraft. The Industry Task Force on Airport Capacity Improvement and Delay Reduction, for instance, recently recommended accelerating the development and implementation of these and other technological and procedural changes aimed at reducing delay. [12] FAA has been studying developments along similar lines for several years and is proceeding with selective implementation in the National Airspace System Plan and the National Airspace Review. OTA has examined these technological measures, supplementing the Task Force Report and FAA studies with independent analysis. This *is* reported in chapter 4.

The question of funding is also crucial. Airport operators, while they seek technological improvements, also maintain that the major benefit will come from expansion of existing airports. The key issues are the amount of capital required, the sources of funds, and the financing mechanisms. The airport financing question is of particular interest because of the effects of airline deregulation. In cooperation with the Congressional Budget Office, OTA studied these questions, which are discussed in chapters 6 and 7.

The organizations and institutions concerned with airport planning and operation play an important role in how the system presently works and in the ability to plan, fund, and implement needed improvements. Roles and relationships are changing because of deregulation, long-term structural changes in the airline industry, Federal policy toward airport aid, and public concern about airport noise and land use. Of particular impor-

[12] *Report of the Industry Task Force on Airport Capacity Improvement and Delay Reduction*, September 1982.

tance is whether airports will be able to control operations and future development in a way that optimizes individual airports and yet assures compatibility with overall system needs. Chapters 2 and 5 address these matters.

Finally, there is the question of Federal policy. The Airport and Airway Improvement Act of 1982 calls for a new approach to airport system planning, called the "National Plan of Integrated Airport Systems." The NPIAS is to be issued in September 1984, and at present its scope and direction are not entirely clear. OTA has examined two aspects of the problem: 1) forecasting and its influence on determining airport needs, and 2) uncertainties that will affect the planning process. These subjects are treated in chapter 8. OTA has also considered features that could be incorporated in the NPIAS to make it an effective planning document. Planning issues are discussed in chapter 9.

ISSUES AND FACTORS IN AIRPORT SYSTEM DEVELOPMENT

Intertwined with these basic questions are issues where the interests of several parties have come into sharp conflict. One such group of issues relates to the strategic policy of the Federal Government in development of the airport system. Some have suggested that past Federal policy has placed too much emphasis on capital investment in new facilities and not enough on methods to make more effective use of existing facilities. A second set of issues involves funding. Some observers have suggested that the Federal role has become too large and pervasive and that responsibility for airport development should devolve either on the airports and their local sponsors or on State governments. Other issues arise from the legal and contractual arrangements traditionally concluded between airports and airlines. These arrangements have evolved over several decades, during a period of extensive Federal regulation of the airlines. There is some concern that these airport-airline agreements may be inappropriate in a deregulated era, either because they may be too rigid to allow airports and airlines to meet new challenges or because they may have anticompetitive features that do not allow the market to operate freely. Another issue is the problem of aircraft noise, which has been a growing environmental and political problem for many airports despite technological advances in reducing noise of jet aircraft. Finally, there are issues surrounding the planning of future airport development, particularly the timing and location of demand growth and the role that the Federal Government will play in defining and meeting airport needs.

Federal Policy and Strategy

Historically, Federal airport development policy has sought to promote the aviation industry and to accommodate growth of traffic demand. Where forecasts of future traffic demand have exceeded existing airport capacity, the solution has generally been to provide capital aid to build new facilities. The Airport Development Aid Program (ADAP), funded with user fees earmarked for the Airport and Airway Trust Fund, was established in 1970 as a response to the congestion and delay problems that plagued airports in the late 1960s. ADAP provided Federal matching grants to airports to pay for certain types of capital improvements, principally construction of new runways, taxiways, and aprons to relieve airside congestion. Federal assistance for capital improvements continues through the Airport Improvement Program (AIP), created by the Airport and Airway Improvement Act of 1982.

FAA projections of future traffic demand indicate that there could be severe airside congestion at a number of major airports over the next 20 years. Although some of the delays might be eased by improved air traffic control technology, the FAA view is that the primary constraint on the growth of the system will be "a lack of concrete" and that there is a need for more runways, taxiways, and ramps.

Thus, basic strategy has been challenged on the grounds that it biases the outcome toward capital-intensive solutions, Critics argue that Federal development grants have, in some cases, encouraged airport operators to overbuild. In other cases, the facilities built with Federal support are substantially different in form and more expensive than needed to accomplish their intended function. But more fundamentally, the existence of a Federal program providing aid for only certain types of capital improvements at airports has distorted investment decisions and led airport operators to build not necessarily what they need but what the Government is willing to help pay for. By accommodating demand wherever and whenever it occurs through increasingly large and complex new capital facilities, more growth is encouraged at precisely those locations where it will be most difficult and expensive to absorb.

Other critics have suggested that projections of traffic growth are too high. Recent changes in the airline industry, such as deregulation, the growth of commuter air carriers, sharp rises in fuel costs, and escalating operating costs, may have caused permanent structural changes in the airline industry such that the great traffic growth of the 1960s and 1970s will not continue. Thus, policies aimed at accommodating high projected levels of growth may lead to overbuilding and excess capacity, and misallocation of resources within the system.

Congestion and delay in the airport system are not evenly distributed. They are concentrated at a few airports, while many others operate far below their design capacity. Thus, an alternative strategic response might be to manage or direct growth of air activity in ways that make more productive use of existing, uncrowded airport facilities.

Some observers believe that growth can be managed through administrative or economic means requiring only limited new capital investments. Administrative responses to growth include rules adopted by airport operators or various levels of government to divert traffic from congested airports to places or times where it can be handled more easily. Economic responses rely on market competition to determine access to airport services and facilities. To some extent, both administrative and economic measures for managing demand are alread y in use at a number of busy airports. However, there are legal, contractual, and even constitutional barriers that might preclude wider use of such techniques. Some of these barriers could be lowered through Federal Government action. A discussion of possible administrative and economic options is presented in chapter 5.

Funding Issues

Before World War II, the Federal Government was inclined to the view that airports, like ocean and river ports, were a local responsibility, and the Federal *role* was confined to maintaining the navigable airways and waterways connecting those ports. At the onset of World War II, the Federal Government began to develop airports on land leased from municipalities. Federal investment was justified on the grounds that a strong system of airports was vital to national defense. After the war, many of these improved airports were declared surplus and turned over to municipalities. Federal assistance to airports continued throughout the *1950s* and 1960s at a low level and was aimed primarily at improving surplus airports and adapting them to civil use. Major Federal support of airport development resumed in *1970* with the passage of the Airport and Airway Development Act, which was in large part a response to the congestion and delay then being experienced at major airports. This act established the user-supported Airport and Airway Trust Fund and ADAP.

Federal assistance to airports under ADAP was distributed as matching grants for capital improvement projects. There were several formulas for allocation—entitlement (calculated from the number of passengers enplaned at the airport), block grant (based on State area and population), and need (discretionary funds). Over the 10-year life of ADAP, outlays from the Trust Fund amounted to approximately $4 billion. ADAP expired in 1980, but a similar program of airport development assistance, AIP, was established in *1982.* Before AIP was enacted there was extensive debate about the future direction of Federal airport aid, sparked by proposals to withdraw assistance for ("to defederalize") major air carrier airports.

Supporters of defederalization advanced two arguments: that the Federal Government is overin-

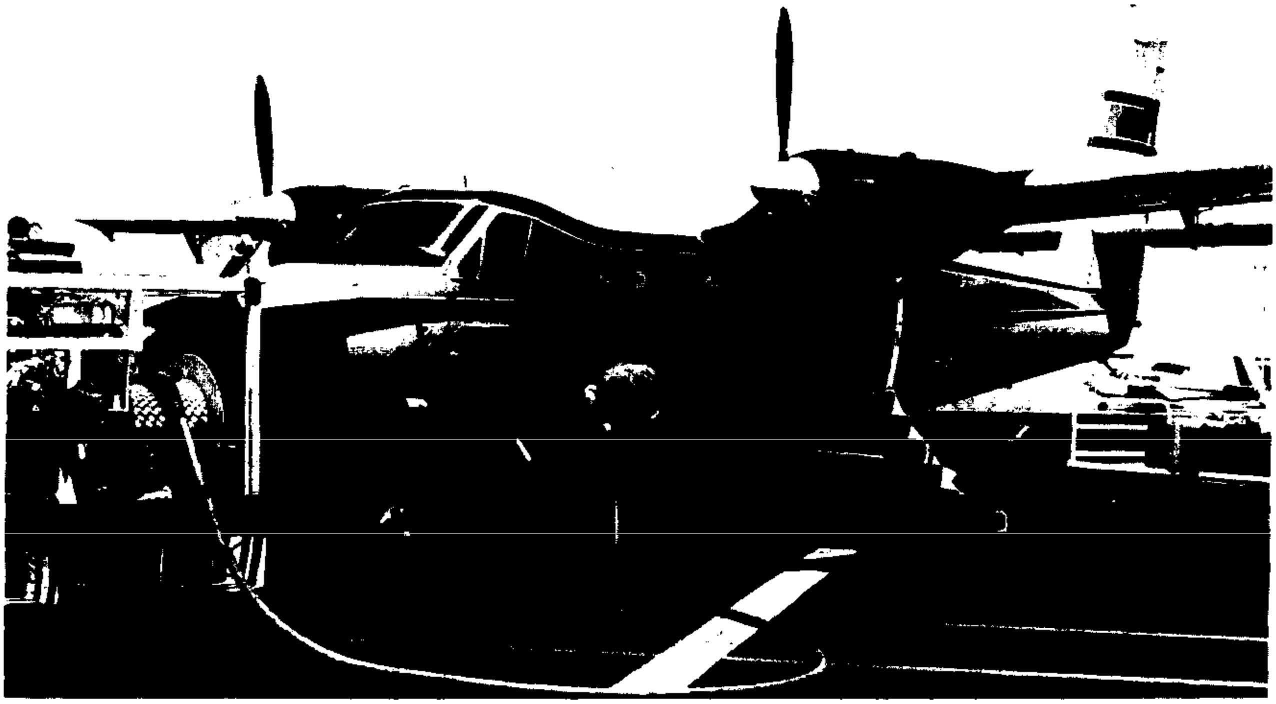


Photo credit' Golden West

Commuter air service, a link to small communities

volved in financing airport development and that Federal assistance is not necessary for large airports because they are capable of financing their own capital development. By excluding large airports from eligibility for Federal grants, the Government could reduce the overall cost of the aid program and at the same time provide more aid to small air carrier and general aviation airports. Under various proposals, the top 40 to 69 airports (in terms of enplaned passengers) would have lost eligibility for Federal aid.[13] The advantage to large airports, as pointed out by supporters of defederalization, would be freedom from many legal and administrative requirements involved in accepting Federal assistance.

[13]S. 508, introduced by Senators Nancy Kassebaum and Howard Cannon, would have defederalized airports in two phases. The first year, airports enplaning more than 0.5 percent of all passengers (the top 40 airports) would have lost funding eligibility. In the second year, those enplaning more than 0.025 percent (69 airports at that time) would have been defederalized. The Administration proposal, as represented by H.R. 2930 would have defederalized only the top 40 airports over a 2-year period.

Opponents of defederalization contended that the proposal was unwise for several reasons. First, it would eliminate Federal assistance for the very airports that provide the bulk of passenger service and have the greatest problems of congestion and delay. It is at these airports, the backbone of the national system, where a Federal presence can most easily be justified. Further, passengers using large airports pay about three-quarters of the taxes supporting the Airport and Airway Trust Fund. Thus, defederalization would lead to subsidy of smaller airports by larger ones. Some observers also questioned the ability of many airports to carry out necessary capital improvements without Federal participation. While agreeing that Federal grants form only a small percentage of total capital budgets at large airports, they argued that it was a needed revenue source for all but the very largest **5** or 10 airports.

Some proponents held that defederalized airports should be allowed to charge a "passenger facility charge" or "head tax" to make up for the loss of Federal funds. Federal law now prohibits airports from taxing passengers. Others objected to the head tax while supporting the concept of defederalization, holding that airports could raise sufficient funds through retained earnings or through the private bond market to cover their capital needs. One major objection to the head tax was that passengers would have to bear a double tax when using a defederalized airport. They would have to pay both a ticket tax supporting the Airport and Airway Trust Fund and a head tax at the arrival or departure airport.

The major airlines, as represented by the Air Transport Association, were indifferent on the question of defederalization but opposed to the head tax. They held that the tax would impose unnecessary administrative burdens on them and would be unfair to passengers. Other observers noted that the underlying reason for the air carriers' objection was that head taxes would give airports an independent source of revenue and weaken the voice that airlines now have in airport investment decisions.

Airport operators were divided. Some very large airports, such as Chicago O'Hare, supported defederalization on the condition that it be accompanied by the freedom to impose a head tax. The Airport Operators Council International, an organization representing airports of all sizes, expressed qualified support of the concept of "optional defederalization" where airports could choose whether or not they wished to receive Federal aid, rather than having the decision made for them on the basis of size and passenger volume. Many airports opposed both defederalization and the head tax.

The question of defederalization is still open. Although the Airport and Airway Improvement Act of 1982 passed without a defederalization provision, it directed the Department of Transportation to study the effects of defederalization and to prepare a report to Congress.

Another approach to airport financing was also raised during the debate over AIP, although it was not introduced into legislation. Under the general concept of "new federalism, " it was proposed to turn increased responsibility for decisions on airport funding and programming over to State aviation agencies and departments of transportation. Supporters contended that State agencies are in a better position to determine the needs of local airports and could distribute grants with less red tape than the Federal Government. They pointed out that some States already have active aviation agencies that evaluate airport improvement projects and approve all applications for Federal assistance. In these cases, the needs of the airports and the State might better be served by allowing State agencies more latitude in distributing airport grants.

A stronger role for State agencies could reduce the Federal role to basically that of a tax collector. Because of the interstate nature of air transportation, it would probably be more efficient to continue to collect ticket taxes, fuel taxes, or other aviation taxes at the national level. However, the funds could be passed through to the States on a formula basis, and the actual decisions on how funds were spent could be made at the State level.

There were several objections to the concept of new federalism. First, State agencies vary in strength. Many do not have the staff or the expertise to take on the responsibilities of evaluating airport development projects or administering grants. A period of transition would be necessary while these States prepared to accept new responsibilities. Others argued that setting up 50 separate agencies to do the work of FAA would add an additional layer of bureaucracy, since FAA involvement could not be completely eliminated. Still others saw interstate or multistate cooperation as a major stumbling block. For example, a State government, perhaps lacking perspective of the airport system as a whole, might find little incentive to aid development of an airport outside its borders or to enter into regional compacts to compensate citizens of adjacent States for airport noise impacts.

The policy implications of the questions of defederalization and State administration are examined further in chapter 10 of this report.

Airport Management Issues

Deregulation has led to changes in the relationship between airports and airlines. Airports traditionally maintained long-term use agreements (of 20 to 30 years) with the airlines that served them.

These agreements covered such arrangements as landing fees and the leasing of terminal space. As a result of these agreements, airlines have had a strong influence on the creditworthiness of airports in the revenue bond market since their financial stability and continued presence was a guarantee of the long-term economic viability of the airport. In some instances, airlines have been party to airport revenue bonds, agreeing to be jointly and severally liable for payment of debt and interest. In return for such guarantees, airlines have gained approval rights for capital improvement projects to be undertaken at the airport.

Since deregulation, however, air carriers' routes and service points are not as stable, and the airlines themselves have experienced financial difficulties. Long-term contracts written in the era of regulation may now inhibit the carriers' freedom to change routes. Conversely, they may also make it difficult for airports to accommodate new carriers. In some cases, carriers with long-term agreements whose service to the airport has declined may be occupying gate and counter space that a new entrant might be able to use more effectively.

Some observers have questioned whether long-term agreements, especially majority-in-interest clauses, may not have anticompetitive effects in the deregulated environment. They point out that incumbent carriers might make use of their agreements to deny new entrants access to the airport, or at least to place them at a competitive disadvantage with respect to terminal space and facilities. They also point out that carriers often negotiate with airport management as a group in a "negotiating committee" or "top committee" and question whether group negotiations involving competing firms are appropriate in a deregulated market.

It has also been pointed out that a capacity limit at a major airport has the effect of reducing free competition among carriers and works as a form of "reregulation" of the industry. Airport operators must be careful that actions taken to manage or control the growth of traffic at individual airports do not have anticompetitive effects. This issue was raised in connection with two recent events, the 1981 air traffic controllers' strike and the Braniff bankruptcy, which brought attention to the question of who owns airport operating "slots."[14]

During the strike, FAA imposed quotas on 22 airports, limiting the number of operations that could be performed each hour. Several methods of allocation were tried—administrative assignment, exchanges among incumbent carriers, and, briefly, auction. New entrant airlines complained that all of these methods were unfair.

When Braniff stopped operating, FAA redistributed its slots among other carriers, despite Braniff's claims that the slots were the airline's property for which it should be paid. Throughout this period there was controversy over whether or not a slot should be considered property, and whether the proceeds from a slot sale should go to the airline, the airport, or the Federal Government. This issue has arisen again in connection with proposed slot auctions at Washington National Airport.[15]

This question may become particularly acute if problems of delay and congestion spread to more airports, and airport operators seek to employ traffic management techniques. If an airport imposes a quota, it must devise some method for allocating slots to present users and for accommodating new entrants. Until the question of slot ownership is resolved, any attempt to use sale or auction as an allocation method is likely to reignite this controversy.

Noise and Environmental Issues

Noise has been a major problem at airports since the introduction of the commercial jet aircraft. Recent technological advances in airframe and jet engine design have made new aircraft much quieter, but many industry experts believe that further large-scale reductions in aircraft noise will not be possible.

The public is very sensitive to noise, which has become an emotionally charged political issue.

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[14]A slot is a block of time allocated to an airport user to Perform an aircraft operation (takeoff or landing).

[15]Aviation Week and *Space Technology,* Aug. 15, 1983, pp. 32-33.

Photo credit” Los Angeles **Times**

Noise, an emotionally charged issue

Noise is probably the single most important constraint on the expansion of airports or the building of new ones. The problem is in large part one of land use, and land use decisions are usually beyond the control of FAA and the airport proprietor. Zoning and land use planning are the responsibility of local jurisdictions, and many jurisdictions have not applied land use controls to prevent residential communities from growing up near airports. Often, intergovernmental cooperation is needed because major airports may be surrounded by several municipalities, each with different zoning policies. The Federal Government has sometimes complicated the issue by financing and approving residential development projects in high-noise areas.

At present, citizens with complaints about airport noise have recourse only to the airport proprietor. While FAA and air carriers have some responsibility for abating aircraft noise, only the airport operator is legally liable. In many cases, airports have had to pay nuisance and damage claims for noise. To reduce their liability and to protect themselves, airports have instituted noise abatement programs that involve restricting aircraft flight paths or hours of operation so as to reduce noise impact on residential areas. Noise abatement procedures can have a detrimental effect on airport capacity, and many airports with serious congestion and delay have found that the need to control noise restricts their freedom of action. In some cases, airports have had to purchase surrounding land or install noise-absorbing insulation in buildings under flight paths.

Some States and localities have enacted special regulations to limit aircraft noise at airports under their jurisdiction. There are several concerns about the proliferation of local noise standards. First, the standards vary from one location to another, adding confusion and complexity to the system. Second, the standards may act as a restraint on interstate commerce. Airlines may have to accelerate their purchases of quiet aircraft in order to serve many points with stringent noise standards. If they are not financially able to make these purchases, the only alternative may be to curtail operations at some locations.

Some argue that the Federal Government should set and enforce a uniform national standard for airport noise. However, FAA has been reluctant to embark on such a policy, in part because the Federal Government might then have to assume liability for violations of the standard.

Planning Issues

Many of the difficulties in planning a national airport system arise from its size and diversity. Each airport has unique problems, and each airport operator—although constrained by laws, regulations, and custom—is essentially an independent decisionmaker. While airports collectively form a "system," it is not a system that is comprehensively planned and centrally managed. FAA's role in planning the system has traditionally been one of gathering and reporting information on individual airport decisions and discouraging redundant development.

Since 1970, the National Airport System Plan has been prepared by FAA regional offices, working in conjunction with local airport authorities. The NASP presents an inventory of the projected capital needs of almost 3,200 airports "in which there is a potential Federal interest and on which Federal funds may be spent."[16] Because the funds available from Federal and private local sources are sufficient to complete only a fraction of the eligible projects, many of the airport improvements included in the NASP are never undertaken.

The NASP has been criticized on three principal points. First, it is not really a plan, in the sense that it does not present time phasing or assign priorities to projects. FAA has attempted to meet this criticism in the latest edition by categorizing projects and needs according to three levels of program objectives: Level I—maintain the existing system, Level II—bring airports up to standards, and Level III—expand the system. Some, however, see this categorization as inadequate.

Second, the criteria for the selection of the airports and projects to be included in the plan have come under criticism. Some have argued that most of the 3,200 airports in the NASP are not truly of national interest and that criteria should be made more stringent to reduce the number to a more manageable set. On the other hand, there are those who contend that the plan cannot be of national scope unless it contains all publicly owned airports. It is argued that, since the NASP lists only development projects eligible for Federal aid and not those that would be financed solely by State, local, and private sources, the total airport development needs are understated by the plan.

A final criticism is that the NASP deals strictly with the development needs of individual airports, without regard to regional and intermodal coordination. This deficiency was addressed by Congress in the 1982 Airport and Airway Improvement Act, which directed FAA to develop a National Plan of Integrated Airport Systems. FAA has begun work on the plan, which is to be completed by September 1984. There is still uncertainty about the form that NPIAS will take and how many airports will be included. Some approaches to developing an integrated national airport system plan are discussed in chapter 9.

[16] *National Airport System Plan: Revised Statistics, 1980-1989* (Washington, DC: Federal Aviation Administration, 1980), p. iii.

Chapter 2

ORGANIZATIONS AND INSTITUTIONS

Photo credit Federal Aviation Adrnfrtfsfraftoi,

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Chapter 2

ORGANIZATIONS AND INSTITUTIONS

A major commercial airport is a huge public enterprise. Some are literally cities in their own right, with their own fire and police departments, road systems, powerplants, hotels, restaurants, and even factories, schools, and churches located on the property. Administration of these facilities is the responsibility of the airport operator, usually a public entity such as a department of city government or a special aviation or port authority. Airports, however, also have a private character in that they must be operated in conjunction with airlines that provide air transportation ***service*** and with concessionaires and other firms doing business on airport property. This combination of public management and private enterprise distinguishes the operation of commercial airports from that of wholly public or wholly private enterprises. In addition, operation of an airport entails interaction with several other parties: general aviation, the public at large, agencies of local, regional, and State government, the Federal Aviation Administration (FAA), and other agencies of the Federal Government. Each of these parties approaches airport operation and development with a different set of concerns, responsibilities, and expectations.

This chapter surveys common types of airport ownership in the United States and reviews relationships between the airport operator and air carriers, general aviation, concessionaires, and other airport users. The roles of airport users and Federal, State, and regional agencies in airport planning and development are also examined, with special emphasis on the intergovernmental and institutional relations involved in building or expanding airports. The issue of aircraft noise and its effects on airport operation is also addressed.

[1]Portions of this chapter are based on work performed by the Congressional Budget Office and published in ***financing U.S. Airports in the 1980s,*** April 1984.

AIRPORT OWNERSHIP AND OPERATION

Public airports in the United States are owned and operated under a variety of organizational and jurisdictional arrangements. Usually, ownership and operation coincide: commercial airports may be owned and run by **a** city, county, or State, by the Federal Government, or by more than one jurisdiction (e.g., a city and a county). In some instances, however, a commercial airport is owned by one or more of these governmental entities but operated by a separate public body, such as an airport authority specifically created for the purpose of managing the airport. Regardless of ownership, legal responsibility for day-to-day operation and administration can be vested in any of five kinds of governmental or public entities:

- a municipal or county government,
- a multipurpose port authority,
- an airport authority,
- a State government, or
- the Federal Government.

More than half of the Nation's large and medium commercial airports, and a greater percentage of small commercial airports, are operated by municipal or county governments (see table 6). A typical municipally operated airport is city-owned and run as a department of the city, with policy direction by the city council and, in some cases, by a separate airport commission or advisory board. County-run airports are similarly organized. Under this type of public operation, airport investment decisions are generally made in the broader context of city- or countywide public investment needs, budgetary constraints, and development goals. To raise investment capital, these airports usually rely on one of the two major forms of tax-exempt municipal bonding: general obligation bonds, which are backed by the full faith, credit, and taxing power of the issuing government; and revenue bonds, for which debt service is paid entirely out of revenues generated by the airport.[2]

[2]These financing mechanisms are discussed further in ch. 7.

Table 6.—Public Operation of Commercial Airports by Size, 1983

Airport operator	Large Number	Large Percent	Medium Number	Medium Percent	Small[a] Number	Small[a] Percent
Municipality or county	14	58	23	49	NIA	61
Port authority	5	21	6	13	N/A	3
Airport authority	3	13	12	26	NIA	31
State	1	4	5	11	NIA	5
Federal Government	1	4	1	2	NIA	o
Total	24	100	47	100	489	100

NOTE: Details in percent columns may not add because of rounding. N/A = Not available.
[a]Percentages reflect data for 172 (35 percent) of 489 existing small commercial airports. There is no evidence to indicate that this is not a representative sample. Data for the remaining 317 small airports were not available.

SOURCE: Congressional Budget Office 1983 survey and data supplied by Airport Operators Council International and American Association of Airport Executives.

Some commercial airports in the United States arerun byport authorities—legally chartered institutions with the status of public corporations that operate a variety of publicly owned facilities, such as harbors, airports, toll roads, and bridges. Multipurpose port authorities run about 21 percent of the large commercial airports and 13 percent of the medium-size airports. In managing the properties under their jurisdiction, port authorities have extensive independence from State and local governments. Their financial independence rests largely on the power to issue their own debt, in the form of revenue bonds, and on the breadth of their revenue bases, which may include fees and charges from marine terminals and airports as well as proceeds (e.g., bridge or tunnel tolls) from other port authority properties. In addition, some port authorities have the power to tax within the port district, although it is rarely exercised.

About one-eighth of all large, and one-fourth of medium-size commercial airports are operated by airport or aviation authorities. Similar in structure and in legal charter to port authorities, these single-purpose authorities also have considerable independence from the State or local governments, which often retain ownership of the airport or airports operated by the authority. Like multipurpose port authorities, airport authorities have the power to issue their own debt for financing capital development, and in a few cases, the power to tax. Compared to port authorities, however, they must rely on a much narrower base of revenues to run a financially self-sustaining enterprise.

State-run airports are typically managed by the State's department of transportation. Either general obligation or revenue bonding may be used to raise investment capital, and State taxes on aviation fuel may be applied to capital improvement projects. Although several States run their own commercial airports, only a handful of large and medium-size commercial airports are operated in this way—those in Alaska, Connecticut, Hawaii, and Maryland.

The Federal Government owns and operates two commercial airports serving the District of Columbia and environs—Washington National and Dunes International. FAA manages these two facilities, with capital development financed through congressional appropriations and project costs recouped by airport landing fees and terminal charges. The Federal Government also levies user taxes and disburses funds for the capital development of other airports through FAA's Airport Improvement Program, as discussed later in this chapter.

Publicly owned general aviation airports may be owned by a municipality, county, or State, or they may be the property of one or more of these jurisdictions but run by a separate public body as part of a multiairport system. Over ***40*** percent of all general aviation airports open to the public are privately owned. Most publicly owned general aviation airports (219 FAA-designated relievers and 2,424 other genera] aviation airports) are managed either by public operators—municipalities, counties, States, or independent authorities—or by private operators who charge for their services and remit a portion of their revenues to the airport owners. Reliever airports often are run as part of local or regional multiairport systems.

Airport-Air Carrier Relations

From the airlines' perspective, each airport is a node in a route system, a point for the pickup and transfer of passengers and freight. In order to operate efficiently, air carriers need certain facilities at each airport. These requirements, however, are not static; they change with traffic demand, economic conditions, and the competitive climate. Before airline deregulation in 1978, response to changes of this sort was slow and mediated by the regulatory process. Carriers had to apply to the Civil Aeronautics Board (CAB) for permission to add or to drop routes or to change fares. CAB deliberations involved published notices, comments from opposing parties, and sometimes hearings. Deliberations could take months, even years, and all members of the airline-airport community were aware of a carrier's intention to make a change long before the CAB gave permission. Since the Airline Deregulation Act of 1978, however, air carriers can change their routes without permission and on very short notice. With these route changes, airline requirements at airports can change with equal rapidity.

In contrast to airlines, which operate over a route system connecting many cities, airport operators must focus on accommodating the interests of a number of users at a single location. Changes in the way individual airlines operate may put pressures on the airport's resources, requiring major capital expenditures or making obsolete a facility already constructed. Further, because airports are multimodal hubs, airport operators must accommodate many users and tenants other than the airlines and must be concerned with efficient use of terminal and landside facilities that are of little concern to the carriers, even though carriers' activities can severely affect (or be affected by) them.

Despite their different perspectives, air carriers and the airport management have a common interest in making the airport a stable and successful economic enterprise. Traditionally, airports and carriers have formalized their relationship through use agreements that establish the conditions and methods for setting fees and charges associated with use of the airport by air carriers. Most agreements also include formulas for adjusting those fees from year to year. The terms of a use agreement can vary widely, from short-term monthly or yearly arrangements to long-term leases of 25 years or more. Within the context of these use agreements, carriers negotiate with the airport to get the specific airport resources they need for day-to-day operations. For example, under the basic use agreement, the carrier may conduct subsidiary negotiations for the lease of terminal space for offices, passenger lounges, ticket counters, and other necessities.

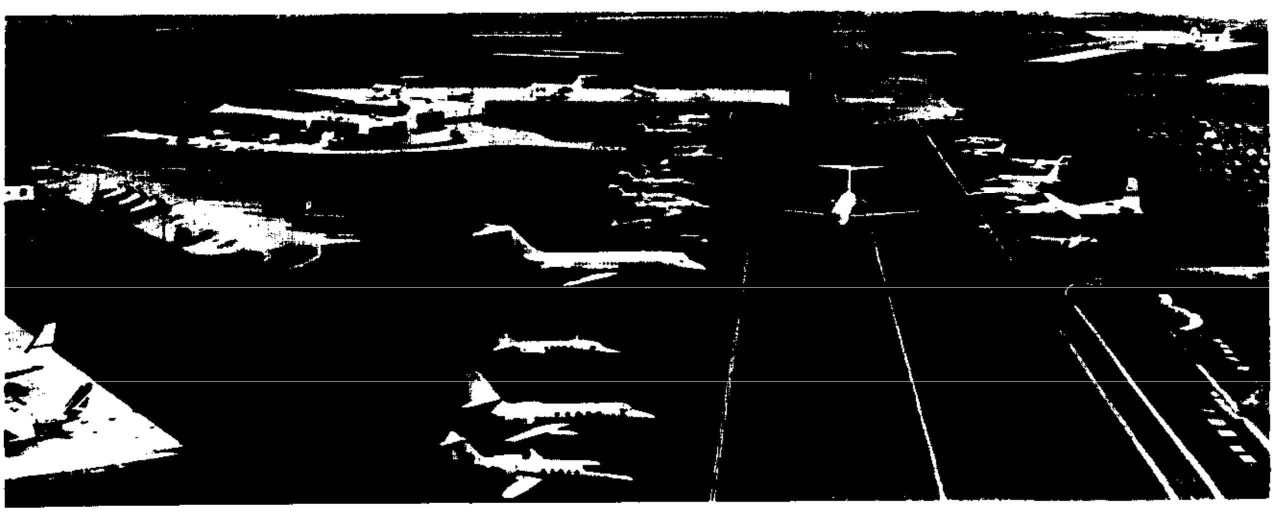

Photo credit" Federal Aviation Adrninisfraf/on

Convergence and competition for airport access

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Long-term agreements between airports and major airlines have traditionally been the rule. One reason is the long-lived nature of the investments involved. A runway may have an economic life of a decade or more, a terminal even longer. When an airport undertakes such an improvement for the benefit of the airlines, the airport may want long-term leases to help ensure that carriers will continue to use the facility and help pay for it. At some airports the use agreements and leases may hold all signatory carriers jointly and severally responsible for payments; at others airlines may be individually responsible for improvements made for their benefit.

As described in chapter 7, which deals with airport financing, revenue bond buyers lend money to the airport to construct a facility, and the airport authority applies the revenues from operation of the facility to repaying the principal and interest. To reduce the risk to bond buyers, and thus lower the interest rate, air carriers may agree to guarantee the airport sufficient revenue to pay the debt. For example, the use agreement may give the airport the right to charge landing fees to generate sufficient funds to cover operating costs and debt service.

In the past, investors perceived the major airlines, who operated as virtual regulated monopolies with clearly defined markets, as stronger firms and better credit risks than individual airports. In recent years, the perception of airlines as stable and the airports as risky has begun to change. Since deregulation, airlines are no longer under an obligation to serve a particular city, nor are they protected from competition by other carriers. They are free to compete, to change their routes, and to go out of business. On the other hand, certain airports have demonstrated that they are creditworthy and have strong travel markets. Regardless of what happens to an individual airline, these strong airports will continue to be served. In these locations, long-term agreements with individual carriers have become less important for airports seeking financing than the underlying economic strength of the community.

Due to the frequent route changes since deregulation, short-term use agreements and leases are becoming more common. Although the cost to the carrier of a short-term lease may be higher, it has the advantage of allowing greater flexibility for both the carrier and the airport. A carrier testing a new market may not be able or willing to enter a long-term agreement or to assume responsibility for capital improvements until it is sure that the market will be profitable. At the same time, an airport may not want to enter into a long-term agreement with a new carrier that has not yet established a reputation for reliability. At some airports, several different kinds of use agreements may be in effect simultaneously.

In exchange for guaranteeing sufficient revenues to service long-term debt, airlines have traditionally assumed some control of, or at least major participation in, important decisions affecting airport operation and capital improvement, especially the latter. In many cases, airports are bound by "majority-in-interest" clauses in their lease agreements whereby they are contractually required to consult with the carriers on major capital improvements and must abide by decisions of the majority of the carriers with whom they have long-term agreements. The recent report of the Airport Access Task Force, chaired by CAB Chairman Dan McKinnon, raised the question of whether majority-in-interest clauses are anticompetitive since they might be used by incumbent carriers to veto airport operator's plans to build facilities for new entrants.[3]

As with major airport planning decisions, negotiations related to the day-to-day needs of the carriers have traditionally been carried out between the airport management and a negotiating committee, called a "top committee, " made up of representatives of the scheduled airlines that are signatories to use agreements with the airport. Top committees have been an effective means of bringing the collective influence of the airlines to bear on airport management.

The nature of negotiations at some airports has changed radically since deregulation. Under reg-

3"Report and Recommendations of the Airport Access Task Force, " March 1983, p. 59. The Task Force was directed by Congress, in the Airport and Airway Improvement Act of 1982, to take a comprehensive look at airport access problems. Members included leaders from all segments of the aviation industry.

ulation, the major carriers-though competitors—had reasonably similar interests and needs. They did not really compete on the basis of price, and the regulatory process guaranteed that no member of the community could surprise the others with sudden changes in operating strategy. The carriers' representatives were a small group of people who sat on the same side of the negotiating table at many different airports. Carriers generally worked with one another in an atmosphere of cooperation and presented a common position in negotiating with the management of an individual airport.

Since deregulation, however, the environment has been characterized by competition rather than cooperation. Carriers may radically alter their routes, service levels, or prices on very short notice. They are reluctant to share information about their plans for fear of giving an advantage to a competitor. These factors make group negotiations more difficult. Some airport proprietors have complained that, in this competitive atmosphere, carriers no longer give adequate advance warning of changes that might directly affect the operation of the airport. Nevertheless, negotiating committees continue to operate, principally because it is essential that there be some mechanism for communication between air carriers and airport management. The CAB Task Force noted that negotiating committees still exert great influence on all aspects of airport operation.[4]

The days when most major airports are dominated by a few large airlines with long-term agreements may be passing away. One reason is the proliferation of air carriers since deregulation. The wide variation in aircraft size and performance, number of passengers, and markets served means that different classes of carriers require somewhat different facilities. Commuter carriers, with their smaller aircraft, usually do not need the same gate and apron facilities as major carriers. While there were commuters before deregulation, they are coming to constitute a larger fraction of users at many airports. Other new entrants, including "no frills" carriers, may also have different needs from those of conventional air carriers—for example, they may want more frequent gate access, but less baggage handling. These minority carriers may come to wield more power in negotiating with the airport for what they need and may challenge major carriers for a voice in investment decisions at an airport,

Not all aviation experts agree with this analysis, at least as an indication of long-term trends. They point out that half of the top 35 hub airports owe a majority of their traffic to no more than two airlines—a near monopoly dominance that is increasing since deregulation. This leads them to foresee that the ultimate effect of deregulation will be more, not less, concentration of the airline industry—major carriers and commuters alike, As the weaker competitors drop out or are absorbed by the stronger, the remaining airlines may exercise even greater dominance of certain large or medium-size airports that serve as home base or principal hubs.

Airport-Concessionaire Relations

Services such as restaurants, book stores, gift shops, parking facilities, car rental companies, and hotels are often operated under concession agreements or management contracts with the airport. These agreements vary greatly; but in the typical concession agreement, the airport extends to a firm the privilege of conducting business on airport property in exchange for payment of a minimum annual fee or a percentage of the revenues, whichever is greater. Some airports prefer to retain a larger share of revenues for themselves and employ an alternative arrangement called a management contract, under which a firm is hired to operate a particular service on behalf of the airport. The gross revenues are collected by the airport management, which pays the firm for operating expenses plus either a flat management fee or a percentage of revenues.

Revenues from concessions are very important to an airport. At some, concessionaires and their customers yield more revenue to the airport than airline fees and leases, resulting—in effect—in cross-subsidy of air carriers by nonaviation service concessions.

Parking and automobile rentals are typically large and important concessions at airports. De-

[4] 1bid., p. 61.

spite growth in the use of buses and other high-occupancy vehicles, the continued importance of parking and car rental revenues is indicative of the symbiotic relationship between the airport and the automobile. An analysis of revenue sources at seven major airports found that public parking facilities were the largest nonairline source of revenues and that car rental revenues were the second largest. At two of these airports, the airport operator's share of parking and car rental fees (after concession or management fees were paid) constituted a larger revenue source than air carrier landing fees.[5] At many locations, the parking and car rental firms operating on the airport are complemented by (or are in competition with) similar services operating off the airport property.

[5] Peat, Marwick, Mitchell & Co., "Comparative Rate Analysis, Dade County Aviation and Seaport Departments, " August 1982.

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Another important type of concessionaire is the fixed base operator (FBO), who provides services for airport users lacking facilities of their own, primarily general aviation. Typically, the FBO sells fuel and operates facilities for aircraft service, repair, and maintenance. The FBO may also handle the leasing of hangars and rental of short-term aircraft parking facilities. Agreements between airports and FBOS vary. In some cases the FBO constructs and develops his own facilities on airport property; in other cases the FBO manages facilities belonging to the airport. FBOs also provide service to some commuter and startup carriers, especially those that have just entered a particular market and have not yet established (or have chosen not to set up) their own ground operations. The presence of an FBO capable of servicing small transport aircraft can sometimes be instrumental in a new carrier's decision to serve a particular airport.

In addition to concessionaires, some airport authorities serve as landlord to other tenants such as industrial parks, freight forwarders, and warehouses, all of which can provide significant revenue. These firms may lease space from the airport operator, or they may build their own facilities on the airport property.

Airport-General Aviation Relations

The relationship between airport operators and general aviation is seldom governed by the complex of use agreements and leases that characterize relationships with air carriers or concessionaires.

General aviation (GA) is a diverse group. At any given airport, the GA aircraft will be owned and operated by a variety of individuals and organizations for a number of personal, business, or instructional purposes. Because of the variety of ownership and the diversity of aircraft type and use, long-term agreements between the airport and GA users are not customary. GA users often lease airport facilities, especially storage space such as hangars and tie-downs, but the relationship is usually that of landlord and tenant. There are instances where owners and operators of GA aircraft assume direct responsibility for capital development of an airport, but this is not common, even at airports where general aviation is a majority user.

It must be remembered that while GA activities make up about half of the aircraft operations at FAA towered airports, the average utilization of each aircraft is much lower than that of commercial aircraft. There are approximately 210,000 GA aircraft, compared to about 4,000 commercial aircraft. Most GA aircraft spend most of the time parked on the ground. Only a small number, usually those operated by large corporations as a sort of private airline for employees and high value goods, are used as intensively as commercial aircraft.

Thus, at the airport, the chief needs of GA are parking and storage space, along with facilities for fuel, maintenance, and repair. While an airliner may occupy a gate for an hour to load passengers and fuel, a GA user may need to park an aircraft for a day or a week while the passenger conducts business in town. At the user's home base, long-term storage facilities are needed, and the aircraft owner may own or lease a hangar or tie-down spot. In most parts of the country, the chief airport capacity problem for GA is a shortage of parking and storage space at popular airports. At some airports in the Southwest and in California waiting lists for GA parking spaces are several years long.

Some airport operators deal directly with their general aviation customers. The airport management may operate a GA terminal, collect landing fees, and lease tie-downs or hangars to users. At some airports condominium hangars are available for sale to individual users. It is not uncommon for corporations with aircraft fleets to own hangar space at their base airport. Often, however, at least some of this responsibility is delegated to the FBO, who thus stands as a proxy for the airport operator in negotiating with the individual aircraft owners for use of airport facilities and collecting fees.

PLANNING AND DEVELOPMENT RESPONSIBILITIES

The airport operator is principally responsible for planning and development of airport improvements, but as in the case of daily operating decisions, that responsibility is shared with many other parties. The airlines and other users, concessionaires, FAA, the regional planning authority, and the surrounding communities may all have an influence on planning decisions and subsequent development.

Airport Users

The users with the strongest voice in airport planning decisions, especially at large operational hubs, are the air carriers, who negotiate individually and collectively for short- and long-term improvements that they believe will facilitate their use of the airport. Because carriers often underwrite the bonds to pay for capital improvements, they have great influence, and their support is crucial.

At airports where one or two carriers account for the majority of operations, decisions about airport development are sometimes dominated by the needs and interests of those carriers. For example, there can be little doubt that Atlanta Hartsfield was designed to serve the route structures of Delta and Eastern Airlines—hub-and-spoke systems with a high volume of transfer passengers. On the other hand, the design of Dallas-Fort Worth was greatly influenced by the type of service Braniff and American Airlines expected to provide there—long-haul origin-destination service, with little need for transfers within the airport. This design has been the source of landside congestion in recent years as carriers have made greater use of hub-and-spoke route structures that require passengers to change planes. Major improvements are being undertaken at the airport to enlarge passenger waiting areas and improve internal traffic circulation.

Some "minority" carriers, even though they are signatories to the long-term agreements, may not have strong negotiating positions. For example, most airports are dominated by passenger carriers, even though revenues from cargo carriers may

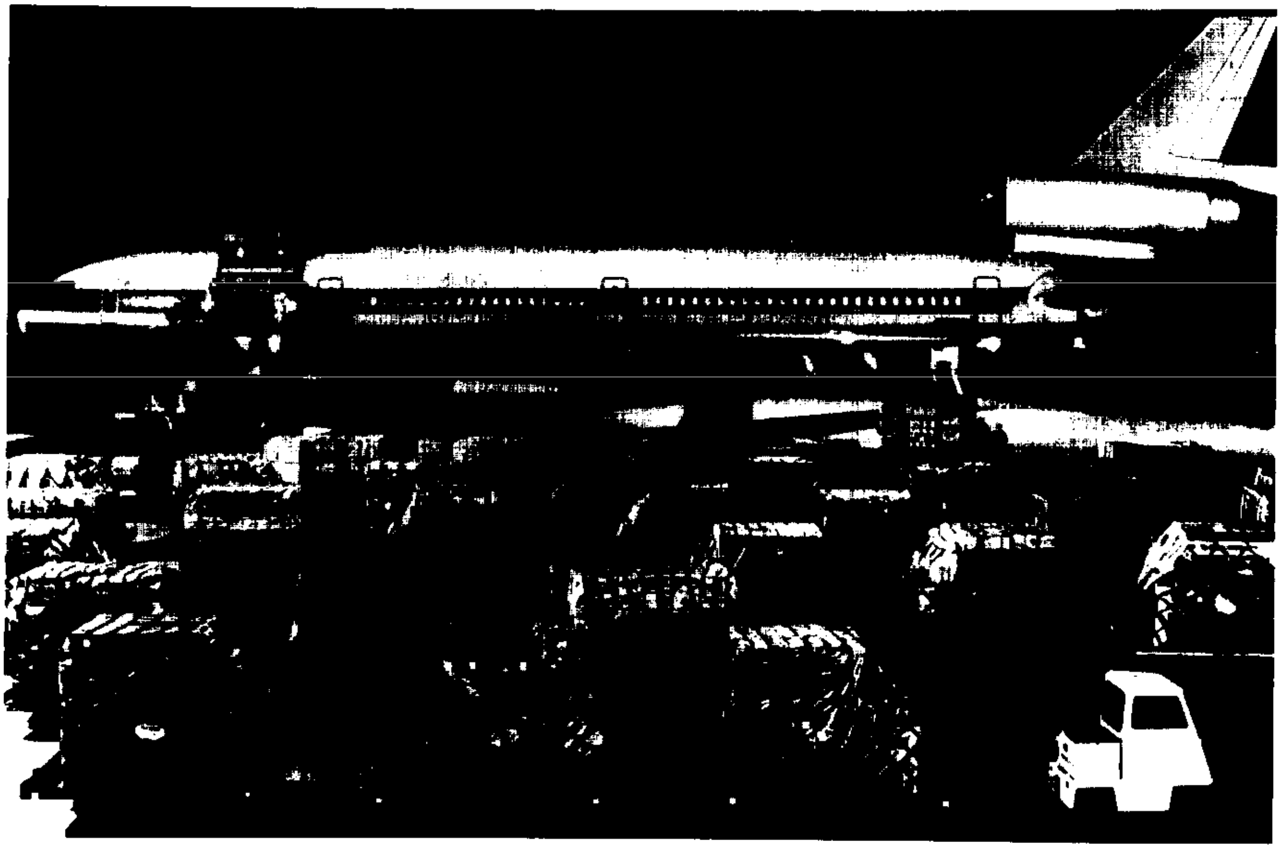

Photo credt: McDonne// Douglas

Air cargo moves mainly at night

make a significant contribution to the airport budget. Air cargo carriers have different facility needs, e.g., they need ramp space and room for sorting cargo rather than gate space and terminal lounges. In some cases, cargo carriers have been unable to interest the majority of carriers in underwriting airport bonds to build cargo facilities, and they have been forced to undertake development projects on their own, even though they are also paying landing fees that are used to underwrite development of passenger facilities.

General aviation, because of its disaggregate nature, is another group that often has little to say in the airport planning process. However, aviation interest groups, trade associations, and fixed base operators may sometimes help to present the position of GA users to the airport operator.

Federal Government

The Federal Government is a major participant in airport planning and development. FAA administers Federal grants to airports for planning and for capital improvements. Since 1970, these funds have come from the user-supported Airport and Airway Trust Fund. In 1983, planning grant funds authorized under the Airport Improvement Program amounted to about $8.8 million, and capital development grants to almost $800 million. [b]

Federal funds may be spent only for certain classes of projects. In general, eligible projects are those for construction or improvement of facilities directly related to the use of aircraft—i.e., runways, taxiways, and ramps. In recent years,

[b] ***Second Annual Report of Accomplishments Under the Airport Improvement Program, Fiscal Year 1982*** (Washington, DC: Federal Aviation Administration, May 1984).

eligibility has also been extended to include common-use areas of passenger terminals and other airport buildings related to the safety of persons or the provision of services to airport users. Federal funds cannot be used for the construction of revenue-producing facilities such as hangars and automobile parking areas or for building access roads off the airport property.[7]

It has been suggested that the availability of Federal funds at a favorable matching ratio has encouraged airports to concentrate on those types of improvements which are eligible for Federal aid. The Federal share for eligible improvements ranges from 70 to 90 percent depending on type of project; but since airports make many improvements without Federal aid, the Federal share of all capital investment at airports constitutes less than 40 percent. [8]This percentage is even less at large airports, where Federal monies often make up less than 10 percent of the capital improvement budget. However, many operators of large airports believe that Federal funding is important for financing improvements that they feel are needed, but which the air carriers are reluctant to pay for.

FAA also influences airport operational decisions because it owns and operates the air traffic control system, including the air traffic control tower, navigational equipment, and landing aids at the airport itself. Airport improvements which require installing, moving, or upgrading this equipment have to be approved and carried out by FAA. Safety and operational standards for airports are also established by FAA. Airport facilities built with Federal funds must be designed in accordance with these standards, which are published in the Federal Aviation Regulations or in FAA Advisory Circulars, manuals, and handbooks.

Finally, FAA does airport system planning. The National Airport System Plan (NASP), a 10-year plan which was published in 1977 and updated in 1980, includes those airports that meet FAA's criteria of "national importance. " In 1982 there were 3,203 such airports. The NASP is not a compilation of individual airport development plans. Rather, it is a summary of projected improvements for each airport eligible for Federal aid, prepared by FAA based on information provided by individual airports, state agencies, and FAA regional offices.

State Aviation Agencies

Forty-seven States have aviation agencies. Most are within State departments of transportation, although eight are independent agencies or commissions. State authority and activity vary widely. All the States with aviation agencies provide some State financial assistance to airports. In most cases this aid is primarily for capital improvements, although a few States make funds available for high-cost operations and maintenance items such as snow removal equipment.[9]In addition, many State agencies provide some technical and planning assistance, particularly to smaller airports. Some States carry out ongoing planning programs for a statewide airport system, complete with year-by-year scheduling for improvements at individual airports, In many cases, States also install and maintain navigation equipment and landing aids.

Some State governments have planning and development responsibilities as owners and operators of airports. Baltimore-Washington International is owned by the State of Maryland, for example, and Honolulu International is owned by the State of Hawaii. In general, however, most of the State-owned airports are general aviation rather than commercial service airports.

States provide much less airport development money than either the Federal Government or the local airport operators. As shown in table 7, State spending in 1982 for airport construction and improvement projects totaled $276 million. This averages $5.5 million per State, but the actual distribution is highly skewed. Table 7 shows that 25 States spent less than $1 million each; 12 States spent between $1 million and $5 million, and 5 spent between $5 million and $10 million. Five States—Alaska, Connecticut, Hawaii, Illinois, and New York—spent ***over $10*** million for air-

[7]14 CFR 151.

[8]***Public Works Infrastructure: Policy Considerations for the 1980s*** (Washington, DC: Congressional Budget Office, April 1983), p. 106.

'National Association of State Aviation officials, DataBank ***1983*** (Washington, DC: NASAO, 1983), p. 2.

Table 7.-State Funding of Airport and Aviation Programs

State and year(s)	State-owned airports: Construction improvement	State-owned airports: Operations maintenance	Other airports: Construction improvement	Other airports: Operations maintenance	Landing & Navaids†	Other airport expenditures	Total	Airport† planning
AL-IW82	$ 200,750	—	402,721	—	—	—	603,471	—
AK-FY82	60,355,700	—	—			—	60,355,700	1,255,200
AZ-FY83	57,752	311,838	2,455,248	—	—	20,000[a]	2,844,838	60,000
AR-FY82	—	—	750,000	—	50,000	—	800,000	—
CA-FY82	—	—	2,200,000	1,000,000		1,000,000[b]	4,200,000	—
CT-FY82[c]	100,700,000	500,000	780,000		—	—	101,980,000	100,000
DE-BI82/83	—	—	300,000	—	25,000	—	325,000	—
FL-FY82	—	—	5,030,500		—	—	5,030,000	250,000
GA-FY82	—	—	700,000	1,000,000	300,000	—	2,000,000	20,000
HI-FY82	15,581,268	77,313,810	—	—	—	—	92,895,078	160,289
ID-FY82	50,000	50,000	454,000	—	30,000	40,000[d]	624,000	—
IL-FY83	—		10,269,229	—	9,000	—	10,278,229	31,000
IN-BI81/82	—	—	1,757,445	—	—	—	1,757,445	—
IA-FY82	—	—	635,600	—	60,000	25,000[e]	720,600	—
KS-FY82	—	—	—	—	—	—	0	9,444
KY-FY82	—	—	610,000	—	100,900	—	710,900	—
LA-FY82	156,729	32,000	3,102,549	—	196,000	—	3,487,278	180,000
ME-BI82/83	303,434	344,000	799,539	—	27,000	324,000[f]	1,797,973	18,237
MD-FY82	3,008,291	19,684,127	375,000	—	26,618	120,484[g]	23,214,520	102,876
MA-FY82	—	—	225,549	—	22,000	—	247,549	18,522
MI-FY82		—	1,874,000	—	600,000	60,000[h]	2,534,000	145,000
MN-FY82	5,9&l	—	3,983,500	1,117,200	598,000	299,000[i]	6,003,600	—
MS-FY83	—	—	70,000	—	—	—	70,000	10,000
MO-FY82	—	—	327,973	228,471	—	—	556,444	—
MT-FY82	20,000	10,000	220,000	—	44,000	—	294,000	26,000
NB-FY82	134,531	223,760	424,031	—	266,292	—	1,048,614	7,757
NV-FY82	—		—	—	—	—	0	—
NH-BI82/83	131,607	27,000	—	18,000	35,000	—	211,607	30,000
NJ-FY82	—	—	—	—	—	—	0	—
NM-BI82/83	—		889,500	—	—	—	889,500	—
NY-FY83	—		27,700,00d	—	—	—	27,700,000	33,000
NC-BI82/83	20,000	—	7,275,967	—	75,000	200,000[k]	7,570,967	(191 ,Ooo)t
ND-CY82	250,000	25,000	1,479,000	—	20,000	—	1,774,000	25,000
OH-FY82	—	—	550,000	—		—	550,000	—
OK-FY82	115,000	—	500,000	—	—	—	615,000	—
OR-BI82/83	255,800	407,728	150,000	—	—	—	813,528	—
PA-FY82	90,000	3,981,983	1,365,000		—	—	5,436,983	68,338
RI-BI81/82	2,657,255	49,937	—	—	59,221	197,283[l]	2,963,696	225,000
SC-FY82	—	—	1,133,215	885,004	22,749	—	2,040,968	124,020
SD-CY82	—		143,182	—	30,466	—	173,648	—
TN-FY82	—	5 , G	1,600,000	100,000	60,000	—	1,785,000	13,000
TX-FY83	—	—	2,500,000	—		—	2,500,000	—
UT-FY82	—	10,000	230,000		2,000,06	—	2,240,000	45,000
VT-FY82	538,199	366,000	8,300	—	12,200	—	924,699	15,500
VA-FY82	—	22,500	428,000	72,600	37,000	—	560,100	51,700
WA-BI82/83	—	40,647	784,745		—	—	825,392	—
WV-FY82	—		330,951	—	—	—	330,951	
WI-FY82	—	—	982,900	—	25,000	220,050[m]	1,227,950	(64,20;t
WY-FY83	—	—	5,505,137	—	—	—	5,505,137	—
Totals:	$164,632,216	103,405,330	91,302,781	4,421,275	4,751,446	2,505,817	391,018,775	3,017,883

†Several additional States funded planning projects and nav/landing aids—amounts are included in total.
[a]AZ—Contingency.
[b]CA—Airport loans to local governments.
[c]CT—$100,000 is for special project at Bradley Airport.
[d]ID—Revolving inventory for navaid/light equipment, etc., for resale to municipally owned airports on State matching fund basis.
[e]IA—Air markers.
[f]ME—Snow removal assistance.
[g]MD—Zoning functions in connection with airport noise.
[h]MI—Painting marking.
[i]MN—Revolving Loan Program for aircraft hangar construction.
[j]NY—$21 million of total to be used as State matching funds for terminal area project at Buffalo.
[k]NC—$200,000 for 100 percent State funding for runway marking, tree clearing, and other safety projects.
[l]RI—CFR and snow removal equipment; security fencing; environmental assessment reports.
[m]WI—$220,050 expended for land and equipment.

SOURCE: National Association of State Aviation Officials, *DataBank 1983* (Washington, DC: NASAO, 1983), pp. 9-10, port development; all of these except New York and Illinois used these funds primarily for State-owned airports. The 28 States that made planning assistance funds available in 1982 spent a combined sum of about $3 million. However, about 40 percent of this amount was spent by Alaska alone.

Total State capita] assistance in 1982 for airports not owned by the State totaled $91 million.l" Often, these funds provided the State share of federally funded projects. In other cases, State funds were used where Federal grants were not available for a project.

Despite the small amount overall, the State role is a vital one, especially for smaller airports. Few GA airports or small commercial service airports have the in-house staff to make traffic forecasts or to plan facility improvements. In addition, because small airport operators often do not have the technical expertise to complete an application for Federal assistance, State agencies are active in helping them through this process. Most State aviation agencies concentrate their resources on helping small commercial service and GA airports because they have found that large commercial airports can take care of themselves. Indeed, most State aviation agencies do not have the staff and expertise to deal with the details of planning and carrying out projects at major commercial service airports. In the case of major airports, the State role may simply be to keep informed of development activities and perhaps to provide some State matching funds.

State control over the distribution of Federal airport development funds varies widely with State law. In most cases, grants from FAA to airports for federally approved projects completely bypass the State agency, Some States, however, have channeling acts which give them some control over Federal funds. In these cases, projects must have State, as well as Federal, approval before the grant can be awarded to the airport. In some cases, too, State law requires that the State act as agent for Federal grant recipients, so that the State receives the funds and passes them through to the airport.

I°Ibid., pp. 9-10.

Regional Planning Agencies

Many States have created regional planning authorities that combine planning and development functions. Regional planning responsibilities are sometimes assumed by Councils of Governments or similar associations of municipalities in a metropolitan area. Some regional agencies conduct extensive transportation and land use planning in their areas of jurisdiction and may be involved in plans for siting new airports or for expanding existing facilities.

Regional agencies are seldom involved in the actual project execution, but they can have great influence over the availability of funds. In some States, their approval of a master plan *or* of ***in***dividual projects is required for the release of State grant funds. Often these same agencies are also responsible for approving the release of Federal funds. Rules for the release of Federal funds for major projects was formerly governed by Office of Management and Budget Circular A-9s, under which regional agencies were required to review major projects to certify that they met Federal guidelines on the use of grant moneys by State and local governments and to ensure that sufficient planning had gone into the project.

This procedure has changed somewhat since the release of Executive Order ***12372.*** Under the new procedure, Federal agencies, such as FAA, are still required to consult and cooperate with State and local governments in the administration of Federal assistance and development programs, but the intent is to give the States more latitude in determining criteria for acceptable projects. Although ***Executive*** Order 12372 places more emphasis on State priorities, the effect is still to require Federal, State, and local agreement before funds are released for major projects. In many cases, the approval power remains in the hands of the same regional planning agencies which handled the A-9s review process.

Other Parties

A commercial airport serves thousands, often millions, of airline passengers Despite their large number, however, passengers typically have no formal way to voice opinion on the service being offered or to influence future airport plans. How-

Photo credit: Federal Aviation Administration

The wait begins

ever, the passengers' behavior—in terms of the preferred hours of travel and the preferred mode for arriving at the airport-will greatly affect how the airport operates, and passenger behavior is a frequent subject of study by airport planners. Moreover, passengers do have the ability to "vote with their feet" in areas where there is a choice of airports. Passenger preference is often among the reasons that one airport in a region is underutilized. If utilization of the airport is to be increased, the operator or the carriers must improve those features that passengers object to—e.g., inadequate groundside access, infrequent flights, or inconvenient parking.

The actions of concessionaires and off-airport firms offering services on the airport property can greatly affect airport development. Often these firms have little say in the long-range planning decisions. Where airport facilities do not accommodate their needs, improvised solutions may contribute to congestion and delay. For example, the use of high-occupancy vehicles, such as shuttle buses, for airport access and circulation should tend to reduce curbside congestion. However, ground access delays at some airports have actually been worsened by the uncontrolled proliferation of private shuttle bus services offered by car rental firms, hotels, and others to carry passengers from the terminal to remote locations. In some cases, inviting these firms to participate in an earlier stage of the planning process and designing facilities to match the needs of shuttle buses rather than automobiles might have resulted in better coordination of airport circulation and less curbside congestion.

Nearly all commercial service airports are publicly owned, most by municipal governments. The city government which is also an airport sponsor must balance the economic benefits of the airport against any direct and indirect costs the airport may impose. The city government is responsible for a number of services which are vital to the airport but beyond the control of the airport manager—e.g., highway construction and mass transit access. Elected officials must choose to allocate funds between projects that might benefit the airport and those related to other municipal services such as hospitals, schools, and housing. The airport is seldom the first priority of the city government.

Other local governments may be involved in, or affected by, the airport planning process. Many major airports are surrounded by several municipalities. Some of these communities may be bothered by noise, automobile traffic, or other problems generated by the airport. Other communities may control services necessary to operation of the airport. In addition, the interests of individuals surrounding the airport may be represented not only by local governments but by public interest groups organized around a particular issue. These groups and individuals may be brought into the airport planning process through public hearings and other means, but their effectiveness and degree of participation vary widely as a function of the receptiveness of airport operators and the aggressiveness with which these groups pursue their interests.

CAPITAL IMPROVEMENT

The most obvious solution to the problem of airside delay at a busy airport is to increase capacity through capital improvements—either by building another airport or by expanding the existing one through construction of new runways, gates, terminals, or whatever is needed. Nearly all the major airports in the United States have gone through at least one period of major capital improvement, many of them in the late 1960s and early 1970s to accommodate jet aircraft. As a solution to delay problems, however, construction of new airport facilities is not without problems, and airport operators can run into a number of difficulties in attempting major airport construction or expansion.

First of all, an airport is a system of interdependent parts. Major expansion of one part may necessitate expansion of another. For example, adding new runways and increasing the number of airside operations will result in the need for new gates and more terminal waiting areas for passengers, and possibly larger automobile parking areas and access roads with higher capacity. Because of the piecemeal way in which these different types of development may be handled, a bottleneck is often not eliminated, but simply moved to another point.

Another problem often encountered in expansion is the lack of suitable land. Many airports are closely surrounded by urbanized areas, land that would be extremely expensive to acquire. Although most airports were originally located on the edge of metropolitan areas, cities have expanded over the years to surround many of them. Some of this development, especially commercial and industrial uses, was actually drawn to the area by the proximity to air transportation. Residential uses often spring up if land use controls are inadequate. Once communities become established in the vicinity, the airport is often perceived as a poor neighbor—generating noise, traffic congestion, and other annoyances for the surrounding communities. Residents may oppose plans for airport expansion that would increase any of these problems.

This *is* not to say that expansion of a major airport is impossible. St. Louis Lambert, for instance, greatly increased airside and terminal capacity over a period of 5 years through development of an existing location. Improvements included lengthening existing runways and taxiways, terminal expansion, and construction of new gates. A major factor was the Environs Plan, a program to mitigate noise problems by installing sound insulation in residential buildings and purchasing property to serve as a noise buffer zone.

Chicago O'Hare is beginning a major expansion of terminal facilities, which will include constructing new loading gates and ramp areas and rebuilding parts of the taxiway system. At one time, construction of an additional runway was also considered, but then dropped in later planning stages. Studies indicated that an additional parallel runway would not provide a capacity increase great enough to justify the high cost. Historically, congestion problems at O'Hare have primarily been due to lack of gate space. The new runway would have required land acquisition and relocation of buildings. It would also have generated additional noise and led inevitably to conflicts with airport neighbors.

Expansion is expensive. At St. Louis, the noise abatement program alone (without which the expansion probably would not have been possible) is expected to cost about $50 million over a 20-year period. The expansion of Chicago O'Hare is expected to cost about $1 billion. Adding the new runway would have increased the cost by 25 percent.

Building a new airport far enough from populous areas to avoid noise problems and to take advantage of lower land prices is a desirable alternative. Ideally, the new airport site should be large enough to provide both room for growth and extensive buffer zones to protect it from encroaching urban development—a tract of many thousands of acres. The Dallas-Fort Worth airport covers an area of 17,600 acres and has agreements protecting an additional 4,000 acres; but, even there, noise is an issue as incompatible urban development moves closer to the airport.

In many metropolitan areas, a suitable tract of land might be distant from the city center, making ground access a problem. In selecting a distant site, several questions arise. If a new airport is a supplement to, rather than a substitute for, the existing airport, would passengers be willing to travel that far to use it? Would air carriers be willing to serve an airport that might attract fewer passengers than the old airport? That the answer to these questions can sometimes be "no" is demonstrated in the case of Dunes and National airports in Washington, DC.

Because of the increasing public concern about aircraft noise, community reaction against the possible siting of an airport has presented problems even in relatively underpopulated areas. The expansion of Lambert airport was made necessary because of the collapse of plans to build another airport outside of St. Louis. The vigorous opposition by citizen groups and local governments surrounding the proposed new site was a major factor in the decision not to build a new airport. This concern affects not only sites for commercial airports but also for GA and relievers airports.

Difficult as it is to find land for new airports, the task is becoming increasingly imperative in some cities. Many observers are pessimistic about the likelihood of constructing new major airports. The FAA, in the 1981 National Airspace System Plan, states that: "few new air carrier airports are anticipated and most major airports have limited expansion capability due to physical, environmental, airspace, runway, and/or landside limitations."[11] The NASP includes the possibility of beginning construction on but one major new airport within the next 10 years.[12]

Despite this general skepticism, some will undoubtedly have to be built as traffic continues to grow. Some cities (Los Angeles and Atlanta, for instance) have anticipated this need and have set aside land for future airport sites. Most cities, however, have not had the foresight or ability to purchase a large tract of land and to protect it for future aviation use, and now even marginally suitable sites are rapidly being lost to other land uses.

[11] *National Airspace System Plan* (Washington, DC: Federal Aviation Administration, December 1981).

[12] *National Airport System Plan: Revised Statistics, 1980-1989* (Washington, DC: Federal Aviation Administration, 1980), p. vi.

AIRCRAFT NOISE

Aviation noise is a fact of life at today's airports and a major, perhaps the major, constraint on airport expansion and development. Citizens living around airports have complained that aviation noise is annoying, disturbs sleep, interferes with conversation, and generally detracts from the enjoyable use of property. There is increasing evidence that high exposure to noise has adverse psychological and physiological effects. People repeatedly exposed to loud noises may exhibit high stress levels, nervous tension, and inability to concentrate.

Conflicts between airports and their neighbors have occurred since the early days of aviation, but airport noise became a more serious issue with the introduction of commercial jet aircraft in the 1960's. FAA estimates that the land area affected by aviation noise increased about sevenfold between 1960 and 1970. Even with this increase, the actual number of people affected by aviation noise is relatively small. It has been estimated that 6 million to 7 million people in the United States (under 5 percent of the population) experience significant annoyance due to aviation noise; about 10 percent of these people live in areas of severe noise impact .13 Nevertheless, airport noise has become a major political issue in certain communities.

New aircraft are much quieter than earlier jets, and the noise levels at the busiest large airports have been reduced to the point that community opposition has abated in some instances, Denver, Atlanta, Houston, and Dallas-Fort Worth have been able to secure community agreement to proceed with airport expansion projects, including new runways. Expansion of terminal buildings, which implies an increase in air traffic, has also been accepted in New York and Chicago. On the other hand, noise levels threaten to increase as jet traffic is introduced at secondary airports in some metropolitan areas. Santa Ana (John Wayne) and Westchester County are notable examples of airports where the surrounding communities are pressing for curfews and other airport use restrictions.

Another trend that may intensify the noise issue is continuation of residential encroachment around airports. As more people come to live in

13Norman Ahford and Paul H. Wright, ***Airport Engineering*** (New York: John Wiley & Sons, 1979).

Photo credit: EPA-Documerica, **Michael** *Philip Manheim*

Homes under the approach path to Boston Logan

noise impact areas, the opportunities for annoyance increase. Equally important, the public has become more sensitive to the issue, and it has become highly politicized. Airport neighbors have sued airports for mental anguish as well as the reduced property values related to noise exposure. Airport operators have begun to adopt noise abatement and mitigation measures so as to reduce their liability and protect themselves in legal proceedings. The noise issue has been instrumental in slowing or stopping several airport expansion programs.

Federal Responsibilities

FAA's role is defined in a 1968 amendment to the Federal Aviation Act of 1958.[14] The amendment charges the FAA Administrator to "prescribe and amend such rules and regulations as he may find necessary to provide for the control and abatement of aircraft noise and the sonic boom. " FAA has worked to alleviate noise by controlling the source—i. e., quieting the aircraft and its engine. Federal Aviation Regulations (FAR) Part 36 establishes noise standards for newly manufactured aircraft engines. Air carriers are replacing noisy aircraft with new ones meeting these standards, so that noncomplying commercial aircraft will eventually be phased out of the fleet. FAA has controlled sonic boom by prohibiting supersonic operations over land by civil aircraft. Military supersonic flights continue, but in a carefully controlled manner.

FAA has established guidelines for measurement of noise and suggested a procedure for carrying out local noise studies and abatement programs. Because FAA also has the authority and responsibility to control aircraft in flight and to prescribe flight paths, it assists local airport operators in developing noise mitigation procedures to suit their area.

FAA has been reluctant to impose a specific Federal standard for airport noise, as this might expose the Federal Government to liability for damages if the standard were to be exceeded. Current policy is that FAA shares responsibility for noise abatement, but does not bear liability. Recent statements by the FAA Administrator and the Secretary of Transportation have reemphasized that local governments and airport operators must take the lead in reducing airport noise. On the other hand, FAA discourages the proliferation of stringent local rules which may have a constraining effect on airport capacity or on interstate commerce.

Measurement of Noise

There are several methods for measuring aircraft noise and its effect on a community. The level of sound can be measured objectively; but noise—unwanted sound—is a very subjective matter, both because the human ear is more sensitive to some frequencies than others and because the degree of annoyance associated with a noise can be influenced by psychological factors such as the hearer's attitude or the type of activity in which engaged. Techniques have been developed to measure single events measured in units such as dBA (A-weighted sound level in decibels) or EPNdB (Effective Perceived Noise Decibels). These measure the level of noise in objective terms, giving extra weight to those sound frequencies that are most annoying to the human ear.

In some cases, annoyance is due not only to intensity of a single event, but to the cumulative effects of exposure to noise throughout the day.

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[14]49 LJ. S.C. 1301 et. seq.

Methods to measure this effect objectively include aggregating single event measures to give a cumulative noise profile by means of such techniques as the Noise Exposure Forecast (NEF), the Community Noise Equivalent Level (CNEL), and the Day-Night Average Sound Level (Ldn). FM uses EPNdB to measure single event aircraft noise as part of its aircraft certification process. FAA has established dbA as the single event unit and the Ldn system as the standard measure of cumulative noise exposure to be used by airports in the preparation of noise abatement studies.

FAA has suggested, but not mandated, guidelines for determining land uses that are compatible with a given Ldn level. Ideally, residential uses should be located in areas below 65 Ldn. In the high noise impact areas (Ldn 80 to 85 or more) FAA suggests that parking, transportation facilities, mining and extraction, and similar activities are the most compatible (see table 8).

Noise and Land Use

The problem of aviation noise is intimately connected with the question of land use since one of the most effective insulators against annoying sound is distance. If possible, an airport should be surrounded by a noise buffer area of vacant or forested land, and the private property near the high noise impact area (e.g., under approach and departure paths and near aeronautical surfaces) should be used for activities that are less sensitive to noise—agriculture, highway interchanges, manufacturing, and other activities where a high level of ambient noise does not detract from performance. Unfortunately, many airports are surrounded by buildings devoted to incompatible activities—e.g., residences, schools, and auditoriums.

Zoning and land use planning are responsibilities of local governments. In many cases these governments have been unable or unwilling to provide mutual protection for airports and residential development. Land is a scarce resource in urban areas; and where there is great demand for housing and shopping centers, underutilized land around airports becomes extremely valuable. Even where local governments have enacted zoning ordinances to prevent encroachment, developers have been able to gain waivers. The tax revenues generated by the higher land uses may seem more important to city governments than the long-range need to protect the airport and the residential areas from one another. In some cases, local governments trying to enforce zoning rules have had them overturned when developers contested them in court.

At least part of the problem is ineffective intergovernmental cooperation. Few airports are located entirely within the borders of the municipality that owns and operates the facility. Surrounding municipalities may have conflicting practices, priorities, and philosophies of government; and each has separate zoning authority. For instance, St. Louis-Lambert Airport is surrounded by 29 municipalities, and Dallas-Fort Worth by 10. A municipality that owns an airport perceives advantages and disadvantages, and it must weigh the economic benefits of the airport against the problems of noise. A municipality that merely borders on an airport may see only disadvantages. Further, because the airport operator has sole liability for damage due to airport noise, some surrounding municipalities have felt little need to enforce zoning rules when complaints will not be directed to them but to the municipality that owns and operates the airport.

Even where sound intergovernmental agreements on zoning have been developed, time can erode them. When Dallas-Fort Worth airport was being planned and built, the surrounding municipalities developed agreements on zoning that were viewed as models of intergovernmental cooperation and coordination. Over the intervening years, there have been changes in local government, in priorities, and in the local economy. There is now encroaching development such that Dallas-Fort Worth now has noise problems, despite its huge 17,600-acre size.

Local Noise Abatement Programs

While aircraft are the source of noise at airports, aircraft operators are not liable for damage caused by noise. The courts have determined that the sole legal liability for aircraft noise rests with the airport operator. The Federal Government, by law and administrative action, has

Table 8.—Land Use Compatibility With Yearly Day-Night Average Sound Levels

Land use	Yearly day-night average sound level (Ldn) in decibels					
	<65	65-70	70-75	75-80	80-85	>85
Residential:						
Residential, other than mobile homes and transient lodgings	Y	N[a]	N[a]	N	N	N
Mobile home parks	Y	N	N	N	N	N
Transient lodgings	Y	N[a]	N[a]	N[a]	N	N
Public use:						
Schools, hospitals and nursing homes	Y	25	30	N	N	N
Churches, auditoriums, and concert halls	Y	25	30	N	N	N
Governmental services	Y	Y	25	30	N	N
Transportation	Y	Y	Y[b]	Y[c]	Y[d]	Y[d]
Parking	Y	Y	Y[b]	Y[c]	Y[d]	N
Commercial use:						
Offices, business and professional	Y	Y	25	30	N	N
Wholesale and retail—building materials, hardware and farm equipment	Y	Y	Y[b]	Y[c]	Y[d]	N
Retail trade—general	Y	Y	25	30	N	N
Utilities	Y	Y	Yb	Y[c]	Y[d]	N
Communication	Y	Y	25	30	N	N
Manufacturing and production:						
Manufacturing, general	Y	Y	Y[b]	Y[c]	Y[d]	N
Photographic and optical	Y	Y	25	30	N	N
Agriculture (except Livestock) and forestry	Y	Yf	yLl	Y[e]	Y[h]	Y[h]
Livestock farming and breeding	Y	Y'	y~	N	N	N
Mining and fishing, resource production and extraction	Y	Y	Y	Y	Y	Y
Recreational:						
Outdoor sports arenas and spectator sports	Y	Y[e]	Y[e]	N	N	N
Outdoor music shells, amphitheaters	Y	N	N	N	N	N
Nature exhibits and zoos	Y	Y	N	N	N	N
Amusements, parks, resorts and camps	Y	Y	Y	N	N	N
Golf courses, riding stables and water recreation	Y	Y	25	30	N	N

NOTES: The designations contained in this table do not constitute a Federal determination that any use of land covered by the program is acceptable or unacceptable under Federal, State, or local law. The responsibility for determining the acceptable and permissible land uses remains with the local authorities. FAA determinations under Part 150 are not intended to substitute federally determined land uses for those determined to be appropriate by local authorities in response to locally determined needs and values in achieving noise compatible land uses.

KEY: SLUCM—Standard Land Use Coding Manual.
Y (Yes)—Land use and related structures compatible without restrictions.
N (No)—Land use and related structures are not compatible and should be prohibited.
NLR—Noise Level Reduction (outdoor to indoor) to be achieved through incorporation of noise attenuation into the design and construction of the structure.
25, 30, or 35—Land use and related structure generally compatible; measures to achieve NLR of 25, 30, or 35 must be incorporated into design and construction of structure.

[a]Where the community determines that residential uses must be allowed, measures to achieve outdoor to indoor Noise Level Reduction (NLR) of at least 25 dB and 30 dB should be incorporated into building codes and be considered in individual approvals. Normal construction can be expected to provide a NLR of 20 dB; thus, the reduction requirements are often stated as 5, 10 or 15 dB over standard construction and normally assume mechanical ventilation and closed windows year round. However, the use of NLR criteria will not eliminate outdoor noise problems.
[b]Measures to achieve NLR of 25 must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise-sensitive areas or where the normal noise level is low.
[c]Measures to achieve NLR of 30 must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise-sensitive areas or where the normal noise level is low.
[d]Measures to achieve NLR of 35 must be incorporated into the design and construction of portions of these buildings where the public is received, offices areas, noise-sensitive areas or where the normal noise level is low.
[e]Land use compatible provided special sound reinforcement systems are installed.
[f]Residential buildings require an NLR of 25.
[g]Residential buildings require an NLR of 30.
[h]Residential buildings not permitted.

SOURCE: Adapted from 14 CFR Part 150, Airport Noise Compatibility Planning.

preempted control of aircraft in flight. Because the Federal Government is immune from suit (without its consent) and because the aircraft operate under Federal regulation, litigants with complaints about aircraft noise have no recourse but to the airport operator. Courts have consistently held that the airport proprietor has the authority to control the location, orientation, and size of the airport and from that authority flows the liability for the consequences of its operation, including the responsibility to protect citizens from residual noise. Litigants have used various appreaches in suing airports and have collected damages on the grounds of trespass, nuisance, and inverse condemnation.

Balancing their extensive exposure to liability claims, airport operators have some authority—albeit limited—to control the use of their airports in order to reduce noise. Basically, any restriction of operations at the airport must be nondiscriminatory. Further, no airport may impose a restriction that unduly burdens interstate commerce. The definition of "undue burden" is not precise, and restrictions at individual airports must be reviewed on a case-by-case basis. Restrictions must be meaningful and reasonable—i.e., a restriction adopted to reduce noise should actually have the effect of reducing noise. Finally, local restrictions must not interfere with safety or the Federal prerogative to control aircraft in the navigable airspace.

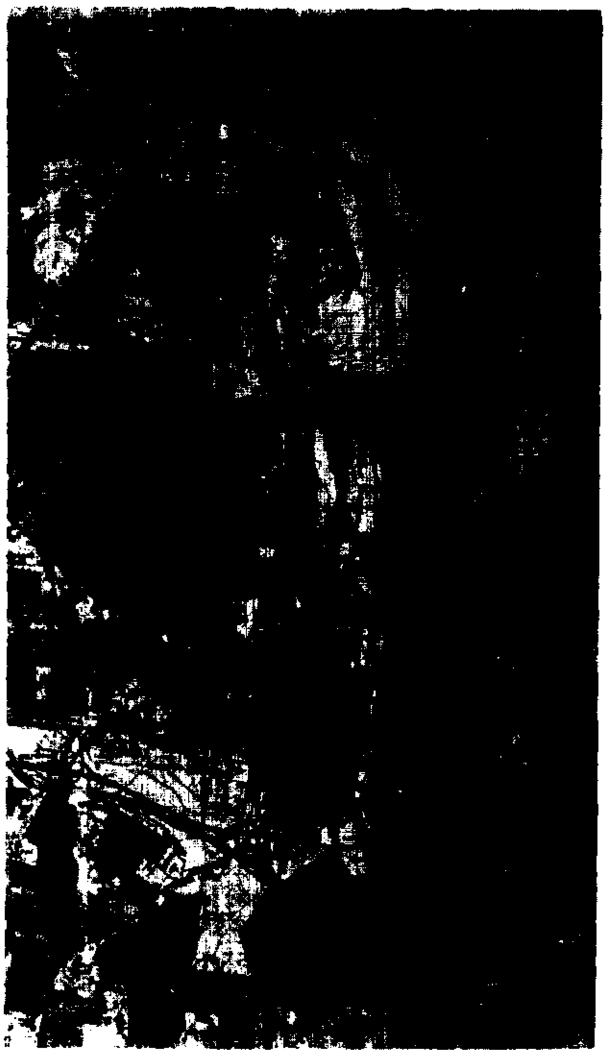


Photo credt: Oorn McGr8fh, Jr.

Noise contour map

Under FAR Part 150, airport operators can undertake noise compatibility studies to determine the extent and nature of the noise problem at a given airport. They can develop noise exposure maps indicating the contours within which noise exposure is greater than a permissible level. They can identify the noncompatible land uses within those contours and develop a plan for mitigating present problems and preventing future ones. Unfortunately, the airport operator's ability to prevent future problems is usually very limited. Unless the airport actually owns the land in question, the authority to make sure it is reserved for a compatible use is usually in the hands of a municipal zoning commission.

Many of these noise abatement programs allowed under current legislation are eligible for Federal aid. They include:

- takeoff and landing procedures to abate noise and preferential runway use to avoid noise-sensitive areas (which must be developed in cooperation with and approved by FAA);
- construction of sound barriers and soundproofing of buildings;
- acquisition of land and interests therein, such as easements, air rights, and development rights to ensure uses compatible with airport operation;
- complete or partial curfews;
- denial of airport use to aircraft types or classes not meeting Federal noise standards;
- capacity limitations based on the relative noisiness of different types of aircraft; and
- differential landing fees based on FAA-certificated noise levels or on time of arrival and departure.[15]

[15]Adapted from J. E. Wesler, "Federal Policies Affecting Airport Noise Compatibility Programs," prepared for American Institute of Aeronautics and Astronautics, International Air Transportation Conference, Atlantic City, NJ, May 1981.

FAA provides assistance to airport operators and air carriers in establishing or modif ying flight paths to avoid noise-sensitive areas. In some cases, aircraft can be directed to use only certain runways, to stay above minimum altitudes, or to approach and depart over lakes, bays, rivers, or industrial areas rather than residential areas. Procedures may be developed to scatter the noise over several communities through some "equitable" rotation program. These noise-abatement procedures can have a negative effect on airport capacity. They may require circuitous routing of aircraft or use of a runway configuration that is less than optimum with respect to capacity.

Restrictions on airport access or on the number of operations have an even more deleterious effect on airport capacity. One form of restriction is the night curfew, which effectively shuts down the airport during certain hours. Only a few airports have officially instituted curfews. One such is Washington National Airport, which has a curfew based on FAA-certificated noise standards. Aircraft with noise ratings over 72 dbA on takeoff or 85 dbA on approach may not use the airport between 10:00 p.m. and 7:00 a.m. This eliminates nearly all jet operations. Some other airports have reached informal agreements with carriers to refrain from operations after a certain hour, and some, like Cleveland, impose a curfew by not supplying jet fuel at night.

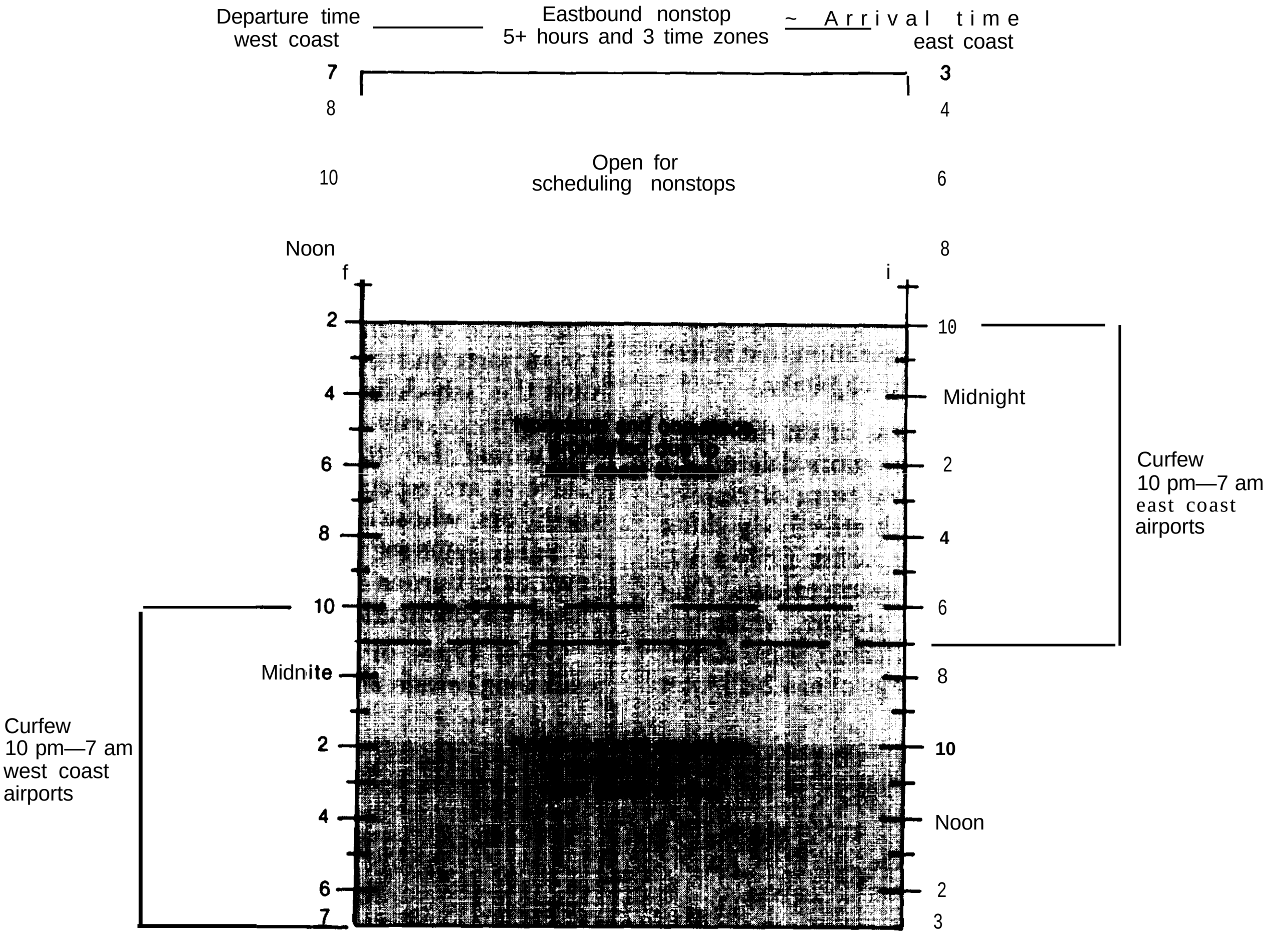
Air carriers are concerned about the spread of curfews as a noise abatement tool because they can play havoc with airline scheduling and reduce the capacity of the entire national airport system. Imposition of curfews at even two or three major airports on the east and west coast could reduce the "scheduling window" for transcontinental flights to only 4 or 5 hours daily (see fig. 3) and would also affect flights within each region. Curfews are especially threatening to air cargo operators, whose business is typically conducted at night. Some see widespread imposition of curfews as a burden on interstate commerce, and hence unconstitutional.

Other types of airport access restrictions—excluding certain aircraft types, instituting special

Photo credit: Dorn McGrath, Jr

Land bought and cleared of houses at Playa del Rey, west of Los Angeles

Figure 3.—Effects of Curfews on Scheduling Transcontinental Service



SOURCE: Peter D. Connolly, "Airport Access and Preservation of the National Airport System: Final Obstacles to a Free Marketplace," prepared for Federal Aviation Administration, *The Law of Aviation Symposium*, Dec. 1, 1981.

fees for noncomplying aircraft, or establishing hourly limits based on a "noise budget"—are subject to the legal tests of nondiscrimination and reasonableness. For example, the ban on jet aircraft instituted at Santa Monica airport was struck down by the court in 1979 because many new-technology jet aircraft that would have been banned by such a rule are quieter than the propeller-driven aircraft that would have been allowed to operate. A later ordinance by the city, banning operations by aircraft with a single-event noise rating of 76 dBA, was upheld. The court rejected the argument that enforcement of a local standard violates Federal preemption .16 On the other hand, a Federal court struck down in 1983 the curfew-quota system in effect at Westchester County airport in New York. Under that system, an average of only six aircraft with noise ratings above 76 dBA were permitted to land between the hours of midnight and 6:30 a.m.

[16]Peter D. Connolly, "Airport Access and Preservation of the National Airport System: Final Obstacles to a Free Marketplace," prepared for the Federal Aviation Administration Law of Aviation Symposium, Dec. 1-2, 1981.

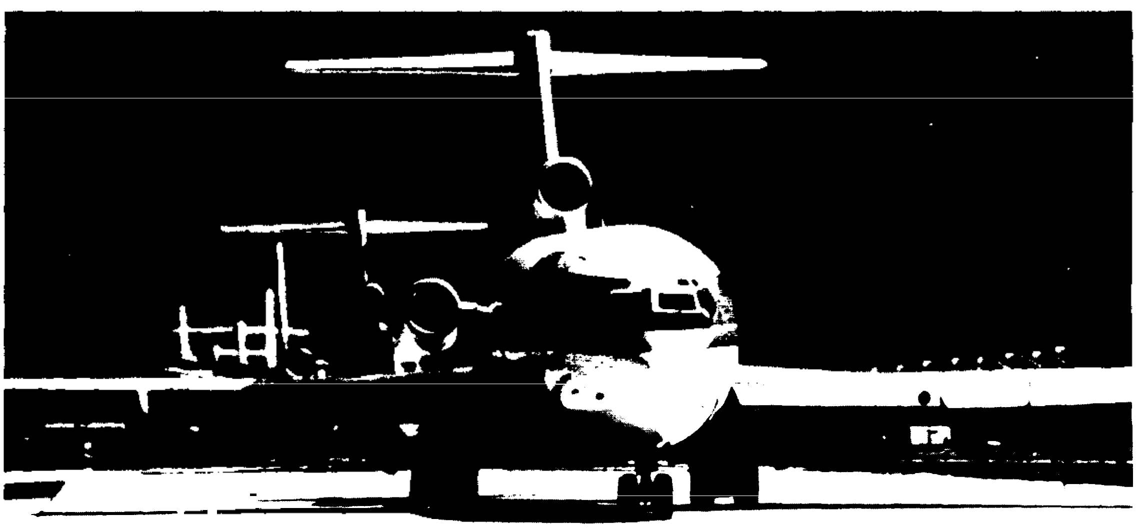
Both air carriers and airframe manufacturers have objected to the proliferation of local noise standards and noise-based quota systems. Boeing[17] for example, has pointed out that airlines are already in the process of replacing or reengining their noisier aircraft in response to FAA regulations. This replacement will require a large capital outlay on the part of carriers—capital that will have to be generated largely by continued operation of the aircraft they already have. If airports adopt local noise standards more stringent than FAA's, carriers will have to accelerate their fleet replacement programs in order to continue serving those markets. According to Boeing's estimates, such acceleration would be beyond the financial means of many airlines.

Federal funds are available to assist airport operators in soundproofing buildings or buying noise-impacted land. Usually, these are extremely expensive remedial measures, but a number of airports have been forced to undertake them. St. Louis Lambert Airport expects to spend about $50 million over the next 20 years under its Environs Plan. The airport has soundproofed some buildings and returned them to public use. In other cases, it has purchased land and resold it for more compatible use. In some cases, the land was "sterilized," that is, the buildings ***were torn*** down and the land left vacant as a noise buffer zone.

[17] Boeing Commercial Airplane Co., "The Economic Impact on the Airlines of Local Airport Operation Limitations Designed To Reduce Community Noise," submitted to the DOT/CAB Airport Access Task Force, Nov. 29, 1982.

Chapter 3

THE PROBLEM OF CAPACITY AND DELAY



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THE PROBLEM OF CAPACITY AND DELAY

A major concern of airport users and operators is delay. Flights cannot be started or completed on schedule because of the queue of aircraft awaiting their turn for takeoff, landing, or use of taxiways and gates at terminal buildings. These delays translate into increased operating costs for airport users and wasted time for passengers. The cause for this delay is commonly referred to as a "lack of capacity," meaning that the airport does not have facilities such as runways, taxiways, or gates in sufficient number to accommodate all those who want to use the airport at peak periods of demand.

The solutions generally advocated by airport operators, airlines, and the Federal Aviation Administration (FAA) are to build additional facilities at crowded airports or to find ways to make more efficient use of existing facilities. The latter course is viewed as attractive because it requires less capital investment and avoids many of the problems associated with increasing the size of the airport and infringing on the surrounding communities. A third course advocated by some is not to increase capacity but to manage demand by channeling it to offpeak times or to alternate sites. The rationale underlying all these approaches is that capacity and demand must somehow be brought into equilibrium in order to prevent or reduce delay.

The relationship of capacity, demand, and delay is considerably more complex than the foregoing suggests. Before addressing solutions, it is necessary to look more closely at matters of definition and to examine how and where delays occur. It is also necessary to look at specific airports where delays are now being encountered to obtain a clearer picture of the severity of the problem and the points at which it could be attacked.

CAPACITY, DEMAND, AND DELAY

Capacity generally refers to the ability of an airport to handle a given volume of traffic (demand)—i.e., it is a limit that cannot be exceeded without incurring an operational penalty.1 As demand for the use of an airport approaches this limit, queues of users awaiting service begin to develop, and they experience delay. Generally speaking, the higher the demand in relation to capacity, the longer the queues and the greater the delay.

De Neufville explains the relationship of capacity, demand, and delay thus:

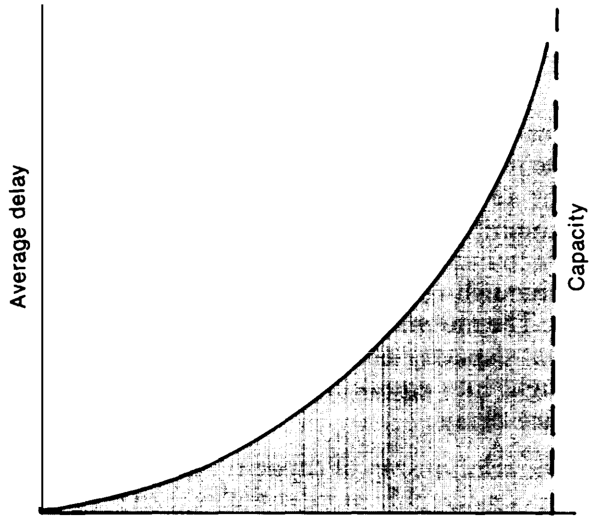
> The performance of a service system is, indeed, sensitive to the pattern of loads especially when they approach its capacity. The capacity of a service facility is, thus, not at all similar to our notion of capacity in everyday life, that is, the volume that a bottle or other vessel can hold. A bottle will accommodate any amount of liquid up to its capacity equally well; and after that, it can hold no more. A service facility, on the other hand, does not provide equal service at all times; its service rapidly deteriorates as traffic nears capacity. A service facility, can, furthermore, eventually handle more than its immediate capacity by delaying traffic until an opportunity for service exists.[2]

The illustration of this theoretical relationship in figure 4 shows that delay is not a phenomenon occurring only at the limit of capacity. Some amount of delay will be experienced long before capacity is reached, and it grows exponentially as demand increases.[3]

[2]R. De Neufville, ***Airport Systems*** Planning (London: Macmillan, 1976), p. 135.

[3]The term congestion, referring to the condition where demand approaches or exceeds capacity, is not commonly defined in the technical literature and is used in this report only as a qualitative descriptor of a situation where demand is high in relation to capacity.

Figure 4.—Theoretical Relationship of Capacity and Delay



SOURCE: Office of Technology Assessment,

Capacity

There are two commonly used definitions of airfield capacity: "throughput" and "practical capacity. " The throughput definition of capacity is the rate at which aircraft can be handled—i. e., brought into or out of the airfield, without regard to any delay they might incur. This definition assumes that aircraft will always be present waiting to take off or land, and capacity is measured in terms of the number of such operations that can be accomplished in a given period of time. Practical capacity is the number of operations (takeoffs and landings) that can be accommodated with no more than a given amount of delay, usually expressed in terms of maximum acceptable average delay. Practical Hourly Capacity (PHOCAP) and Practical Annual Capacity (PANCAP) are two commonly used measures based on this definition.[4] PANCAP, for example, is defined as that level of operations which results in not more than 4 minutes average delay per aircraft in the normal peak 2-hour operating period.[5]

[4] ***Airfield and Airspace Capacity/Delay Policy Analysis,*** FAA-APO-81-14 (Washington, DC: Federal Aviation Administration, Office of Aviation Policy and Plans, December 1981).

[5] ***Airside Capacity Criteria Used in Preparing the National Airport pLAN,*** AC 150/5060-lA (Washington, DC: Federal Aviation Administration, July 1968).

Delay

Delays occur on the airfield whenever two or more aircraft seek to use a runway, taxiway, gate, or any other airside facility at the same time. One must wait while the other is accommodated. If all users of the airfield sought service at evenly spaced intervals, the airfield could accommodate them at a rate determined solely by the time required to move them through the facility.

Aircraft, however, arrive and leave not at a uniform rate but somewhat randomly, which means that delay can occur even when demand is low in relation to capacity. Further, the probability of simultaneous need for service increases rapidly with traffic density, so that the average delay per aircraft increases exponentially as demand approaches throughput capacity. When demand exceeds capacity, there is an accumulation of aircraft awaiting service that is directly proportional to the excess of demand over capacity. For example, if the throughput capacity of an airfield is 60 operations per hour and the demand rate is running at 70 operations per hour, each hour will add 10 aircraft to the queue awaiting service and 10 minutes to the delay for any subsequent aircraft seeking service. Even if demand later drops to 40 operations per hour, delays will persist for some time since the queues can be depleted at a rate of only 20 aircraft per hour.

Figures indicates the relationship between practical and throughput capacity. As demand approaches the limit of throughput capacity, delays increase sharply and, theoretically, become infinite when demand equals or exceeds throughput capacity. Practical capacity, which is always less than throughput capacity, is that level of airfield utilization which can be attained with no more than some acceptable amount of delay.

The acceptability of delay is the key to the concept of practical capacity. Unlike throughput capacity, which can be objectively determined by analysis of airfield components and traffic patterns, practical capacity is value judgment-a consensus among airport users and operators—about how much delay they can tolerate.

Although practical capacity is usually stated in terms of an average figure, the acceptability of

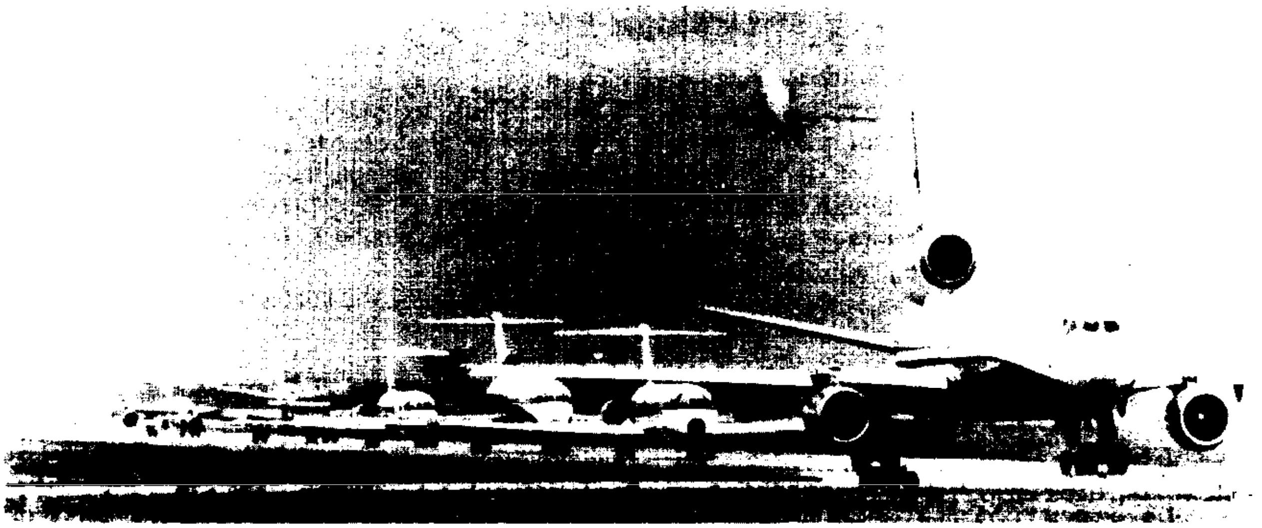
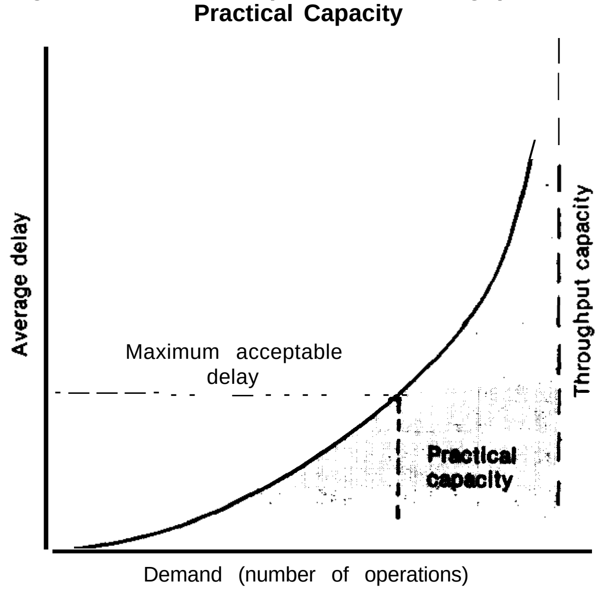


Photo credif Federa/ Aviation Administration

As demand approaches capacity, queues develop

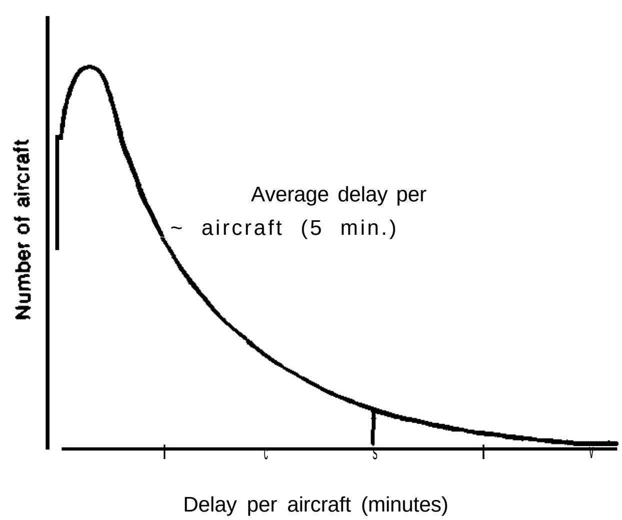
delay is actually determined not so much by the average but by the probability that the delay for a given aircraft will be greater than some amount. Just as demand tends to be nonuniformly distributed, so, too, is delay. Figure 6 shows a typical distribution of delays encountered by aircraft at a particular level of demand. Note that most delays are of short duration and that, even though the average delay is low (5 minutes), there are a few aircraft encountering relatively long delays of 15 minutes or more. Thus, while practical capacity is usually specified as that level of operations which—on average—will result in a given amount of delay, it is understood that the average implies that some percentage of delays will be considerably longer.

Figure 5.— Relationship Between Throughput and Practical Capacity



SOURCE: Office of Technology Assessment,

Figure 6.–Typical Probability Distribution of Aircraft Delay



SOURCE: Office of Technology Assessment

How much delay is acceptable? This is a judgment involving three factors. First, it must be recognized that some delay is unavoidable since it occurs for reasons beyond anyone's control—wind direction, weather, aircraft performance characteristics, the randomness of demand for service. Second, some delay, though avoidable, might be too expensive to eliminate—i.e., the cost of remedial measures might exceed the potential benefit. Third, even with the most vigorous and successful effort, the random nature of delay means that there will always be some aircraft encountering delay greater than some "acceptable" length. Thus, acceptable delay is essentially a policy decision about the tolerability of delay being longer than some specified amount, taking into account the technical feasibility and economic practicality of available remedies. [b]

[b] ***Airfie/d*** and ***Airspace Capacity/Delay Policy Analysis,*** op. cit.

FACTORS AFFECTING CAPACITY AND DELAY

The capacity of an airfield is not constant over time; it may vary considerably during the day or the year as a result of physical and operational factors such as airfield and airspace geometry, air traffic control rules and procedures, weather, and traffic mix. When a figure is given for airfield capacity, it is usually an average based either on some assumed range of conditions or on actual operating experience.

In fact, it is the variability of capacity, rather than its average value, that is more detrimental to the overall operation of an airfield. Much of the strategy for successful management of an airfield involves devising ways to compensate for factors that, individually or in combination, act to lower capacity or to induce delay. These factors can be grouped in five categories.

Airfield Characteristics

The physical characteristics and layout of runways, taxiways, and aprons are basic determinants of the ability to accommodate various types of aircraft and the rate at which they can be handled. Also important is the type of equipment (lighting, navigation aids, radar, and the like) installed on the airfield as a whole or on particular segments. For any given configuration of runways and taxiways in use, capacity is constant. Capacity varies, however, as configurations change,

Airspace Characteristics

The situation of the airfield in relation to other nearby airports and in relation to natural obstacles and features of the built environment determines the paths through the airspace that can be taken to and from the airport. Basically, the airspace geometry for a given airfield does not change over time. However, when there are two or more airports in proximity, operations at one airport can interfere with operations at another, causing the acceptance rate of one or both airports to suffer or requiring aircraft to fly circuitous routes to avoid conflict. In some cases, the interdependence of approach and departure paths for nearby airports can force one to hold departures until arrivals at the other have cleared the airspace or necessitate that each leave gaps in the arrival or departure streams to accommodate traffic at the other.

Air Traffic Control

The rules and procedures of air traffic control, intended primarily to assure safety of flight, are basic determinants of airfield capacity and delay. The rules governing aircraft separation, runway occupancy, spacing of arrivals and departures, and the use of parallel or converging runways can have an overall effect on throughput or can induce delays between successive operations. ATC rules and procedures have an especially important influence on capacity and delay at airfields where two or three runways may be in use at the same time or where there may be several arrival streams that must be merged on one final approach path.

A related factor affecting delay is the noise-abatement procedures adopted by FAA and by local airport authorities. These usually take the form of restrictions on flight paths over noise-sensitive areas or reduction (or outright prohibition) of operations during certain hours. These noise-control measures can have an adverse effect on capacity. For example, the runway configuration with the highest capacity may not be usable at certain times because it leads to unacceptably high noise levels in surrounding areas. Similarly, some noise-abatement procedures involve circuitous flight paths that may increase delays. The airport must thus make a tradeoff between usable capacity and noise control, with the usual result being some loss of capacity or increase of delay.

Meteorological Conditions

Airport capacity is usually highest in clear weather, when visibility is at its best. Fog, low ceilings, precipitation, strong winds, or accumulations of snow or ice on the runway can cut capacity severely or close the airport altogether. Even a common occurrence like a wind shift can disrupt operations while traffic is rerouted to a different pattern; if the new pattern is not optimum, capacity can be reduced for as long as the wind prevails. A large airport with multiple runways might have 30 or more possible patterns of use, some of which might have a substantially lower capacity than the others.

For most airports, it is the combined effect of weather, runway configuration, and ATC rules and procedures that results in the most severe loss of capacity or the longest delay queues. In fact, much of the effort to reduce delays at these airports, through airfield management strategy and installation of improved technology, is aimed at minimizing the disparity between VMC and IMC capacity.[7]

Demand Characteristics

Demand—not only the number of aircraft seeking service, but also their performance characteristics and the manner in which they use the airport—has an important effect on capacity and delay. The basic relationship among demand, capacity, and delay described earlier *is* that as demand approaches capacity, delays increase sharply. But, for any given level of demand, the mix of aircraft with respect to speed, size, flight characteristics, and pilot proficiency will also determine the rate at which they can be handled and the delays that might result. Mismatches of speed or size between successive aircraft in the arrival stream, for example, can force air traffic controllers to increase separation, thus reducing the rate at which aircraft can be cleared over the runway threshold or off the runway.

For any given level of demand, the distribution of arrivals and departures and the extent to which they are bunched rather than uniformly spaced also determines the delay that will be encountered. In part, this tendency of traffic to peak at certain times is a function of the nature of the flights using the airport. For example, at airports with a high proportion of hub-and-spoke operations, where passengers land at the airport only to transfer to another flight, the traffic pattern is characterized by closely spaced blocks of arrivals and departures. Accommodating this pattern can cause much greater delays than if arriving and departing flights are spread and more uniformly intermixed.

Photo credit Federal Av/a//on Administration

Much delay is in the terminal

[7]Visual Meteorological Conditions (VMC) are those in which atmospheric conditions permit pilots to approach, land, or take off by visual reference and to see and avoid other aircraft. Instrument Meteorological Conditions (IMC) are those in which other aircraft cannot be seen and safe separation must be assured solely by ATC rules and procedures. Under IMC, pilots must also rely on instruments for navigation and guidance to the runway.

MEASUREMENT OF DELAY

FAA regularly collects and analyzes data on delay, which are maintained in four data bases.[8] The most extensive data base is that maintained by the National Airspace Command Center (NASCOM). It is made up of daily reports from controllers at about 60 major airports and contains information on the number of delays, the time of beginning and end, and judgments by controllers about the primary and secondary causes. The principal value of NASCOM is that it allows FAA to monitor general trends of delay at major airports on a continuous basis. The subjective nature of controller reports limits the value of NASCOM data in analyzing the causes of delay.

The Standard Air Carrier Delay Reporting System (SDRS) contains reports from American, Eastern, and United Air Lines on their entire systems and at 32 specific airports (about 13 percent of all air carrier operations). SDRS provides data on the flight phase where delays are incurred (taxi-out, taxi-in, at gate, and airborne), measured against a standard ground time and a computer-projected flight time. The cause of delay is not reported. Like NASCOM, SDRS is used principally to monitor trends in delay on a daily basis.

The Performance Measurement System (PMS) is similar in structure to NASCOM, except that it is maintained manually rather than on a computer. Delays of 15 minutes or longer are reported by controllers at about 20 airports. A fourth delay monitoring system, developed by the FAA Office of Systems Engineering Management (OSEM), uses data from the Civil Aeronautics Board on operational times actually experienced by air carrier flights. Delay is measured by OSEM as the difference between an arbitrary standard flight time and the actual time reported for each flight.

All of these delay measurement and reporting systems suffer from basic faults. NASCOM and PMS are based on controller reports, and the quality and completeness of reporting vary considerably with controller workload. Further, NASCOM and PMS include only the longer delays (30 minutes or more for NASCOM, 15 minutes or more for PMS).[9] Since delay is a highly skewed distribution, measuring only the "tail" of the distribution produces a distorted picture of the incidence and magnitude of delay. It is impossible to infer the true value of average delay from such extreme statistics, and both NASCOM and PMS probably exaggerate mean delay by a substantial margin.

All four FAA data bases measure delay against the standard of flight times published in the Official Airline Guide. This, too, probably results in an overestimation of delay since there is wide variation in the "no-delay" time from airport to airport and, at a given airport, among various runway configurations. Many operations, when measured against a single nominal standard, are counted as delays but are, in fact, within the normal expectancy for a given airport under given circumstances. There may also be a distortion in the opposite direction. Most airline schedules—especially for flights into and out of busy airports—have a built-in allowance for delay. In part this is simply realistic planning, but there is also a tendency to inflate published flight times so as to maintain a public image of on-time operation,

Finally, all the delay measuring systems incorporate whatever delay may be experienced en route. Delays en route may not be attributable to conditions at the airport; and including them in the total for airports probably leads to overestimation.

While it is clear from the data that delays do occur at many airports, it is probably true also that actual delay is not as great as FAA data bases indicate, either in terms of the number of aircraft delayed or the average length of delay. The following estimates, based on FAA data, should therefore be interpreted with caution. They afford the best available picture of the pattern of delay,

[8] *Airfield and Airspace Capacity/Delay Policy Analysis,* op. cit., pp. 32-35.

[9] At the beginning of 1982, the threshold for reporting delay in the NASCOM system was lowered to 15 minutes. While this makes the NASCOM and PMS data bases more compatible, it prevents direct comparison with NASCOM data from previous years when only delays of 30 minutes or more were reported. As a rule of thumb, FAA estimates that changing the definition of reportable delay from 30 to 15 minutes increased the number of recorded delays by a factor of between 2 and 3.

but they almost certainly overstate the length of average delay and the number of air carrier operations affected. It may also be that, because some are based on subjective reports, the cause of delay is not correctly attributed. '”

NASCOM data for 1976 through 1983 (table 9) indicate that, through the first half of 1981, roughly 80 percent of all delays were due to weather, which either forced temporary closing of the airport or required that operations be conducted under Instrument Flight Rules (which usually entail greater separation than under Visual Flight Rules) in order to assure safety. The next largest category of delay was also weather-related (weather and equipment failures), typically occurring when landing aids required for instrument operations malfunction or are otherwise unavailable at a time when visibility is reduced by rain, fog, or snow. Delays caused by traffic volume in excess of throughput capacity typically accounted for about 6 percent of all delays reported by NASCOM. Nearly all volume-related delays (over 95 percent) were at the departure airport.

Since 1981, the pattern of causality suggested by NASCOM data is somewhat confused by two factors. First, the requirement for reporting delays to NASCOM was lowered from 30 to 15 minutes. Thus, part of the sharp increase in the number of delays in the past 2 years is simply an artifact of the reporting procedure. FAA estimates that this factor alone has led to as much as a threefold increase in the number of reported delays. A second factor contributing to more reported delays is the imposition of flow control procedures by FAA, initially to cope with the effects of the strike by air traffic controllers in August 1981 and now to prevent overloading of certain airports at peak periods. Flow control delays (which are volume-related delays) accounted for over half of all delays in 1982 and were running at slightly less than one-quarter of all delays for the first 6 months of 1983, Flow control shifts the phase of flight where delays occur, under the rationale that

[10]As pointed out earlier, the discussion here focuses on airfield delays encountered by air carriers, primarily because this is the only type of airport delay on which data are collected on a nationwide and continual basis. Delays experienced by noncommercial flights (general and business aviation) are probably of comparable magnitude and similarly distributed, but there are almost no studies to support this. De Neufville (in *Airport Systems Planning*, op. cit., pp. 135-139) presents a general discussion of the difficulty of measuring capacity and delay and notes the inadequacy of commonly employed measurement techniques. He also describes factors that affect estimation of capacity and delay in passenger facilities such as moving sidewalks, baggage conveyors, mobile lounges, and on-airport transit.

Table 9.–Air Carrier Delays Reported to NASCOM, 1976-83

	1976	1977	1978	1979	1980	Jan.-July 1981[a]	1981[b]	1982'	Jan.-June 1983C
Total delays.	36,196	39,063	52,239	61,598	57,544	39,24'/	95,352	322,321	IUY, [81
Percent due to:									
Weather	76	83	79	84	78	80	46	35	63
Equipment failures.	4	2	7	3	4	4	3	1	1
Weather and equipment failures . . .	11	5	3	4	6	5	3	1	3
Runway closed for construction	1	3	3	3	3	1	1	1	2
Traffic volume[d].	5	2	5	4	4	6	3	4	8
Other causes.	3	4	3	2	5	3	45	1	0
Flow control[e].	—	—	—	—	—	—	—	57	23
Total air carrier operations (millions) . . .	9.57	9.88	10.21	10.33	9.96	4.94[f]	9.34	9.16	4.85[f]
Delays (per 1,000 operations)	3.8	3.9	5.6	6.0	5.8	7.9	10.3	35.2	22.7

[a]The period before the air traffic controllers' strike in August 1981.
[b]Data distorted by the effects of the air traffic controllers' strike and the imposition of quotas at 23 major airports.
[c]Data not comparable with previous years because the threshold for reporting delays to NASCOM was lowered from 30 to 15 minutes
[d]Almost exclusively departure delays.
[e]Delays due to flow control were counted as "other causes" in 1981 and in a separate category thereafter.
[f]Estimated.

SOURCE: FAA National Airspace Command Center (NASCOM).

it is less wasteful of fuel and less burdensome on the ATC system to have delays on the ground at the departure gate than in the air at the arrival airport. Despite the high incidence of flow control delays, the NASCOM data for 1983 indicate that weather-related delays still accounted for about two-thirds of all delay.ll

Table 10, based on SDRS data, shows the distribution of delays by the phase of flight where they occur. While the average delay per flight has remained surprisingly constant over the 7-year period, the effects of flow control in 1981 and 1982 are evident. Airborne arrival delays have been cut nearly in half compared with 1976-80, and taxi-out (departure) delays have been correspondingly increased.

Table 11, also drawn from SDRS, shows the distribution of delay times by flight phase for a typical month in 1982. Average departure delays (gate-hold plus taxi-out) were 6.7 minutes, and average arrival delays (airborne plus taxi-in) were 4.5 minutes. Since roughly 96 percent of all flights encountered no delay at the gate, it can be inferred that the principal point of delay was in the taxi-out phase, where about one flight in five encountered delay of **10** minutes or longer. Similarly, about 55 percent of delayed arrivals were at the gate within **10** minutes of scheduled time and 93 percent were no more than 20 minutes late, with the delay about equally distributed between the airborne and taxi-in phases.

*'Some of these weather delays occur at airports where the runway configuration is inefficient for certain combinations of wind, visibility, and precipitation. This is an airport design problem, and at certain locations it may be possible to lessen weather delays by building new runways or otherwise changing the runway layout so that the airport is less vulnerable to meteorological conditions.

Table 11 .—Distribution of SDRS Delay Time by Flight Phase, September 1982

Minutes of delay	Percent of operations delayed by flight phase: Gate-hold	Taxi-out	Airborne	Taxi-in
0	95.7	8.7	55.8	18.2
1	0.3	8.9	7.9	27.5
2	0.2	11.8	7.0	22.8
3-4 : ; : : :	0.5	23.2	11.4	21.9
5-9	1.0	29.2	12.5	7.5
10-14	0.7	10.6	3.7	1.2
15-19	0.5	4.1	1.0	0.5
20-24	0.3	1.7	0.4	0.2
25-29	0.3	0.8	0.1	0.1
30-44	0.4	0.7	0.2	0.1
45-59	0.1	0.2	0.1	0
60+ . : : : : :	0.1	0.1	0	0
Average delay (min.)	0.7	6.0	2.3	2.3

SOURCE: FAA Standard Delay Reporting System (SDRS)

Table 12 shows the mean delay at a sample of busy airports in 1982, when the average delay systemwide was slightly less than 6 minutes per operation. Delays at the 27 airports in the sample ranged from 3.5 to 9.9 minutes per operation. The average delay at most airports was of short duration, 7 minutes or less, as measured against the published schedule. Further, table 12 shows that mean delay is roughly correlated to the level of operations; the airports with the greatest mean delays tend to be those with the highest ratio of actual operations to PANCAP. Thus, while delay affects a large number of flights at the busier airports, the average delay at these airports is relatively short—7 minutes or less at all but seven airports, which is less than **10** percent of the average operating time of a flight from gate to gate.

Delay averaging, however, can be deceptive, in that it may diminish the apparent severity of the problem. Combining data for peak and slack

Table 10.–SDRS Trends, 1976-82

	Average delay per flight (minutes): 1976	1977	1978	1979	1980	1981	1982
Flight phase:							
Gate-hold.	0.06	0.12	0.12	0.12	0.17	0.57	0.84
Taxi-out	4.46	4.51	4.78	5.06	5.10	6.00	6.25
Airborne.	4.28	4.27	4.36	4.40	4.13	3.17	2.50
Taxi-in	2.16	2.23	2.41	2.57	2.43	2.25	2.23
Average per flight	10.96	11.13	11.67	12.15	11.83	11.99	11.91
Average per operation.	5.48	5.57	5.84	6.08	5.92	6.00	5.96

SOURCE: FAA Standard Delay Reporting System (SDRS).

Table 12.—Delay at Selected Airports, 1982

Airport	Mean Delay (min. per operation)	Operations	Ratio of operations to PANCAP[a]
Kennedy (JFK)	9.9	312,245	1.15
La Guardia (LGA)	9.5	307,719	1.25
Dallas-Fort Worth (DFW)	8.8	457,403	0.82
Chicago O'Hare (ORD)	7.8	591,807	0.96
Boston (BOS)	7.5	296,405	0.98
Los Angeles (LAX)	7.2	473,470	1.06
Washington National (DCA)	7.1	304,276	1.11
Newark (EWR)	6.9	215,026	0.77
Houston (IAH)	6.6	338,789	1.13
Denver (DEN)	6.4	467,508	1.32
Atlanta (ATL)	6.2	565,584	1.20
Miami (MIA)	6.2	349,368	0.88
Philadelphia (PHL)	6.1	328,313	1.11
Orlando (MCO)	6.0[b]	149,134	0.51
San Francisco (SFO)	5.8	315,003	0.79
Detroit (DTW)	5.7	250,481	0.53
Honolulu (HNL)	5.5	305,992	0.58
Phoenix (PHX)	5.3	350,995	1.06
St. Louis (STL)	5.0	289,826	1.16
Tampa (TPA)	5.0	244,467	0.69
Pittsburgh (PIT)	4.8	295,960	0.51
Las Vegas (LAS)	4.5[b]	296,256	0.90
New Orleans (MSY)	4.4	193,504	0.70
Seattle (SEA)	4.1	212,287	0.64
Fort Lauderdale (FLL)	4.1[b]	244,237	0.57
Minneapolis-St. Paul (MSP)	3.8	265,329	0.74
Cleveland (CLE)	3.5	208,436	0.71

[a]Practical Annual Capacity.
[b]Average for 3 months only (October, November, and December 1982).
SOURCE: FAA Standard Delay Reporting System (SDRS).

periods, obscures the impact of delay at times of heavy demand. If delays at peak periods alone were examined, delay would be longer, and there would be a much greater incidence of extreme delays of 30 minutes or more.

Table 12 also reveals an interesting aspect of PANCAP, which is defined as the level of operations that produces no more than 4 minutes average delay per aircraft in the normal peak 2-hour operating period. Practical Annual Capacity does not necessarily mean that the airport cannot accommodate more operations or even that congestion has reached an intolerable level. Actual operations at 10 of the airports in the sample exceeded PANCAP by a margin of up to 32 percent without delay running appreciably longer than the systemwide average of 6 minutes, except for the extreme cases of Kennedy and La Guardia.

Operating experience such as this suggests that PANCAP is an unnecessarily low measure of practical capacity and that estimates of future capacity needs based on the ratio of actual operations to PANCAP tend to be inflated. FAA itself considers PANCAP not as a limit of acceptable delay but as a warning signal that an airport is approaching a congested condition and that action may have to be taken to increase capacity. In the National Airspace System Plan, for example, FAA's estimate of future airport capacity needs is based on 140 percent of PANCAP, i.e., when operations at an airport reach a level of 40 percent above PANCAP, the airport is considered to have "severe airside congestion"—a term not otherwise defined. Other sources at FAA have indicated that the upper limit of tolerable delay may not be reached until operations are at 190 percent of PANCAP, at which time mean delay per peak-period operation would run nearly 20 minutes. But even this may not be absolute. Tolerability is, after all, an essentially subjective judgment about the cost imposed by delay.

Photo credit: U.S. Department of Transportation

Airport access is another source of delay

A related, and more general, observation is that the present methods of measuring capacity and delay are not adequate. The absolute capacity of an airport, or its parts, cannot be determined except by computer simulation or measurement of an asymptote on a graph. The extreme condition of unlimited demand and infinite delay can be assumed theoretically, but never observed. The data bases themselves are partial and highly selective at best. There are virtually no published empirical studies of delay for all types of flights, much less delay encountered by passengers in all segments of an air trip (travel to and from the airport, in the terminal, and during the flight). Thus, it is difficult to quantify, except in the most general and inexact terms, the extent and severity of airport capacity and delay problems.

Cost of Delay

A 1981 FAA study attempted to estimate the cost of delay to air carriers and the extent to which this cost could be avoided.[12] FAA calculated the total delay cost in 1980 to be about $1.4 billion, based on 5.9 minutes average delay per operation systemwide, at a cost of $1,398 per hour. Of this delay, FAA estimated that about one-third was attributable either to weather or to unavoidable queuing delays at peak operating times. Subtracting these delays left about $904 million in potentially avoidable delay costs for airline operations in 1980, or about $89 per flight.

The FAA study also calculated future delay costs that would result if air traffic continues to grow and no remedial actions to reduce delay were undertaken. FAA estimated that by 1991 average systemwide delay would increase to 8.7 minutes, with annual delay costs to airlines reaching $2.7 billion (1980 dollars). Deducting unavoidable delays due to severe weather and queuing, FAA estimated that $1.7 billion per year might be subject to control. For the average flight, the cost of unavoidable delays would rise from $89 to $125, an increase of 40 percent, but still not much more than the average price of one airline ticket.

OTA finds these estimates to be reasonable, but probably near the high end of the range. For the

[12] *Airfield and Airspace Capacity/Delay Policy Analysis,* op. cit.

reasons cited above, FAA data bases tend to overestimate delay. Because of the skewed distribution of delay and the inaccuracies in the various reporting systems used by FAA, it is difficult to fix the magnitude of the overestimate, but it may be on the order of 25 to 50 percent. Thus, actual systemwide 1980 delay costs may have been between $0.7 billion and $1.4 billion, with the avoidable costs ranging from $0.5 billion to $0.9 billion.

A second reason for treating the FAA estimates with caution has to do with the tolerability of delay costs–either total costs or those defined by FAA as subject to control. The FAA report rightly points out that much of the avoidable delay results from airline scheduling practices. Airlines operations peak in part because of public demand to travel at certain times of day. However, another equally important cause of peaking is airline competitive practice and concern about losing market share to other airlines offering service at popular times. Airlines also concentrate arrivals and departures of flights to capture connecting passengers for their own airline. Presumably airlines find the delays caused by such practices tolerable since they continue to schedule operations in this way despite the cost. (Recall that all measures of practical capacity involve some judgment about what constitutes acceptable delay.) If, for the sake of illustration, delay of more than 15 minutes is assumed to be "unacceptable," the NASCOM data for 1982 show that only about 3.5 percent of flights were so delayed.

From this, one should not draw the conclusion that delay is an insignificant problem and that measures to increase airport capacity would be unwarranted. Delay is an important source of additional cost to airlines and passengers at the Nation's airports, and there is legitimate reason for concern about the future capability of airports to serve the expected increase of demand. The point is that there is not now a systemwide capacity crisis, nor perhaps even a crisis at the busiest air carrier airports, if crisis means intolerable delays. FAA data show that about 98 percent of all flights depart or arrive within 15 minutes of schedule.

Certainly, delays are being experienced, and they could increase as economic recovery leads to resumption of demand growth. If this increase cannot be accommodated, the air transportation system will suffer. But these problems are to some extent foreseeable and they can be managed, though not entirely eliminated, by a combination of the technological and administrative means which will be examined in later chapters.

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Chapter 4
TECHNOLOGY

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Chapter 4

TECHNOLOGY[1]

The airport system in place in the United States today is extensive and highly developed; in general, it serves the Nation well. Still, there are problems of congestion and delay at the busiest airports, where facilities are not adequate to accommodate demand at all times and in all conditions of weather and visibility. The Federal Aviation Administration (FAA) forecasts that growth of commercial and private aviation could be constrained by lack of airport capacity, which it considers to be the most serious problem facing civil aviation through the remainder of this century.[2]

Recent policy statements by FAA acknowledge that, with a few exceptions, the direct solution of building new airports and expanding existing ones may not be practical due to lack of suitable new airport sites, physical limitations of present facilities, and concerns about environmental impacts of aviation on surrounding communities.[3] Similar views have been expressed in two recent studies of airport capacity,[4,5] and there is a widely held opinion that, while the airport system is expandable in the broad sense, there is little hope of creating major new facilities in those key metropolitan areas where air travel demand and aviation activity continue to outstrip available airport capacity unless airport planners can persuade surrounding communities that airports can be good neighbors.

For this reason, the aviation community and FAA have sought technological solutions that will ease congestion by allowing fuller and more efficient use of the airports we already have. This technology includes new equipment for surveillance, navigation, and communication and revised procedures for using the airspace and airport facilities. In this way, it is hoped that additional demand can be absorbed within the infrastructure now in place, without adversely affecting surrounding communities.

This chapter examines technological measures, either currently available or under development, that could be employed to relieve congestion and delay. It consists of a survey of possible improvements in airport technology, with emphasis on the circumstances in which this technology would be applicable, the extent to which it could increase the amount of traffic handled, and the prospects for development and deployment over the coming years.

In aviation, the term technology typically brings to mind sophisticated electronic and mechanical devices used for navigation, surveillance, communication, and flight control. Such devices are clearly of interest, but for the purposes of this report, technology is interpreted in a broader sense. As used here, technology refers not only to new devices and equipment but also to new operational concepts and procedures that they make possible. Also, many in the aviation community draw a distinction between technology (meaning equipment and sometimes procedures) and civil engineering (referring to the design and construction of physical components of the airport—the concrete, so to speak). While recognizing that different engineering disciplines and techniques are involved, this report does not make such a ciistinction and considers the design and construction of improved physical components such as runways, taxiways, and terminal buildings as simply one more form of technology that will add to airport capacity or permit more effective and economical use of the airport as a whole.

[1]This chapter is based on material prepared for OTA by Landrum & Brown, Inc.

[2]*National Airspace System Plan,* revised edition (Washington, DC: Federal Aviation Administration, April 1983), p. 11-10.

[3]1bid., p. I-5.

[4]*Report of the Industry Task Force on Airport Capacity Improvernent and Delay Reduction* (Washington, DC: Airport Operators Council International, September 1982).

[5]*Report and Recommendations of the Airport Access Task Force* (Washington, DC: Civil Aeronautics Board, March 1983).

THE AIRPORT AND ITS COMPONENTS

The airport is a complex transportation hub serving aircraft, passengers, cargo, and surface vehicles. It is customary to classify the several components of an airport in three major categories: airside facilities; landside facilities; and the terminal building, which serves as the interchange between the two' (see fig. 7).

Airside components, sometimes called the aeronautical surfaces, or more simply the airfield, are those on which aircraft operate. Principally, they are the runways where aircraft take off and land, the taxiways used for movement between the runway and the terminal, and the apron and gate areas where passengers embark and debark and where aircraft are parked. Because the airspace containing the approach and departure paths for the airfield has an important effect on runway utilization, it is also customary to include terminal area airspace as part of the airside.

The terminal consists primarily of the buildings serving passengers and is made up of passenger loading and waiting areas, ticket counters, baggage handling facilities, restaurants, shops, car rental facilities, and the like. Loading, handling, and storage areas for air cargo and mail, often separately located, are also part of the terminal complex.

The landside is essentially that part of the airport devoted to surface transportation. It begins at the curbside of the terminal building and includes roadways, parking facilities, and—in some cases—rail rapid transit lines and stations that are part of a larger urban mass transit system. Customarily, only roadways and transportation facilities on the airport property are considered part of the landside, even though they are actually extensions of, and integral with, the urban and regional transportation network.

In the discussion that follows, attention is focused initially on those airside components where capacity and delay problems tend to be severe. The landside and terminal areas are not trouble-free, however, and congestion of these facilities can have an important effect on the overall capacity of the airport. An examination of possible technological improvements in terminals and landside access is included at the end of this chapter.

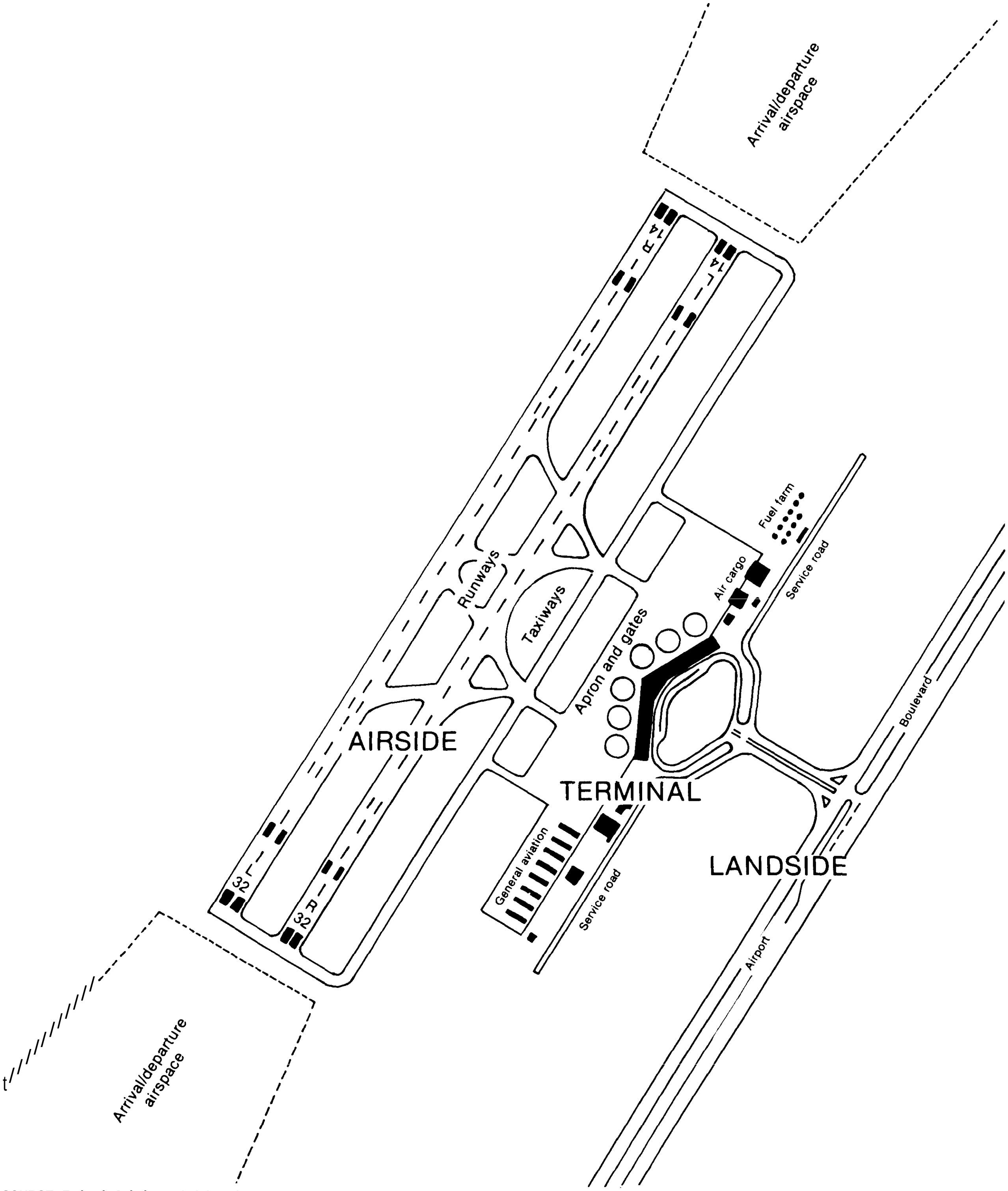
6 Some experts do not employ this tripartite classification. For example, R. Horonjeff and F. X. McKelvey, Planning and ***Design of Airports (New*** York: McGraw Hill, 3d cd., 1983), distinguish only between the airside and the landside, making the division at the passenger loading gates and including the terminal as part of the landside.

AIRPORT AND AIRSPACE TECHNOLOGY

Technological approaches to expanding airport capacity or reducing delay fall into three broad categories. First, there are improved devices and procedures that will expedite the flow of air traffic into and out of the airport—i.e., techniques that will augment airside capacity or mitigate ***aircraft*** delay by increasing the runway operation rate. The second category includes techniques to facilitate movement of aircraft on the airport surface. The purpose of these technologies is to move aircraft from the runway to the passenger loading gates and back again as expeditiously as possible, thereby shortening the taxi-in and taxi-out components of delay and easing congestion on taxiways, aprons, and loading ramps. The third category embraces techniques that can be used to aid the transit of ***passengers*** through the terminal building and the flow of ***vehicles*** on airport circulation and access roads. In contrast with the first two categories, where the aim is to alleviate aircraft delay, the third category is intended to facilitate the movement of people and to reduce that part of delay incurred in getting to and from aircraft.

Thus, the survey that follows addresses the broad question of *airport* capacity, not just airside capacity or aircraft delay. The intent is to examine ways to improve the overall adequacy and efficiency of the airport as a transportation hub. The underlying proposition is that delay–any form of delay—ultimately affects the passenger through loss of time and increased cost of air transportation service. In this sense, it is parochial

Figure 7.—Airport Components



SOURCE Federal Avlatlon Admlnlstratlon

to speak only of aircraft delay since the basic purpose of the air transportation system is to move people from origin to destination, in safety, with minimum expenditure of time and money. All measures taken at airports to shorten travel time, to lower travel cost, or to lessen inconvenience are of equal importance, regardless of whether they apply to the airside, the landside, or passage through the terminal.

The scheme of organization for this survey is outlined in table 13, which lists various forms of technological improvements and identifies the area of the airport where they could be applied and the purpose they could achieve. Discussion of specific technologies listed in table 13 is presented in the sections that follow, which make up the bulk of this chapter. In the concluding part of the chapter is a survey of the capacity and delay problems at a representative sample of airports and a tabulation of possible forms of technological relief.

GUIDANCE, SURVEILLANCE, AND CONTROL

The position and spacing of aircraft in the airborne traffic stream is a key factor in determining airfield capacity. For the pilot, it is vital to know where the aircraft is in relation to the runway and the airspace corridors around the airport. This is accomplished by ground-based navigation equipment and airborne receivers. The air traffic controller uses surveillance radar to monitor the position of the aircraft on approach and departure paths and in relation to other aircraft using the airport. The success of these activities—navigation by the pilot and surveillance by the controller—is affected by the inherent accuracy of the equipment used. (Is the aircraft in fact where the pilot and controller think it is?) The data update rate is also important. (How recent is this information and what may have happened since the last position reading?)[7]

In conditions of good visibility, when visual cues can be used by the pilot to confirm the position of the aircraft and to supplement guidance systems, the spacing between aircraft can be reduced to the minimum permitted by safe operating procedures. When visibility is lessened by darkness, rain, or fog, the pilot must rely on instruments and the controller on radar. In such circumstances, a margin of safety must be added to the interval between aircraft, in effect increasing the time that must be allowed for each to use an assigned portion of the airspace or to occupy the runway, and correspondingly lowering the throughput rate. If the accuracy of navigation and surveillance devices could be improved, the capacity of the airfield under Instrument Meteorological Conditions (IMC) could be closer to that attainable under Visual Meteorological Conditions (VMC).

Three technologies that could improve aircraft guidance, surveillance, and control are planned for deployment in the next few years. They are the Microwave Landing System, improved surveillance radar, and automated traffic-management systems for the air traffic controller.

Microwave Landing System

The guidance system for approach and landing now in use is the Instrument Landing System (ILS), which has been the standard system in this country since 1941 and is widely used by civil aviation throughout the world. ILS provides guidance by radio beams that define a straight-line path to the runway at a fixed slope of approximately 30 and extending 5 to 7 miles from the runway threshold. All aircraft approaching the airport under ILS guidance must follow this path in single file, spaced at intervals dictated by standards for safe longitudinal separation and the need to avoid wake vortex. This long, straight-in approach is a bottleneck that reduces the runway utilization rate, especially when fast and slow aircraft are mixed in the approach stream or when arrivals from different directions must be merged

‘To appreciate the magnitude of this uncertainty, consider that at typical jet approach speeds, an aircraft can travel almost 1,000 ft horizontally and descend 50 to 60 ft in the 4 seconds between successive scans of the radar presently used for air traffic control at airports.

Table 13.–Technology To Increase Airport Capacity and Reduce Delay

Technology	Area of application	Purpose	Benefit
Aircraft guidance, surveillance, and control:			
Microwave Landing System	Airspace	Improve precision of navigation; make more flexible use of airspace	Increased capacity; reduced delay; less noise impact
Surveillance radar	Airspace	Improve surveillance; reduce separation	Improved safety; increased capacity
Traffic management techniques	Airspace	Improve traffic flow	Reduced delay
Airspace use procedures:			
Reduced lateral separation for parallel and converging runways	Airspace	Increase utilization of multiple runways in IMC	Increased capacity
Reduced longitudinal separation	Airspace	Reduce in-trail separation	Increased capacity
Separate short runways for small aircraft	Airspace	Segregate air traffic by size and speed	Increased capacity; reduced delay
Weather and atmospheric effects:			
Wake vortex detection	Airspace	Reduce in-trail separation	Increased capacity
Wind shear detection	Airspace	Alert pilots to wind shear	Improved safety; reduced delay
Noise control and abatement:			
Control of aircraft noise	Airspace	Reduce aircraft noise	Increased capacity; reduced delay
Aircraft operating procedures	Airspace	Lessen or distribute noise impacts	Increased capacity: reduced delay
Airport surface utilization:			
Surveillance and control	Taxi ways	Improve surveillance, control, and guidance of aircraft on ground	Increased capacity; reduced delav; improved safety
High-speed turnoffs and improved taxiways	Runway	Reduce runway occupancy time	Increased capacity
Taxiway marking and lighting	Taxi ways	Increase efficiency of taxiway use	Reduced delay
Apron and gate facilities	Ramps and aprons	Improve docking at gate; improve aircraft maintenance and servicing	Increased capacity; reduced delay
Terminal facilities and services:			
Terminal building design	Terminal	Increase utility and efficiency of terminal building	Increased capacity; reduced delay
Passenger movers	Terminal	Improve circulation in terminal; reduce walking distance	Reduced delay; greater passenger convenience
Ticketing	Terminal	Expedite ticket purchase and passenger check-in	Reduced delay
Baggage handling	Terminal	Expedite baggage check-in, transfer, and pickup	Reduced delay
Passenger security screening	Terminal	Make screening faster and more reliable	Reduced delay; improved security
Federal Inspection Service	Terminal	Expedite customs and immigration clearance	Reduced delay
Airport access:			
Terminal curbfront design	Terminal; landside	Facilitate airport entrance and exit	Reduced delay
Airport circulation roads	Landside	Facilitate automobile traffic flow	Reduced delay
Airport ground access	Land side	Reduce access time; lessen road congestion	Reduced delay

SOURCE Office of Technology Assessment

on the common final approach path. As a result, the capacity of the airfield under IMC, when the long ILS common approach path must be used, is usually less than under VMC.

The runway utilization rate under IMC could come closer to that attainable under VMC if aircraft could follow multiple approach paths, descend at different approach angles, or aim at different touchdown points on the runway—none of which is practical with ILS. If this flexibility were possible, as it is under VMC, airfield capacity would be less affected by weather conditions, and throughput would be governed almost exclusively by runway geometry and aircraft performance characteristics.

The Microwave Landing System (MLS), which has been under development by FAA for over a decade, would overcome some of the disadvantages inherent in the ILS. Because MLS uses a beam that scans a wide volume of airspace, rather than the pencil beam of ILS, it permits aircraft to fly any of several approach angles (including two-step glide slopes) and, in the horizontal plane, to approach along curving paths that intersect the extension of the runway centerline at any chosen point. In effect, MLS offers a degree of freedom in using the airspace that is closer to that enjoyed under conditions of good visibility (see fig. 8).

The chief motive for FAA in seeking to develop and deploy the MLS is not the potential capacity benefits, however, but its operational advantages —more precise guidance, ease of installation, improved reliability, less susceptibility to electromagnetic interference, and greater number of transmission channels. The capacity benefits are secondary but still of great importance at some airports where the present ILS acts to constrain capacity in adverse weather conditions. In terms of its effect on capacity, the chief advantage of MLS is that, in IMC, it allows pilots and controllers greater flexibility in selecting an approach path so as to shorten the approach time, to avoid air turbulence generated in the wake of preceding aircraft, or to avoid noise-sensitive areas. Another advantage is that MLS can provide guidance for the aircraft during missed approach, allowing a safe exit from the terminal airspace and smooth reentry into the approach pattern. The availability of missed approach guidance could have a significant capacity benefit at those airports with parallel or converging runways that cannot now be used in IMC. A third advantage is that MLS can be installed on runways where ILS is not possible due to siting problems and on short auxiliary runways reserved for commuter and small general aviation (GA) aircraft.[8] On some runways, MLS can increase capacity during IMC by providing lower landing minimums than ILS and thereby allowing the airport to remain open in marginal weather conditions. A fourth advantage of MLS is its capability to provide nonconflicting routes into closely situated airports, where approach or departure paths may mutually interfere and limit capacity utilization.

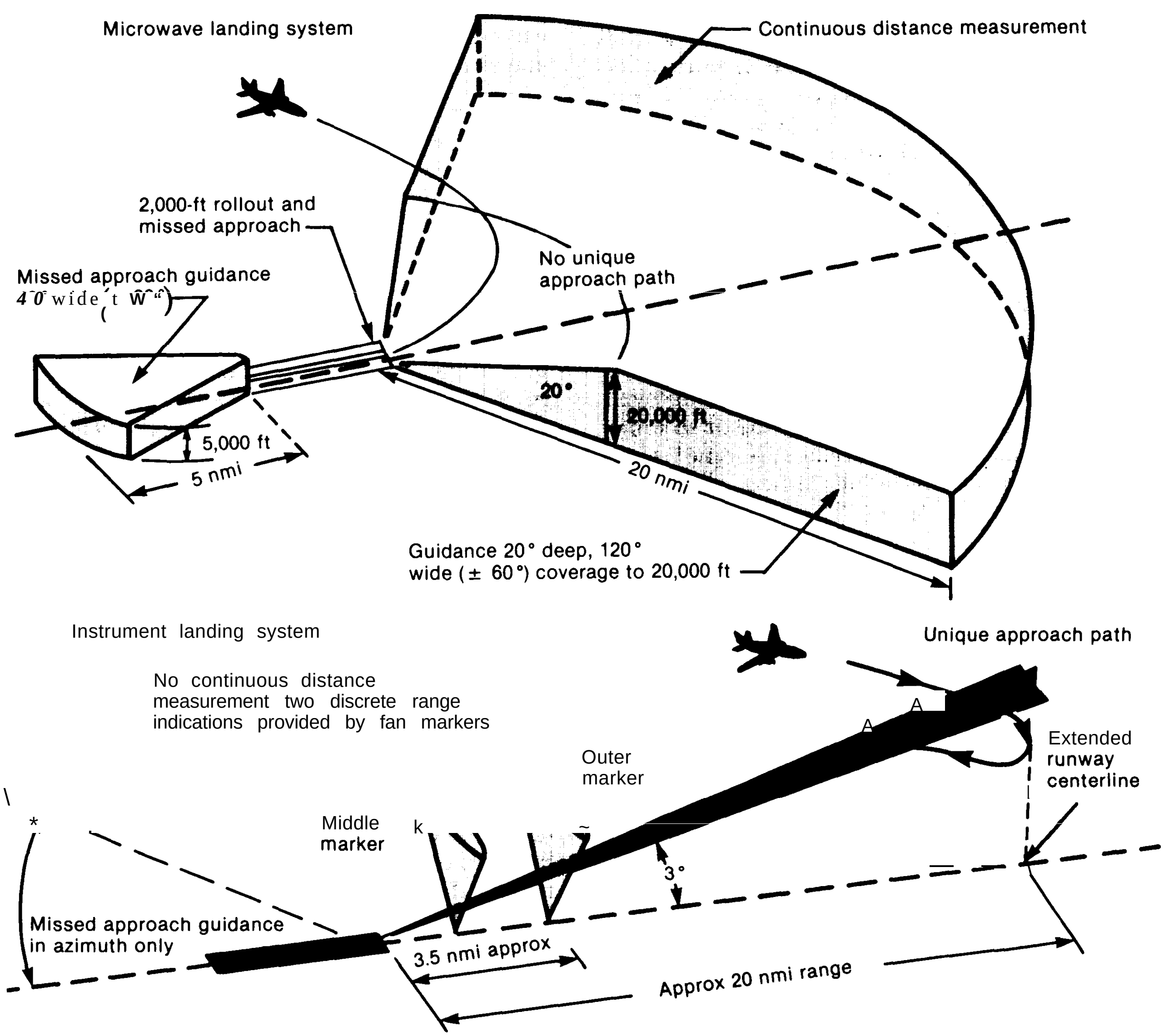
The capacity benefits of MLS are highly site-specific—depending on the runway configuration, the prevalence of adverse weather, the mix of aircraft using the airport, and the extent to which these aircraft are equipped with MLS receivers. Estimates by FAA indicate that the benefits could range up to 10 or 15 percent greater capacity at some airports under IMC. The overall effects on capacity at these airports would be somewhat smaller since they depend on how often Instrument Meteorological Conditions occur. The net economic benefits are estimated by FAA to be $500 million over a 20-year period (1976 dollars), principally to air carriers and commuter airlines in the form of reduced delay costs and savings of passenger time.[9]

This estimate has been challenged in a recent report by the Industry Task Force on Airport Capacity Improvement and Delay Reduction. The Task Force found that the chief advantages were at small or remote airports served by helicopters and commuter airlines and in high-density traffic areas where MLS could permit commuter aircraft to approach and land on separate short run-

[8]For a further discussion of MLS technology and its benefits, see ***Airport and Air Traffic Control System*** (Washington, DC: U.S. Congress, Office of Technology Assessment, OTA-STI-175, January 1982), pp. 92-96, 117; and ***Improving the Air Traffic Control System: An Assessment of the National Airspace System Plan*** (Washington, DC: Congressional Budget Office, August 1983), pp. 9-18.

[9]***An Analysis of the Requirements for, and the Benefits and Costs of the National Microwave Landing System (MLS),*** FAA-EM-80-7 (Washington, DC: Federal Aviation Administration, June 1980).

Figure 8.—Comparison of Microwave Landing System and Instrument Landing System



SOURCE: Federal Aviation Administration

ways.[10] The direct benefits to major air carriers are much less clear, according to the Task Force, because they depend on use of curved or segmented approaches and multiple glide paths—procedures that have not yet been tested and proven in an operational environment.[11]

FAA is now proceeding with MLS implementation. A contract for production and installation of 172 units was let in late 1983, with follow-on

[10] For instance, a study conducted at Denver showed that when commuter and GA aircraft make use of separate short runways, the delay to air carrier using the long runways could be reduced significantly.

[11] *Report of the Industry Task Force on Airport Capacity Improvement and Delay Reduction*, op. cit., pp. 9-10.

procurements planned for 1985-95 (900 units) and 1996-2000 (350 units), making a total of approximately 1,425 installations by the beginning of the next century. Priority will be given to large and medium hub airports and to those airports now lacking ILS because of siting restrictions or lack of available transmission channels.[12] FAA estimates the total cost of ground equipment to be $1.33 billion. User costs for MLS receivers are estimated to be an additional $1.63 billion, bringing the total cost for full deployment of MLS to nearly $3 billion over the coming 20 years.[13] [14]

Replacement of the existing ILS poses two problems that may complicate the transition to MLS and delay realization of the full benefits. There are at present about 650 ILS units in commission at some 460 airports and another 150 or so units in various stages of procurement—some as replacements for existing units, others as new installations. The MLS transition plan calls for these ILS units to remain in service for many years to come, until at least 60 percent of the aircraft routinely using the ILS / MLS runway are equipped with MLS. While ILS and MLS can be colocated and operated simultaneously without signal interference, there may be procedural difficulties in blending aircraft equipped with ILS (and therefore capable of only straight-in approaches) into a traffic stream with MLS-equipped aircraft flying curved or segmented approaches. Thus, the full capacity benefits of MLS may not be attainable at a given airport until all or nearly all aircraft are MLS-equipped and the ILS can be decommissioned.

A second factor that may delay taking full advantage of MLS at specific sites is the agreement with the International Civil Aviation Organization whereby the United States is committed to retaining ILS service at international gateway airports until 1995. There are 75 such airports, generally the busiest U.S. airports and those most prone to capacity and delay problems. Retaining ILS service at these airports may influence some users to defer purchasing MLS equipment for another 10 years or more.

While the capacity gains attributable to MLS may be rather small for the airport system as a whole, MLS does appear to offer promise at those airports where it could be used to create a more flexible traffic pattern or to provide commuter and small GA aircraft access to an alternate runway in IMC, thereby relieving pressure on the main runway used by large air carrier aircraft. Beyond these direct benefits, moreover, MLS may permit procedural changes that could also increase capacity or reduce delay. These potential benefits of MLS are discussed in a later section on airspace use procedures.

Surveillance Radar

Surveillance is accomplished by radar and associated electronic and computer systems that locate, identify, and display the position of aircraft in the airspace. In terminal areas, two types of radar are presently used for this purpose: search radar (technically termed "primary radar") and the radar beacon system (sometimes called "secondary radar"). Search radar emits signals and displays the returns reflected from the body of the aircraft, objects on the ground, and precipitation or weather fronts, thereby providing a basic two-dimensional map of the airspace. The beacon system, known as the Air Traffic Control Radar Beacon System or ATCRBS, displays only replies from aircraft equipped with electronic devices, called transponders, that send out a coded signal when interrogated by the radar beacon. This signal indicates not only the position of the aircraft but also its identity (flight number) and altitude (if the aircraft is equipped with an altitude-encoding transponder). The beacon system is presently the main source of surveillance information for air traffic control (ATC).

This radar-derived information is correlated and presented to the air traffic controller on one of four different types of display systems: TPX-42, ARTS II, ARTS III, or ARTS 111A. The TPX-42 is the least sophisticated equipment. It is a non-

12 The aviation industry has voiced strong opposition to the Proposal for installing MLS at large and medium airports first, and in May 1984 FAA agreed to a complete review of the deployment strategy. Depending on the outcome of this review, the early stages of the MLS program schedule might be set back a year or more.

13 Microwave Landing *System Transition Plan, APO-81-1 (Washington, DC*: Federal Aviation Administration, May 1981).

14 Preliminary Analysis of *the Benefits and Costs To Implement the National Airspace System Plan, DO~/~AAIEM-82-2?2* (Washington, DC: Federal Aviation Administration, June 1982).

programmable device that correlates and displays search radar data and beacon returns on each successive sweep of the antenna. The TPX-42 is used at airports with little traffic. The Automated Radar Terminal System (ARTS II) is a programmable data processor that displays primary and secondary radar data on the controller's scope but does not track aircraft or predict their position. It is used at airports with low to medium levels of activity.

ARTS III detects, tracks, and predicts the position of aircraft. This information is presented on the controller's display as computer-generated symbols (denoting altitude, ground speed, and identity) positioned alongside the secondary radar return. ARTS 111 also incorporates features that alert the controller when aircraft descend below minimum safe altitude or when two aircraft are approaching too closely and require action to assure safe separation—a feature known as conflict alert. ARTS 111A is a refinement of ARTS 111 that is capable of tracking aircraft detected by search radar alone—i.e., aircraft not equipped with an ATCRBS transponder. ARTS 111 and ARTS 111A equipment is installed at the 62 busiest air traffic hubs.

FAA is now in the process of replacing much of the primary radar and display equipment. The existing primary surveillance radars used at airports (ASR-4, ASR-5, and ASR-6) are based on vacuum tube technology that suffers from reliability problems and maintenance difficulties. Newer solid-state equipment (ASR-7 and ASR-8) has been installed at some locations, but these radars, like earlier versions of ASR, are adversely affected by ground clutter, false targets generated by flocks of birds, propagation anomalies, and masking of aircraft returns by weather. Of these shortcomings, weather masking is perhaps the most severe operational problem. The strong return from storms conceals the weaker return from aircraft detected on primary radar alone. To compensate, controllers alter the polarization of the radar to reduce weather echoes and make the aircraft return stand out more clearly, but this lessens the apparent severity of weather fronts and precipitation.

Between 1986 and 1990, FAA plans to install a new primary radar system (ASR-9) which will have a separate weather channel allowing the controller to assess the severity of storms while retaining the ability to detect small aircraft without transponders. The ASR-9 will also incorporate an improvement called Moving Target Detection to overcome the problems of ground clutter and spurious targets. These improvements in primary radar information, when coupled with the present radar beacon display, will provide the controller with a clearer and more accurate picture of the airspace—thereby lessening workload and creating a better basis for decisionmaking about aircraft movement around the airport. The estimated cost of installing 105 ASR-9 systems is $480 million, with the option of adding 35 more in the 1990s at a cost of roughly $125 million.[15]

As radar systems are being upgraded, FAA also plans to improve the data processing and display equipment used by air traffic controllers. Initially, the TP)(-42 system will be replaced by a new version of ARTS II, designated ARTS 11A, which will incorporate minimum safe altitude warning and conflict alert features like the present ARTS III. The ARTS III equipment will also be enhanced with greater memory to handle heavier traffic loads and improved software that will reduce the number of false conflict alerts. In the period 1990-95, ARTS II and III will be replaced by new data processing and display consoles, called sector suites, that will provide improved presentation of surveillance and weather data, display of traffic management and planning information, and automated assistance to the controller in separating and routing traffic in terminal airspace.[16]

The immediate capacity benefit of the ASR-9 radars will be surveillance information of improved reliability and accuracy, which will provide the controller with a better picture of the airspace situation. Of even greater importance, the improved ASR-9 radar, the upgraded ARTS II and III, and the eventual installation of new sector suites will support changes in traffic management techniques that will help the controller make

[15] *National Airspace System Plan* (Washington, DC: Federal Aviation Administration, April 1983), ch. IV.
[16] Ibid., ch. III.

more efficient use of the airspace. These prospects are discussed next.

Traffic Management Techniques

A major task of the air traffic controller is management of traffic so as to maintain a smooth flow of aircraft to and from the airport with minimum delay. This is done by the techniques of metering, sequencing, and spacing.[17] With current technology, these are largely matters of controller art that depend heavily on the individual's skill and experience. On a typical day, the controller must make literally hundreds of related decisions about the order and timing of aircraft movements in the traffic pattern under the prevailing conditions of wind and weather. The chief problems that the controller must deal with in performing these activities are randomness in the arrival and departure streams and differences in the speed and flight characteristics of successive aircraft using the airspace. The extent to which the controller is successful in applying the techniques of traffic management has a significant influence on delay and efficient use of airport capacity.

It has long been recognized by ATC experts that the key to more effective traffic management, especially in circumstances of heavy demand, is to involve computers in the decisionmaking process. In some instances, this means providing the controller with computerized aids to decisionmaking—devices to collect, integrate, and display information that will give a better picture of the traffic situation and help in executing a control strategy. In other instances—particularly where decisionmaking is routine, repetitive, and reducible to unambiguous rules—the approach is to substitute the computer for the human operator, thus relieving him of workload and guarding against human error and inconsistency.

As part of the planned modernization of the ATC system, FAA is developing new software packages that will assist in traffic management at and around airports. Known under the collective designation of Traffic Management System (TMS),[18] this new software will perform several important functions to increase the efficiency of airport and airspace utilization: airspace configuration management, dynamic planning and computation of acceptance rate, tactical execution of control strategy, runway configuration management, and departure flow metering.

For incoming flights, TMS will establish an acceptance rate and order of landing based on estimated arrival time and predetermined flight paths. As aircraft progress toward the runway, TMS will adjust landing time and spacing between aircraft as necessary to eliminate gaps or surges in the traffic stream and to make efficient use of airspace and runways. In the earlier stages of implementation, the computer will generate recommended instructions and command messages for the controller to relay to pilots by voice radio. In later stages, the computer will transmit commands directly to individual aircraft by the Mode S data link.[19]

17 Metering is regulating th, arrival time of aircraft in the terminal area so as not to exceed a given acceptance rate. Sequencing entails specifying the exact order in which aircraft will take off or land. Spacing involves establishing and maintaining the appropriate interval between successive aircraft, as dictated by considerations of safety, uniformity of traffic flow, and efficiency of runway use.

18 TMS is a relatively new term for a concept that was originally called Integrated Flow Management.

19 Mode S (for selective) is a proposed addition to the ATCRBS transponder that will permit direct, automatic exchange of digitally encoded information between the ground controller and individual aircraft.

Photo credit: Federal Aviation Administration

Traffic management can smooth the flow

Other components of TMS will contribute to more efficient traffic management in other ways. Runway configuration management, a software program that has been under development at Chicago O'Hare since 1980, will assist controllers in establishing the most efficient combination of arrival and departure runways for given conditions of weather and demand. Departure flow metering will help assure an appropriate blend of takeoffs and landings and will feed aircraft out of the terminal area and into en route airspace.

FAA plans do not call for implementation of TMS all at once, nor at all airports. The components are being developed separately and will be tested and put in place as ready and where needed. The overall timetable is contingent on the development and installation of new computers and sector suites in terminal area control centers and on the development of companion software packages for the en route ATC system—the Advanced En Route Automation (AERA) program. Full implementation of TMS, AERA, and related technological changes will not occur until 1995 or later.

TMS and AERA are tied together because FAA's long-term response to air traffic growth involves a general application of the flow management concept so as to provide strategic and tactical planning, continuous performance monitoring, and flexible and adaptive exercise of control for the airspace as a whole. For example, en route metering—which is a feature of AERA-will contribute to efficient runway use by treating all arrivals along all routes as a single traffic pattern and adjusting in-trail separation so as to achieve a steady rate of delivery into the terminal area. The present method of flow management, which uses uniform, preestablished in-trail separation, can result in inefficient runway utilization (surges and gaps in the traffic flow) because it cannot adapt readily when flow along arrival routes does not exactly match the nominal rate used as the basis for selecting in-trail spacing.

The capacity benefits of TMS are difficult to estimate on a systemwide basis. The anticipated benefits are highly specific to conditions at the airport site and particular patterns of demand. Further, it is not always possible to distinguish between the benefits of TMS and those that would result from other planned improvements in the ATC system. Estimates published by FAA as part of an analysis of overall benefits and costs of the National Airspace System Plan (NAS Plan) suggest that the benefits arising from improved traffic management and flow planning in terminal areas could be fuel savings on the order of 0.75 to 1.25 percent. FAA calculates the value of these savings to be between $165 million and $280 million per year (1982 dollars) for the period 1993-2005. Of these savings, about 60 percent would accrue to air carriers, with the remainder about equally distributed between business and private general aviation.[20]

The FAA report does not provide a projected cost for TMS alone, but lumps these costs with those of AERA and other airport and airspace programs in the NAS Plan (see table 14). The total

[20] *Preliminary Analysis of the Benefits and Costs To Implement the National Airspace System Plan*, op. cit.

Table 14.-Summary of NAS Plan Benefits and Costs (billions, 1982 dollars)

	20-year totals			Present (discounted) values[a]		
	Benefits	costs	Net	Benefits	costs	Net
Aviation users:						
Microwave Landing System Program	2.6	1.6	1.0	1.0	0.2	0.8
Airport Throughput Improvement Program	5.7	b	5.7	1.7	b	1.7
Increased fuel efficiency[c]	16.4	2.4	14.0	4.1	0.9	3.2
Total for aviation users	24.7	4.0	20.7	6.8	1.1	5.7
Federal Aviation Administration	24.3	8.0	16.3	9.0	5.0	4.0
Total	49.0	12.0	37.0	15.8	6.1	9.7

[a] 10-percent discount rate.
[b] Avionic costs for this program are included in the costs shown for other programs.
[c] Chiefly AERA program benefits.

SOURCE: Federal Aviation Administration, *Preliminary Analysis of the Benefits and Costs To Implement the National Airspace System Plan*, DOT/FAA/EM-82-22, June 1982 costs are estimated to be $12 billion ($4 billion to aviation users and $8 billion to FAA) over the next 20 years; the associated 20-year benefits are calculated to be $24.7 billion to users, primarily in fuel savings attributable to AERA and $24.3 billion to FAA in operating cost savings. (All estimates in 1982 dollars.)

Supporting Technologies

In addition to programs aimed specifically at reducing delay and increasing the throughput of major airports, FAA is pursuing other technological developments that will either facilitate the ATC process or provide greater assurance of safety. Three particularly important developments of this sort are the Mode S data link, the Cockpit Display of Terminal Information (CDTI), and the Traffic Alert and Collision Avoidance System (TCAS). These technologies will not, by themselves, provide relief to the problems of congestion and delay in terminal areas, but they could make possible other technological improvements or procedural changes to improve the flow of traffic.[21]

The addition of Mode S to the present ATCRBS transponder has perhaps the most far-reaching implications for air traffic control. Mode S will allow the air traffic controller to interrogate aircraft individually and will make possible direct and selective two-way digital communication between air and ground. Mode S thus will form the basis for the more automated forms of air traffic control envisioned in the TMS and AERA programs. Equally important, Mode S will open up a new, high-capacity channel of communication that will provide more complete and rapid exchange of information and greatly reduce controller and aircrew workload by relieving them of the time-consuming process of transmitting, receiving, and acknowledging messages by voice radio. A third benefit of Mode S is that it can enhance the surveillance function by reducing interference among transponder replies of aircraft operating close together in terminal airspace.

An important potential application of the Mode S data link is that it could be used to improve the quantity and quality of information available in the cockpit by providing a display of traffic in the surrounding airspace. This display, CDTI, has been under development for several years and has been recommended by pilots and ATC experts as a valuable new tool to enhance safety and to aid maneuver in terminal airspace. The CDTI, by showing the location and path of nearby aircraft, could give the pilot an overall view of the traffic pattern and could provide an additional source of information under conditions of reduced visibility.

The CDTI is not envisioned as a substitute for ground-based air traffic control nor as the basis for independent maneuver to avoid collision or to assure safe separation. Rather, it is intended as a supplemental display that will allow the pilot to "read" the air traffic pattern and to cooperate more effectively and confidently with the ground-based controller in congested airspace. FAA, in cooperation with the National Aeronautics and Space Administration (NASA), is currently exploring roles for a CDTI. The focus of this effort is to develop CDTI system requirements and to determine the compatibility of these requirements with Mode S and TCAS data sources.

The overriding concern in seeking ways to increase airport throughput and runway acceptance rates is maintaining safe separation among aircraft. Basic separation assurance is provided in two ways: by application of the "see-and-avoid" principle in Visual Flight Rules (VFR) and by ATC procedures and ground-based surveillance in Instrument Flight Rules (IFR). Pilots and others concerned with aviation safety have long advocated additional assurance in the form of an airborne (i.e., ground-independent) collision avoidance system. The system currently proposed by F&l—Traffic Alert and Collision Avoidance System—is an independent airborne device designed to use ATCRBS (or Mode S) transponder information for generating a warning to the pilot that an approaching aircraft is a threat and that evasive maneuver may be called for.

TCAS is in the development stage at present and may not be ready for operational use until the late 1980s. The availability of TCAS, or an equivalent system of airborne collision avoidance,

"See ***Airport and Air Traffic Control System,*** op. cit., for more detailed discussion of these technologies.

will be an important factor in the decision to adopt revised procedures for increasing the efficiency of airspace use. Without assurance that safe separation can be maintained and that there is a backup to ground-based air traffic control, neither airspace users nor FAA are likely to have the confidence to proceed with revision of present longitudinal and horizontal separation standards.

AIRSPACE USE PROCEDURES

Procedures governing the use of terminal airspace and airport runways, which are designed primarily to assure safety, sometimes slow or disrupt the flow of traffic. In general, these procedures consist of rules and standards pertaining to the permissible distances between aircraft in various weather conditions and approach patterns. Actually, there are two sets of procedures: one for use in Visual Meteorological Conditions (VMC) and another, more stringent, set for use in Instrument Meteorological Conditions (IMC). Instrument Flight Rules—which are largely determined by available navigation, communication, and surveillance technology—often cause delays at busy airports because of the increased separation standards and special safeguards that must be applied in restricted visibility.

There is a widely held, but not unanimous, view among airspace users that revisions of the existing instrument flight procedures are practical and that they would be warranted in the interest of reducing delay. While these revisions are sometimes spoken of as capacity improvements, they would not in most cases actually increase the capacity of airports. Instead, they would allow existing capacity to be used more fully or with greater efficiency and would bring the throughput attainable under IMC closer to that which prevails under VMC.

In response to urging from airspace users, FAA instituted a comprehensive examination of airspace use procedures in October 1981. This effort, known as the National Airspace Review (NAR) is a 42-month joint undertaking by FAA and the aviation industry "to identify and implement changes which will promote greater efficiency for all airspace users and simplify [the ATC] system. Additionally, the NAR will match airspace allocations and air traffic procedures to technological improvements and fuel efficiency programs."[22] The portion of NAR concerned specifically with terminal area ATC procedures was completed in July 1984.

Many of the procedural changes sought by airspace users and under study by FAA in NAR were also examined by a special aviation industry task force convened at the request of FAA under the auspices of the Airport Operators Council International. The task force report, issued in September 1982, strongly urged FAA to revise present airspace use procedures, especially those pertaining to the use of multiple runways under Instrument Meteorological Conditions.[23]

Reduced Lateral Separation

Several of the proposed revisions would permit changes in the standards for lateral separation of aircraft under instrument flight conditions. The present standards often severely restrict throughput because they preclude use of all the available runways when visibility is reduced. If the airport could continue to operate these runways, the disparity between IMC and VMC acceptance rates could be substantially narrowed. The following are the major capacity-related changes under consideration.

Converging Runways

Converging runways are those whose extended centerlines meet at a point beyond the runways themselves. Simultaneous approaches to converging runways are presently authorized only during VMC. The proposed procedure would ex-

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[22] *Federal Register*, vol. 48, No. 153, Aug. 10, 1981, p. 40654.

[23] *Report of the Industry Task Force on Airport Capacity Improvement and Delay Reduction*, op. cit. In a subsequent letter to FAA Administrater Helms, dated Dec. 9, 1983, the Task Force put forth proposals for simulation and demonstration of IFR approaches to converging and independent parallel runways. The Task Force also endorsed studies to evaluate reduced longitudinal separation in certain circumstances.

tend this authorization to IMC in certain circumstances. The major problem to be overcome in using converging runways under instrument conditions is development of procedures to assure separation in the event of a blunder by one of the aircraft during the approach or in case both aircraft must execute a missed approach at the same time. These procedures, in turn, depend on the availability of improved surveillance radar, MLS to provide missed approach guidance, and perhaps automated aids for the controller to coordinate simultaneous approaches to two runways.

In time, it maybe possible to extend these procedures to the case of intersecting runways-those whose surfaces actually cross at some point. In addition to the problems of blunder protection and separation assurance during missed approaches, this configuration poses the risk of collision between two aircraft on the ground, and there must be adequate safeguards that aircraft on both runways can stop or turn off before reaching the intersection. Because of the inherent safety problems, most observers are skeptical about the feasibility of using this type of runway layout for instrument operations.

Dependent Parallel Runways

At present, instrument approaches maybe conducted on parallel runways that are as close as 3000 ft apart so long as a diagonal separation of 2 nautical miles (nmi) is maintained between adjacent aircraft. For parallel runways separated by 2,500 ft, the diagonal spacing requirement is 2.5 nmi. In addition, aircraft must be separated by 1,000 ft vertically or 3 nmi horizontally as they turn onto their parallel approach paths. These runways are termed dependent because the approaches to each must be coordinated to maintain the prescribed diagonal spacing. Hence, the operational rate attainable on either is constrained by the movement of aircraft on the other.

FAA studies suggest that the diagonal spacing requirements for IFR operation on dependent parallel runways could be reduced. For runways separated by 2,500 ft, the standard could be reduced from the present 2.5 nmi to 2 nmi with current technology and no other changes in existing procedures.[24] Reducing the spacing requirements for approaches to parallel runways less than 2,500 ft apart requires: 1) that the pilot be able to confirm that he is, in fact, on approach to the proper runway since radar surveillance would no longer be sufficient; and 2) that wake vortices from aircraft approaching one runway do not interfere with operations on the other. Because of wake vortex, current procedures require that aircraft approaches to closely spaced parallel runways (less than 2,500 ft apart) be treated as approaches to a single runway and separated accordingly.

An operational solution to the wake vortex problem on closely spaced parallel runways entails that the following additional conditions be met:

- there must be a steady crosswind to diminish the effects of wake vortex, but the wind velocity must be less than maximum crosswind limitation;
- small aircraft that are vulnerable to wake vortices must use the upwind runway of the closely spaced pair;
- the threshold of the upwind runway must be displaced from that of the downwind runway;
- the upwind runway must have a high-angle glide slope to allow for a steeper descent by vulnerable aircraft so that they can remain above, and hence avoid, wake vortices; and
- wind monitors must be set up along the approach path to ascertain that conditions are favorable for the dissipation of wake vortices.

Satisfying these requirements may be difficult at airports that do not have runways with suitably staggered thresholds and a sufficiently large number of aircraft that can approach at a steeper than normal glide slope to avoid wake turbulence. In addition, there are operational difficulties that may limit the applicability or the capacity benefits of this procedure. First, the wake vortex generated by a heavy aircraft carrying out a missed

[24] A. L. Haines and W. J. Swedish, *Requirements for Independent and Dependent Parallel Instrument Approaches at Reduced Runway Spacing*, FAA-EM-81-8 (Washington, DC: Federal Aviation Administration, Office of Systems Engineering Management, May 1981).

approach could interfere with operations on the other runway. One possible solution would be to require that both the leading and trailing aircraft execute missed approaches along diverging paths whenever the leading heavy aircraft misses the approach. Second, interference from departures could limit capacity gains since it may be necessary to retain present longitudinal separation standards between heavy aircraft departing on one runway and small aircraft landing on the other in order to avoid wake turbulence. Finally, as the distance between parallel approaches is reduced, there will be a need for more accurate surveillance to verify that aircraft are on approach to the proper runway. The radar now in use, which has a 5-milliradian accuracy and a 4-second update rate, is probably not adequate for this purpose and may have to be replaced with new radar capable of l-milliradian accuracy and 1-second update .25 Such radar performance has been achieved in the Precision Approach Radar system formerly installed at some airports but now decommissioned. Military radar also has this capability but would have to be adapted and tested before use in civil aviation.

Independent Parallel Runways

Independent instrument approaches to parallel runways separated by at least 4,300 ft are presently authorized under the following conditions: 1) when aircraft are turned onto the approach path, they must be separated vertically by at least 1,000 ft or laterally by 3 nmi from aircraft turning on approach to the other runway; and 2) a "No Transgression Zone, " at least 2,000 ft wide, must be maintained between the approaches, with a separate controller assigned to monitor this zone. A study by FAA indicates that, as with dependent parallel runways, reducing lateral spacing for independent parallel runways from 4,300 to 3000 ft would require installation of more accurate radar but no other changes in current procedures. 26

[25] 1bid.
[26] Ibid.

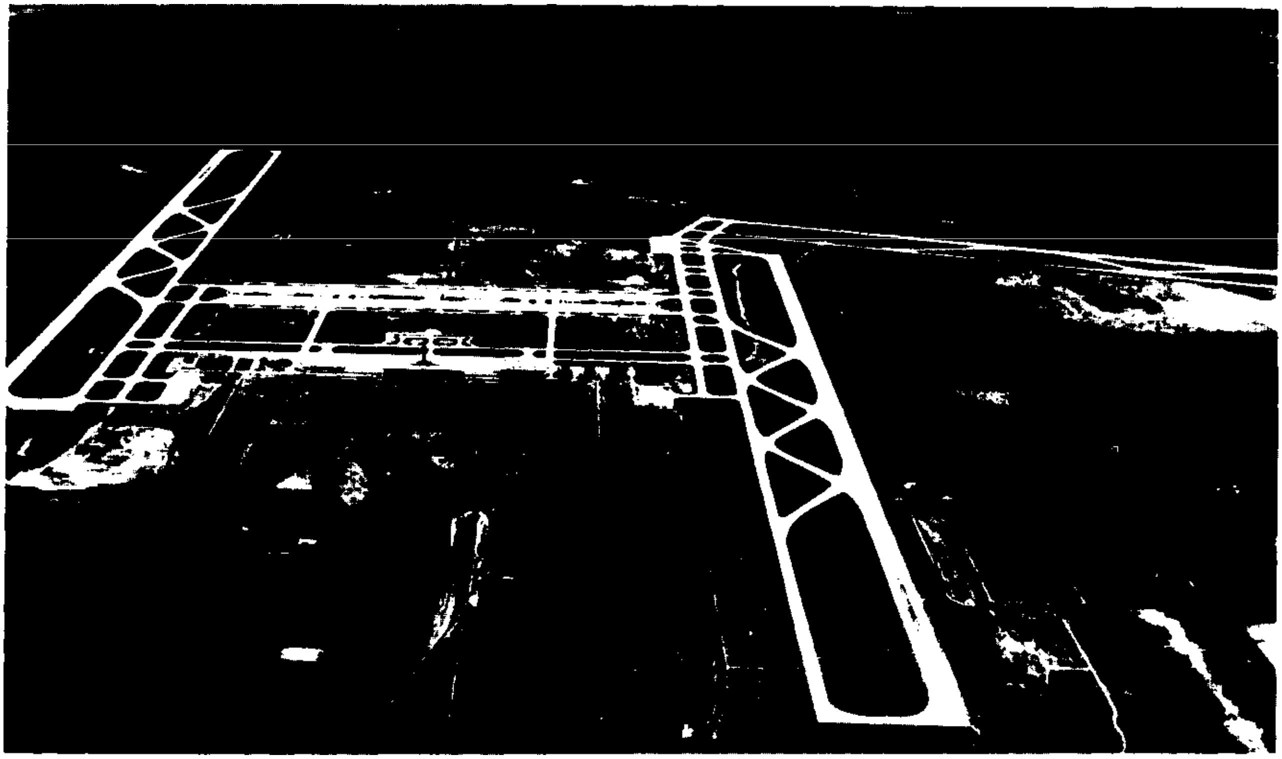
Triple Parallel Runways

Demand at some of the busier airports, such as O'Hare, Atlanta, Dallas/Fort Worth, Pittsburgh, and Detroit, sometimes exceeds the capacity of the runway system in IMC, and addition of a third approach stream would be desirable. Current ATC procedures allow approaches to triple parallel runways only during VMC. Revision of separation standards to permit their use during IMC would significantly expand the time that maximum airfield capacity is available at these few very busy airports.

While the requirements for three parallel approaches are similar to those for two parallel approaches, the addition of a third runway complicates the approach procedures and limits possible gains in capacity utilization. To be most effective, at least the outside pair of approaches should be independent from each other, although both may be dependent on the middle runway. If all three parallel runways were dependent, there would be only a minor increase in throughput compared to that attainable with two dependent runways. Also, since a blunder ***on*** one of the outside approaches could affect more than one other aircraft, establishment of triple independent parallel approaches necessitates two "No Transgression Zones, " with a separate controller assigned to monitor each. Because the l, 000-ft vertical separation rule for aircraft turning onto parallel approach paths still apply, final approach courses, particularly for the center runway, would be longer–thereby diminishing somewhat the throughput gain attainable with the triple parallel configuration.

A few airports have runway layouts that allow a converging approach to be added to two existing parallel approaches. This third approach is used during VMC, but in IMC the converging runway must be closed because separation between aircraft executing missed approaches cannot be assured visually.

The requirements for three approaches, one of which is converging, are similar to those for two converging approaches. However, establishing the third converging approach for use with a parallel pair involves additional safeguards because a blunder by an aircraft on one of the outside ap-



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preaches affects more than one other aircraft. The missed approach path for the converging runway must be coordinated with those of the other two runways—a procedure that is quite complex and cannot be implemented without further research and evaluation. In particular, FAA is studying whether MLS will be required to provide non-conflicting missed approach paths .27

Reduced Longitudinal Separation on Final Approach

Current procedures require longitudinal (in-trail) separation of 3 nmi between aircraft conducting instrument approaches to the same runway In VMC, in-trail separations of 2.5 nmi and even 2 nmi are not uncommon depending on the runway geometry, the observed runway occupancy time, and the mix of aircraft. Proposals have been advanced to reduce the IMC standard to 2.5 nmi immediately, and perhaps to 2 nmi eventually for certain airports and runway configurations.[29]

One determinant of the longitudinal separation standard is the length of time needed for aircraft to leave the runway after landing (runway occupancy time). As a safety measure, current ATC procedures do not permit two aircraft to occupy a runway at the same time. FAA studies have shown that runway occupancy time at many major airports averages between 41 and 63 seconds.[30]

[27] *Response to the Industry Task Force on Airport Capacity Improvement and Delay Reduction* (Washington, DC: Federal Aviation Administration, FAA Management Steering Group, May 25, 1983), p. 6.

[28] When there is a hazard of wake turbulence, these longitudinal separation standards are increased to 4 to 6 nmi depending on the size of the leading and following aircraft.

[29] See, for example, *Report of the Industry Task Force on Airport Capacity Improvement and Delay Reduction*, op. cit., pp. 6-7; and letter from the Task Force Chairman to the FAA Administrator, Dec. 9, 1983.

[30] *Analysis of Runway Occupancy Times at Major Airports*, FAA-EM-78-9 (Washington, DC: Federal Aviation Administration, May 1978); and W. J. Swedish, *Evaluation of the Potential for Reduced Longitudinal Spacing on Final Approach*, FAA-EM-79-7 (Washington, DC: Federal Aviation Administration, August 1979).

For those airports where runway occupancy time averages so seconds *or less,* FAA studies indicate that minimum in-trail separation of 2.5 nmi could be allowed in circumstances where wake vortex and ATC workload permit. Flight tests conducted by the U.S. Air Force have demonstrated the feasibility of 2.5-mile separation for military use. However, safety standards for commercial operations are different than those for military operations, and analysis of radar accuracy and update rates, controller and pilot response times, and aircraft performance characteristics will be needed to determine whether 2.5-mile separation during IMC is safe for civil aviation. Since there is a direct relationship between in-trail separation and throughput, this procedural change would be a very effective method to reduce delay under instrument flight conditions.

Present ATC procedures specify that the nominal longitudinal separation standards for VMC or IMC be adjusted to compensate for the possible effects of wake turbulence. These separation standards, shown in figure 9, are based on a three-way classification of aircraft according to gross takeoff weight and attempt to account for the wake-turbulence characteristics of aircraft and their vulnerability to wake vortex encounters:

- heavy ah-craft—maximum gross takeoff weight (GTW) in excess of 300,000 lb,
- ***large*** aircraft—maximum GTW between 12,500 and 300,000 lb, and
- ***small*** aircraft—maximum GTW less than 12,500 lb.

Definition of aircraft categories based on GTW alone is not an accurate index of of wake vortex generation for all aircraft, notably those aircraft whose GTW is slightly over 300,000 lb such as the DC-8 and B-767. As the number of B-767 aircraft in the fleet grows and as the re-engining program for DC-8S proceeds, aircraft whose GTW ***is*** roughly 300,000 lb will become an increasingly large proportion of the commercial aircraft fleet. If these aircraft continue to be classified as "heavy," greater arrival separations will be required, with adverse effects on capacity and delay.

If aircraft were classified on the basis of more precise analytical or empirical data concerning their specific aerodynamic and wake-vortex characteristics, it might be possible to reduce the in-trail separation rules for some types. As a minimum, the use of approach weight rather than maximum GTW as the basis for separation criteria could be considered. To be even more pre-

Figure 9.—Arrival and Departure Separations

Minimum Arrival Separations—Nautical Miles

Visual Flight Rules*

Lead \ Trail	S	L	H
S	1.9	1.9	1.9
L	2.7	1.9	1.9
H	4.5	3.6	2.7

Instrument Flight Rules

Lead \ Trail	S	L	H
s	3	3	3
L	4	3	3
H	6	5	4

Minimum Departure Separations—Seconds

Visual Flight Rules*

Lead \ Trail	S	L	H
s	35	45	50
L	50	60	60
H	120	120	90

Instrument Flight Rules

Lead \ Trail	S	L	H
S	60	60	60
L	60	60	60
H	120	120	90

*VFR separations are not operational minima but rather reflect what field data show under saturated condition

KEY: S = Small, L = Large, H = Heavy (see text.)

SOURCE: Adapted from *Parameters of Future ATC Systems Relating to Airport Capacity/Delay* (Washington, D.C.: Federal Aviation Administration, June 1978), pp. 3.3, 3.5.

cise, wingspan, approach speed, and engine and flap configurations should also be taken into account. A recommendation to this effect was made in the report of the Industry Task Force on Airport Capacity Improvement and Delay Reduction and is now under consideration by FAA.[31]

Separate Short Runways for Small Aircraft

The current practice in air traffic control is to organize aircraft on approach according to time of arrival, not type of aircraft. So long as the traffic mix is reasonably uniform, this practice has a minor effect on throughput. At many airports, however, small aircraft represent a significant portion of traffic. To avoid wake turbulence generated by the heavy and large classes of transports, these small aircraft are required to follow in trail at distances of 4 to 6 nmi from the larger aircraft. Since many of these small aircraft operate at slow speeds, safety requires that larger and faster aircraft be spaced more than 3 nmi behind so that the leading small aircraft are not overtaken on approach. One way to overcome these operational penalties would be to segregate small general aviation and some commuter aircraft into a separate traffic stream using a different (short) runway. At some airports such a runway is already available but not usable for instrument approaches because of inadequate instrumentation; at others, new runways would have to be built and equipped with MLS.

There is some disadvantage to separate short runways in that they do not provide as much operational flexibility as a full-length additional air carrier runway. However, the separate short runway can be built at a fraction of the cost of an air carrier runway, and runway siting problems as well as local environmental issues may be easier to resolve.

Ideally, the separate short runways for small aircraft should be parallel to and operate independently from the main runway used by large air carrier traffic. A short runway that is not parallel to the main runway would not be available for use in IMC unless revised procedures for converging instrument approaches are also implemented; but even so, dependency on the main runway would limit the throughput gain because of the need to coordinate the two traffic streams. If the procedures described above to reduce spacing requirements for independent and dependent parallel approaches prove feasible, the siting of these short secondary runways could become easier. Another development that would facilitate siting of short runways and broaden the applicability of the concept would be installation of MLS to allow curved approaches and steeper glide slopes by small aircraft, not only to alleviate wake turbulence problems but also to achieve a greater rate of runway use.

[31] *Report of the Industry Task Force on Airport Capacity Improvement and Delay Reduction,* op. cit., pp. 3-4.

WEATHER AND ATMOSPHERIC EFFECTS

Perhaps the single greatest technological need in relieving delay at airports, aside from improved radar to monitor aircraft more closely spaced in terminal airspace, is development of techniques to improve the detection and prediction of weather and atmospheric effects. Weather-related technologies are typically viewed as safety improvements rather than capacity improvements, but there are significant exceptions—notably methods to protect from wake vortices. Current aircraft arrival and departure separations are predicated in large part on avoidance of wake vortices, and the key to many of the revised approach procedures described above is a better method to detect or to predict the occurrence of wake turbulence.

Beyond this, improvement in the ability to prediet weather and atmospheric phenomena could lead to general reductions in delay. Present technology does not always permit sufficiently accurate prediction of the time and magnitude of adverse weather conditions, making it necessary to increase safety margins and thereby reduce throughput. The ability to foresee disruptions due to weather would permit planning to compensate fer the impacts on traffic flow.

Wake Vortex

Wake vortex is an aerodynamic disturbance that originates at the wingtips and trails in corkscrew fashion behind the aircraft. Since the strength of the turbulence increases with lift, the strongest vortices occur behind heavy aircraft. These vortices spread downward and outward in the wake of the aircraft and may persist along the flight path for as long as 2 or 3 minutes in still air. When the aircraft *is* within 300 ft of the ground, the vortices can bounce off terrain and rise back toward the flight path, creating even more disturbance. Wake turbulence can be of such strength and duration that it poses a hazard to following aircraft (especially smaller aircraft), and present procedures require separation of 3 to 6 nmi depending on the size of the leading and following aircraft and the movement of the airmass.[32]

Alternatives to the present procedural method of avoiding wake turbulence are being sought both in the interest of safety and for the capacity benefits that could be realized through closer spacing of aircraft in the approach zone. Two avenues are being taken. FAA has concentrated on development of techniques to detect wake vortex and to predict its movement and persistence. NASA has focused on aerodynamic research to provide better understanding of the mechanics and causes of wake vortex and to develop designs to alleviate it at the source. NASA research indicates that certain combinations of flaps, spoilers, and protrusions on wing surfaces can reduce turbulence or cause it to dissipate more quickly. Unfortunately, many of these techniques also tend to increase noise and reduce energy efficiency. Work is continuing on ways to minimize wake vortex at an acceptable price in terms of noise and fuel consumption, but no ready solution is in sight. This *is* an important area of research and development since the alternative—wake vortex detection and avoidance—has not been perfected to the point that pilots have confidence in its reliability.

FAA has sought to develop equipment and a concept of operation that provide real-time vortex sensing capability and to devise a predictive algorithm that will warn pilots and controllers. An experimental device, known as Vortex Advisory System (VAS), was installed and tested at O'Hare in 1978. VAS is made up of wind sensors mounted on towers along the approach path, a central computer to process wind data and predict the strength and movement of wake turbulence, and a display to alert the controller when a hazardous condition exists. VAS has not yet proven operationally acceptable, and FAA plans further development and test.

The disadvantage of VAS is that it does not detect wake vortices; it only measures wind direction and velocity, from which an inference can be made about the presence and strength of wake turbulence. This deficiency is particularly evident further out on the approach path (beyond the middle marker) and in crosswind conditions where turbulence on one approach path may migrate to a parallel approach. To overcome these limitations, FAA is also investigating other technological approaches such as short-wave radar, lasers, and infrared devices that could provide better long-range sensing and wider coverage.

No practical solution is now in view, and it seems likely that procedural methods to avoid wake turbulence will continue to be employed. So long as wake vortices cannot be reliably detected and predicted, the present separation standards (perhaps with some modification to account for the aerodynamic characteristics of specific types of aircraft) will remain in force and preclude any throughput gains that might be achieved through reduced in-trail spacing.

Wind Shear

Wind shear is any sudden change in wind velocity or direction. It may be associated with warm and cold fronts, low-level jet streams, or mountainous terrain. One of the most dangerous types of wind shear is a downward surge of air striking the ground and spreading out in all directions. This kind of wind shear is often associated with thunderstorms, but it may occur in other weather conditions. These downdrafts, called microbursts, are difficult to predict because they are small and

[32] J. N. Barrer, "Operational Concepts for Reducing Vortex Spacings on Closely Spaced Parallel IFR Approaches, " The MITRE Corp., WP-81W520, September 1981.

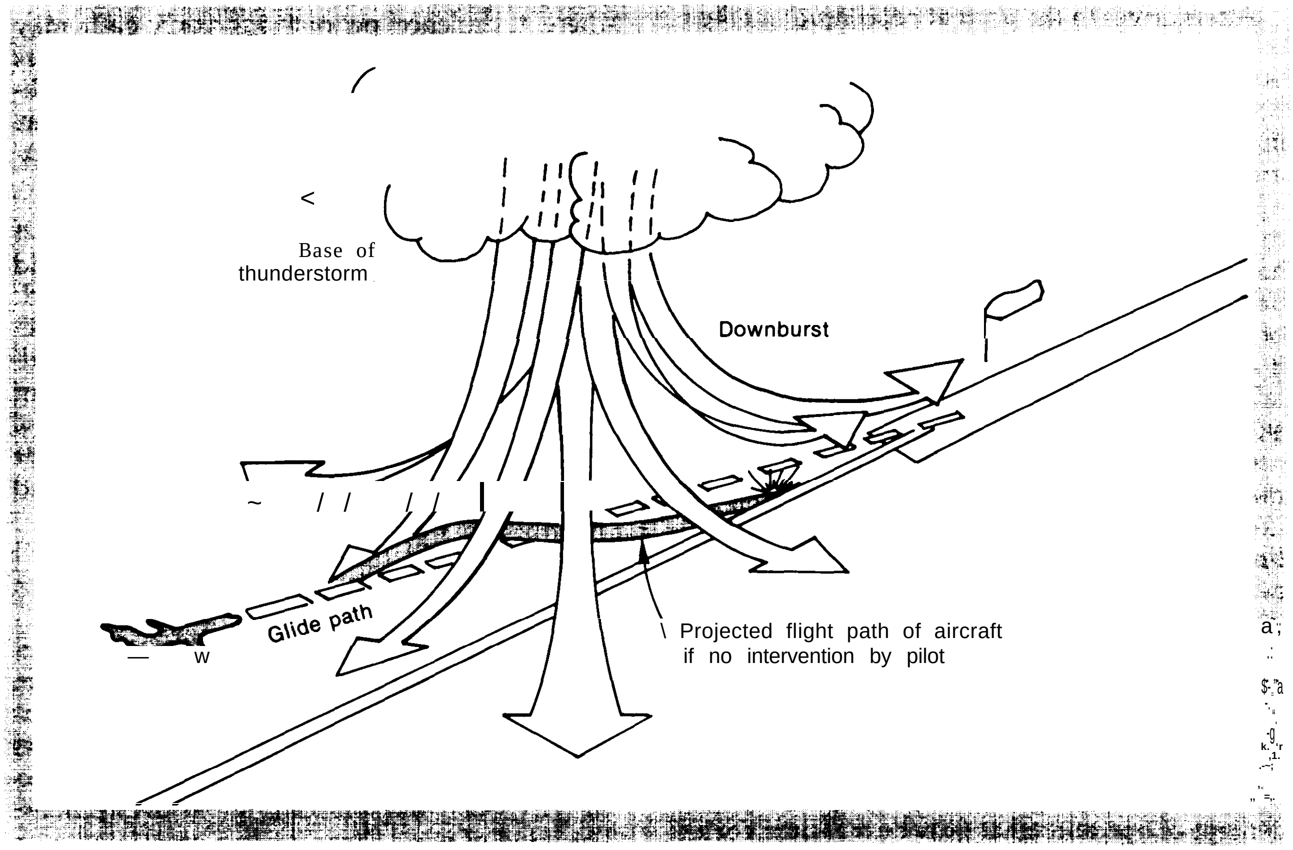
localized, extending only 2 or 3 miles and often lasting less than 5 minutes.

For the pilot of an aircraft, wind shear is experienced as an abrupt increase or decrease of lift (or often one rapidly followed by the other) caused by a sudden shift in the relative wind. In this condition, the aircraft may gain or lose altitude unexpectedly and become difficult to control in angle of attack and flight path (see fig. **10).** If this occurs near the ground on takeoff or landing, there can be extreme hazard.[33] While the primary concern is safety of flight, wind shear also disrupts airport activities and can cause suspension of operations until the condition abates.

In **1982,** The Federal Government undertook a project known as Joint Airport Weather Studies (JAWS) to provide a better understanding of wind shear, thunderstorms, and related weather hazards and to identify weather conditions that could be warning signs to pilots. A multi-agency effort involving the National Science Foundation, the National Aeronautics and Space Administration, the National Oceanic and Atmospheric Administration, and the Federal Aviation Administration, JAWS collected data on downbursts at Denver Stapleton airport during a 3-month period in the summer of **1982.** The knowledge of wind shear

[33] On July 8, 1982, a Pan American World Airways Boeing 727 crashed at Kenner, LA, near New Orleans International Airport, shortly after taking off in a thunderstorm. Wind shear was determined to have been the cause.

Figure 10.—Effects of Low=Aititude Wind Shear



The downburst spreads out as it nears the ground. The aircraft, instead of following a straight path to the runway, encounters first an abrupt increase in headwind which lifts the nose, and then a sudden strong tailwind, which forces the nose down. If the pilot cannot compensate for these wind changes at low altitude, the aircraft may crash.

SOURCE: ICAO Bulletin

gained through JAWS will contribute to the Low Level Wind Shear Alert System (LLWSAS) which provides the air traffic control tower with information on wind conditions near the runway. LLWSAS consists of an array of anemometers that read wind velocity and direction around the airport and signal the sudden changes that indicate wind shear. LLWSAS is now installed at ***60*** airports, and FAA plans to deploy ***50*** more by **1985.**

Over the longer term, FAA is developing other systems intended to provide better and more timely weather information at airports, both to improve safety and to help in traffic management. The Automated Weather Observing System (AWOS) will gather weather data from urtrnanned sensors, automatically formulate weather reports, and distribute them to airport control towers. AWOS will also broadcast this information to pilots as voice synthesized messages over VHF radio. Implementation of the system, scheduled for the period ***1983-90,*** began with a l-year demonstration program in June 1983, when 21 units were put into operation at towered and non-towered airports in various locations. Full deployment at 745 airports is scheduled to begin in 1986.[34] A similar system, Joint Automated Weather Observation System (JAWOS), is planned for installation at ***some*** medium and large hub airports. JAWOS will automatically gather local weather data and distribute it to other air traffic control facilities and to the National Weather Service.

In cooperation with the Department of Defense and the National Oceanic and Atmospheric Administration, FAA is also developing a next generation nationwide weather network based on pulsed Doppler radar (NEXRAD). This network will provide more accurate information on precipitation, reflectivity, wind velocity, and turbulence. NEXRAD will probably not provide the minute-to-minute observations needed to detect small localized downbursts that produce wind shear, nor will it be able to detect wind shear in the absence of precipitation. Still, NEXRAD will greatly improve the quality and comprehensiveness of the weather information available to air traffic controllers and will be a significant aid in managing traffic to compensate for adverse weather conditions. A total procurement of ***160*** units is planned, with the last scheduled to be in place and the system fully operational by 1992.

“Several GA user groups have argued that the AWOS timetable could be accelerated by a year or more and have asked FAA to reconsider the deployment schedule.

NOISE CONTROL AND ABATEMENT

Aircraft noise, especially the noise of jet aircraft, is one of the greatest barriers to airport utilization and expansion, and it is the most common subject of complaint by airport neighbors. The areas of severest noise impact are just beyond the ends of runways, but noise levels can be unacceptably high elsewhere along approach and departure paths where aircraft are close to the ground. In legal actions brought by airport neighbors, the courts have generally found that the airport operator is responsible for injury due to reduced property value or nuisance and have awarded damages to property owners and others affected by noise.

There are two ways to reduce noise. One is to quiet the aircraft themselves, notably the engines, and FAA has imposed progressively stricter noise standards for aircraft in FAR ***36*** and FAR 91E.[35] As a result, new aircraft entering service are much quieter than earlier models, and some older aircraft have been equipped with new, quieter engines. While research is continuing on aircraft noise, airframe and engine manufacturers tend to the view that large-scale and cost-effective advances in the technology of noise suppression will be increasingly difficult to find.

35FAR part 36 defines noise requirements for certification of new aircraft and engines. FAR Part 91 Subpart E sets the timetable for compliance and calls for retirement or retrofit of aircraft (both foreign and domestic) that do not comply with FAR Part 36 by 1985. To protect air service to small communities, FAR Part **91** Subpart E allows three additional years (until 1988) for twin-engine aircraft with 100 or fewer seats to achieve compliance.

The other approach has been to impose operational restrictions on airports—principally in the form of limits on the hours of use, frequency of flights, and the approach and departure routes that may be taken. Airport operators and airlines have resisted these measures since they reduce the capacity of the airport overall or at peak times and because noise abatement flight procedures often result in lengthier, less fuel-efficient paths to and from the airport. Two studies of airport capacity published recently have stressed the need to lessen some of these restrictions in the interest of increasing airport capacity and making more efficient utilization of aircraft.[36] 37

The discussion that follows addresses first prospective improvements in aircraft technology that might lessen noise, and then procedural solutions to alleviate the noise problem.

Aircraft Noise

Aircraft noise has two components: engine noise produced by moving engine parts and by air flow through the engine, and airframe noise caused by the passage of air over aircraft surfaces. In early jet aircraft, the engine was the predominant noise source. Advances in engine technology over the past 20 years have reduced engine noise to the point where the engine and the airframe are now about equal contributors to aircraft noise on landing. The engine is still the major noise source on takeoff.

Engine Noise

The principal sources of noise in a jet engine are: 1) the fan, 2) the compressor and turbine, and 3) the exhaust. The relative importance of these sources varies somewhat with the design of the engine and the operating regime, but exhaust noise is generally the greatest of the three.

Efforts to reduce fan noise have centered on altering the design of the fan blades and incorporating sound absorbing material in the fan case and the inlet and discharge ducts. Typically, this sound absorption is accomplished by a liner of porous material backed by cavities to trap sound. The newer aircraft engines now in service incorporate these design concepts, but further, small noise reductions may still be achieved.

Compressor and turbine noise are generated inside the engine by the compression, heating, and expansion of the air passing through. Methods for reducing compressor and turbine noise have included redesign of compressor parts and turbine blades to modify their sound characteristics, and use of sound absorbing material. Since the ability to alter the design or configuration of the compressor or turbine is limited by mechanical and aerodynamic considerations and engine load requirements, it is expected that the principal method to attain further reductions in compressor and turbine noise will be acoustic treatment in the intake ducts. Research is now aimed at development of improved acoustic material capable of withstanding the hot and cold environment of the compressor and turbine, and at reducing the cost of these noise suppression treatments.

Exhaust noise results from the turbulent mixing of hot, high-speed exhaust gases with the ambient air. The way to reduce this noise is through techniques that lower the temperature and velocity differential between the exhaust and the outside air, but without loss of engine efficiency and thrust. In the early, pure turbojet engines, all of the intake air was passed through the hot section of the engine, from which it exited at high velocity. These engines were very noisy. A later development diverted some of the air from the compressor around the combustion chamber and turbine and merged it with the exhaust stream—thus shielding the high-velocity exhaust with a cooler, slower moving sheath of air from the compressor. These low bypass ratio engines were more efficient and proved, on average, to be about 8 decibels (dB) quieter than pure turbojets.[38] Engines introduced in the ***1970s*** made use of an even higher bypass ratio to achieve both greater fuel efficiency and a further 8- to 10-dB reduction of noise .39

36 Report and Recommendations of ***the Airport Access Tskk Force*** (Washington, DC: Civil Aeronautics Board, March 1983).

37 Report of the Industry Task ***Force on Airport*** *Capacity Improvement and Delay Reduction,* op. cit.

38 The bypass ratio is the amount of air diverted around the combustor relative to that which passes through it.

39 For reference, a change of 3 dB is just perceptible to the human ear. A reduction of about 10 dB is perceived as halving the amoyance of a sound source.

Engine manufacturers are continuing to explore techniques such as high-pressure turbines, exhaust diffusers, and improved internal cooling methods–principally to increase engine efficiency but also for their potential to reduce noise. They are also evaluating internal flow mixers to combine low-velocity bypass air with higher velocity engine flow to produce an exhaust stream with less turbulence and a more uniform exit velocity. These efforts are yielding diminishing returns since further noise reduction involves very tightly coupled tradeoffs with fuel efficiency, production techniques, and maintenance costs. Attainment of noise levels significantly lower than those of FAR Part *36* appears to be very difficult without a sacrifice of fuel efficiency or a large cost penalty.

Airframe Noise

Airframe noise stems primarily from turbulent air flow past the undercarriage, leading and trailing edges of high-lift devices, aircraft cavities, and projections from the aircraft surface. For an aircraft in flight, these noises intermingle and are not usually distinguishable as to source. The principal methods available to reduce aerodynamic noise are wing design, high lift systems, and aircraft streamlining.

Recent exploratory development in aircraft wing design has included supercritical airfoil sections and winglets. Aircraft using these wing design features are currently being flight tested. Fundamentally, the supercritical airfoil and winglets would reduce drag and provide additional lift, but they also serve to reduce aerodynamic noise somewhat. Drag is exhibited as turbulence in the wake of aircraft, and turbulence produces noise. Further, insofar as reduced drag and increased lift permit the aircraft to be operated at lower power settings on takeoff and landing, these aerodynamic improvements might provide a secondary benefit of reduced engine noise.

Advanced high-lift systems make use of two-segment trailing edge flaps and a variable camber on the leading edge of the wing. High-lift devices of this sort are currently used on Short Takeoff and Landing (STOL) aircraft such as the deHavilland DHC 7. They have also been incorporated in some large transport aircraft. The 747 and later model *727* aircraft have triple-slotted flaps, and the *767* has both variable camber leading-edge flaps and double-slotted trailing edge flaps. These systems do not necessarily produce quieter aircraft; in fact, they may be noisier. However, high-lift devices permit steeper approach and takeoff paths, thereby reducing the size and severity of the aircraft noise footprint on the ground and leading—in effect—to less aircraft noise overall.

Techniques to streamline aircraft include placement of fairings around extended landing gear and other projections from the aircraft surface and enclosure of wing and body cavities. Such features are intended primarily to improve the aerodynamic performance of the aircraft, but they could also lessen aerodynamic noise. Another streamlining technique involves strategic placement of the engines at locations where the airframe can act as a shield for engine noise. There are critical tradeoffs between engine placement and aircraft performance and safety that need to be treated carefully. There is also a need for additional research to improve the understanding of how the engines and airframe interact in the production and suppression of noise.

Many of the techniques described above might lessen aerodynamic noise, but the overall reduction would probably be rather small. There is a widely held view among aircraft designers that the newest aircraft are close to the practical lower limit of aerodynamic noise and that further reductions will be technically difficult, prohibitively costly, and perhaps disadvantageous for other aspects of aircraft performance. While some of these techniques will be pursued and might be incorporated in future aircraft, the general opinion is that there are no aerodynamic solutions that will lead to large-scale reductions in aircraft noise.

Aircraft Operating Procedures

In addition to technological measures to reduce noise at the source, there is the the procedural solution of operating aircraft in a way that alleviates the effect on noise-sensitive areas. Many such measures have already been adopted—some locally, some more generally—and work is continuing to improve these procedures, to devise new ones, or to extend their application more widely.

Procedures in use today are limited, in some cases, by safety and capacity considerations and by the capabilities of the ATC system. The ability to apply these procedures is also affected by conditions of wind, weather, and visibility. Perhaps the greatest deficiency, however, is that restrictions are applied airport by airport—often as a result of local ordinance—in a fashion that is fragmentary, confusing, and inefficient. Aircraft operators complain that both airport capacity and aircraft utility are wasted and that market opportunities are lost. The Airport Access Task Force of the Civil Aeronautics Board (CAB) devoted major attention to the question of noise abatement procedures and urged the Federal Government to reduce the number of locally imposed aircraft operating restrictions and to develop nationally applicable procedures that would appropriately balance public concerns about noise with the interests of air commerce.[40]

Prospective advances in technology might make some of the procedures in use today more effective or less onerous to aircraft operators. One such procedure is departure thrust management, which necessitates adjustments in power settings during climbout and exit from the terminal area. As newer aircraft with better performance characteristics and quieter engines come to predominate in the fleet, these departure practices may be easier to implement, or—in some instances—they may not be required as often. The CAB Airport Access Task Force estimated that phasing out aircraft with low bypass engines (from 94 percent of the fleet in 1980-81 to 10 percent by 2000) would produce an average noise reduction of almost 6 dB systemwide, even if operations were to increase by 50 percent.[41]

Preferential runway use is another method for reducing the extent or severity of noise impact on the surrounding community. This involves using, whenever possible, those runways that minimize the number of people or the area exposed to aircraft noise. The effectiveness of preferential runway use is site-specific since it depends on the runway layout in relation to land use patterns, the prevailing wind and weather, and the installation of navigation and landing aids. Implementation of the Traffic Management System and deployment of MLS might make it possible to extend this practice to other airports or allow it to be used in a wider spectrum of weather conditions.

On the other hand, preferential runway use has the effect of exposing the unfortunate few who live or work in affected areas to more unremitting noise than might be considered their "fair share." For this reason, it may be more equitable to temper preferential runway use with some variation of runway use patterns. Distributing noise more uniformly among areas surrounding the airport would lessen the impact on some, but at the risk of antagonizing perhaps far more who are not presently exposed to aircraft noise.[42]

Preferential flight paths are prescribed routings for arriving and departing aircraft to avoid overflight of noise-sensitive areas. This procedure is frequently combined with preferential runway use, but may be used even where the airport has only a simple runway layout. At some airports

[40] *Report and Recommendations of the Airport Access Task Force*, op. cit.

[41] Ibid., p. 17.

[42] The controversy over the scatter plan tested at Washington National Airport in early 1984 is a classic illustration of how attempts to distribute aircraft noise more uniformly simply engender new opposition, chiefly from those who find their previously quiet areas subjected to noise.

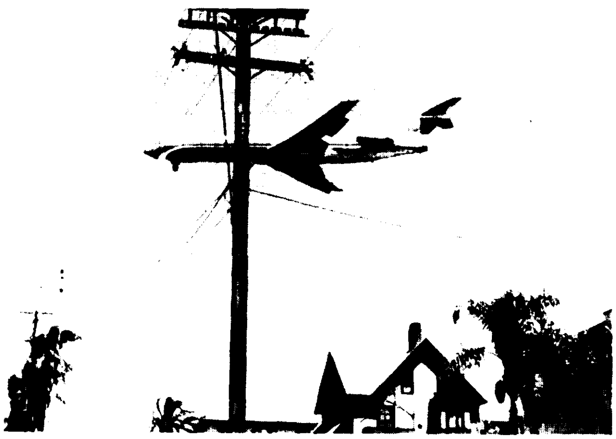


Photo credit: Dom McGrath, Jr.

Houses under the approach path to San Diego airport the use of preferential flight paths is limited by the availability or capability of the installed landing and navigation aids. It is expected that MLS will enhance the ability to use noise-avoidance flight paths since it provides more precise and flexible approach guidance with a wider range of coverage than the existing ILS. MLS would permit multiple final approach paths, including curved approaches. The ability to fly curved approach paths will enable aircraft to avoid noise-sensitive areas in IMC much as they do now in VMC and will aid in the reduction of noise levels for airports with noise-sensitive land uses located under the straight-in approach path. MLS would also allow some aircraft to fly steeper approach paths, which—by keeping aircraft higher as they pass over development around the airport-will reduce the area of high noise impact. In FAA studies of the application of MLS to specific sites, it was found that the use of curved and segmented IMC approaches made possible by installation of MLS at airports such as La Guardia, Minneapolis, San Francisco, Seattle, and Washington National could lead to significant noise reductions.

AIRPORT SURFACE UTILIZATION

An airport is an interconnected set of physical facilities and components. For it to function efficiently, the capacities of each of these elements must be matched. Relief of a bottleneck in one part of the airport will not have the desired effect on overall throughput unless other parts are capable of absorbing a greater influx of traffic. Indeed, a common experience is that enlargement of one part of the airport complex simply shifts the delay elsewhere, to the next most constraining element.

Nowhere is this more evident than on the airport surface. Measures to augment runway capacity or to increase the flow of traffic through the airspace may be of little practical benefit unless aircraft are able to move expeditiously on and off runways and to and from the terminal building. It is on airport taxiways and aprons that aircraft are closest together and that their speed is lowest. If the movement of aircraft on the airport surface is constrained by runway and taxiway design and layout, by operational procedures, or by poor visibility, the effect ripples throughout the airport and airspace, and delays accumulate.

This section examines three types of technology deployed on the airport surface: surveillance and control systems, taxiway design and lighting, and equipment used at parking aprons and gates. In general, new airport surface utilization technologies will not lead to major increases of airside capacity, which is largely determined by available runways and airspace use procedures. The primary capacity benefits are indirect—increased safety, especially during inclement weather, and relief of operational impediments to making efficient use of the airside.

Surveillance and Control

Surveillance and control of aircraft movement on the airport surface is accomplished largely by visual means. In darkness or fog—and even in good visibility at large, complex airports-Airport Surface Detection Equipment (ASDE) is used by air traffic controllers to augment and confirm information obtained from visual surveillance of the airport surface. Used primarily at high activity airports, ASDE allows controllers to locate and monitor the movement of aircraft and ground equipment on runways, taxiways, and apron areas.

The existing equipment, designated ASDE-2, utilizes tube technology, which presents reliability and maintenance problems. In addition, utility of ASDE-2 is limited by display resolution, brightness, airport map definition, and poor weather penetration capability. The last is particularly significant under conditions of precipitation or fog, when the system is needed the most. Under these conditions, visual surveillance is virtually impossible, and ASDE is the controller's primary means to obtain the necessary information.

A new system utilizing solid state technology is programmed for deployment by ***1986-89.*** This system, ASDE-3, is expected to increase reliability and reduce system maintenance, in addition to improving display resolution and weather penetration. More accurate information on the specific location and movement of aircraft and ground equipment on the airport surface provided by ASDE-3 might allow reductions in safety-dictated separation of aircraft and promote more efficient utilization of runways and taxiways. Ultimately, small gains in airfield capacity could result.

Research and development on more advanced systems will be needed since even ASDE-3 cannot identify aircraft and surface vehicles under all weather conditions or be used by the controller to guide them to their destinations. At present, the capability of navigation systems to help aircraft land in very low visibility (Category IIIC operations) exceeds that of surveillance and control systems to guide them after they are on the airport surface.

The Tower Automated Ground Surveillance System (TAGS) is a display enhancement intended for use in conjunction with ASDE at major airports. The ASDE-3 search radar provides a map of the airport and the location of aircraft on the airport surface, which are shown graphically on the ASDE display. TAGS will provide, for transponder-equipped aircraft, a flight identification label alongside the position indicator on the ASDE display. Since TAGS operates by receiving a signal transmitted directly by aircraft equipment, the system would be virtually immune to weather. Presentation of flight identity by TAGS would also improve ground control capability in good visibility. TAGS is presently in the exploratory phase of development and probably will not be ready for deployment until the 1990s.

Taxiways

The design and layout of taxiways, particularly those that provide egress from runways, have an important effect on runway occupancy time (ROT).[43] The placement of exit taxiways, where landing aircraft turn off the runways, and the angle at which these taxiways intersect the runways can be crucial. Poorly placed exit taxiways prolong runway occupancy by forcing incoming aircraft to taxi at low speed for some distance before clearing the runway. Taxiways that leave the runway at right angles force the aircraft to come almost to a complete stop before turning. Since the runway occupancy rule (with a few exceptions in VMC) does not allow an approaching aircraft to cross the runway threshold while the preceding aircraft remains on the runway, longer runway occupancy either forces the air traffic controller to increase arrival spacing or causes some approaching aircraft to execute a go-around—both of which are disruptive of throughput.

At some airports, relocating taxiways so that aircraft with shorter stopping distances can leave the runway sooner would lower ROT by as much as 20 to 30 percent. At others, providing a drift-off area alongside the runway or redesigning taxiways so that they diverge from the runway gradually and allow aircraft to turn off at higher speeds (i.e., sooner after landing) would have much the same effect. However, translating reduced ROT into a corresponding throughput gain is not straightforward since it depends on whether the runway layout, the airspace geometry, and the ATC procedures will permit closer arrival spacing to take advantage of the shorter runway occupancy. Still, it is an avenue to be explored, and among the recommendations of the Industry Task Force on Airport Capacity Increase and Delay Reduction were several that urged FAA and airport operators to adopt measures that would assist faster exit from runways.[44] One of these was to adopt procedures and rules that would increase the motivation of pilots to use specified rapid exits and improve the coordination between controllers and pilots in minimizing ROT.

Marking and lighting of taxiways can be as important as their design and physical layout in expediting ground movement of aircraft. For runway exits to be used to their full potential, pilots must be able to detect their location and identify the one they are to use with ample leadtime. This is especially critical at night and during periods of poor visibility. A taxiway marking and lighting system that conveys the necessary information to

[43] Runway occupancy is measured from the time an approaching aircraft crosses the threshold until it turns off the runway or from the time a departing aircraft takes the active runway until it clears the departure end. Current ATC rules prohibit two aircraft from occupying the runway at the same time.

[44] Report of the Industry~ *Task Force on Airport Capacity Improvement and Delay Reduction,* op. cit., pp. 11-14.

pilots in a clearly understandable fashion will promote more efficient utilization of airfield pavements.

Research and development are in progress on several aspects of marking and lighting. For exit taxiways, the major efforts are to improve the lighting pattern and the configuration, spacing, and orientation of components in a way that promotes ready identification of the exit and provides visual guidance for safe and prompt transition from the runway to the taxiway. Among the areas under study are improved lighting and signing for taxiway intersections, traffic control signals and lighting systems for ground guidance, and methods for controlling lighting patterns and intensity from the tower. Development is also proceeding on new lighting techniques such as lights that use low voltage electricity, light-emitting diodes, and electroluminescent components to relieve some of the deficiencies of present lighting, which pilots characterize as "the blueberry pie maze. "

To optimize the use of airport pavements and to make proper decisions related to safety, pilots and controllers must have accurate and up-to-date information on surface conditions that affect aircraft ground movement and stopping characteristics. Perhaps the most noticeable changes in these characteristics are aircraft braking and stopping distance on wet or icy pavement, which are important not only from a safety standpoint but also because of the effect on capacity.

One major effort is to devise pavement designs and surface treatments that will improve traction. Research is also being conducted on means to provide information that will allow pilots and controllers to predict aircraft stopping capability and skid risk more accurately under various runway surface conditions. Items such as pavement sensors that continuously monitor pavement condition and coefficients of friction are being examined. Attention is also directed at development of better methods to convey this information to the pilot and, ideally, to provide braking guidance or warning of specific hazardous conditions and locations. The primary concern is safety, but better information about pavement condition and aircraft performance when traction is reduced would also yield a capacity benefit in that a more accurate delineation of safety limits might make

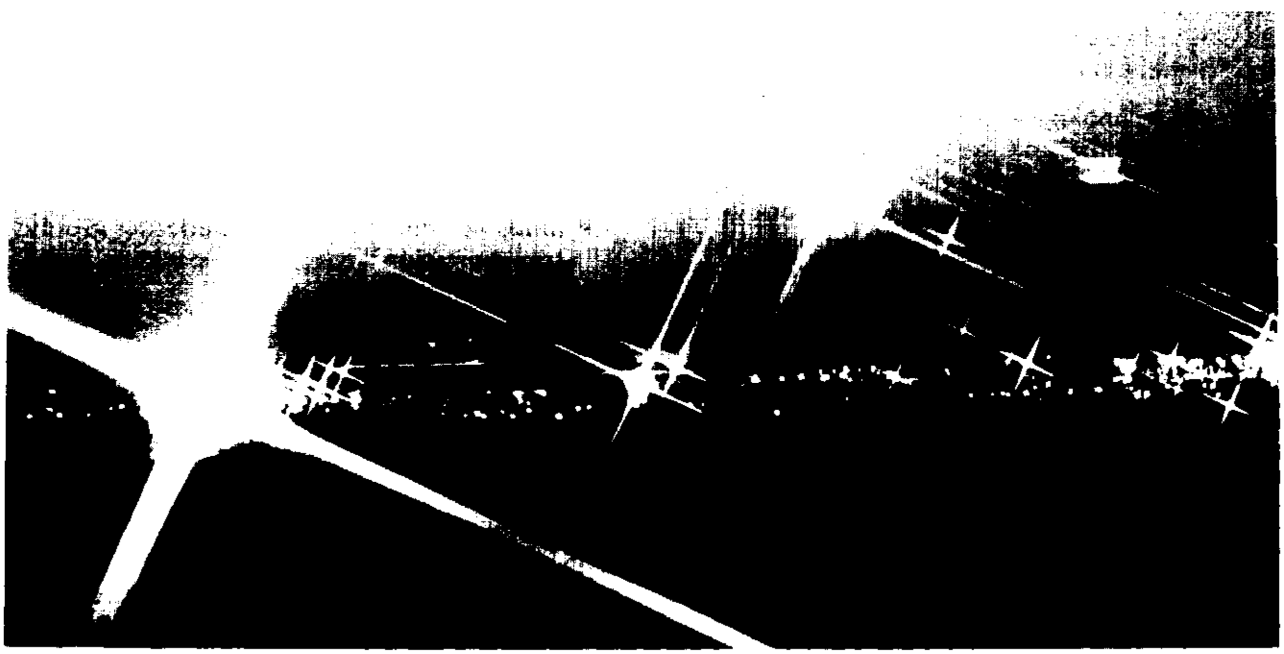


Photo credit' **Federal Aviation Administration**

Night life at Chicago O'Hare

it possible to relax some of the present conservative rules governing aircraft movement on the surface in slippery conditions.

Apron and Gate Facilities

Opportunities to relieve airport surface congestion extend up to the parking spaces at the gates. Aircraft docking is typically accomplished by a ramp agent with flashlights and hand signals guiding the flight crew for proper parking of the aircraft and assuring that the wing tips have safe clearance from buildings, ground equipment, and other aircraft. New optical, electrical, electronic, and mechanical devices are being developed to provide flight crews with positive visual guidance that will permit more rapid and accurate docking. This technology will allow apron space to be used more efficiently and help prevent the delays that arise when aircraft must be repositioned in order to mate with fixed ground support systems and passenger loading bridges.

While needs and procedures vary by airline and by airport, the aircraft servicing functions commonly performed at an airport include fueling, engine start, galley and cabin service, electrical ground power, towing, passenger stair or loading bridge operation, and handling of baggage, mail, and cargo. In addition, various routine or special aircraft maintenance functions are conducted.

Several technological advances offer reductions in servicing time and cost. At some airports, ground power is now being provided by fixed systems mounted on the passenger loading bridge or in underground pits. Similarly, fixed pneumatic systems are being developed to provide ground power and aircraft engine start. These installations ease the congestion caused by mobile units clustered around aircraft on the ramp and provide for a more efficient servicing operation. Auxiliary power units now provided on most newer aircraft alleviate congestion by replacing ground equipment needed for electric service, air start, and air-conditioning. These self-contained units also assist in quick turnaround, thereby reducing gate occupancy time. Special pallets and handling equipment provide for efficient transfer and loading of bags and cargo. While use of this technology saves time at the gate, the loading and unloading of the pallets themselves can sometimes be time-consuming due to mechanical problems and alignment difficulties.

These improvements in technology help ease surface congestion in two ways, Those that speed turnaround lessen gate delays and enhance throughput. Those that reduce the apron space needed for service vehicles and equipment allow more aircraft to be parked in a given area, thereby directly increasing apron capacity and helping to ease airport surface congestion in general.

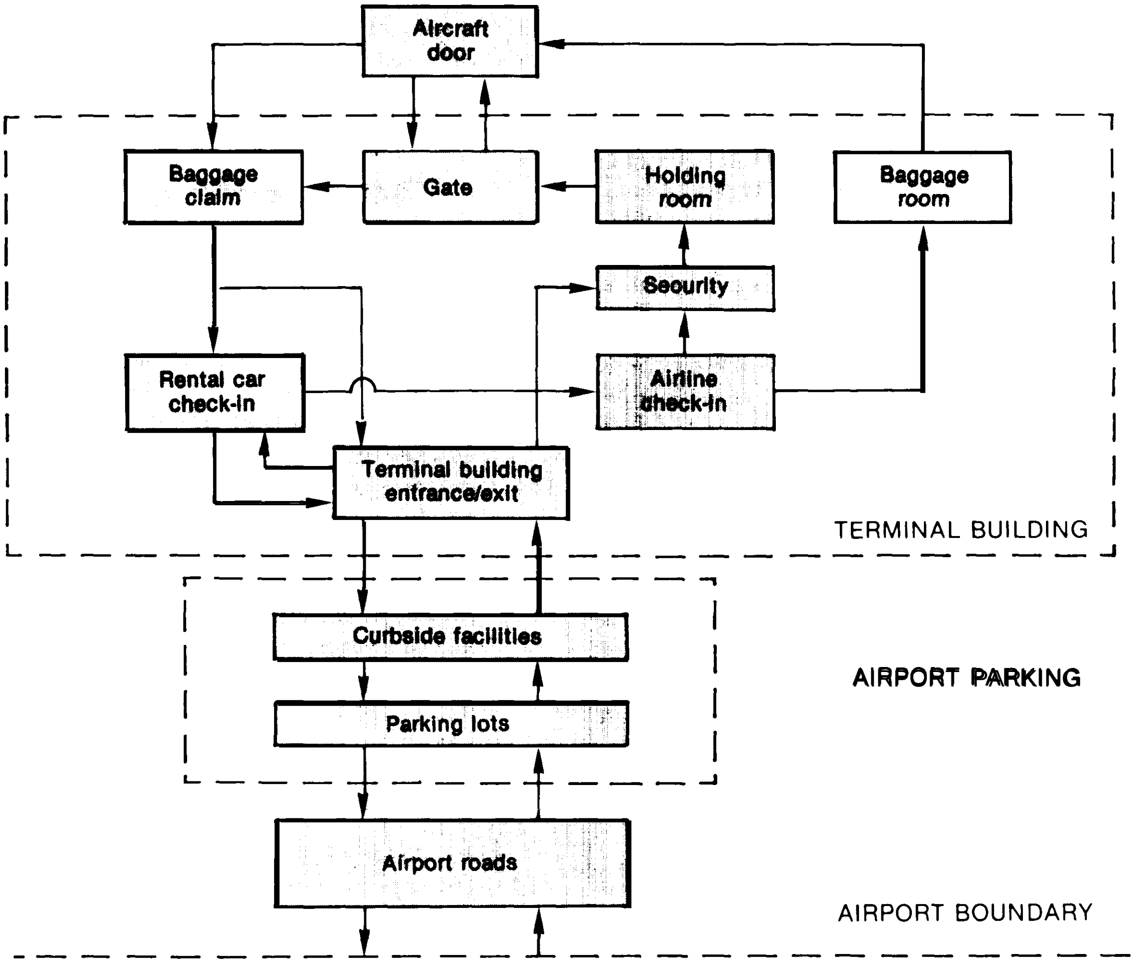
Terminal Facilities and Services

The airport terminal-the building itself and the paved areas surrounding it on the airside and the landside—is the zone of transition for passengers, providing the link between surface and air transportation. Design and operation of the terminal have an influence on both airside capacity and ground access and on overall throughput of the airport complex. This basic relationship, illustrated in figure 11, dictates that the design of the terminal complex must reconcile the requirements of three operational areas:

- airside—where aircraft are serviced and passengers board,
- ***terminal*** building—the collection point containing facilities for passenger processing and services during transfer between airside and landside, and
- landside—the area accommodating ground transportation (roadways, parking areas, etc.).

Basically, the terminal and associated landside facilities are long-term installations with relatively stable patterns of use. They are largely independent of the specialized aircraft and airline passenger processing functions that occur on the airside. In contrast, the airside is characterized by short-term, impermanent use which is closely tied to changing aircraft technology with a useful life of about 10 to 15 years. The essence of airport terminal design is to strike an appropriate balance

Figure 11.—Airport Landside Functional Flow



SOURCE: L. McCabe and T. Carberry, "Simulation Methods for Airport Facilities," in *Airport Landside Capacity*, Transportation Research Board, Spec!al Report 159, 1975"

between these somewhat contradictory requirements.[45]

The principal effect of the terminal on the airside is through the design of aprons and gates, which determines the number of aircraft that can be accommodated at one time and the turnaround time for passenger boarding and aircraft servicing. As seen in the previous section, gate and apron operations can also have a wider—though not major—effect on airside throughput. The impacts of terminal design usually do not extend beyond the apron and gate area, and terminal building characteristics have scant influence on the design of other airside components such as taxiways and runways.

Overall, the influence of the terminal on the functional requirements and performance of airside facilities is relatively small compared with the inverse effect that the airside exerts on the terminal.[4b] The primary purpose of the terminal is to transfer passengers and their baggage between surface and air transportation with minimum time, confusion, and inconvenience. The func-

[45]Leigh Fisher Associates, Inc., "Recommended Planning Criteria for New Passenger Terminal Facilities at Tampa International Airport," July 1963; cited in R. E. Horn and J. C. Orman, "Airport Airside and Landside Interaction," in *Airport Landside Capacity*, Transportation Research Board, Special Report 159, 1975.

[4"]Horn and Orman, op. cit.

tional requirements and choice of design for a terminal complex must take into account the passenger and baggage flows resulting from aircraft size, traffic mix, schedules of operation, and type of service provided (origin-destination or connecting flights). As a design task, this involves the integration of three major parts of the terminal: airside gates, passenger collection and service areas, and landside access and egress. Since these parts are highly interactive, it is important that the separation between them be kept to a minimum and that traffic flow smoothly among the parts.

This would be a fairly straightforward task were it not for the need to design the airside interface so that it can be adapted to accommodate continually changing aircraft technology, airline service patterns, and traffic volumes. At some large hubs, the steadily increasing size of aircraft and their fixed-point servicing requirements, when coupled with growing passenger and automobile traffic, have led to terminal complexes of a size that imposes inconvenience and delay on passengers. In response, airport designers have been forced to add an intermediate transportation mode within the terminal itself (moving sidewalks, transport buses, fixed rail systems, and other such people movers) to aid passengers in transferring between the airside and the landside.[47]

The discussion that follows touches first on general questions of terminal building design and then on technology of specific features that might be improved to facilitate passenger movement or to reduce passenger inconvenience and delay. It should be recognized that these aspects of design and operation will have little, if any, effect on airside capacity and throughput even though they might lead to substantial reductions in the overall trip time for air travel. It should also be recognized that such matters have been of little interest to FAA or to policymakers in the Federal Government. They are, of course, keenly important to airport operators and—to a lesser extent—airlines because they constitute investment needs that must be balanced against airside capacity expansion in the overall program of capital improvement for airports. Recent estimates indicate that over half of the large hub airports are experiencing congestion and delay within terminal buildings and that over *30* large and medium hubs are contemplating investments in terminal expansion or improvement, with a total cost of $4 billion.[48 49]

Terminal Building Design

Airport terminals can be grouped into four categories according to their basic design concept:

- ***centralized with finger piers—a*** common hall with branching corridors leading to aircraft gates;
- ***centralized with satellites—a*** central concourse surrounded by small, separate clusters of gates and waiting areas, each connected to the concourse by walkways or people movers;
- ***linear or gate arrival***—usually semicircular buildings with ground access on one side and aircraft gates on the other, designed so as to minimize walking distance through the terminal; and
- ***transporter***—a compact passenger facility with buses or special vehicles used for transport to a remote aircraft parking apron.

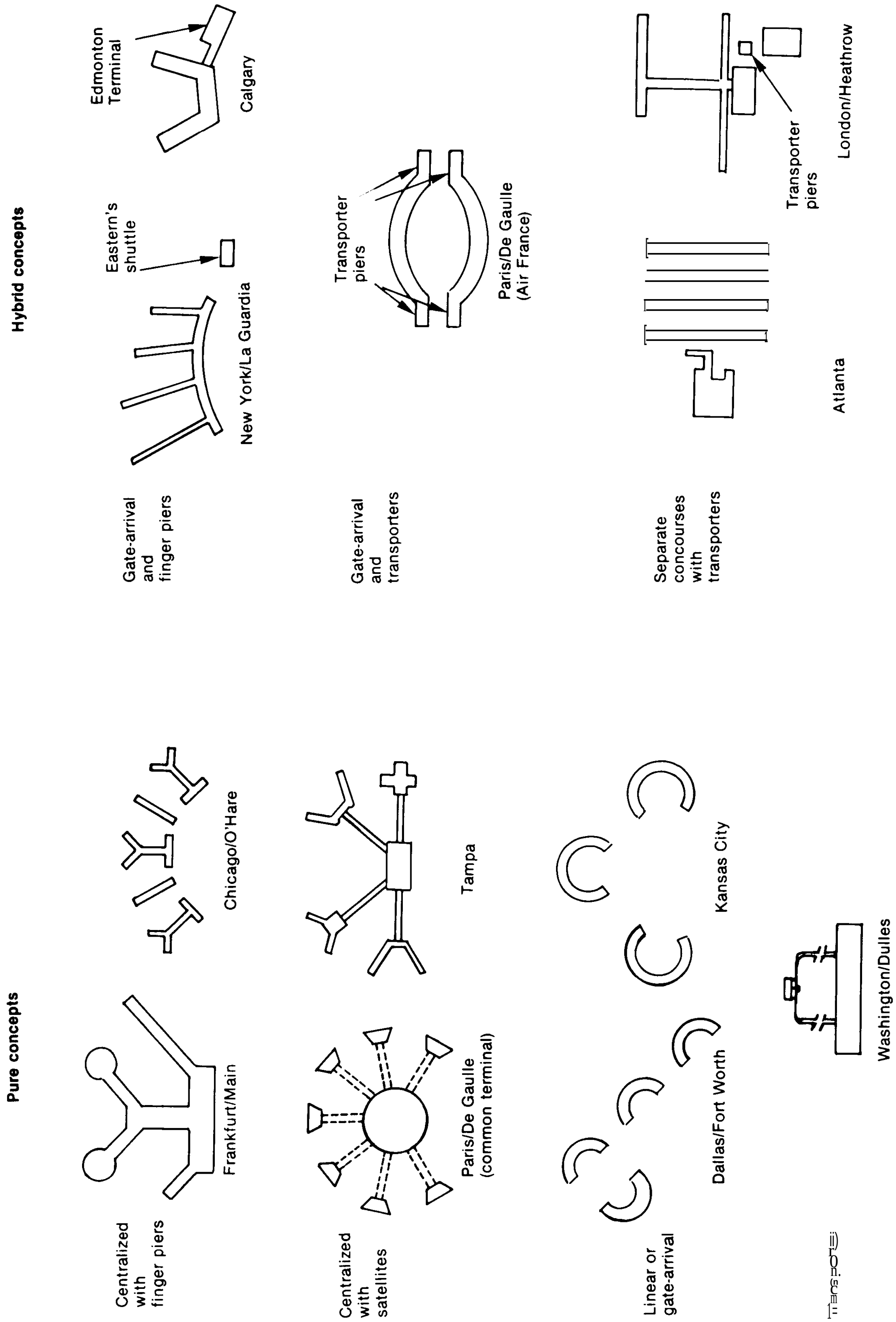
These concepts are embodied in pure form only at a few airports which have been built on entirely new sites. At most airports the design of the terminal building has evolved and been modified in response to traffic growth and local conditions, giving rise to a hybrid that incorporates features of two or more of the basic concepts (fig. 12). At airports with land available adjacent to the existing facility, the design has tended to evolve into a finger pier arrangement, sometimes with separate unit terminals for commuter airlines or groups of new air carriers for whom there is not room in the main terminal. At airports where the terminal has grown to the limits of available land area, satellite terminals and remote hardstand parking have typically developed. Transporter and satellite terminal concepts utilizing people-

"M. Brink and D. Maddison, "Identification and Measurement of Capacity and Levels of Service of Landside Elements of the Airport," in ***Airport Landside*** Capacity, op. cit.

[48]*Report of the Industry Task Force on Airport Capacity Improvement and Delay Reduction,* op. cit.

[49]*Metropolitan Area Assessment Report* (Washington, DC: Federal Aviation Administration, Office of Airport Planning and Programming, April 1982).

Figure 12.—Airport Terminal Design Concepts



SOURCE: R. De Neufville, *Airport Systems Planning* (London: MacMillan, 1975).

moving equipment have been adopted at some airports to enhance the attractiveness of the terminal for passengers since they eliminate the extreme walking distances associated with long piers extending from central terminals. The transporter concept has the additional advantage of allowing a small terminal building, free of the constraints imposed by aircraft parking gates.

At a new site, the choice of terminal design is largely dependent on the volume and type of traffic expected. Centralized terminals are best for airports with a high proportion of transferring passengers, especially those changing from one airline to another. The gate-arrival design works well for origin-destination passengers and commuter airlines since it shortens the transit from the curbfront to the aircraft gate. The unit terminal with passenger transporters can handle peaks of traffic efficiently, but only if the traffic is made up largely of origin-destination passengers. In the expansion of existing terminals, these same considerations come into play, but the choice may be constrained by the design of the existing structure, the available land, and the on-airport road net.

Misestimation of traffic volume or the type of service to be provided can sometimes render even a well-conceived design inefficient or inappropriate. Dallas-Fort Worth Airport, for example, was planned with the expectation that origin-destination traffic would predominate. Since airline deregulation, the growth of hubbing—which typically requires passengers to change planes at the airport—has thwarted the effectiveness and convenience of the design. At O'Hare, the need to adapt the concourses for passenger security screening has created long and circuitous routes for transferring passengers. Efforts to encourage greater use of Dunes Airport for short and medium-length domestic flights have been hindered by the design of the terminal since the need to go from apron to terminal and back again by mobile lounges greatly increases the time and inconvenience of interline connection. Kennedy Airport, planned with separate terminals for major airlines, is well-suited for origin-destination passengers and for transfers to flights on the same airline, but very inconvenient for interlining domestic passengers and those coming in on international flights and continuing to other U.S. destinations.

Clearly, no single design is best for all circumstances. Traffic patterns, traffic volume and flow characteristics (e.g., peaking), the policies of individual carriers using the airport, and local considerations (e.g., esthetics and civic pride) dictate different choices from airport to airport and from one time to another. The airport planner, who is required to anticipate conditions 10 to 15 years in the future, must often resort to guesswork. Even if the guess is right initially, conditions change—as the above examples illustrate—and result in a mismatch between terminal architecture and the traffic to be served. To guard against this, airport planners now tend to favor flexible designs that can be expanded modularly or offer the opportunity for low-cost, simple modification as future circumstances may demand.

Terminal Services

These precautions, of course, are of little help in terminals that have already been built for one type of traffic but forced to accommodate another, or where demand outstrips capacity. Many airports will continue to suffer from inappropriate or outdated designs that lead to congestion and delay in passenger areas and diminish the overall utility of the airport as a transportation hub. For such airports, an alternative to a new or expanded terminal as an avenue of relief from congestion is to correct specific features that cause bottlenecks by applying improved technology that will compensate for design inadequacies. Some of these partial technological remedies are discussed next.

Passenger Movers

To speed passenger movement through the terminal and to lessen the inconvenience of walking long distances to board flights or to reach landside exits, some airports have turned to passenger movers.[50] Several technologies are available, covering a broad spectrum of cost. They in-

[50] At airports designed as unit terminals with remote aircraft parking, some form of passenger mover is, of course, a necessity.

elude buses, mobile lounges, moving sidewalks, and automated guideway systems. The choice of any of these involves a tradeoff between their service characteristics and cost (capital and operating) against those of adding new gates or terminal wings. This tradeoff is very sensitive to the rate of use, the specific vehicle chosen, and the cost of gate construction. Passenger movers tend to be more cost effective than gates if the rate of use is high. Variation in traffic load is also important, and analysis indicates that passenger movers are best suited to serving those locations and intraterrninal trips where there is a great fluctuation in demand. 5l

Buses and mobile lounges add to airside surface traffic; they are also labor-intensive and therefore costly to operate. For these reasons, airports with finger piers or satellite terminals have sometimes opted for automated vehicles such as moving sidewalks or guideway transit systems. Moving sidewalks are not an entirely satisfactory option. They are costly to operate and maintain, and their speed must be slow to allow passengers to board and descend safely. Thus, they provide only a marginal decrease in passenger movement time, although they greatly reduce the effort of long passages through the terminal complex. There is some experimentation with accelerating devices and transition techniques that would permit greater line speeds and still afford comfortable and safe boarding and descent. If these experiments are successful, the utility of moving sidewalks will be greatly increased.

For longer distances or where the volume of traffic is large, automated guideway systems are sometimes practical. Several different types are available, varying principally in terms of propulsion, vehicle size, and complexity of the guideway network and control system. Reliability and train control system design were problems in the first systems installed at airports (Dallas-Fort Worth, for example), but the technology has improved rapidly and now appears to give good service at airports such as Atlanta and Orlando. Capital costs of vehicles and guideway construction remain high, and they are still difficult and expensive to maintain. The view of airport designers is that these systems are cost effective only at a few very large airports, and there is reluctance to utilize this technology except as a last resort.

51 R. De Neufville, Airport Systems Planning (London: Macmillan, 1976); pp. 118 ff.

Ticketing

The ticket counter serves three major functions: ticket transactions, baggage check-in, and flight information. Of these, the most time-consuming are ticket transactions (which often include baggage check-in for the individual passenger). Technologies to speed ticket counter operations or to eliminate them altogether are being explored, both to reduce delays in the terminal and to cut airline personnel costs. Computerized ticket systems available today offer passengers advance reservations and sales, preassignment of seats, and automatic tagging of baggage. They will probably be used more widely by the major air carriers, some of whom may also offer them to small carriers under a service contract. A companion development is the computerized aircraft manifest that has been implemented by some airlines. These systems typically produce aircraft load sheets, passenger manifests, and automatic telex reservations. They greatly reduce the administrative work at the counter and expedite airline dispatch from the gate.

Ticket dispensing machines similar to those used for banking are now in limited use by some airlines at a few locations and for selected routes. Improvement of these machines so that they can handle a larger number of routes and fare structures could promote wider use, with corresponding reduction in the amount of activity that must be conducted at the ticket counter. This technology could also be extended to sale of tickets off the airport property. With the deregulation of travel agencies, the range of services provided by these firms has expanded, offering passengers an alternative to purchasing tickets at the airport. Travel agents now account for more than ***60*** percent of airline ticket sales in the United States. The entry of mass-marketing firms such as Sears and Ticketron into the air travel field may further decrease the need for ticketing at airport terminals, reducing airline personnel and equipment requirements, and alleviating congestion at terminal ticket counters.

Baggage Handling

The handling of baggage, especially baggage claim at the end of a flight, is a common and= for passengers—particularly onerous form of delay in terminals. At most airports, baggage handling is the responsibility of the individual air carriers, but some airports operate a consolidated baggage service—either with airport personnel or on a contract basis—in the interest of speeding the process and reducing the cost. Reduction of the delays and passenger inconvenience associated with baggage handling has been approached in three ways: more efficient procedures for check-in and claim, automated handling and sorting, and elimination of some baggage handling by encouraging carry-on luggage.

One of the simplest and most widely applied methods to expedite baggage handling is curbside check-in. This separates baggage handling from other ticket counter and gate activities, thereby disencumbering those locations and allowing baggage to be consolidated and moved to aircraft more directly. Another method is replacement of the baggage claim carrousel with loop conveyor belts that allow passengers greater access to their luggage without increasing the size of the claim area.

Sorting baggage, moving it to and from the apron, and aircraft loading and unloading are time-critical and labor-intensive operations. Technologies to improve this process include high-speed conveyors to transport baggage between the terminal and the flight line, often used in conjunction with pallets or containers that can be put on and taken off aircraft with labor-saving equipment. Computerized sorting equipment, capable “ of distributing bags with machine-readable tags, has been installed at some airports. These devices are not yet fully satisfactory since the encoding and reading of tags are time-consuming and somewhat unreliable.

To handle peak loads, automated systems must have a larger capacity because they are less flexible than manual systems. Redundancy is a must with an automated system, which increases the capital cost. As these automated systems improve and come into wider use, **a** further step is to install self-service systems that allow passengers to check and claim luggage either in the terminal, at the curbside, or at remote locations on or off the airport property. While such a development would be primarily a labor-saving measure by airlines and airport operators, it might also speed transit through the airport for many passengers.

The functional equivalent of automated, self-service baggage handling systems—and one that may be cheaper and more reliable—is expanded capacity within the aircraft for carry-on luggage. With the advent of stronger and lighter materials, aircraft designers have been able to reconfigure cabins to provide larger and more secure storage space on board. New aircraft universally contain such overhead storage bins, and many airlines have converted older aircraft to incorporate similar enclosed overhead storage. A further development might be provision of a common baggage space either within the cabin or in a special module that could be transferred to the cargo bay. Passengers entering and leaving the aircraft would pass through this space and handle their own baggage.

Passenger Security Screening

To deter aircraft hijacking, the Federal Government has established regulations to ensure safe passage for the traveling public. These regulations, implemented in January 1973, require security screening of passengers and carry-on articles. Over the past decade, security screening has become an accepted fact of life for air travelers and a problem for airport designers and operators since the security checkpoints tend to disrupt passenger flow and—in some instances—force remodeling of the terminal.

The equipment used today consists of X-ray machines with moving belts and magnetometers for metal detection. This system, which replaced manual search, significantly increased the capacity and capability of the screening process. The chief drawback of the existing equipment is that, while effective in detecting metal, it has limited capability to detect explosives and volatile substances.

New technology for screening cargo and baggage is being investigated. The aim is both to speed the screening process and to increase the thoroughness and reliability of detection. The new

Photo credit' Los Angeles Department of Airpofls

Customs and immigration: once gracious . . .

systems under development make use of improved bomb and explosive sensing techniques such as vapor detection, bulk detection, and computerized tomography.

Federal Inspection Service

The United States has ***24*** airports of foreign entry where Federal Inspection Service (FIS) for clearing passengers and cargo is provided by Customs, Immigration, and Agriculture officials. Clearance procedures are rigid and time-consuming, and FIS processing has been a major cause of delay at high-volume ports of entry.

The U.S. Department of State is now issuing machine-readable passports that may help expedite FIS clearance. Additional procedures and technologies are being investigated to achieve greater capacity, reduced clearance time, and higher agent productivity. Alternative procedures and physical arrangement of facilities are the principal areas of concentration.

The system employed at most airports of entry today is the Customs Accelerated Passenger Inspection Service (CAPIS), which provides separate immigration and customs checkpoints. CAPIS is highly time-consuming for passengers and labor-intensive to operate. A new system, referred to as One Stop, combines immigration and customs functions at a single station. Although promising, this system has not yet achieved its expected capacity in tests and demonstrations. Chicago O'Hare and Houston Intercontinental Airport are experimenting with another approach that uses a modified version of the standard European system known as "Red-Green," where travelers who do not have goods to declare are separated from those who do, with only the latter passing through a secondary inspection station. Also under study are hybrid systems that combine features of CAPIS, One-Stop, and the "Red-Green" concepts.

Photo credit: U.S. Depatiment of Transportation

. . . now streamlined

LANDSIDE ACCESS

It is a truism that nearly every airplane trip begins and ends with an automobile ride, and there is no clearer manifestation of our dependence on the automobile than at the terminal curbside and on the access roads to the airport. While the figures vary among airports, it is generally estimated that over 90 percent of all airline passenger trips to and from airports are by private automobile or taxi. At medium and small airports, the figure is probably close to 100 percent since these communities tend not to have well-developed public transit providing a practical alternative to the automobile.

A further indication of the symbiosis between the airplane and the automobile is the emergence and growth of the car rental industry. This business has its origin in the need for air travelers to have transportation to and from airports in cities away from home. While many car rental firms have since branched out into other markets, the bulk of their business is still rentals to airline passengers, and revenues from this activity are a major source of income for airport operators.

Not all trips to the airport are made by airline passengers or those who come to meet travelers or drop them off. For airport workers (accounting for perhaps one-third of all access trips) and calls by delivery vans, service representatives, and others with business on the airport property (also about one-third of all access trips), the automobile likewise predominates. Some (especially airport workers) come at times when public transit is not available or when service is infrequent, and they have almost no alternative but to drive to the airport and park.

At many airports, automobile traffic is a principal source of landside congestion and delay. Of the 33 major airports surveyed by the Industry Task Force on Airport Capacity Improvement and Delay Reduction, the most common problem areas were at the curbside (20 airports) and on airport circulation and access roads (11 airports) .52 Similar findings were obtained in a survey of airports performed for this assessment. Of the 39 large, medium, and small hubs and commuter airports sampled, 23 indicated present or anticipated problems with parking, curbfront circulation, on-airport roads, or access routes. A recent review of airport problems by FAA found that 23 of 41 major metropolitan area airports are suffering from capacity constraints imposed by landside congestion or lack of adequate access.[53]

Perhaps the best known example of the effect that landside access can have on airport operations is at Los Angeles International Airport (LAX). Because of limited capacity of airport circulation roads and the inability of the freeways and city streets near the airport to absorb a greater volume of automobile traffic, regional transportation authorities imposed a capon aircraft operations and annual passenger volume permitted at the airport. Much of the impetus for the recent expansion at LAX was to relieve this landside constraint, and a large share of the $700 million modernization program now nearing completion there was expended to double-deck roads leading to and from the terminal and to remodel the terminal complex so as to segregate arriving and departing automobile traffic .54

LAX is not an isolated example. Chicago O'Hare is proposing a $1 billion program of airport modernization, a large share of which will be to "bring aging and congested terminal and roadway facilities into balance with underutilized airside capacity. "5[5] St. Louis spent $78 million of the total ***$273*** million in funds programmed through 1983 on highways and airport frontage roads on or adjacent to the airport property.[sb] The Port Authority of New York and New Jersey has launched a $1.5 billion modernization plan for the three New York airports. Important parts of this plan are new roadways and local transportation to improve airport access and additional parking space around the terminals. [s']

Only a few landside improvements and airport access projects are eligible for Federal aid from the Airport and Airway Trust Fund. The Federal Highway Administration (FHWA) and the Urban Mass Transportation Administration (UMTA) also provide funds for landside development, and the airport operator or local airport authority contributes an important share through retained earnings and revenue bonds. Funding of landside investments is a complex multijurisdictional arrangement with wide variation from airport to air-

52 Report of the Industry Task *Force on Airport Capacity* Improve***ment and Delay Reduction,*** op. cit.

53 Metropolitan Area ***Assessment Report,*** op. cit.

54B. Sweetman, "The New LAX Prepares 1984," *hteravia,* July 1983, pp. 724-725.

55 J. Ott, "$1 Billion Upgrade Planned at O'Hare," ***Aviation Week & Space Technology,*** Aug. 8, 1983, pp. 35-36.

"J. Ott, "Expansion Eases St. Louis Congestion," ***Aviation Week & Space Technology,*** May 23, 1983, pp. 35-36.

"E. Kozicharow, "New York Port Authority Boosting Airport Capacity," ***Aviation Week & Space Technology,*** May 9, 1983, pp. 33-34.

port. The capital improvements sponsored by FAA are limited to on-airport roadways, guideways, and walkways. Off the airport property, projects to improve landside access may receive FHWA and UMTA grants or be supported by State and local funds[58] (see fig. 13).

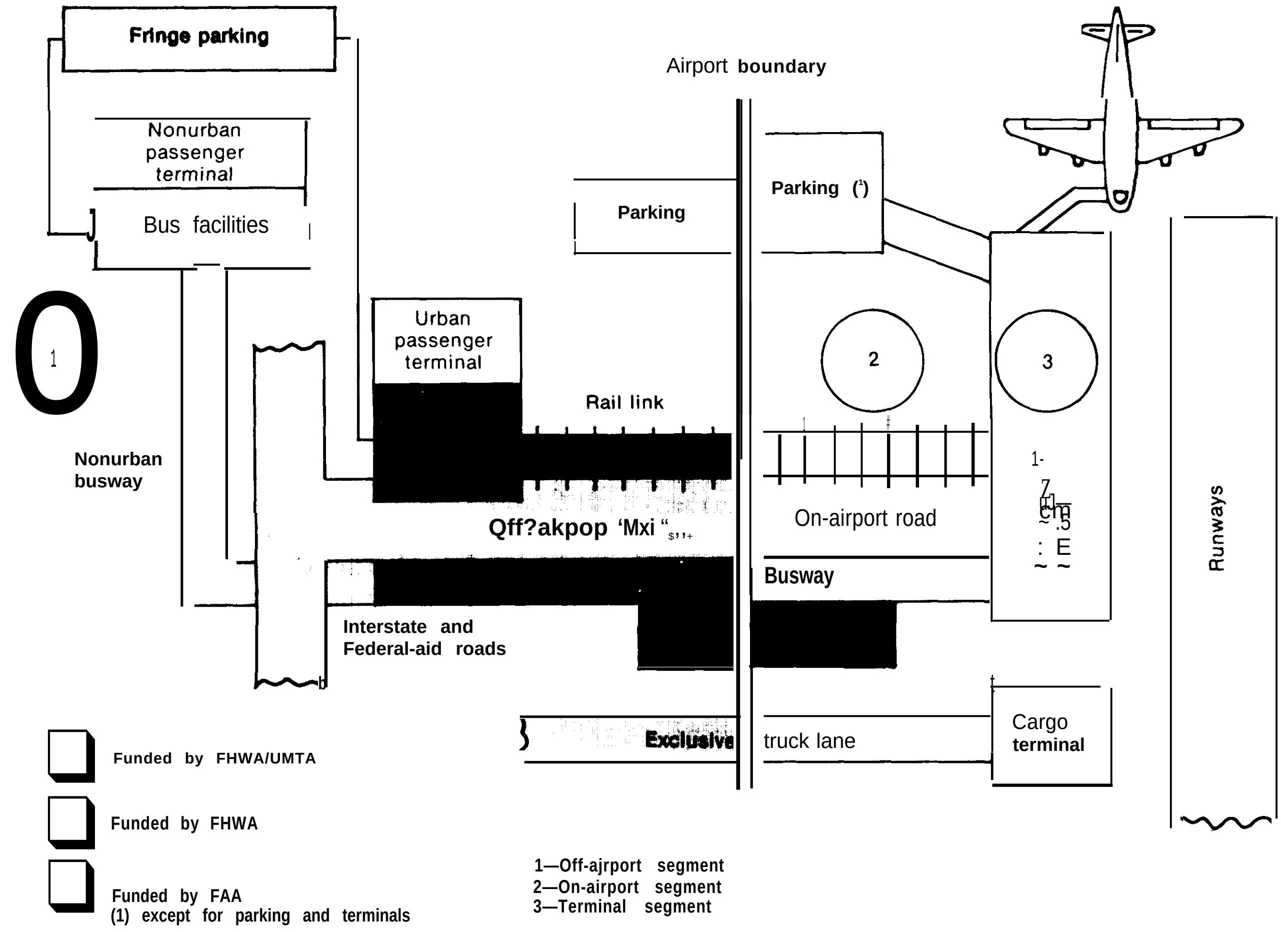
In general, the solution to landside problems does not appear to be ***new*** technology, but application of management techniques to make better use of the facilities available and construction of new facilities (based on existing technology) to add to landside capacity. In a larger sense, there is also a need to look at the question of airport access from the perspective of the regional transportation system and to find ways to integrate the airport more effectively into the urban area it serves. The sections that follow focus on approaches that can be taken or applied more widely to alleviate the problems of traffic flow on the airport property and to reduce the cost and inconvenience of access from the surrounding metropolitan area.

58A. J. Negrette, "Airport Landside and Off-Airport Interaction," in ***Airport Landside Capacity,*** op. cit.

Terminal Curbfront

The terminal curbfront provides temporary vehicle storage during passengers' transition between the terminal and the landside, and it ***is*** at the curbside that all passengers, except those using nearby parking or transit facilities, either enter or leave some form of ground transportation.

Figure 13.—Federal Capital Funding of Airports and Related Facilities



SOURCE: Transportation Research Board, *Airport Landside Capacity*, Special Report 159, 1975.

Curbfront congestion is a particularly difficult problem to solve because the facilities there are intimately tied to the design of the terminal building and airport characteristics such as activity level (peak passenger volume), user characteristics (mode of transportation, mix of passengers and well-wishers, and number of bags), and vehicle characteristics (type, number of passengers, and dwell time at the curb). The most practical approaches are physical expansion or modification of facilities and procedural changes to improve passenger and vehicle flow.

The most common forms of physical improvement are additional curbfrontage, bypass lanes, multiple entry and exit points in the terminal building, remote park and ride facilities, and pedestrian overpasses or underpasses. These improvements are intended to increase the utilization of curbfrontage by vehicular traffic or, in the case of park and ride, to reduce demand on the curbfront by diverting passengers from private cars to high-volume vehicles. Walkways to segregate foot and vehicular traffic promote pedestrian safety and facilitate roadway traffic by eliminating conflicts between pedestrians and vehicles.

In some cases, procedural changes—either alone or in conjunction with low-cost physical modifications such as signing or lane dividers—are an effective alternative to expensive construction or remodeling of the curbfront. For example, parking restrictions combined with strict enforcement will reduce curbside congestion and dwell time in discharging and boarding passengers. Short-term parking islands or reserved sections along the curbfront, defined by roadway marking or simple dividers, may segregate vehicles picking up or discharging passengers from those that must handle baggage or enter the terminal for brief errands. Similarly, separation of private cars from taxis, buses, and limousines can diminish conflicts among these kinds of traffic and improve the flow to and from the curbfront. An effective approach at some airports has been provision of bus service from remote parking to the terminal and regulations to discourage bringing private automobiles to the terminal building. None of these measures is a substitute for adequate curbside capacity, but they can lead to more efficient use of the facilities available and perhaps compensate for deficiencies in terminal and curbfront design.

Airport Ground Access

Aside from expansion or improvement of the road network leading to the airport, most effort to facilitate airport ground access has focused on substitutes for the automobile. Bus or airline limousine service has proved workable in some cities, but patronage is generally low because of the infrequency of service or the inconvenience of getting between origin or destination and a centrally located bus terminal. Helicopter shuttle between the airport and city center has been tried; but it is expensive, unreliable because of weather, and objectionable to the community because of noise.

A solution that has been advocated by many planners is a rail rapid transit system, either operated exclusively to and from the airport or as part of a regional network. Cleveland, for example, built a rapid transit extension to Hopkins International Airport in 1968; and the Washington, DC, Metro system includes a station near, but not at, the main terminal at National Airport. Proposals to provide such service-either by construction of a new line to the airport or by linking an existing line to the airport by a feeder bus—have been advanced for several other cities.[59]

In part, this interest has been stimulated by examples in foreign countries, which either have or are planning rail service to airports. Paris Charles de Gaulle Airport has a rail station a little over a mile from the terminal with connection provided by shuttle bus. Amsterdam (Schiphol), Birmingham, Dusseldorf, Frankfurt, Gatwick, Heathrow, Orly, Vienna, and Zurich already have rail stations in or immediately adjacent to the airport terminal. Cologne and Munich 2 will have such service by 1985. Haneda Airport in Japan has a monorail

59 A survey by the U.S. Aviation Industry Working Group in 1979 found that eight U.S. airports-AtIanta, Baltimore-Washington International, Kennedy, Los Angeles International, Oakland, Miami, Ontario (California), and San Francisco—were considering some form of rail link. Of these, Kennedy and Oakland have established such service, but in both cases it is by a bus connection with transit station off the airport property.

line from the center of Tokyo to the terminal, which brings passengers to within 300 ft of check-in counters. Toronto and Montreal (Dorval) in Canada have rail lines that are close by but not integral with the terminal (a connecting bus or taxi trip is needed to complete the link), and Montreal International (Mirabel) will soon have direct service from the airport to the downtown area with 13 intermediate stops. Figure 14, a cutaway drawing of the Zurich airport, illustrates the concept of the integrated airport-rail complex.

De Neufville points out that rail transit is not a universal solution to the airport access problem.[60] In most major U.S. cities, there is not a regional rail network to be tied into the airport; and, without it, there is little prospect that an exclusive line between downtown and the airport would be viable. Few passengers want to travel between the airport and the central business district, and even fewer want to go during rush hour. Rail transit, with its fixed routes and corridor structure, does not serve well in the U.S. setting, where there is wide dispersion of origins and destinations for airport passengers. The capital costs of such systems are likely to be high, and it is doubtful that operating expenses could be covered from the fare box, necessitating subsidy from the municipality or the airport. There may be public resistance to building a system to serve airport users exclusively when other parts of the metropolitan area could profit perhaps more from rail rapid transit service. Finally, the service characteristics of rail transit do not lend themselves particularly well to airport trips. Passengers encumbered by baggage find rail transit inconvenient because there is no storage space on trains and narrow aisles may be difficult to negotiate with luggage in hand. If there are intermediate stops—as there almost certainly would be if the rail line attempts to serve more than a few who want to travel from city center to the airport—the trip is prolonged, and trains may be crowded with passengers riding for other purposes.

These arguments do not necessarily deny the validity of foreign experience, but they raise doubts about the viability of rail transit access to airports in this country—where we do not have the population densities, the existing urban rail network, and the tradition of public transit that are characteristic of Europe and Japan.

An alternative to rail transit, which accomplishes the same purpose but with greater flexibility and somewhat lower cost, ***is*** the remote airline terminal (fig. 15). This is a facility for processing arriving and departing passengers at a site off the airport property and transferring them to the terminal by group transportation. The off-airport terminal may include facilities for ticketing, baggage handling, and parking. Connection with the airport can be provided by public transit, special airport bus, or helicopter shuttle. The technology to implement this concept exists, and it has been tried in several cities.

The popularity of the remote terminal concept has waned in recent years, largely because indirect costs tend to offset the benefits. Trip origins and destinations are becoming more and more scattered throughout the urban area, to the extent that trips to and from the city center now account for less than a quarter of airport patronage. On the other hand, the increasingly tighter restrictions on airport terminal and landside expansion may make this concept worth reexamining, particularly if a way can be found to build and operate a network of small dispersed facilities adapted to the urban-suburban pattern of business and residence in major metropolitan areas.

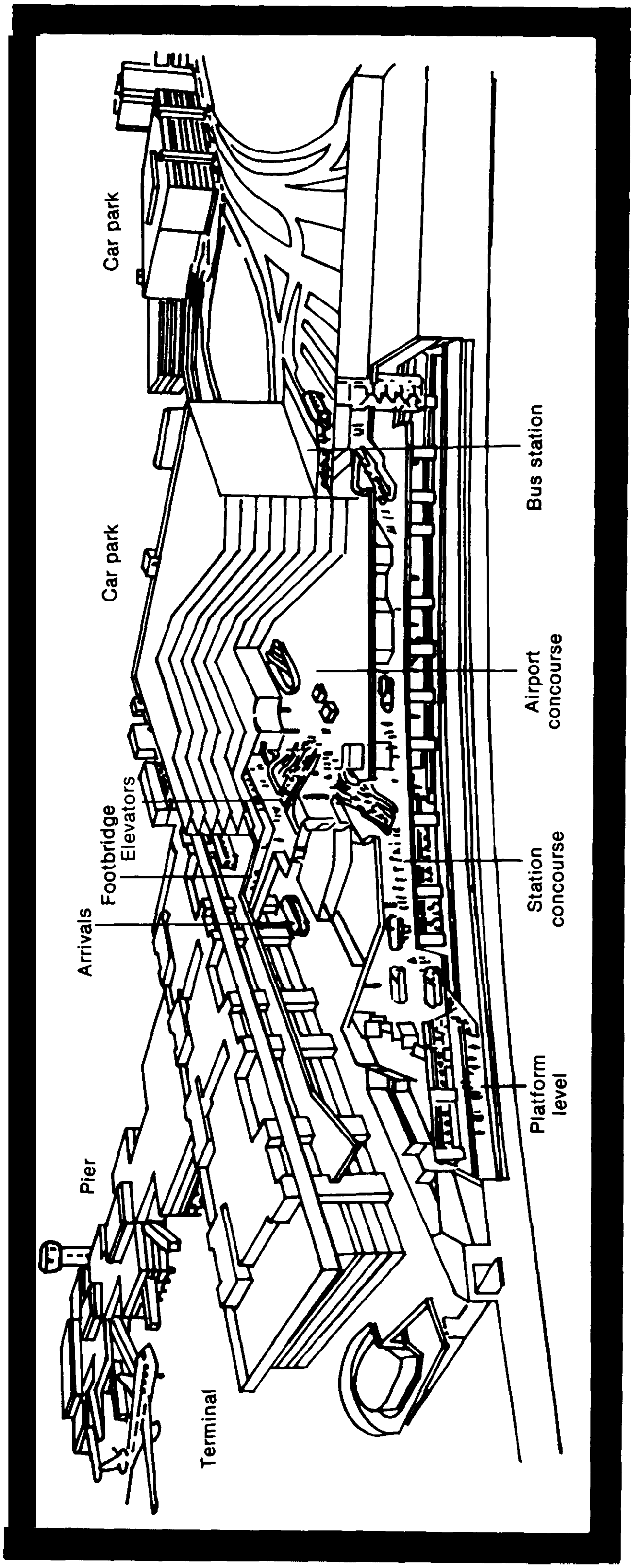
60 De Neufville, op. cit., p. 7.

APPLICATIONS OF TECHNOLOGY TO AIRPORT PROBLEMS

In the search for solutions to capacity and delay problems, the value of new technology is typically measured by its ability to achieve one or more of the following results:

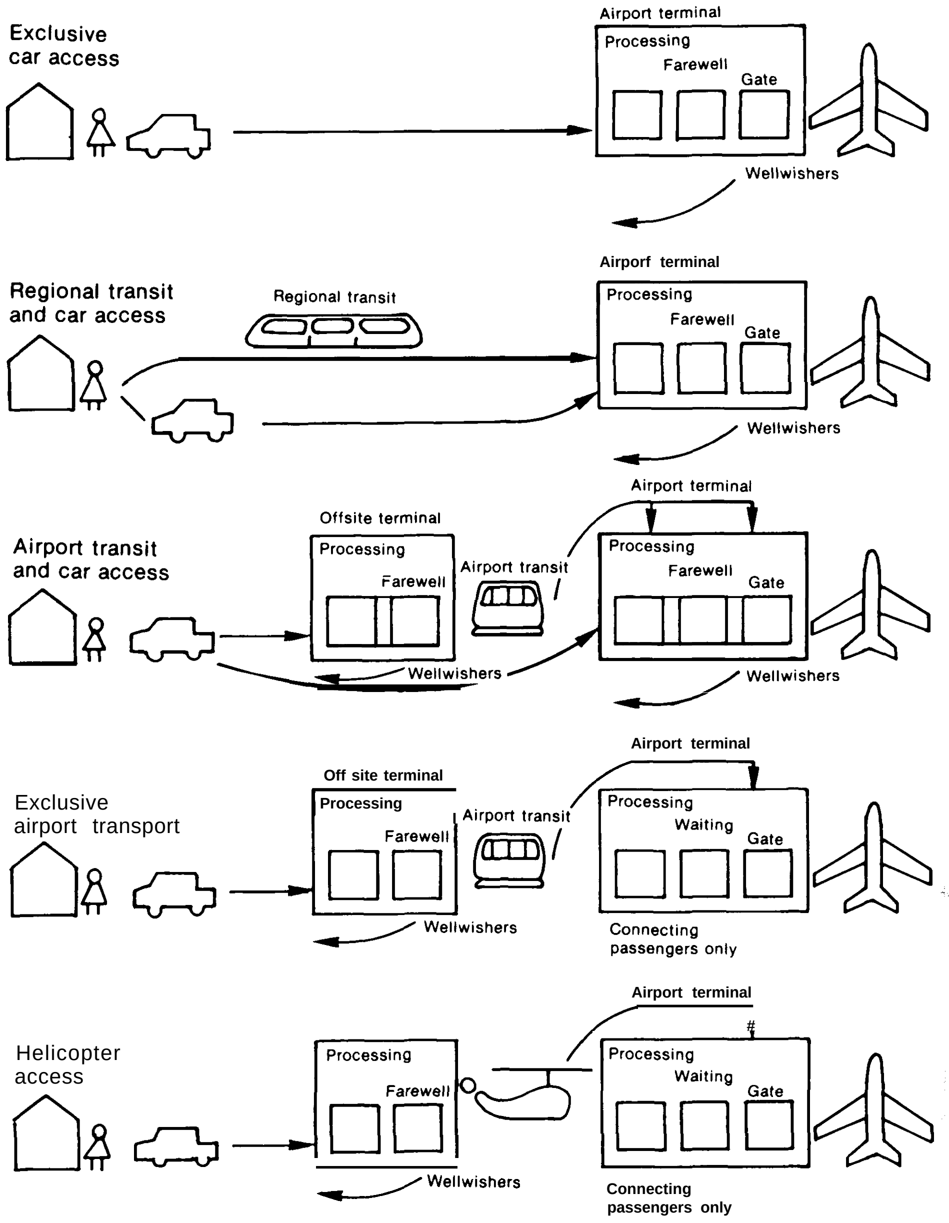
- increased capacity,
- higher efficiency (or throughput),
- greater safety,
- improved reliability,

Figure 14.—Zurich Airport and Rail Terminal Complex



SOURCE: European Conference of Ministers of Transport, *The Interface Between Air and Land Transport in Europe*, OECD Seminar Report, 1983.

Figure 15.—Off-Site Passenger Terminal Concepts



SOURCE: *Airpoti Landside Capacity,* **Transportation Research Board, Special Report 159, 1975.**

- greater accuracy,
- lower cost, and
- greater convenience.

The first two are direct benefits; they constitute relief of the problem of how to accommodate a higher level of demand. Safety is of prime importance, but it has little relationship to capacity and delay unless—as is often the case with procedures and rules—the requirement for safety precludes some measure for increasing capacity or throughput. Thus, if some new method of assuring safety is found and it also allows a subsequent change in procedures or utilization of airport facilities, safety improvements may give rise to a secondary capacity-related benefit. Reliability, accuracy, cost, and convenience are operational benefits. They are worth seeking in and of themselves, but they have little direct relation to capacity except insofar as they are attributes that lead to adoption of new technology or hasten its implementation.

The description of airside, terminal, and landside technologies presented in the first part of this chapter has touched on all of these prospective benefits. The emphasis has been on their potential to relieve capacity and delay problems, but other attributes have been cited where they appear relevant either to the future use of the technology or to the choice of one form of technology over another.

To provide additional perspective on the value of new and emerging technologies from the standpoint of capacity and efficiency, OTA surveyed a sample of 54 airports to determine the nature of the capacity and delay problems they now face or expect to face within 10 years. The survey also examined specific technological remedies that might be applied at each airport. The results of this survey, presented below, should not be interpreted as a prescription for planning and implementation of new technology at these airports or for the airport system as a whole. Rather, the survey attempts to show the general extent to which technology can improve the capabilities of the airport system and relieve congestion and delay.

No attempt is made to quantify the systemwide capacity increase or delay reduction that might result from application of new technology. These benefits are highly dependent on the operational conditions and physical characteristics of the individual airport. Although certain airports may be similar in some respects, there is little basis for concluding that what works at one will necessarily be of the same benefit to others. Thus, the tabulation of technological measures considered appropriate to the airports surveyed should be viewed simply as a general map of the forms of relief available and their possible application to the problems at representative airports.

Capacity and Delay Problems at Selected Airports

The airports surveyed consist primarily of large, medium, and small hubs, cross-categorized by the predominant type of traffic—long-, medium-, and short-haul. Also included are a few commuter service, reliever, and general aviation airports. The sample was not scientifically drawn and stratified to represent the airport system as a whole. In choosing these 54 airports, the intent was to include as many types as possible so as to indicate the general problems that airports face, but the focus was on those where congestion and delay tend to be greatest and have the more pronounced effect on air transportation—hence, the predominance of large and medium hubs in the sample.

Another consideration governing the choice of airports was other recent studies of airport capacity and delay. The report of the Industry Task Force on Airport Capacity Improvement and Delay Reduction contained a survey of 33 major airports; 19 of these are included in the OTA sample. A study of capacity and delay performed by FAA in 1981, examined 19 large airports, of which the OTA 'sample includes 13.[61] Another FAA study described airport problems in 41 metropolitan areas.[62] The OTA sample includes airports in 27 of these metropolitan areas, although not always the major airport or all the airports that FAA examined in their survey of the region. By overlapping the OTA sample with these other studies, the intent was to provide a cross-reference to these reports and an indication of the similarity of findings.

Table 15 indicates the nature of the capacity and delay problems found in the OTA survey. For each of the airports, deficiencies and bottlenecks in the following areas were identified:

- airspace,
- airfield,
- taxiway,
- apron,

[61] *Airfield and Airspace Capacity/Delay Policy Analysis*, FAA-APO-81-14 (Washington, DC: Federal Aviation Administration, Office of Aviation Policy and Plans, December 1981).

[62] *Metropolitan Area Assessment Report*, op. cit.

- gates,
- terminal building,
- parking,
- curbfront,
- on-airport roads,
- off-airport roads, and
- environment and noise.

Entries in the table indicate whether problems or limitations exist now (E) or are expected in the future (F). The most severe problem area is identified by a dagger. In all cases, this information was obtained from published sources (FAA reports, airport master plans, regional transportation studies, and the like), supplemented with telephone interviews to confirm the findings or to resolve differences among the source documents.

One of the highlights of this survey is that airspace and airfield problems are widespread and affect airports of all sizes. Of the 30 large and medium hub airports, 23 reported existing or future airside limitations. So, too, did 17 of the 24 smaller airports—an indication that this form of capacity limitation is not solely a function of the size of the airport. Gate and terminal problems, not surprisingly, are confined almost exclusively to larger airports served by major air carriers.

Perhaps the most striking result of the survey is that landside congestion and delay at the curbfront, in parking areas, and on circulation and access roads are of equal rank with airside problems at large and medium hub airports. The same number of airports—*23* large and medium hubs—cited the landside and the airside as problem areas. For 10 of these airports, the airside is or will be the most severe problem; for 8 it is the landside. This suggests that efforts to relieve congestion and delay should not focus entirely on the airfield and airspace. Landside access is also a pressing concern. The point is even stronger if the terminal building is grouped with the landside. The airside is the most severe problem area at 10 large and medium airports, while at 15 the problem is in nonaeronautical areas.

Prospective Technological Solutions

To complete the analysis, an assessment was made of the various forms of technology that might be applied to remedy problems at the sample airports. Table ***16*** lists the results. The specific problem areas cited earlier in table 15 have been combined into four general categories: airside, airport terminal, surface access, and environment and noise. Listed under these headings are technologies that have the potential to relieve or mitigate capacity and delay problems at the ***54*** sample airports.

Table ***16*** does not constitute a comprehensive list of all technologies that might be applied, only OTA'S estimate of those that offer the greatest promise or would be the most practical to implement. Identification of a technology as applicable to a given airport does not necessarily imply that FAA or the airport operator plans to implement it, nor that capacity and delay problems would thereby be "solved. " In some cases, the capacity gains provided by these technologies will be small, or they may provide benefits only in certain weather conditions or for a small part of the day. Thus, table **16** should be interpreted simply as a general indication of how the technologies described here can be related to a set of typical airports. For those familiar with conditions at these particular airports, table 16 may also provide insights on the relationships among various measures to increase capacity or to reduce delay and on the dynamics of airside, terminal, and landside interactions.

Table 5.—Airport Capacity Survey

Airport	Airspace	Airfield	Taxiway	Apron	Gates	Terminal	Auto parking	Curbfront	On-airport roads	Off-airport roads	Environ/ noise	Comments
Large hub:												
Long haul:												
Atlanta, GA	E,F	E,F†	—	—	—	—	—	—	—	—	E,F	Airfield saturation by 1987-90
Chicago O'Hare, IL	E,F	F	—	—	E†	E	[illegible]	E	E	E,F	E,F	Terminal expansion being initiated
Dallas-Fort Worth, [illegible]	E,F	E†	E	—	E	E	[illegible]	E	E	—	E,F	Early arrivals and schedule banking congests airfield
[illegible]	—	E,F	—	—	E,F	E,F	[illegible]	E,F	—	E,F†	E,F	Many interim improvements to be made
[illegible] Metropolitan, MI	—	F	—	—	E,F†	F	[illegible]	F	E,F	E,F	E,F	New South Terminal would solve most problems
Houston Intercontinental, TX	E	E†	—	—	—	E	—	—	—	—	E,F	Needs new runway
Las Vegas McCarran, NV	—	F	—	—	E	E†	[illegible]	E	E	E	—	Terminal expansion being started
Los Angeles, CA	E,F†	—	E	—	E	E	—	E	—	E,F	E,F	Annual passenger cap; terminal and access road expansion just completed
Philadelphia, PA	[illegible]	—	E	—	—	—	—	—	—	E†	E,F	Tie-in to I-95 needed; regional air traffic problem with New York and Cleveland
St. Louis Lambert, MO	—	—	—	[illegible]	[illegible]	[illegible]	[illegible]	—	E	—	E,F	Terminal expansion under way; roadway construction started
Medium haul:												
La Guardia, NY	[illegible]	F	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	E†	E,F†	E,F	Limitation on type of aircraft that can use airport
Santa Ana, CA	[illegible]	E,F	[illegible]	[illegible]	[illegible]	[illegible]		E,F	E	—	E,F	Curfew; departure quotas; large number of GA operations
Washington National, [illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	E	E,F	E,F	E,F†	Annual passenger cap; curfew; and limitation on type of aircraft that can use airport
Short haul:												
Chicago Mid[illegible]	[illegible]	[illegible]	E	—	[illegible]	E	[illegible]	F	[illegible]	E	[illegible]	Terminal and airfield improvements planned
Detroit City, MI	—	[illegible]	—	[illegible]	[illegible]	—	[illegible]	—	[illegible]	—	—	Severe noise problem; landlocked
Houston Hobby, TX	E	[illegible]	F	[illegible]	[illegible]	E	[illegible]	E	[illegible]	E,F†	E,F	Airside, terminal, and parking construction under way
Long Beach, CA	[illegible]	—	—	—	—	—	—	—	—	—	E,F	Annual passenger cap
Medium hub:												
Long haul:												
Baltimore-Washington International, MD	[illegible]	—	—	—	—	—	[illegible]	—	—	—		Airfield and terminal expansion under way
Memphis, TN	—	[illegible]	—	—	—	—	—	—	—	—	—	Closely spaced runways constrain IFR operations
Milwaukee Mi chell WI	—	—	—	—	—	[illegible]	[illegible]	—	—	—	—	Terminal expansion under way
Orlando, FL							[illegible]	—	—	—	—	Expansion planned to meet future needs

†Most severe problem.
E = Problems or limitations are now being experienced in this area.
F = Problems or limitations are anticipated for the future in this area.

SOURCE: Office of Technology Assessment.

Table 15.—Airport Capacity Survey (continued)

Airport	Airspace	Airfield	Taxiway	Apron	Gates	Terminal	Auto parking	Curbfront	On-airport roads	Off-airport roads	Environ/ noise	Comments
Reno, NV	—	[illegible]	—	—	—	—	[illegible]	—	—	E	—	New runway to be built; terminal recently expanded
Salt Lake City, UT	—	[illegible]	—	[illegible]	[illegible]	E	—	—	—	[illegible]	I	Expansion program started
San Diego, CA	E	—	—	—	—	—	[illegible]	—	—	[illegible]	I	No tie to Interstate; backup from LAX and Denver flow control
San Jose, CA	—	—	—	E	E	E	—	—	—	—	[illegible]	Expansion under way; curfew in effect 11:30 p.m.-7:30 a.m.
West Palm Beach, FL	—	[illegible] +	E	[illegible]	E	[illegible]	[illegible]	E	[illegible]	[illegible]	[illegible]	Expansion planned; GA reliever needed
Medium haul:												
Buffalo, NY	—	I	—	—	—	[illegible]	E	—	[illegible]	—	—	Master plan being prepared
Charlotte, NC	—	I	E	E†	E	—	—	—	—	—	E,F	Apron, taxiway, and concourse expansion under way; noise abatement plan in effect
San Antonio, TX	[illegible] +	—	—	—	—	—	—	—	—	—	—	Airspace conflicts with military bases; new terminal being built
[illegible]	—	—	—	—	—	E	—	—	—	[illegible]	—	Terminal expansion started
Small hub:												
Daytona Beach, FL	[illegible]	—					—	—	—	—	—	Converging approaches; separate short runways; reduced separation; MLS
Ontario, CA	—	—	—	[illegible]	—	[illegible]	—	—	—	—	E,F	Annual passenger cap; terminal expansion planned
Commuter service:												
Anchorage Merrill, AK	[illegible]	—	—	E	—	—	—	—	[illegible]	I	I	Complex VFR airspace; other airports in proximity
Chicago Meigs, IL	E,F†	E,F	—	—	—	—	—	—	—	I	I	Closes at 9:00 p.m.
Farmingdale Republic, NY	E,F†	E,F	E	[illegible]	—	—	[illegible]	—	—	—	[illegible]	Saturated airspace; heavily peaked demand; landlocked
For Worth Meecham [illegible]	—	—	—	[illegible] +	—	—	—	—	—	—	—	Airport near capacity; shortage of hangars and tie-downs
[illegible]	[illegible]	[illegible]	—	[illegible]	—	—	—	—	—	—	—	[illegible]andlocked; limited expansion planned
Houma, L[illegible]	—	—	E†	E	—	—	—	—	—	—	—	Needs new parallel taxiway
Reliever:												
Arapahoe County, CO	F	E,F	—	[illegible]	—	1	[illegible]	—	—	[illegible]	—	[illegible]vailable land and ground access are biggest problems
Baltimore Glenn L. Martin, [illegible]	—	III	E	1	—	—	—	—	—	—	—	
Crystal, MN	E		—		—	—	—	—	—	—	—	
Dallas Addison, TX	E	[illegible]	—	[illegible]	—	—	—	—	—	—	—	Regional IFR problem; affected by DFW operation
[illegible]	E,F		—	[illegible]	—	—	—	—	—	—	—	[illegible]andlocked; no expansion possible
Fort Lauderdale Executive, FL	—	F	—	E,F†	—	—	—	—	—	—	E,F	

†Most severe problem.
E = Problems or limitations are now being experienced in this area.
F = Problems or limitations are anticipated for the future in this area.
SOURCE: Office of Technology Assessment.

25-420 0 - 84 - 8

Table 15.—Airport Capacity Survey (continued)

Airport	Airspace	Airfield	Taxiway	Apron	Gates	Terminal	Auto parking	Curbfront	On-airport roads	Off-airport roads	Environ/ noise	Comments
Hartford Brainard, CT	E,F	E,F	–	E,F	–	–	–	–	—	—	E,Ft	Severe noise problems; landlocked
Kansas City Downtown, MO.	—	—	—	—	—	—	—	—	—	—	—	Ample capacity
Mesa Falcon, AZ	—	Et	–	E	–	E	E	–	·	—		New runway to be built; hangar facilities and fixed base operator space needed
Novato, CA	E,F	E,F	E,F	E,Ft	–	–	–	–	—	E,F		Landlocked; adjacent land is too expensive; wetlands laws may preclude further expansion
Van Nuys, CA	—	—	—	—	—	—	—	—	—	—	E	Airport saturated; no further growth is projected; 74 dBA noise limit
General aviation:												
Aurora, OR.	—	—	—	—		—	—	—	—	—		
Carlsbad, CA	E,F	E,F	E,F	E,Ft	=	–	–	–	—	—	E,F	Landlocked; local ordinance prohibits airport expansion
Cincinnati Lunken, OH	—	F	E	E,F	–	–	E,Ft	–	—	—	—	Landlocked
Greeley-Weld County, CO	E,F	E,Ft	–	E,F	–	–	E,F	–	—	·	—	Needs parallel runway and additional land; constrained by two other airports
Vero Beach, FL.	—	E,Ft	E,F	E,F	–	E,F	E,F	E,F	E,F	E,F	E,F	Maior expansion ~roaram needed

tMost severe problem.
E = Problems or limitations are now being experienced in this area.
F = Problems or limitations are anticipated for the future in this area.

SOURCE: Office of Technology Assessment.

Table 16.—Airport Technology Summary

Airport	Rank order by operatlons[a]	Airside	Airport termmal	Surface access	Environmental/no6e
Large hub:					
Long haul:					
Atlanta Hartsfield, GA	2	E,F† Reduced separation, aircraft reclassification, TMS, ASR-9, WVAS, ASDE-3, TAGS	—	—	E,F Departure thrust management, preferential flight paths
Chicago, O'Hare, IL	1	E,F Converging approaches, triple approaches, separate short runways, reduced separation, aircraft reclassification, runway configuration management, MLS, TMS, ASR-9, ASDE-3, TAGS, airport surface condition information, WVAS	Et Curbfront improvements, termmal conftguratlon, FIS procedures	E,F Roadways, mass transportation, helicopter shuttle	E,F Departure thrust management, preferential runway use, preferential fllght paths
Dallas-Fort Worth, TX	7	E,F† Triple approaches, reduced separation, aircraft reclassification, separate short runway, WVAS	E Curbfront Improvements, termmal configuration	E Roadways, mass transportahon	E,F Preferenhal runway use, departure thrust management, preferenhal flight paths
Denver Stapleton, CO	6	E,F Converging approaches, dependent parallel approaches (with operational solution to wake vortex), MLS, TMS, ASR-9, ASDE-3, TAGS, WVAS	E,F Curbfront Improvements, terminal configuration	E,Ft Roadways, mass transportation	E,F Departure thrust management, preferential runway use, preferential flight paths

[a]Federal Aviation Administration, *FAA Air Traffic Activity, FY 1982*.
†—Most severe problem.

SOURCE: Office of Technology Assessment.

Table 16.—Airport Technology Summary (continued)

Airport	Rank order by operations[a]	Airside	Airport terminal	Surface access	Environmental/noise
Detroit Metropolitan Wayne, MI	39	F Independent parallel approaches, reduced separation, aircraft reclassification, triple approaches, TMS, ASR-9, WVAS	E,F† Curbfront improvements, terminal configuration	[illegible] Roadways, mass transportation	E,F Departure thrust management, preferential flight paths
Houston Intercontinental, [illegible]	15	E† Converging approaches, reduced separation, aircraft reclassification, MLS, TMS, ASDE-3, TAGS, WVAS	E FIS procedures, terminal configuration	—	E,F Departure thrust management, preferential flight paths
Las Vegas McCarran, NV	29	[illegible] Reduced separation, aircraft reclassification, WVAS	E† Curbfront improvements, terminal configuration	E Roadway, mass transportation	—
Los Angeles, CA	5	[illegible] †Reduced separation, aircraft reclassification, TMS, ASR-9, ASDE-3, TAGS, WVAS	E Terminal configuration, curbfront improvements	E,F Roadways, mass transportation, helicopter shuttle	E,F Departure thrust management, preferential flight paths
Philadelphia, PA	17	[illegible] Converging approaches (with runway extension), reduced separation, aircraft reclassification, MLS, TMS, ASR-9, ASDE-3, TAGS, WVAS	—	E† Roadways	E,F Departure thrust management, preferential flight paths, preferential runway use
St. Louis Lambert, MO	32	[illegible] Reduced separation, aircraft reclassification, MLS, TMS, ASR-9, ASDE-3, TAGS, WVAS	[illegible] † Terminal configuration, FIS procedures	E,F Roadways, mass transportation	E,F Departure thrust management preferential runway use, preferential flight paths
Medium haul:					
New York La Guardia, [illegible]	22	[illegible] Converging approaches, separate short runways, reduced separation, aircraft reclassification, MLS, TMS, ASR-9, ASDE-3, TAGS, WVAS	F Terminal configuration	E,F† Roadways, mass transportation, helicopter shuttle	E,F Departure thrust mangement, preferential flight paths
Santa Ana, CA	8	[illegible] †Separate short runway, reduced separation, MLS, TMS	[illegible] Curbfront Improvements, terminal configuration	[illegible] Roadways	[illegible] Departure thrust management, preferential flight paths
Washington National, [illegible]	24	[illegible] Reduced separation, MLS, TMS, ASR-9, ASDE-3, TAGS	[illegible] Self-ticketing, baggage handling systems, terminal configuration, curbfront improvements	[illegible] Roadways	[illegible] †Departure thrust management, preferential flight paths
Short haul:					
Chicago Midway, IL	[illegible]	[illegible] †Reduced separation, MLS, TMS	[illegible] Curbfront improvements, terminal configuration	E Roadways, mass transportation, helicopter shuttle	[illegible] Departure thrust management, preferential flight paths
Detroit City, MI	196	[illegible] Reduced separation, TMS, ASR-9	[illegible] Terminal configuration	—	—
Houston Hobby, [illegible]	14	[illegible] Reduced separation, MLS, TMS, ASR-9, airport surface operation procedures	[illegible] Curbfront improvements, terminal configuration	E,F† Roadways, mass transportation, helicopter shuttle	[illegible] Departure thrust management, preferential flight paths
Long Beach, CA	4	[illegible] Reduced separation, TMS, ASR-9	—	—	E,F Departure thrust management, preferential flight paths
Medium hub:					
Long haul:					
Baltimore-Washington International, MD	[illegible]	[illegible] Reduced separation, aircraft reclassification, MLS, TMS, WVAS	[illegible] Parking	—	—
Memphis, TN	[illegible]	[illegible] Converging approaches, independent parallel approaches, MLS, WVAS, reduced separation, aircraft reclassification	—	—	—
Milwaukee Mitchell, WI	[illegible]	—	[illegible]	—	—
Orlando, FL	[illegible]	—	[illegible] —	E Mass transportation	—
Reno, NV	[illegible]	[illegible] † Separate short runway, reduced separation, aircraft reclassification, WVAS	[illegible]	E Roadways	—

[a]Federal Aviation Administration, *FAA Air Traffic Activity, FY 1982*.
†—Most severe problem.

SOURCE: Office of Technology Assessment.

Table 16.—Airport Technology Summary (continued)

Airport	Rank order by operations[a]	Airside	Airport terminal	Surface access	Environmental/noise
Salt Lake City, [illegible]	44	[illegible] Converging approaches, independent parallel approaches, reduced separation, aircraft classification, MLS, WVAS	E Baggage handling systems, terminal configuration	E	—
San Diego, CA	155	[illegible] Reduced separation, aircraft reclassification, WVAS	[illegible]	[illegible] Mass transportation	[illegible] Departure thrust management, preferential flight paths
San Jose, CA	26	E	E† Terminal expansion	—	[illegible] Departure thrust management, preferential flight paths
West Palm Beach [illegible]	52	E,F Airport surface operational procedures, taxiway design, WVAS, MLS	[illegible] Curbfront improvements, terminal configuration	E Roadways	[illegible] Departure thrust management, preferential flight paths
Medium haul:					
Buffalo, NY	[illegible]		E,F† Parking, terminal expansion	[illegible]	—
Charlotte, NC	[illegible]	[illegible] Airport surface operational taxiway design	E Terminal configuration		[illegible] Departure thrust management, preferential flight paths
San Antonio, TX	[illegible]	[illegible] Converging approaches, MLS			—
Tucson, AZ	[illegible]	—	[illegible] Terminal expansion	[illegible]	—
Small hub:					
Ontario, CA	195	E —	E† Terminal configuration	—	[illegible] Departure thrust management, preferential flight paths
Daytona Beach, [illegible]	63	[illegible] Converging approaches, separate short runways, reduced separation, MLS	—	—	—
Commuter service:					
Anchorage Merrill, AK	27	[illegible] Reduced separation	—	E Roadways	—
Chicago Meigs, IL	299	[illegible]	—	—	
Farmingdale Republic, NY	76	[illegible] Reduced separation	[illegible]	—	E,F Preferential flight paths
Fort Worth Meecham, TX	11	[illegible]	—	—	
Fullerton, CA	112	[illegible] Reduced separation	—	—	—
Houma, LA	—	[illegible] Taxiway design, LLWSAS	—	—	—
Relievers:					
Arapohoe County, CO	16	[illegible] Converging approaches, MLS	[illegible]	[illegible]	—
Baltimore Glenn L. Martin, MD	—	[illegible] Taxiway design	—	—	—
Crystal, MN	171	[illegible]	—	—	—
Dallas Addison, TX	140	[illegible] Reduced separation	—	—	—
El Monte, CA	164	[illegible] MLS	—	—	—
Fort Lauderdale Executive, FL	101	[illegible]	—	—	E,F Preferential flight paths
Hartford Brainard, CT	180	[illegible]	—	—	E,F† Preferential flight paths
Kansas City Downtown, MO	160	[illegible] —	—	—	—
Mesa Falcon, AZ	—	[illegible]	[illegible]	—	—
Novato, CA	—	[illegible]	—	[illegible] Roadways	—
Van Nuys, CA	3	[illegible]	—	—	[illegible] Preferential flight
General aviation:					
Aurora, OR	—	—	—	—	—
Carlsbad, CA	88	[illegible]	—	—	E,F Preferential flight paths
Cincinnati Lunken, OH	115	[illegible] Taxiway design, MLS	E,F	—	—
Greeley-Weld County, CO	—	[illegible]	E,F	—	—
Vero Beach, FL	119	[illegible] Taxiway design	E,F	[illegible] Roadways	E,[illegible] Preferential flight paths

[a]Federal Aviation Administration, *FAA Air Traffic Activity, FY 1982*.
†—Most severe problem.

SOURCE: Office of Technology Assessment.

Chapter 5

OTHER APPROACHES TO REDUCING DELAY

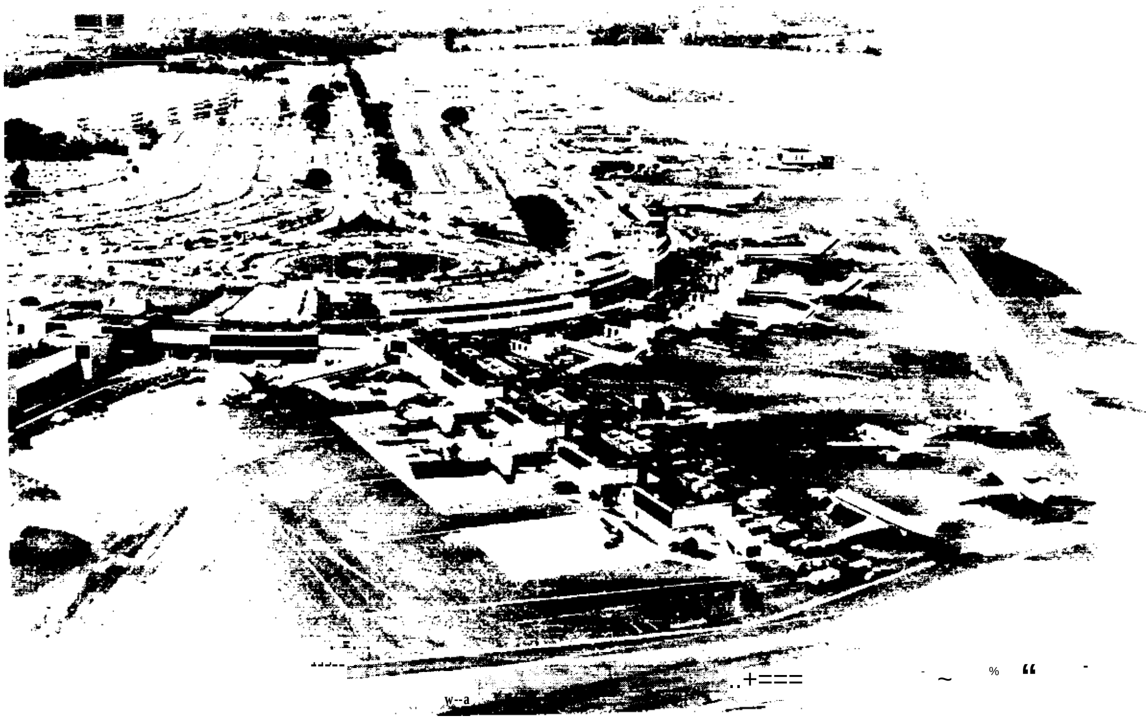


Photo credit: Federal Aviation Administration

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OTHER APPROACHES TO REDUCING DELAY

Airport congestion and delay are at least partly amenable to technological solutions, but there are other approaches to dealing with the problem. Chronic delay is limited to a very few specific times and places, and one of the principal causes is the "peakiness" of traffic flow. Most travel is between a few major airports and at certain times of day. While technological improvements and construction of new facilities can help airports absorb growing traffic demand and lessen delay, these solutions are capital-intensive and may entail prohibitive costs. An alternative approach is to manage the demand to fit within existing capacity.

There are two basic approaches to managing demand, both with the same objective: to ease congestion by diverting some traffic to times and places where it can be handled more promptly or efficiently. This may be done through administrative means; the airport authority or another governmental body may allocate airport access by setting quotas on passenger enplanements or on the number and type of aircraft operations that will be accommodated during a specific period. The alternative approach is economic—to structure the pricing system so that market forces allocate scarce airport facilities among competing users. Thus, demand management does not add capacity; it promotes more effective or economically efficient use of existing facilities.

Any scheme of demand management denies some users free or complete access to the airport of their choice. This denial is often decried as a violation of the traditional Federal policy of freedom of the airways and the traditional "first-come, first-served" approach to allocating the use of airport facilities. Economists reject this argument on the grounds that it is a distortion of the concept of freedom to accord unrestricted access to any and all users without regard to the societal costs of providing airport facilities. Attempts to manage demand are also criticized for adversely affecting the growth of the aviation industry and the level of service to the traveling public. Nevertheless, as growth in traffic has outstripped the ability to expand and build airports, some forms of demand management have already come into use, and many industry observers, including the Task Force on Airport Access, have taken the position that some form of airport use restriction will become increasingly important in dealing with delay and in utilizing existing airport capacity efficiently.[1]

[1] *Report and Recommendations of the Airport Access Task Force* (Washington, DC: Civil Aeronautics Board, March 1983), p. 21.

ADMINISTRATIVE OPTIONS

Several administrative measures could be adopted to manage demand at individual airports or for a metropolitan region. Among these are: required diversion of some traffic to reliever airports, more balanced use of metropolitan air carrier airports, restriction of airport access by aircraft type or use, and establishment of quotas (either on the number of operations or on passenger enplanements). At the national level, demand might be managed by administrative actions to encourage "rehubbing" or redistributing transfer traffic from busy airports to underused airports.

Diversion of Traffic

In some metropolitan areas, the shortage of airport capacity may not be general, but confined to one overcrowded airport. There may be other airports in the region that could absorb some of the demand. The Federal Aviation Administration (FAA) lists 27 airports in the Chicago area, 51 in the Los Angeles basin, and 52 in the Dallas-Fort Worth region. The vast majority of these airports are small and suited only for general aviation (GA) aircraft, but in some cases there is also an underutilized commercial service airport.

The best regionwide solution to the problem of delay at a major airport may be to divert some traffic away from the busy airport to either a general aviation reliever airport or a lightly used commercial airport. To some extent, this can occur as a result of natural market forces. When delays become intolerable at the busy airport, users begin to divert of their own accord. While those who choose to move to a less crowded facility do so for their own benefit, they also reduce somewhat delays incurred by users that continue to operate at the crowded airport. Public policy might encourage this diversion through administrative action or economic incentives before traffic growth makes conditions intolerable or necessitates capital investment to accommodate peaks of demand at the busy airport.

Diversion of general aviation from busy air carrier airports is often an attractive solution. GA traffic, because it consists mostly of small, slow-moving aircraft, does not mix well with faster, heavier air carrier traffic. GA operators, themselves, especially those flying for recreational or training purposes, want to avoid the delays and inconveniences (and sometimes the hazards) of operating at a major airport. These fliers are often willing to make use of GA airports located elsewhere in the region if suitable facilities are available.

Diversion of GA traffic from commercial air carrier airports has been taking place for many years. As air carrier traffic grows at a particular location, it almost always tends to displace GA traffic. FAA has encouraged this trend by designating **219** airports as “relievers” or “satellites” to air carrier airports, and earmarking funds especially for developing and upgrading these airports.[2] Many other airports, although not specifically designated as relievers, serve the same function; they provide an alternative operating site for GA aircraft well removed from the main commercial airport of the region.

To be attractive to a broad spectrum of GA users, a reliever airport should be equipped with instrument approaches and provide runways capable of handling the larger, more sophisticated GA aircraft. In addition, users need facilities for aircraft servicing, repair, and maintenance as well as suitable ground access to the metropolitan area.

Not all GA aircraft can make use of reliever airports. Some may be delivering passengers or freight to connect with commercial flights at the air carrier airport. Others may be large business jets that require the longer runways of a major airport. Even at the busiest air carrier airports, GA traffic accounts for about **10** percent of total operations (see fig. ***16).***

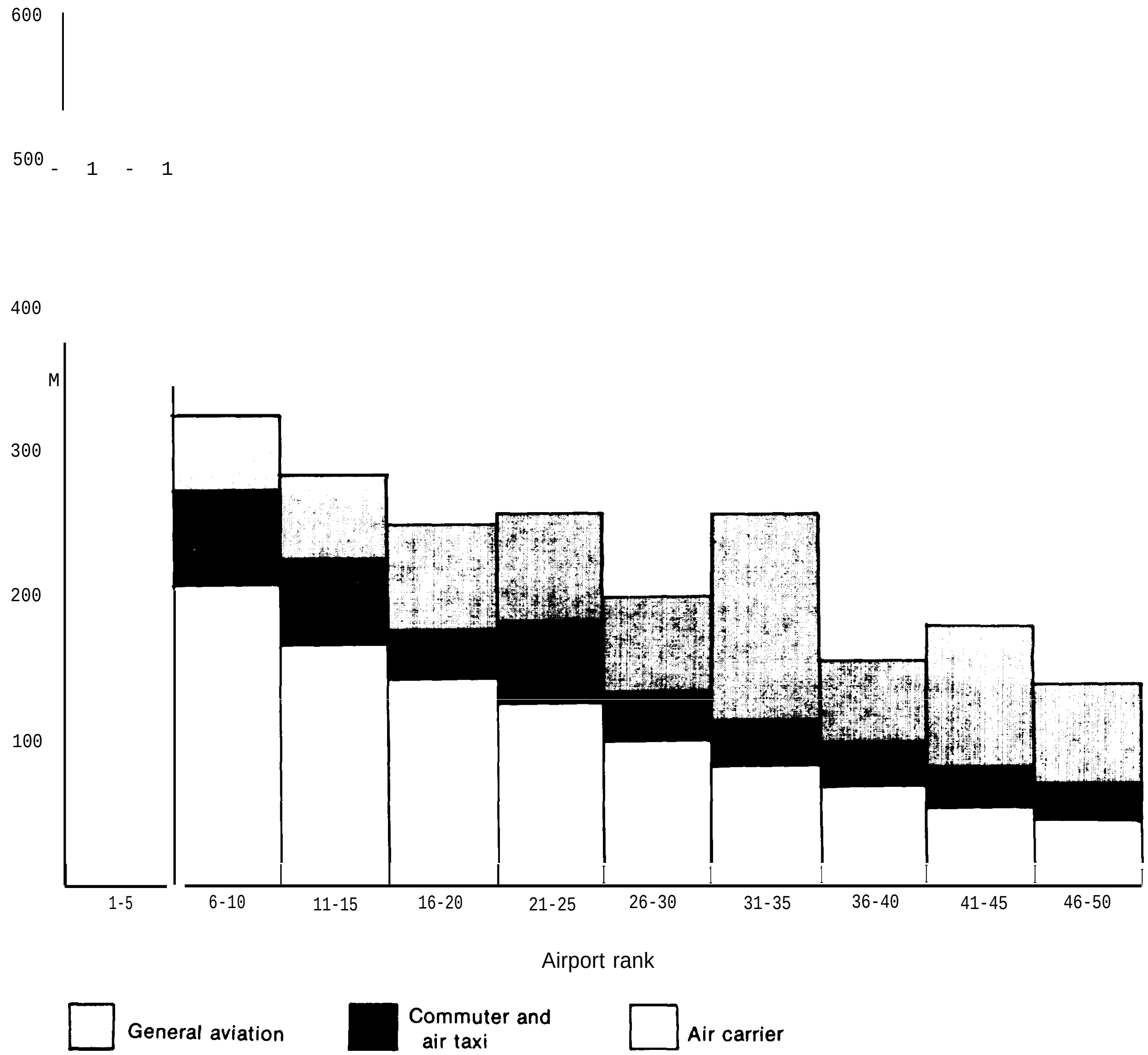
In general, airport authorities do not have the power to exclude GA as a class, although this has been attempted on occasion. For example, in the late ***1970s*** the airport management and city government of St. Louis attempted to exclude all private aircraft from Lambert Airport. This ordinance was overturned by the courts as discriminatory.

Where they have had any policy on the matter, local airport authorities have attempted to make GA airports attractive to users by offering good facilities or by differential pricing schemes, This approach is most effective where the commercial airport and the principal reliever are operated by the same entity. The State of Maryland, owner of Baltimore-Washington International Airport, operates a separate GA airport, Glenn L. Martin Field, and has a specific policy of encouraging GA traffic to use it rather than the main airport. The master plan for Cleveland Hopkins International Airport depends on the availability of the city-owned Lakefront Airport as a reliever. If that airport should for some reason cease operation as a GA reliever, Hopkins would experience a great increase in traffic which might necessitate additional construction that is not now planned.

Most local airport authorities, however, do not operate their own GA relievers. Some large airport authorities plan and coordinate activities with nearby reliever airports operated by other municipalities or private individuals, but this has not been the general case. The system of relievers

‘Over the 10 years of the Airport Development Aid Program, about $140 million was designated for relievers. ‘The Airport Improvement Fund sets aside almost $480 million for the period 1983-87.

Figure 16.-Activity at the Top 50 Commercial Airports (ranked by air carrier operations, fiscal year 1982)



SOURCE: Federal Aviation Administration, *FAA Air Traffic Activity, FY 1982*, September 1982.

in each region has tended to grow up without any specific planning or coordination on the regional level.

Development of GA relievers is not without problems. These airports are also subject to complaints about noise, and they experience the same difficulties as commercial airports in expanding their facilities or in developing a new airport site. Further, because many GA airports are small and function just on the ragged edge of profitability, problems of noise or competing land use can actually threaten the airport's existence. The number of airports available for public use in the United States has been declining. Between 1980 and 1983, for example, the number of public-use airports declined from 6,519 to 5,897. Although most of the airports that closed were small, privately owned facilities, some industry observers worry that the Nation is irrevocably losing many potential reliever airports, just as it has become clear that they are vital.

Balanced Use of Large Airports

At the largest commercial service airports, GA activity consists primarily of flights by large business and executive aircraft. This type of GA traffic accounts for about **10** to 20 percent of the use of major airports, a figure that many consider the "irreducible minimum. " The delays that persist at these airports are primarily the result of air carrier demand which can be satisfied only by another commercial service airport. In several metropolitan areas, it is clear that the commercial airports are not used in a balanced manner. For example, San Francisco International is experiencing delay problems while nearby Oakland Airport is underutilized. Washington National is overcrowded while Dunes International and Baltimore-Washington International are looking for business. Newark is underutilized compared with busy La Guardia and Kennedy. Similar pairs exist in Chicago (O'Hare and Midway), Dallas (Dallas-Fort Worth and Love Field), and Houston (Houston Intercontinental and Hobby). A policy designed to divert traffic from busy to underutilized airports would have a generally positive effect on the ability of metropolitan areas to accommodate air traffic. Further, it might obviate the need for expansion or expensive technological improvements designed to reduce delays at the busy airport.

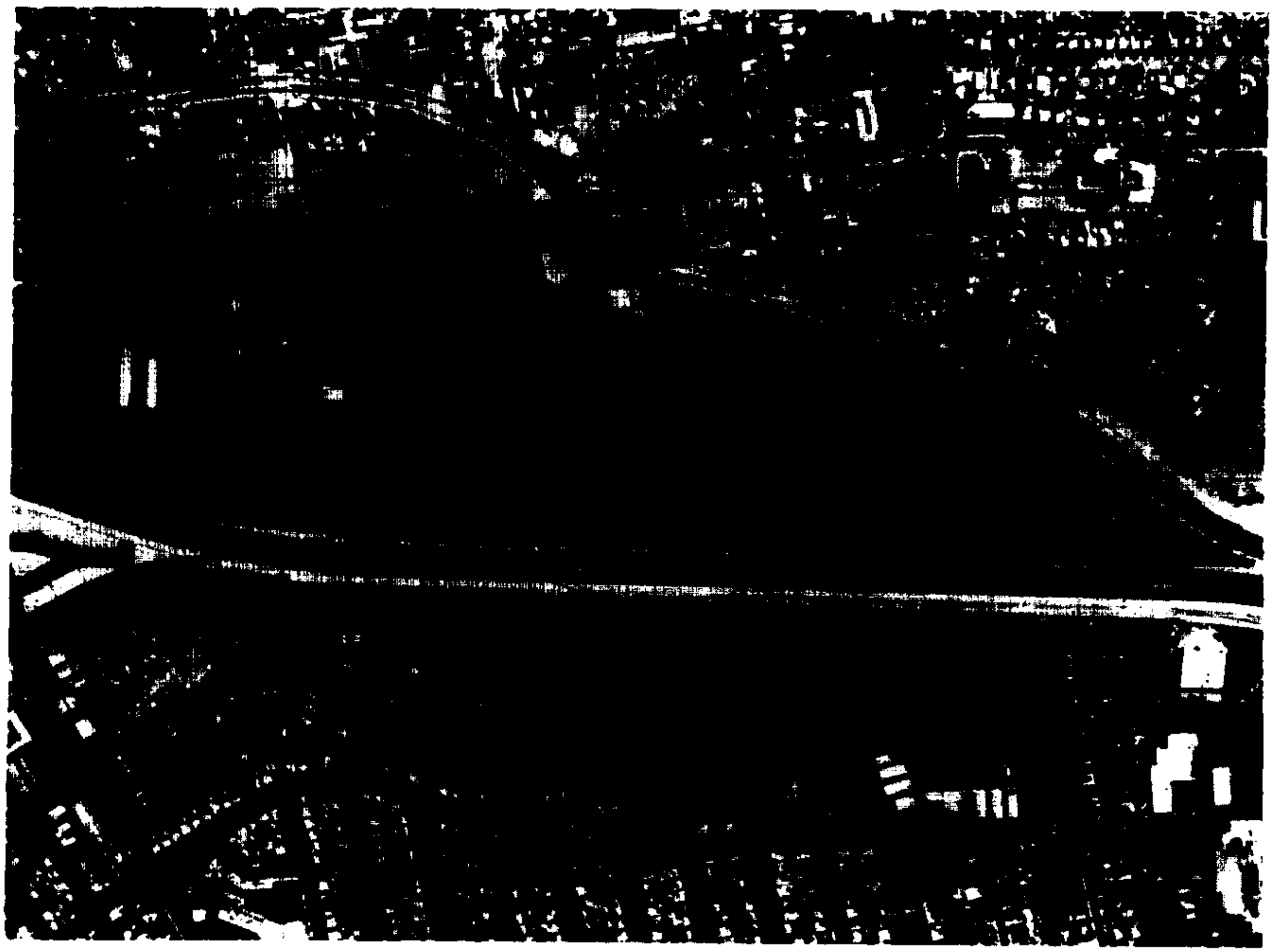


Photo credit: Aviation Division, County of Los Angeles

A threatened reliever airport

Diverting air carrier traffic to alternate airports is not a simple solution; there are a number of problems. One is simply the habits of the traveling public. People are accustomed to using the busier airport. They may prefer the better ground access, the larger choice of flight times and destinations, the greater variety of carriers, and other advantages that the busy airport offers.

Air carriers, sensitive to public preferences, tend to concentrate their service at the busier airport, where they perceive a larger market. It is in the carriers' economic interest to serve the airport where passengers want to go. The busier airport is a known and viable enterprise, while the underutilized alternate airport is a risk. Air carriers are justifiably reluctant to isolate themselves from the major market by moving all their service to the less popular airport. On the other hand, serving both airports imposes an economic burden that carriers seldom choose to bear, as they would incur the additional expense of setting up and operating duplicate ground services. In addition, splitting their passengers between two airports might make scheduling of flights more complicated and lead to inefficient utilization of aircraft.

These obstacles have sometimes been overcome in locations where airport operators have the authority to encourage a diversion of traffic from one airport to another. For example, in the New York area the Port Authority of New York and New Jersey operates all three air carrier airports. In theory, this gives the Port Authority the ability to establish regulatory policies or economic incentives to encourage the diversion of some traffic to Newark. In practice, however, measures adopted to promote traffic redistribution have not been fully effective. The recent growth of traffic at Newark has been due primarily to new carriers entering the New York market and not diversion of established carriers.

In contrast, San Francisco and Oakland airports are operated by separate sponsors. San Francisco, despite severe problems of delay, would rightly be reluctant to encourage passengers and air carriers to move to Oakland. Even though more balanced regional airport use might be achieved and the long-range need for expansion at San Francisco reduced, the short-range effect would be that San Francisco would lose revenues to a competitor. There is no regional authority with the power to promote this reallocation of traffic.

Restriction of Access by Aircraft Type

One means of diverting certain traffic from a busy airport to one with unused capacity is to restrict access to the busy airport on the basis of aircraft type or use. Restriction of aircraft access to airports by size or performance characteristics might affect airport capacity and delay in several ways. First, the mix of aircraft using a runway system helps to determine capacity. When aircraft are of similar size, speed, and operating characteristics, runway acceptance rate is greater than when performance characteristics vary widely. Similar aircraft can be more uniformly and accurately spaced on approach and departure, thereby smoothing out irregularities in the traffic stream, which is a major factor causing delay. Thus, at airports where the bottleneck is in the runway sys- “ tern, restrictions which narrow the range of aircraft using that system might have a beneficial effect. Diversion of small GA or commuter aircraft to other airports or construction of a separate short runway dedicated to their use could improve the ability of the airport to handle larger transports or the overall traffic mix.

A second implication of limiting access to specific aircraft types is that it might reduce the need for capital improvements required to accommodate a larger variety of aircraft. For example, Washington National Airport does not accept jumbo jet aircraft or long-range flights (nonstop flights in excess of 1,000 miles). FAA's policy is to divert these flights to Dunes. Allowing larger aircraft into National would probably necessitate changes in runways, taxiways, aprons, and gates. In addition, the larger number of passengers per aircraft would put additional strain on National's already congested terminal and landside facilities, making a number of collateral improvements necessary.

Access restrictions at Washington National are combined with a cap ***on*** passenger enplanements. Although the cap is still under debate, it is currently set at **16** million passengers annually. (National currently handles 13 million.) FAA considers the cap necessary because limiting aircraft size, without also setting a ceiling on the number of passengers, might lead to more aircraft operations than the airport can handle safely or efficiently and worsen the congestion that already exists at National.

The purpose of the access restrictions, the cap on passengers, and the quota system (discussed below) is to divert traffic from National Airport to Dunes. Most local airport managers would not be able to adopt such measures unless there were a nearby underutilized airport, also under their control, to handle the diverted traffic. To forbid some portion of the traffic to use an airport without an available alternative would most likely be construed as a restriction of interstate commerce or discriminatory practice.

Quotas

One technique of demand management now in use at a few airports is the quota system—an administratively established limit on the number of operations per hour. Because delay increases exponentially as demand approaches capacity, a small reduction in the number of hourly operations may have a significant effect on delay. This makes the quota an attractive measure for dealing promptly (and inexpensively) with airport congestion.

Examples of airports with quotas are O'Hare, La Guardia, JFK, and Washington National—airports covered by the FAA high-density rule. The quotas at these airports were established by FAA in 1973 based on estimated limits of the air traffic control (ATC) system and airport runways at that time. FAA is currently considering lifting the rule at some of these locations because of improvements made to airport facilities and slower than expected growth in air traffic. An example of a locally imposed quota is John Wayne Airport in Orange County, CA, which limits scheduled air carrier operations to an annual average of 41 operations per day. This quota is based on noise considerations as well as limitations on the size of the terminal and gate areas.

During busy hours, demand for operational "slots" typically exceeds the quota. At the airports covered by the high-density rule, the slots are allocated among different user classes. For example, at National, where there are ***60*** slots available per hour, ***37*** are allotted to air carriers, 11 to commuter carriers, and 12 to general aviation. During Visual Meteorological Conditions, more than 60 operations can be handled, and aircraft without assigned slots may be accommodated at the discretion of air traffic controllers and the airport manager.

At airports where the quota system is in force, slots may be allocated in various ways—through a reservation system, by negotiation, or by administrative determination. The GA slots are generally distributed through a reservation system—the first user to call in for a reservation gets the slot. However, for commuters and air carriers, the slots at the high-density-rule airports are allocated by negotiation. Two scheduling committees, one made up of carrier representatives and one of commuter representatives, meet under antitrust immunity to negotiate the flights to be allotted to each user. If the negotiators fail to reach agreement ("default"), FAA reserves the right to allocate slots.

Under airline regulation, when the number of carriers and routes were fairly stable, the work of the scheduling committee was easy—merely allocating the existing number of slots to the incumbent carriers. Since 1979, however, the committees have had to accommodate new entrants and the changing market strategies of incumbent carriers. On several occasions since 1979, the negotiators at Washington National have been close to defaulting, and FAA had to consider seriously using administrative means to distribute slots.

One objection to quota systems is that they tend to favor incumbents over new entrants. Another is that quotas allocate scarce slots without any price signals to show whether capacity is being used efficiently; there is no long-range guide provided by the market to show what improvements might be economically justified or which users most value their operating rights. These problems can be partly overcome through selling or auctioning slots as discussed below.

Photo credit: Business and Commercial Aviation Magazine

Business and corporate aviation—a growing sector

Rehubbing

A systemwide response to alleviate delays at busy airports is redistribution of operations to other, less busy airports in other regions. Some air carriers, especially those with a high proportion of interconnecting flights, may voluntarily move their operations to underutilized airports located at some distance from the congested hub. Transfer passengers account for a large percentage of traffic at some large airports. About three-fourths of passengers at Atlanta, and nearly half of passengers at Chicago, Denver, and Dallas-Fort Worth arrive at those airports merely to change planes for some other destination. here is an advantage for carriers in choosing a busy airport as a transfer "hub' '-they can offer passengers a wide variety of possible connections. However, when the airport becomes too crowded, the costs of delay may begin to outweigh the advantages of the large airport, and carriers may find it attractive to establish new hubs at smaller, less busy airports.

This "rehubbing" of the airport system is already a trend (a subject to be examined further in ch. ***8).*** Redistribution of operations has certainly been facilitated by the deregulation of the airline industry, which allowed carriers greater freedom in restructuring their routes. Medium-size airports appear to be receiving increased air carrier activity since deregulation, and some carriers are shifting their transfer operations to these less congested facilities. For example, Piedmont has developed Charlotte (North Carolina), Dayton (Ohio), and Baltimore-Washington (Maryland) as regional hubs. Western has developed Salt Lake City (Utah) as its principal hub. In addition to relief from congestion, carriers who have moved to less busy airports find another, perhaps more compelling, advantage. Because there is often little service by competing carriers at those locations, the hubbing carrier has greater control of passengers, who can transfer only to departing flights of the airline that brought them, not to a competitors.

While it is doubtful that rehubbing has actually reduced delay problems at major airports, it does seem clear that development of transfer hubs at medium airports has allowed for growth that might not have been possible had the carriers sought to concentrate their activities at the major hubs. Further, rehubbing has taken advantage of a certain "overcapacity" in the national airport system by making greater use of the facilities available at medium airports.

ECONOMIC OPTIONS

Administrative limits on airport use—whether by restricted access for certain types of aircraft, by demand balancing among metropolitan area airports, or by selection imposition of quotas—offer the promise of immediate and relatively low-cost relief of airport congestion. As long-term measures, they may not be as attractive. Administrative limits tend to bias the outcome toward maintenance of the status quo when applied over a long period of time. Since the economic value of airport access is not fully considered in setting administrative limits, incumbents cannot be displaced by others who would place a higher value on use of the airport. Further, incumbents and potential new entrants alike have no way to indicate the true economic value they would place on increased capacity. Economists contend that a vital market signal is missing and that airport operators and the Federal Government cannot obtain a true picture of future capacity needs. Administratively limiting demand, they say, creates an artificial market equilibrium that—over the long term-distorts appreciation of the nature, quality, and costs of air transportation service that the public requires. Economists, therefore, favor a scheme of allocating airport access that relies on the mechanism of price.

At present, price plays a rather weak role in determining airport access or in modulating demand. Access to public use airports, except for the few large airports where quotas are imposed, is generally unrestricted so long as one is willing to pay landing fees and endure the costs of congestion and delay. Landing fees, most often based solely on aircraft weight and invariant by time of day, make up a very small fraction of operational cost—typically 2 to 3 percent for air carriers and even less for GA. Further, landing fees are not uniform from airport to airport. In many cases, landing fees are set so that—in the aggregate—they make up the difference between the cost of operating the airport and the revenues received from other sources such as concessions, leases, and automobile parking fees.[3]

This leads economists to the conclusion that landing fees are somewhat arbitrary and do not reflect the costs imposed on the airport by an aircraft operation.[4] Economists suggest that, by including airport costs and demand as determinants of user fees, delay could be significantly reduced. The two most commonly advocated methods of achieving this are differential pricing and auctioning of landing rights.

Differential Airport Pricing

Many economists argue that weight-based landing fees are counterproductive because they do not vary with demand and, consequently, provide no incentive to utilize airport facilities during offpeak hours. Further, they do not reflect the high capital costs of facilities used only during peak hours. Thus, economists contend, a more effective pricing method would be to charge higher user fees during peak hours and lower fees during offpeak hours. Theoretically, the net effect of such a pricing policy would be a more uniform level of demand.

Much of the traffic moved away from peak hours by higher landing fees would probably be GA. Correspondingly, the benefits of peak-hour fees would be greater at airports with a high proportion of GA activity. But, peak-hour fees could also be structured so as to affect the pattern of air carrier activity. These charges would have to be fairly high because landing fees represent only a small fraction of air carrier operating costs and because increases can be passed on to passengers.

Despite increases in landing fees, carriers would want to continue to use the airport at peak times, either to have access to a large number of passengers or because long-haul scheduling problems

[3]See ch. 6 for a more detailed examination of airport pricing methods.

[4]The following, based on a survey conducted by Peat, Marwick, Mitchell & Co, in July 1982, is a sampling of aircraft landing fees at six airports:

1. Miami International—79a per 1,000 lb.
2. Boston Logan International-$1.246 per 1,000 lb.
3. Chicago O'Hare International-$1.095 per 1,000 lb.
4. Denver Stapleton International–34c per 1,000 lb.
5. Honolulu Internationa145c per 1,000 lb.
6. Houston Intercontinental-85 .7~ per 1,000 lb.

require them to serve a particular airport during certain hours. Thus, they would absorb some increase in landing fees, just as they absorb the cost of delays, as part of the cost of doing business. However, some flights might be moved to offpeak hours if the charges were high enough. In fact, it is possible that properly structured peak-hour prices, if they were reflected in fares, could have an effect not only on the airlines' scheduling patterns but on passengers' travel habits as well. If significant savings were possible, some passengers would choose to travel during offpeak hours.

It it is difficult to project accurately the changes in patterns of airport use that might be brought about by peak-hour surcharges. FAA has estimated that peak-hour surcharges, along with improvement of the ATC system, would reduce anticipated air carrier delay costs by approximately ***80*** percent at the Nation's ***25*** busiest airports over the next ***25*** years.[5] A recent Congressional Budget Office (CBO) report suggests that, although expansion may be inevitable at many airports, peak-hour surcharges could significantly delay the need for expansion and reduce financial pressure at a number of airports.[6] Another important aspect of peak-hour surcharges noted by CBO is that, even if they do not reduce traffic levels at peak hours to the desired levels, they could provide airports with increased revenues to expand facilities and, consequently, to reduce delays.

Some observers reject this line of reasoning. They contend that, to be effective in shifting demand to slack periods, peak-hour charges would have to be set so high that they would be politically unacceptable. Further, there is no assurance that airlines would not average the higher costs of peak-hour access at certain airports with the lower cost at other times and places and pass this along to all passengers as a general fare increase. Airlines would thus create an internal cross-subsidy in their fare structure to cover the higher costs of access to some airports. Since the average fare increase would likely be small, the economic signal to the public would be diminished such that it would have scant effect on travel behavior.

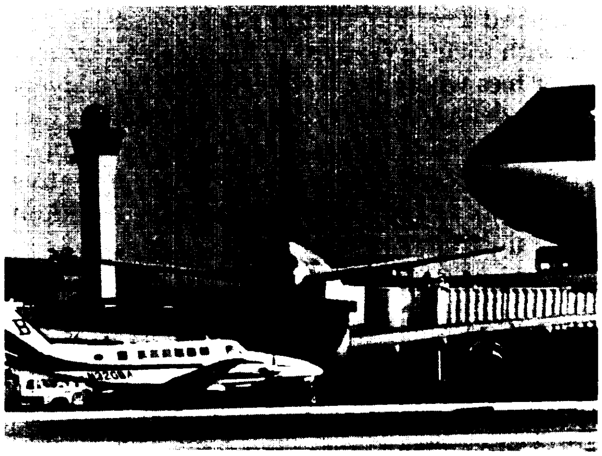


Photo credit; Federa/ Aviation Administration

Competition

A major problem with the concept of peak-hour surcharges is how to determine the level of surcharge. One widely advocated method is to charge the airport user the full marginal costs of airport facilities. In other words, each airport user pays a share of the additional capital and operating costs to the airport authority of providing service **at** the time demanded. For example, if a user lands at an airport during a period of peak demand where two or more runways are necessary to handle the traffic, the charge should include a contribution to the cost of building, operating, and maintaining those additional runways. On the other hand, if the user lands during an offpeak hour when the one runway in use is not sought by others, there would be no additional charge. While both onpeak and offpeak users would pay fees to cover maintenance, wear and tear, or other costs, only peak-hour users would pay the additional costs associated with the time of use. The resulting user fees would be directly related to the levels of airport activity, producing the desired effect of higher fees during peak hours and a strong price signal to use the airport at offpeak hours.

Some contend that a system of marginal cost pricing should be based on the delay costs which each peak-hour user imposes on other users. For example, during peak hours, airport users would

[5] Policy Analysis of ***the Upgraded Third*** Generation ***Air Traffic Control System*** (Washington, DC: Federal Aviation Administration, January 1977), p. 71.
[6] ***Public Works Infrastructure: Policy Considerations*** for ***the*** 1980s (Washington, DC: Congressional Budget Office, April 1983), p. 113.

be charged a fee based on the delay costs associated with their operations. This creates a system of user fees where the fees become progressively larger as delays increase. Proponents contend that using marginal delay costs as the basis for pricing airport access provides a stronger incentive for off-peak airport use than a scheme based on marginal facility costs alone.

Implementing a policy of differential pricing—whether based on marginal facility cost, marginal delay cost, or some purely arbitrary scheme—is difficult. It is likely that a significant increase in airport user fees will raise questions of equity. Higher fees might be more burdensome for small airlines and new entrants than for established carriers. There are a number of examples where airport operators have attempted to increase user fees and been challenged by air carriers and general aviation. In some cases, air carrier landing fees are established in long-term contracts that cannot be easily changed.[7]

GA users often contend that differential pricing is discriminatory because it favors those with the ability to pay and illegal because it denies the right to use a publicly funded facility. Economists rebut this argument by pointing out that time-of-use price is neither discriminatory nor illegal so long as price differences reflect cost differences and that it is fair and just to set prices based on the costs that each user imposes on others and on society generally.

Despite the difficulties inherent in increasing airport user fees, there are two well-documented examples of differential pricing policies that have been in effect for several years. In the early 1970s, the British Airport Authority implemented peak-hour surcharges at London's Heathrow Airport. In the late 1960s, the Port Authority of New York and New Jersey began imposing peak-hour surcharges on general aviation. Both differential pricing policies sought to move traffic to offpeak hours, even though the pricing methods employed were considerably different.

Because of the large volume of international traffic, activity at Heathrow increases significantly during the summer months, compounding delay problems. As a result, the surcharges imposed at Heathrow in 1972 were set on both an hourly and seasonal basis. The hours of greatest delay were from 8:00 a.m. to 1:00 p.m. During the summer, surcharges were applied for the entire S-hour period each day. During the remaining months, surcharges were levied only for the period between 9:00 and 11:00 a.m., Monday through Friday. The effects of peak-hour surcharges at Heathrow were not clear cut. During 1972 and 1973, there was an apparently steady movement of traffic away from peak periods. This trend, however, was reversed in the following year and fluctuated thereafter, leaving some doubt as to the effectiveness of the surcharges.

The surcharges imposed by the Port Authority of New York and New Jersey were aimed specifically at general aviation using of the three major commercial airports in the New York metropolitan area. During July 1968, 17 percent of all aircraft operations at the three commercial airports were delayed by more than 30. minutes.[8] During that same month, GA traffic constituted 25 percent of the airport traffic—30 percent during peak hours. In an effort to shift this GA traffic away from peak hours, the Port Authority increased the landing fee for aircraft with fewer than 25 seats to $25 during peak hours—a fivefold increase. The fee remained at the $5 level during offpeak hours.

Peak-hour surcharges produced significant results at all three New York airports. Following the imposition of the surcharges, GA activity during August and September decreased 19 percent overall and 30 percent during peak periods. More important, delays—in terms of the percentage of aircraft operations experiencing delays of over 30 minutes—declined markedly.

To be sure, there are factors other than surcharges that affect airport use; and, undoubtedly, some could have influenced the outcomes in both New York and London. For example, the fuel

[7] In 1981, the Indianapolis Airport Authorities brought suit against six airlines for refusing to pay new landing fee rates. The court, eventually, decided in favor of the airlines, ruling that the rate increase was unreasonable. In 1976, a court in North Carolina ruled that the Raleigh-Durham Airport could only raise its landing fees to 22.3a per 1,000 lb instead of the proposed 33 to 35¢ per lb.

[8] Port Authority of New York and New Jersey Memorandum, Aviation Department, "Effects of FAA Allocations, Summer 1969," Nov. 20, 1969.

crisis of 1973 unquestionably influenced the traffic at Heathrow and masked somewhat the effects of the surcharge. A controller slowdown at New York's airports during the summer of 1968 intensified delay problems and could have accounted for some of the traffic diversion attributed to the surcharges.

In general, peak-hour surcharges represent an attempt to manage demand by charging cost-based landing fees. Access to airports is not limited except by the user's willingness to bear the additional cost imposed during peak hours. Another method of reducing peak-hour airport activity involves limiting airport access through a process by which landing rights (slots) are auctioned to the highest bidder. The auction is a hybrid process—partly administrative, partly economic—in which access is regulated, but the right of access is distributed through a market-oriented mechanism.

Slot Auctions

Slot auctions have been advocated as the best method of allocating scarce airport landing rights on the grounds that, if airport access must be limited, it should be treated as a scarce resource and priced accordingly. The method to accomplish this is a system whereby the price of airport access is determined by demand. Slot auctions allow peak-hour access only to those users willing to pay a-market-determined price.

Slot auctions are particularly unpopular with new air carriers, who feel that they would be inhibited in serving new markets or perhaps excluded altogether. These earners contend that auctions would place them at a disadvantage with incumbent airlines, which could hoard slots and, potentially, limit competition.

There are several practical problems in implementing slot auctions. First, there is the question of who should actually organize the auction—the local airport authority or the Federal Government. Local authorities are probably in the best position to determine accurately the number of available slots, but some experts argue that the Federal Government has a systemwide perspective that is better suited to determining the overall effects of slot allocations on airport traffic nationally.

Photo credit: Federal Aviation Administration

slots

A related problem is who should receive the proceeds of the auction. Some contend that the proceeds should be turned over to the airport authority, which bears the burden of operating the facility and making necessary capital improvements and maintenance outlays. Others argue that, like other user fees, funds raised by auctions should be placed in the Airport and Airway Trust Fund and distributed as needed for airport capital projects. A novel approach, advanced by the Port Authority of New York and New Jersey, is that funds obtained from peak-hour slot auctions should be distributed to airlines operating offpeak thereby providing them an incentive to offer service at such times.[9]

[9] J. Ott, "U.S. Reviews Airport Slot Policy," ***Aviation Week & Space Technology, Apr. 16, 1984,*** pp. 32-33.

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Another problem is the status of the slots once they have been auctioned. One view is that they become the property of the airlines, to be bought and sold at will. Another is that they should remain the property of either the local airport authority or the Federal Government, which could retain control over the transferal of slots through another auction.

Finally, there is the special problem of international users who need to gain access to Federal immigration and customs facilities, which are available only at certain airports. If an aircraft entering the United States is required to clear customs and immigration and can do so conveniently only at an airport with slot restrictions, equity would appear to dictate that access be afforded, and at no additional cost. On the other hand, such aircraft are using a valuable commodity for which others must compete and pay, and there is little economic justification in distinguishing between domestic and foreign flights since both impose equal cost on the airport at the time of use.

FACTORS AFFECTING THE USE OF DEMAND= MANAGEMENT ALTERNATIVES

The demand-management techniques enumerated above could, in theory, reduce delay. Some have actually been tried, with mixed results. However, there are factors that may affect the ability of airport operators or the Federal Government to implement them on a wide scale.

Some argue that regulations restricting airport access are unconstitutional because they interfere with interstate commerce and abridge the right of access for some users. Many industry observers shudder to think that the kinds of access restrictions in effect at National Airport might become common at major airports. Determination of whether they would be an undue burden is a delicate matter which must be decided on a case-by-case basis, depending on the parties involved, the location of the airport, and its importance to the national system. FAA itself does not appear to encourage the spread of quotas and other restrictions imposed by airports, operators, even though they are in use at federally owned Washington National Airport. For example, FM contested the imposition by John Wayne Airport of a perimeter rule forbidding the operation of long-range flights.

Deregulation has made the allocation of slots through negotiation a more difficult process, as the scheduling committees must constantly accommodate new entrants or changes in incumbent carriers' levels of service. The Civil Aeronautics Board's Task Force on Airport Access has noted that scheduling committees are capable of discriminating against new entrants and cautioned that the whole negotiation process might be anticompetitive.l"

Policies to encourage development of reliever airports or more balanced utilization of airports in metropolitan regions are unlikely to be implemented in locales where airports are competitors and not operated by the same sponsor. Congress has attempted to address the regional implications of airport development in its mandate for FAA to develop a National Plan of Integrated Airport Systems. It remains to be seen whether this planning document, or any other action at the Federal level, can improve regional coordination of airport facilities.

The basic theory of demand-related airport access fees and the general principle that fees should be proportional to marginal delay costs are well understood. It is also commonly acknowledged that the present scheme of pricing services, especially at congested airports, is far from economically efficient. However, market-related approaches, such as peak-hour pricing and congestion surcharges, may be difficult to implement, and they are likely to encounter stiff opposition from some classes of users, especially GA. Despite the theoretical attractiveness of marginal-cost pricing, it maybe difficult in practice to determine the true marginal cost of a landing or a takeoff. There are

[10] *Report and Recommendations of the Airport Access Task Force*, op. cit.

analytic problems and policy issues to be resolved, as well as the underlying question of whether economic efficiency should be a primary goal of airport management. Several years of experimentation might be needed to establish the most effective fee structure for controlling delay and covering airport costs.

There are some dangers inherent in these experiments. It is possible that, in a deregulated environment where carriers are frequently changing routes and levels of service, airports would be unable to determine the effects of their experiments or to guard against unpredictable (and undesirable) side effects on the airline industry or on other airports. The process of diverting air carrier operations to offpeak might be self-defeating for some airports. Rather than schedule operations in slack hours at airports that they perceive as marginal, carriers might prefer to move out of the airport altogether. While this might be a desirable effect from the system perspective, it would be the opposite for the airport operator, who would lose revenue.

Further, in order to be effective in shifting air carrier traffic to offpeak hours, landing fees during peak hours might have to be raised substantially. In many cases, use agreements between air carriers and airports would prevent such radical changes in fees. If it were determined to be in the national interest for airport operators to make such changes in their fee structures, the Federal Government might have to take action to abrogate or modify existing use agreements. On the other hand, some believe it is unwise for the Federal Government to become so directly involved in the pricing decisions of individual airports.

Economic policies or administrative actions to reduce GA traffic at congested major airports could have two effects. The intended effect would be diversion of some GA traffic to other nearby landing places. However, for some types of aircraft and for some GA users, there will be no other facility as suitable as the main air carrier airport; and they would have to pay the cost if they wish to continue using it. Alternatively, some users might find the monetary cost or inconvenience too high and choose to use commercial flights rather than continuing to operate their own aircraft.

The sale or auction of slots is controversial with regard to ownership and the right of sale. The confusion over slots following the Braniff bankruptcy is a case in point.[11] At that time, FAA's post-strike cap on operations was in effect at 22 airports, and Braniff argued that their assigned slots were assets that had monetary value which should accrue to the airline. FAA's position was that the slots were under FAA control. (FAA did in fact reassign those slots to other carriers on an emergency basis after Braniff stopped flying.) From the airport operator's point of view, however, slots represent the essential attributes of the airport, namely runway time and space. If they are determined to be property at all, the airport operator would argue that they belong to neither FAA nor the carriers, but to the airport.

A 1981 FAA report illustrates the general benefits of demand management.[12] The report examined projected demand and traffic mix at the 39 busiest air carrier airports to determine those with future capacity problems and to identify remedial measures that could be applied to alleviate delay. About half (19 of the 39 airports studied) were expected to face serious delay problems by 1991. Analysis of the traffic mix at these airports identified seven with a high proportion of GA traffic, and FAA concluded that demand-management techniques aimed at diverting GA to offpeak hours or to reliever airports could obviate the need for new construction to expand capacity.

At four other airports, a different form of demand management offered potential relief. Each of the four (San Francisco, Dallas-Fort Worth, Chicago O'Hare, and Washington National) has another nearby airport with underutilized capacity. By shifting some peak-period traffic (air carrier and GA) to these alternate airports, capital improvements at the overcrowded airport could be avoided. The results of this analysis, summarized in table 17, indicate that demand management could eliminate or substantially reduce capital expenditures for new capacity at 11 of the

[11] See, for example, *Aviation Week & Space Technology*, May 17, 1982; May 24, 1982; and June 14, 1982.

[12] *Airfield and Airspace Capacity/Delay Policy Analysis*, FAA-APO-81-14 (Washington, DC: Federal Aviation Administration, December 1981).

Table 17.—Application of Demand Management to Soiving Probiems of Capacity and Deiay

Airports where *diversion of GA could relieve congestion*

Airport	Operations forecast, 1991 (Xl,ooo)		PANCAP[a] (Xl,ooo)	Air-carrier/ PANCAP ratio	Percent operations in 3" peak hours
	Air carrier	GA			
Houston	316	185	300	1.05	24
Las Vegas	254	296	330	0.77	28
Memphis	288	287	355	0.81	30
Oakland	201	585	595	0.34	NA[b]
Phoenix	195	276	330	0.59	27
San Diego	137	98	180	0.76	
Santa Ana	353	565	385	0.92	l%'

Ahports when? dlverslon of traffic to another iocai airport couid relieve congestion

Airport	Operations forecast, 1991 (Xl,000)		PANCAP[a] (Xl,ooo)	Air-carried PANCAP ratio	Percent operations in 3 peak hours	Alternate airport
	Air carrier	GA				
Chicago O'Hare	965	60	616	1.57	24	Chicago Midway
Dallas Fort Worth	620	20	340	1.82	26	Dallas Love Field
San Francisco	478	29	400	1.20	24	Oakland
Washington National	399	117	275	1.45	21	Dunes, Baltimore-Washington International

Airports requiring* additional capacity *by 1991

Airport	Operations forecast, 1991 (Xl,ooo)		PANCAP[a] (X1,000)	Air-carrier/ PANCAP ratio	Percent operations in 3 peak hours
	Air carrier	GA			
Atlanta	725	57	472	1.54	27
Boston	441	75	303	1.46	25
Denver	611	90	355	1.72	28
Los Angeles	758	35	448	1.69	25
New York, JFK	329	46	272	1.21	32
New York, La Guardia	454	48	247	1.84	22
Philadelphia	528	43	295	1.79	24
St. Louis	448	40	280	1.60	27

[a]PANCAP—Practical Annual Capacity.
[b]Not available.

SOURCE: *Airfield and Airspace Capacity/Delay Policy Analysis,* FAA-APO-81-14 (Washington, DC: Federal Aviation Administration, December 1981).

19 major airports expected to have high levels of demand by 1991.

The FAA findings lend credence to the general notion that demand management, either by administrative or economic means, is worthy of consideration as an alternative to capital investment in new capacity and to technological approaches to reduce delay. The attractiveness of the concept stems in part from the fact that demand management can be implemented in far less time than it takes to construct new facilities or to install new technology. On the other hand, it must be recognized that demand management would be controversial. Administrative measures to redistribute demand would be viewed by many in the aviation community as an arbitrary and unwarranted exercise of government power, either Federal or local. Pricing schemes such as marginal-cost pricing or slot auctions would be scarcely more palatable to users accustomed to low-cost and unrestricted access to airports. Either approach would be such a sweeping departure from traditional policy that aircraft operators forced to shift their activities to other airports or times of day would be likely to resist on the grounds of discrimination or undue hardship. Airport operators, themselves, would also be reluctant to venture into an area where there is so little experience to guide them and where analysts and economic theoreticians cannot predict the benefits and risks except in general and carefully qualified terms. Still, from the standpoint of efficient use of existing resources and avoidance of large new capital investment, demand management is an option worthy of serious consideration and experimentation.

Chapter 6

AIRPORT FINANCIAL MANAGEMENT AND PRICING

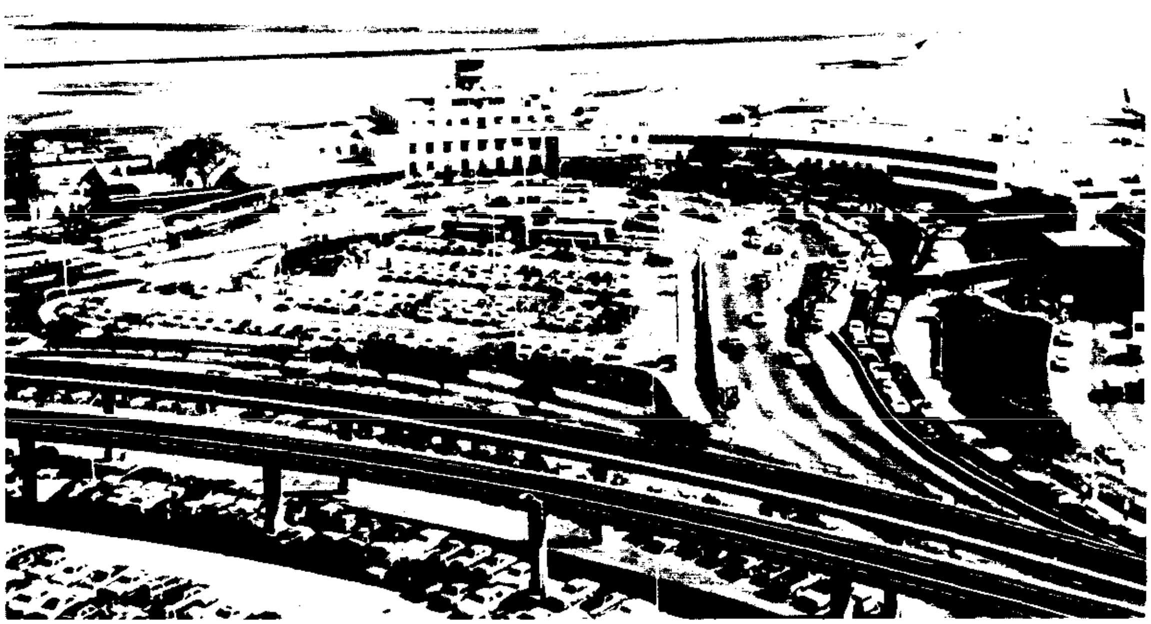

Photo credit: Federal Aviation Administration

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Chapter 6
AIRPORT FINANCIAL MANAGEMENT AND PRICING[1]

Unlike airports in other countries, many of which are owned and run by national governments, U.S. commercial airports are typically owned and managed by local governments or other non-Federal public authorities. Although the management approach varies, major U.S. commercial airports function as mature enterprises, applying up-to-date techniques of financial management and administration. These publicly owned and managed facilities are operated in conjunction with private industry-the commercial airlines, which are the airports' link to their patrons. This peculiar public-private character distinguishes the financial operation of commercial airports from that of wholly public or private enterprises, distinctly shaping airport management practices, the pricing of facilities and services, and the investment planning process.

On the basis of a survey conducted by the Congressional Budget Office (CBO) in **1983** (app. B), this chapter develops a profile of financial policies and practices now followed at 60 of the Nation's larger commercial airports and assesses trends in airport financial management since Federal deregulation of the airline industry in 1978. Brief attention is also given to management and financing practices of smaller airports, including publicly owned general aviation (GA) airports.

APPROACHES TO FINANCIAL MANAGEMENT

At most commercial airports, the financial and operational relationship between the airport operator and the airlines is defined in legally binding agreements that specify how the risks and responsibilities of running the airport are to be shared. These contracts, commonly termed "airport use agreements, " establish the terms and conditions governing the airlines' ***use*** of the airport.[2] They also specify the methods for calculating rates airlines must pay for use of airport facilities and services; and they identify the airlines' rights and privileges, sometimes including the right to approve or disapprove any major proposed airport capital development projects.

Although financial management practices differ greatly among commercial airports, the airport-airline relationship at major airports typically takes one of two very different forms, with important implications for airport pricing and investment:

- The ***residual-cost approach,*** under which the airlines collectively assume significant financial risk by agreeing to pay any costs of running the airport that are not allocated to other users or covered by nonairline sources of revenue.
- The ***compensatory approach,*** under which the airport operator assumes the major financial risk of running the airport and charges the airlines fees and rental rates set so as to recover the actual costs of the facilities and services that they use.

The Residual-Cost Approach

A majority of the Nation's major commercial airports surveyed by CBO—14 out of ***24*** large airports and **21** of **36** medium airports—have some form of residual-cost approach to financial management (see box A and table **18).** Under this approach, the airlines collectively assume significant

IThis chapter was prepared by the Congressional Budget Office and appears in unabridged form in Financing *U.S.* Airports ***in the 1980s,*** April 1984. The version here has been condensed and edited to conform to the OTA report format.

"'Airport use agreement" is used generically hereto include both legal contracts for the airlines' use of airfield facilities and leases for use of terminal facilities. At many airports, both are combined in a single document. A few commercial airports do not negotiate airport use agreements with the airlines, but instead charge rates and fees set by local ordinance.

Box A.—CBO Airport Classification

The CBO analysis presented in chapters 6 and 7 groups commercial service airports in three categories, based on passenger boardings (enplanements) on flights by domestic and foreign-flag carriers, commuter airlines, and air taxis in calendar year 1982. Boardings are passenger trips through to destination points. A passenger on a through flight with a stopover, at which he may deplane and reboard the same flight, is counted as one boarding. A passenger on a connecting flight, which requires changing planes, is counted as a multiple boarding.

- *Large airports* handle 1 percent or more of all yearly passenger boardings in the United States. There were 24 airports in this category, with boardings of at least 3,091,521 passengers, in 1982.
- *Medium airports* handle between 0.25 percent and 1 percent of yearly passenger boardings. There were 47 airports in this category, with boardings of at least 772,880 and not more than 3,091,520 passengers, in 1982.
- *Small airports* are the remaining airports receiving scheduled air service. They handle no more than 772,880 (0.25 percent) but not fewer than 2,500 boardings per year. This category included [illegible] airports in 1982.

General aviation airports [illegible] In 1982, there were [illegible] Of these, 219 were [illegible] cial airports.

financial risk. They agree to keep the airport financially self-sustaining by making up any deficit—the residual cost—remaining after the costs identified for all airport users have been offset by nonairline sources of revenue (automobile parking and terminal concessions such as restaurants, newsstands, snack bars, and the like).

Although applications of the residual-cost approach vary widely, a simplified example can illustrate the basic approach (see table **19).** Most airports have a number of different cost centers, such as terminal buildings, the airfield, roads and grounds, and the air freight area. At a residual-cost airport, the total annual costs—including administration, maintenance, operations, and debt service (including coverage) —could be calculated for each cost center, and offset by all nonairline revenues anticipated for that center.[3] The residual between costs and revenues would then provide the basis for calculating the rates charged the airlines for their use of facilities within the cost center. Any surplus revenues would be credited to the airlines and any deficit charged to them in calculating airline landing fees or other rates for the following year.[4]

Table 18.—Financial Management of Commercial Airports, 1983

Approach	Large Number	Large Percent	Medium Number	Medium Percent
Residual cost[a]	14	58	21	58
Compensatory[b]	10	42	15	42
Total	24	100	36	100

Note: Data include all large airports and 77 percent of medium commercial airports. Data for small airports were not available.
[a]Includes one airport using a noncompensatory approach but which does not calculate airline fees and charges on a residual-cost basis.
[b]Includes airports that use a "cost of services" approach, which is sometimes classified as a third approach because of differences in the way airport terminal rental rates are calculated.

SOURCE: Congressional Budget Office, 1963 Survey.

The Compensatory Approach

Under a compensatory approach, the airport operator assumes the financial risk of airport operation, and airlines pay rates and charges equal to the costs of the facilities they use as determined by cost accounting. In contrast to the situation at residual-cost airports, the airlines at a compensatory airport provide no guarantee that fees and

[3]Debt service coverage is the requirement that the airport's revenues, net of operating and maintenance expenses, be equal to a specified percentage in excess of the annual debt service (principal and interest payments) for revenue bond issues. The coverage required is generally from 1.25 to 1.40 times debt service, thereby providing a substantial cushion that enhances the security of the bonds. This is discussed further in ch. 7.

[4]Harold B. Kluckholn, "Security for Tax-Exempt Airport Revenue Bonds," summary of remarks presented at the New York ***Law Journal*** Seminar on Tax-exempt Financing for Airports, 1980.

rents will suffice to allow the airport to meet its annual operating and debt service requirements. A compensatory approach is currently in use at 10 of the 24 large commercial airports and **15** of the **36** medium airports surveyed by CBO.

Although individual airports have adopted many versions of the compensatory approach, the simplified example set out in table 19 illustrates the basics. First, for each cost center a calculation would be made of the total annual expense of running the center, including administration, maintenance, operations, and debt service (with coverage). The airlines' shares of these costs would then be based on the extent of their actual use of facilities within each cost center. The airlines would not be charged for the costs of public space, such as terminal lobbies. Nor would they receive any credit for nonairline revenues, which offset expenses in the residual-cost approach but are disregarded under a compensatory approach in calculating rates and charges to the airlines.

Comparison of Residual-Cost and Compensatory Approaches

These two major approaches to financial management of major commercial airports have significantly different implications for pricing and investment practices. In particular, they help determine:

- an airport's potential for accumulating ***retained earnings*** usable for capital development;
- the nature and extent of the airlines' role in making airport capital investment decisions, which may be formally defined in ***majority-in-interest*** clauses included in airport use agreements with the airlines; and
- the length of ***term*** of the use agreement between the airlines and the airport operator.

These differences, examined below, can have an important bearing on an airport's performance in the municipal bond market, as will be discussed in chapter 7.

Retention of Earnings

Although large and medium commercial airports generally must rely on the issuance of debt to finance major capital development projects, the availability of substantial revenues generated in excess of costs can strengthen the performance of an airport in the municipal bond market. It can also provide an alternative to issuing debt for the

Table 19.—Comparison of Residual-Cost and Compensatory Methods of Calculating Airport Fees[a]

	Residual cost		Compensatory	
Requirement	Terminal	Airfield	Terminal	Airfield
Maintenance, operations, and administration	$ 40,000	$ 40,000	$ 40,000	$ 40,000
Debt service	40,000	20,000	40,000	20,000
Debt service coverage	10,000	5,000	10,000	5,000
Deposits to special funds	5,000	20,000	5,000	20,000
Other	5,000	15,000	5,000	15,000
Total requirement	$ 100,000	$ 100,000	$100,000	$100,000
Cost center revenue from nonairline sources	–$50,000	–$50,000	NA[b]	NA
Airline share (percent)	NA	NA	65	75
Residual cost	$ 50,000	$ 50,000	NA	NA
Activity level	6,500 ft²	100,000lb gross landing weight	6,500 ft²	100,000lb gross landing weight
Rental rate (per square foot)	$ 7.69	NA	$10.00	NA
Landing fee rate (per 1,000 lb gross landing weight	NA	$ 0.50	NA	$ 0.75

[a]This is not a comparison of actual rate calculations but a simplified illustration. Rates are not necessarily higher under either approach but differ according to the volume of traffic, amount of debt, and other factors.
[b]NA = Not applicable.

SOURCE: Congressional Budget Office, adapted from Kluckhohn, "Security for Tax-Exampt Airport Revenue Bonds."

financing of some portion of capital development. Residual-cost financing guarantees that an airport will always break even—thereby assuring service without resort to supplemental local tax support—but it precludes the airport from generating earnings substantially in excess of costs.[5]

By contrast, an airport using a compensatory approach lacks the built-in security afforded by the airlines' guarantee that the airport will break even every year. The public operator undertakes the risk that revenues generated by airport fees and charges may not be adequate to allow the airport to meet its annual operating costs and debt service obligations. On the other hand, because total revenues are not constrained to the amount needed to break even, and because surplus revenues are not used to reduce airline rates and charges, compensatory airports may earn and retain a substantial surplus, which can later be used for capital development. Since the pricing of airport concessions and consumer services need not be limited to the recovery of actual costs, the extent of such retained earnings generally depends on the magnitude of the airport's nonairline revenues.[b]

Because the residual-cost approach is not designed to yield substantial revenues in excess of costs, residual-cost airports, as a group, tend to retain considerably smaller percentages of their gross revenues than do compensatory airports. A few residual-cost airports, however, have modified the approach to permit accumulation of sizable retained earnings for use in capital projects. At Miami and Reno International Airports, for example, certain airport-generated revenues are excluded from the revenue base used in calculating the residual cost payable by the airlines; the revenues flow instead into a discretionary fund that can finance capital development projects.

Majority=in-interest

In exchange for the guarantee of solvency, airlines that are signatory to a residual-cost use agreement often exercise a significant measure of control over airport investment decisions and related pricing policy. These powers are embodied in so-called majority-in-interest clauses, which are a much more common feature of airport use agreements at residual-cost airports than at airports using a compensatory approach (see table **20).** At present, more than three-quarters of the large commercial airports using a residual cost approach have some form of majority-in-interest clause in their use agreements with the airlines, and two-thirds of the medium residual-cost airports have such clauses. Of the airports surveyed, only one-tenth of the large and one-third of medium commercial airports that use a compensatory approach to financial management have majority-in-interest clauses in their use agreements.

‘Peat, Marwick, Mitchell & Co., “Comparative Rate Analysis: Dade County Aviation and Seaport Departments, ” August 1982, p. 3.

‘Market pricing of concessions and other nonairline sources of revenue is a feature of both residualcost and compensatory airports.

Table 20.—Role of Airlines in Approving Capitai Projects at Commercial Airports, 1983[a]

Airline role	Large		Medium	
	Number	Percent	Number	Percent
Residual cost				
Majority-in-Interest clause	11	79	14	67
No formal requirement of airline approval	3	21	7	33
Total	14	100	21	100
Compensatory				
Majority-in-Interest clause	1	10	5	33
No formal requirement of airline approval	9	90	10	67
Total	10	100	15	100
Grand total	24	—	36	—

[a]Data include all large commercial airports and 77 percent of medium airports. Data for small airports were not available.

SOURCE: Congressional Budget Office, 1983 Survey.

Majority-in-interest clauses give the airlines accounting for a majority of traffic at an airport the opportunity to review and approve or veto capital projects that would entail significant increases in the rates and fees they pay for the use of airport facilities.[7] This arrangement provides protection for the airlines that have assumed financial risk under a residual-cost agreement by guaranteeing payment of all airport costs not covered by nonairline sources of revenue. For instance, without some form of majority-in-interest clause, the airlines at a residual-cost airport could be obligating themselves to pay the costs of as-yet-undefined facilities that might be proposed in the 15th or 20th year of a 30-year use agreement. Under a compensatory approach, where the airport operator assumes the major financial risk of running the facility, the operator is generally freer to undertake capital development projects without consent of the airlines that account for a majority of the traffic. Even so, airport operators rarely embark on major projects without consulting the airlines that serve the airport. Potential investors in airport revenue bonds would be wary of a bond issue for a project lacking the airlines' approval.

Specific provisions of majority-in-interest clauses vary considerably. At some airports, the airlines that account for a majority of traffic can approve or disapprove all major capital development projects—e.g., any project costing more than $100,000. At others, projects can only be deferred for a certain period of time (generally 6 months to 2 years). Although most airports have at least a small discretionary fund for capital improvements that is not subject to majority-in-interest approval, the general effect of majority-in-interest provisions is to limit the ability of the public airport owner to proceed with any major project opposed by the airlines. Sometimes, a group of just two or three major carriers can exercise such control.

The combination of airlines that can exercise majority-in-interest powers varies. A typical formulation would give majority-in-interest powers to any combination of "more than so percent of the scheduled airlines that landed more than 50 percent of the aggregate revenue aircraft weight during the preceding fiscal year" (standard document wording).

Term of Use Agreement

At the airports examined in the CBO study, residual-cost airports typically have longer term use agreements than do compensatory airports. This is because residual-cost agreements historically have been drawn up to provide security for long-term airport revenue bond issues; and the term of the use agreement, with its airline guarantee of debt service, has generally coincided with the term of the revenue bonds. More than 90 percent of the large and 75 percent of the medium residual-cost airports surveyed by CBO have use agreements with terms of 20 or more years (see table 21). Terms of 30 years or longer are not uncommon.

By contrast, about 60 percent of the large and 40 percent of the medium compensatory airports surveyed have use agreements running for 20 years or more. Four of the compensatory airports surveyed have no contractual agreements whatever with the airlines. At these airports, rates and charges are established by local ordinance or resolution. This arrangement gives airport operators maximum flexibility to adjust their pricing and investment practices unilaterally, without the constraints imposed by a formal agreement negotiated with the airlines, but it lacks the security provided by contractual agreements.

Pricing of Airport Facilities and Services

Major commercial airports are diversified enterprises that provide a wide range of facilities and services for which fees, rents, or other user charges are assessed. Most commercial airports, regardless of size, type, or locale, offer four major types of facilities and services:

- *airfield facilities,* made up of runways, taxiways, aprons, and parking ramps for use by commercial and general aviation;
- *terminal area facilities and services* provided to concessionaires and consumers, including auto parking and ground transportation, restaurants and snack bars, specialty stores (e.g., newsstands and duty-free shops), car rental companies, passenger convenience facilities (e.g., porter service, restrooms, telephones, and vending machines), personal

Table 21.–Term of Airport Use Agreements at Commercial Airports, 1983

Length of term	Large Number	Large Percent	Medium Number	Medium Percent
Residual cost				
20 years or more	13	93	16	76
11-19 years	0	0	2	10
6-10 years	0	0		5
5 years or less	1	7	:	0
Negotiations in process	0	0	2	10
Total	14	100	21	100
compensatory				
20 years or more	6	60	6	40
11-19 years	0	0	2	13
6-10 years	1	10	2	13
5 years or less	0	0	3	20
No use agreements	3	30	1	7
Negotiations in process	0	0	1	7
Total	10	100	15	100
Grand total	24[a]	—	36[b]	—

[a]All large commercial airports.
[b]77 percent of medium commercial airports.

SOURCE: Congressional Budget Office, 1983 Survey.

services (e.g., barbershops and valet services), game rooms and amusement facilities, office space, and hotels;

- *airline leased areas* in the terminal and elsewhere, including ticket counters, gate space, passenger waiting rooms, baggage handling areas, office space, operations and maintenance areas, hangars, cargo terminals and aprons, ground rentals;[8] and
- *other airport facilities* leased to nonairline tenants and related services, including cargo terminals, ground rentals, fixed base operations,[9] industrial areas, fuel and servicing of aircraft, agricultural land, warehouses, and other buildings and grounds.

At major commercial airports, the facilities and services provided to users generate the revenues necessary to operate the airport and to support the financing of capital development. Smaller commercial airports and GA airports typically offer a much narrower range of facilities and services, for which only minimal fees and charges often are assessed. Revenue bases shrink as airports decrease in size, and many of the smallest do not generate sufficient revenue to cover their operating costs, much less capital investment. Among GA airports, those that lease land or facilities for industrial use generally have a better chance of covering their costs of operation than do those providing only aviation-related services and facilities.[10]”

The combination of public management and private enterprise uniquely characteristic of the financial operation of commercial airports is reflected in the divergent pricing of airport facilities and services. The private enterprise aspects of airport operation—the services and facilities furnished for nonaeronautical use—generally are priced on a market pricing basis. On the other hand, the pricing of facilities and services for airlines and other aeronautical users is on a cost-recovery basis, either recovery of the actual costs of the facilities and services provided (the compensatory approach) or recovery of the residual costs of airport operation not covered by nonairline sources of revenue. This mix of market pric-

[8]Ground rentals are leases of land in which the lessee pays the cost of constructing any facilities, such as terminals, upon it.

[9]Fixed base operators are private concerns that lease aircraft and offer aviation services, such as fuel sale, flight instruction, and aircraft maintenance.

[10]See Joel Crenshaw and Edmund Dickinson, “Investment Needs and Self-Financing Capabilities: U.S. Airports, Fiscal Years 1981-1990,” report prepared for the U.S. Department of Transportation, July 1978, pp. 12, 45; and Laurence E. Gesell, The ***Administration of Public Airports,*** Coast Aire Publications, 1981, pp. VI 6-13.

ing and cost-recovery pricing has important implications for airport financing, especially with regard to the structure and control of airport charges and the distribution of operating revenues,

Structure and Control of Airport Charges

At major commercial airports, the structure and control of fees, rents, and other charges for facilities and services are governed largely by a variety of long- and short-term contracts, including airport use agreements with the airlines, leases, and concession and management contracts. For each of the four major groups of facilities and services outlined above, the basic kinds of charges assessed at residual-cost and compensatory airports can be compared in terms of:

- method of calculation,
- term of agreement, and
- frequency of adjustment.

Airfield Area

The major fees assessed for use of airfield facilities are landing or flight fees for commercial airlines and GA aircraft. Some airports also levy other airfield fees such as charges for the use of aircraft parking ramps or aprons. In lieu of landing fees, many smaller airports, especially GA airports, collect fuel "flowage" fees, which are levied per gallon of aviation gasoline and jet fuel sold at the airport.

At residual-cost airports, the landing fee for airlines is typically the item that balances the budget, making up the projected difference between all other anticipated revenues and the total annual costs of administration, operations and maintenance, and debt service (including coverage). Landing fees differ widely among residual-cost airports, depending on the extent of the revenues derived from airline terminal rentals and concessions such as restaurants, car rental companies, and automobile parking lots. If the nonairline revenues are high in a given year, the landing fee for the airlines may be quite low. In recent years, several airports—including Los Angeles and Honolulu International—have approached a "negative" landing fee. At some residual-cost airports, the landing fee is the budget-balancing item for the airfield cost center only. At such airports, the surplus or deficit in the terminal cost center has no influence on airline landing fees, and terminal rental rates for the airlines may be set on a residual-cost or a compensatory basis.

The method of calculating landing fees at residual-cost airports is established in the airport use agreement and continues for the full term of the agreement. To reflect changes in operating costs or revenues, landing fees are typically adjusted at specified intervals ranging from **6** months to 3 years. At some airports, fees maybe adjusted more often if revenues are significantly lower or higher than anticipated. Often, the nonsignatory airlines (those not party to the basic use agreement) pay higher landing fees than the signatory carriers. General aviation landing fees vary greatly from airport to airport, ranging from charges equal to those paid by the commercial airlines to none at all. Most landing fees are assessed on the basis of certificated gross landing weight. "

At compensatory airports, airline landing fees are based on calculation of the average actual costs of airfield facilities used by the airlines (see table 22). As in the case of residual-cost airports, each airline's share of these costs is based on its share of total projected airline ***gross*** landing weights (or, in a few cases, gross takeoff weight). In addition to fees determined by this weight-based measure, three compensatory airports—Boston Logan International and John F. Kennedy and La Guardia airports in New York—assess a surcharge on GA aircraft during hours of peak demand. At present, however, no major airports

"This practice of basing landing fees ***on*** aircraft weight tends to promote use of commercial airports by general aviation. Since most GA aircraft are relatively light (under 10,000 lb), they pay very low landing fees at most commercial airports-typically $10 or less. The smallest GA aircraft (under 2,500 lb) often pay no fee. Among the airports surveyed by CBO there is no clear indication that landing fees for GA differ systematically as a function of pricing policy. Residual-cost and compensatory airports alike have landing fees for GA that are so small as to be a negligible, either as a source of revenue to the airport or as a deterrent to use of congested facilities.

Table 22.–Profiie of Landing Fees at Four Major Airports, 1982

Basis of fee	Airline landina fee: Method of calculation	Airline landina fee: Fee[a]	General aviation landing fee
Boston Logan International			
Compensatory; based on recovery of all costs of providing and operating "public aircraft facilities"[b]	Fee = public aircraft facilities costs divided by total projected scheduled airline landing weights; adjusted annually	$1.24	**$1.24 per 1,000 lb of maximum gross landing weight, subject to $50 minimum during peak periods and $20 in offpeak periods**
Denver Stapleton International			
Compensatory; based on recovery of maintenance, operations, and debt service costs for airfield area	Fee = airfield cost center expenses divided by total projected airline landing weights; adjusted annually	$0.34	**$0.34 per 1,000 lb of maximum gross landing weight, subject to $3 minimum with fuel flowage fees credited against minimum**
Los Angeles International			
Residual cost; based on recovery of all costs (maintenance, operations, and debt service), net of all revenues other than landing fees	Fee = residual cost divided by estimated total landing weights of all airlines; adjusted semiannually	$0.75[c]	**$0.80 per 1,000 lb of maximum gross landing weight, subject to $10 minimum for aircraft under 12,500 lb and $15 minimum for aircraft from 12,500 to 25,000 lb**
New Orleans International			
Residual cost; based on recovery of all costs (maintenance, operations, and debt service), net of all revenues other than landing fees	Fee = residual cost divided by estimated total landing weights of all airlines; adjusted every 3 years	$0.23	**$0.40 per 1,000 lb of maximum gross landing weight**

[a]Fee per 1,000 lb of maximum gross landing weight. A typical commercial jet airliner (727-200) weighs about 200,000 lb; a typical general aviation jet (Lear 25D) weighs 15,000 lb.
[b]Defined as including the capital costs of public aircraft facilities; cost of equipment; replenishment of Maintenance Reserve Fund; administration, operations, and maintenance costs; and allocated portions of payments in lieu of taxes.
[c]$0.80 for nonsignatory carriers.

SOURCE: Congressional Budget Office, updated and adapted from Peat, Marwick, Mitchell & Co., *Comparative Rate Analysis: Dade County Aviation and Seaport Depafiments,* August 1982.

impose such peak-hour surcharges on commercial airlines to help ease congestion problems.1[2]

Landing fees at compensatory airports are established either in airport use agreements with the airlines or by local ordinance or resolution. The frequency of adjustment of the fees is comparable to that at residual-cost airports.

Terminal Area

The structure of terminal concession and service contract fees is similar under both pricing approaches. Concession contracts typically provide the airport operator with a guaranteed annual minimum payment or a specified percentage of the concessionaire's gross revenues, whichever is greater. Restaurants, snack bars, gift shops, newsstands, duty-free shops, hotels, and rental car operations usually have contracts of this type. Terminal concession contracts are often bid competitively, and they range in term from month-to-month agreements to contracts of **10** to ***15*** years' duration. (Hotel agreements generally have much longer terms, often running for ***40*** years or more.) Airport parking facilities may be operated as concessions; they may be run by the airport directly; or they may be managed by a contractor for either a flat fee or a percentage of revenues.

Airline Leased Areas

At both residual-cost and compensatory airports, airlines pay rent to the airport operator for the right to occupy various facilities (terminal space, hangars, cargo terminals, and land). Rental rates are established in the airport use agreements, in separate leases, or by local ordinance or resolution. Terminal space may be assigned on an exclusive-use basis (to a single airline), a preferential-

[12]Peak-hour surcharges could reduce congestion by giving airlines and other providers of air transportation services the opportunity to save money (and offer lower fares) by flying during uncongested periods. If peak-period demand continued to cause congestion, the increased revenue generated by the surcharges could help finance the expansion necessary to accommodate peak-hour traffic. See Congressional Budget Office, *Public Works Infrastructure,* April 1983, ch. VII, and *Charging for Federal Services,* ch. V. See also ch. 5 of this report.

use basis (if a certain level of activity is not maintained, the airline must share the space), or on a joint-use basis (space used in common by several airlines). Most major commercial airports use a combination of these methods. In addition, airports may charge the airlines a fee for use of any airport-controlled gate space and for the provision of Federal inspection facilities required at airports serving international traffic. Some airports have long-term ground leases with individual airlines that allow the airlines to finance and construct their own passenger terminal facilities on land leased from the airport.

Among residual-cost airports, the method of calculating airline terminal rental rates varies considerably. If airline fees and charges are calculated on a residual-cost basis within each cost center, the method of calculating rental rates resembles that of the simplified example shown in table 19. To arrive at the airline fee, total nonairline revenues generated within the terminal cost center are subtracted from the total costs of the center (administration, operations and maintenance, and debt service). Each airline's share is based on the square footage it occupies, with proration of jointly used space.

On the other hand, at residual-cost airports where receipts from airline landing fees alone are used to balance the airport budget, the terminal rental rates for the airlines may be set in various ways—on a compensatory basis (recovering the average actual costs of the facilities used), by an outside appraisal of the property value, or by negotiation with the airlines. In all cases, each airline's share of costs is based on its proportionate use of the facilities. Rental rates may be uniform for all types of space leased to the airlines, or they may differ according to the type of space provided—for example, they may be significantly higher for leases of ticket counters or office space than for rental of gate or baggage claim areas.

At residual-cost airports, the rental term for airline leased areas generally coincides with the term of the airport use agreement with the airlines. The frequency of adjustment of terminal rental rates ranges considerably—annually at many airports, but up to 3 to 5 years at others.

At compensatory airports, the method of calculating terminal rental rates for the airlines is based on recovery of the average actual costs of the space occupied. Each airline's share of the total costs is based on the square footage leased. Typically, rates differ according to the type of space and whether it is leased on an exclusive, preferential, or joint-use basis. The rental term for airline leased areas often coincides with that of the airport use agreement. (It is set by ordinance at airports that operate without agreements.) Rates are typically adjusted annually at compensatory airports.

Other Leased Areas

A wide variety of arrangements are employed for other leased areas at an airport, which may include agricultural land, fixed base operations, cargo terminals, and industrial parks. The methods of calculating rental rates and the frequency of adjustment differ according to the type of facility and the nature of use. What these disparate rentals have in common is that, like terminal concessions and services, they are generally priced on a market basis; and the airport managers have considerable flexibility in setting rates and charges in the context of market constraints and their own policy objectives.

Variation in the Source of Operating Revenues

1n general, revenue diversification enhances the financial stability of an airport. In addition, the specific mix of revenues may influence year-to-year financial performance. Some of the major sources of airport revenue (notably landing fees and terminal concessions) are affected by changes in the volume of air passenger traffic, while others (e.g., airline terminal rentals and ground leases) are essentially immune to fluctuations in air traffic.

The distribution of operating revenues differs widely according to factors such as passenger enplanements, the nature of the market served, and the specific objectives and features of the airport's approach to pricing and financial management. Airport size generally has a strong influence on the distribution of revenues. The larger commercial airports typically have a more diversified revenue base than smaller airports. For example, they tend to have a wider array of income-producing facilities and services in the passenger terminal complex. In general, terminal concessions can be expected to generate a greater percentage of total operating revenues as passenger enplanements increase. On average, concessions account for at least one-third of total operating revenues at large, medium, and small commercial airports, compared to about one-fifth at very small (nonhub) commercial airports and a smaller fraction still at GA airports (see table **23).**

Factors other than airport size also affect distribution of operating revenues. At commercial airports, for example, parking facilities generally provide the largest single source of nonairline revenues in the terminal area. Airports that have a high proportion of connecting traffic may, however, derive a smaller percentage of their operating income from parking revenues than do so-called "origin and destination" airports. Other factors that may affect parking revenues include availability of space for parking, the volume of air passenger traffic, the airport pricing policy, availability and cost of alternatives to driving to the airport (e.g., mass transit and taxicab service), and the presence of private competitors providing parking facilities at nearby locations off the airport property.

The approach to financial management, because it governs the pricing of facilities and services provided to airlines, significantly affects the distribution of operating revenues. Since so many other factors play an important role in determining revenue distribution, however, the mix of operating revenues at an airport cannot be predicted on the basis of whether the airport employs a residual-cost or a compensatory approach. The mix of revenues varies widely among residual-cost airports. With airline landing fees characteristically picking up the difference between airport costs and other revenues at residual-cost airports, airfield area income differs markedly according to the extent of the airport's financial obligations, the magnitude of terminal concession income and other nonairline revenues, and the volume of air traffic. In **1982,** for example, airfield area revenues provided anywhere from 10 percent (Tampa International) to more than 50 percent (Chicago O'Hare International) of total operating revenues at residual-cost airports. By contrast, compensatory airports show a considerably smaller range of variation in the distribution of revenues.

Table 23.–Average Operating Revenue by Revenue Source, Commercial and Generai Aviation Airports, 1975-76

	Source of revenue (percent)					
Airport size	Airfield area[a]	Terminal area concessions[b]	Airline terminal leased areas[c]	Hangar and building area[d]	Other[e]	Total
Commercial						
Large	36	33	16	11	4	100
Medium	33	38	14	11	4	100
Small[f]	30	36	15	12	8	100
Nonhub	37	21	10	26	8	100
General aviation						
Large	23	12	5	47	13	100
Medium	22	9	9	57	4	100
Small	28	4	—	60	8	100

[a]Includes fees for landing, fuel and oil flowage, airline catering, and aircraft parking.
[b]Includes auto parking income, auto rental fees, restaurant and lounge fees, shop lease income, advertising, hotel and motel revenues, ground transportation, and miscellaneous concession revenues.
[c]Includes airline terminal rentals, government leases, and miscellaneous terminal rental income.
[d]Includes hangar rentals, ground leases, commercial and industrial leases, government leases, and airport revenue frm fixed base operations.
[e]Includes utility fees and other systems and services revenues.
[f]Excludes nonhub and commuter airports.

SOURCE: Congressional Budget Office from survey data provided by Aerospace Systems, Inc., *Terminal Area Financial Data Study,* prepared by U.S. Department of Transportation, January 1978.

TRENDS IN AIRPORT MANAGEMENT SINCE DEREGULATION

FederaI deregulation of the airline industry has radically changed the market in which airlines—and airports—operate. Once subject to strict regulation of routes and fares, commercial air carriers are now free to revise routes, adjust fares, and introduce or terminate service to particular airports as market conditions seem to warrant. This new freedom from Federal intervention has had pronounced effects on the airline industry. It has spurred intense competition and even price wars among the airlines, led to reconfiguration of the route system, and encouraged the startup of new carriers. For some of the established airlines, serious financial difficulties have ensued. Although deregulation has not caused radical changes in the financial management of airports, recent trends do reflect the uncertainties of a new, open market. Deregulation also appears to have accelerated certain shifts in management policy and practice that were under way before deregulation.

Since the early days of commercial air travel, would-be investors in airport revenue bonds have held long-term use agreements in high regard, considering them evidence of the airlines' commitment to serve an airport for long periods—spans usually coincident with the terms of bond issues. As the industry has matured, however, investors and analysts have increasingly recognized that an airport's financial stability—hence its capacity to generate a stream of revenue adequate to secure revenue bond issues—depends more on the underlying strength of the local air travel market than on long-term use agreements.

Deregulation has reinforced this shift, as the strength of the airlines' financial commitment to an airport is significantly diluted by their new flexibility to withdraw from a market virtually at will. Confidence has also been shaken by the financial problems now plaguing many airlines. Although changes in airport financial management occur very slowly (many standing use agreements run through the 1990s or later), three important trends in financial management are now emerging at major commercial airports:

- shorter ***term*** contracts—shorter terms for airport use agreements, nonairline leases, and concessionaires' contracts, and more frequent adjustment of rates and charges;
- ***modification*** of ***residual-cost approach***—modification of residual-cost ratemaking and majority-in-interest provisions, with movement in the direction of more compensatory forms of financial management; and
- ***maximization*** of revenues—concerted effort by airport managers to maximize revenues by means of a variety of strategies intended to strengthen and diversify the revenue base of the airport.

Shorter Term Contracts

Deregulation appears to have hastened a trend toward shorter term airport use agreements that was already under way prior to **1978.** Shorter term contracts give airport operators greater flexibility to adjust pricing, investment policies, and space allocation to meet shifting needs in a deregulated environment. For example, several airports with long-term use agreements in force have given much shorter term agreements to air carriers that have begun serving the airport since **1978.** Contracts for such recent entrants often run for 5 years or less, and they may take the form of yearly or even month-to-month operating agreements (similar to those used for air taxi and commuter operators). At least 15 percent of the large and medium airports surveyed by CBO have granted new carriers such relatively short-term terminal leases and/or use agreements. Moreover, as existing long-term use agreements expire, many airport operators indicate an intention to negotiate shorter term use agreements with all carriers serving the airport. At least a dozen of the airports surveyed by CBO either have recently concluded shorter term agreements or anticipate that new use agreements (planned or in negotiation) will be significantly shorter than ones now standing. In part, this reflects the fact that many post-deregulation agreements have not involved major capital development programs requiring long-term bond financing.

Many airports also report that, as old contracts expire, they are routinely shortening the terms of nonairline leases and contracts with concession-

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aires. Some are also moving to more frequent adjustment of rates and charges under existing agreements to meet the escalating costs of airport operation.

Modifications of Residual= Cost Approach

Some residual-cost airports appear to be modifying their approach to financial management. In recent years, some airports have introduced changes to the residual-cost approach, such as more compensatory methods of calculating airline fees and charges, weakening or elimination of majority-in-interest clauses, and provisions allowing for greater retention of earnings usable for capital development.[13] Many more airports with use agreements expiring over the next several years have indicated a desire or intent to move towards a more compensatory approach to financial management. In general, the compensatory approach becomes attractive as airports develop strong markets and thus increase their revenue-generating potential. Such airports are better able to assume the financial risks of airport operation without relying on "break-even" guarantees by the airlines, and they may maximize revenues by adopting a compensatory approach.

Maximization of Revenues

No matter how they approach financial management, many commercial airports are now seeking to increase and diversify their revenues by a variety of strategies. These include raising existing fees and rental rates, seeking more frequent adjustment of charges, using competitive bidding for concessionaires' contracts, increasing the airport's percentage of gross profits, and exploiting new or untapped sources of revenue—e.g., videogame rooms, industrial park development, and leasing of unused airport property. Some airports are looking to future possibilities, as well. For example, two large airports that recently renegotiated airport use agreements—Chicago O'Hare and Greater Pittsburgh International-included clauses in the new contracts protecting the airport's right to levy a passenger facility charge (or head tax) if and when Federal law permits. In general, this effort to diversify and expand revenue sources reflects the paramount importance of a guaranteed stream of income to assure an airport's financial success.

[13]See J. J. Corbett, "Analysis of Trends in Airport Lease/Use Agreements Executed With Airlines Since Deregulation," presentation before the Joint Meeting of the Airport Operators Council International Legal Standing and Economic Standing Committees, Vancouver, B.C., Canada, Oct. 17, 1983.

Chapter 7

AIRPORT FUNDING

Photo credit: Federal Aviation Administration

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Chapter 7
AIRPORT FUNDING[1]

This chapter examines the financial condition of U.S. airports and their ability to compete for private capital. It begins with a brief outline of the evolution of Federal airport funding programs and summarizes the demand for airport investment under current policy. This is followed by analysis of the financial performance of airports in recent years compared to other municipal enterprises, with special attention to the effects of airline deregulation. Since tax-exempt municipal bonds are a primary source of capital for commercial airports, extended treatment is given to the ability of airports of different kinds and sizes to compete in the bond market.

FEDERAL AIRPORT DEVELOPMENT AID

Federal capital spending on airports is financed by user fees, levied chiefly as excise taxes on domestic airline tickets and general aviation (GA) fuel. These taxes, which originated in **1933** and 1941, were not formally linked to airport expenditures until ***1970,*** when the Airport and Airway Revenue Act established the Airport and Airway Trust Fund. Most of the Trust Fund income (over ***80*** percent) derives from an **8** percent tax on domestic passenger tickets. A tax of 14 cents per gallon on GA jet fuel (12 cents for gasoline) contributes about 5 percent of Trust Fund revenues. Funds are disbursed to major airports in the form of matching grants determined by a formula based on passenger volume and through discretionary grants to meet special needs. Federal grants can be used for a wide range of airport development projects, including new construction and upgrading of runways, taxiways, and aprons, construction or improvement of public-use terminal areas, and projects related to safety and noise reduction. Over the next few years, Federal aid to airports is projected to increase from the average of ***$600*** million per year for the period **1970-82** to **$800** million by **1986** (all in **1982** dollars, see table **24).**

[1]This chapter was prepared by the Congressional Budget Office and appears in unabridged form in *Financing U.S. Airports in the 1980s,* April 1984. The version here has been condensed and edited to conform to the OTA report format.

Investment Trends

Between **1960** and 1982, cumulative public and private investment in the Nation's airports totaled $25.1 billion (in **1982** dollars), of which the Federal share accounted for $9 billion, or just above one-third.[2] These overall figures, however, mask wide year-to-year fluctuations in the Federal share

[2]This excludes the value of tax expenditures stemming from tax-exempt bonds issued by municipal and airport authorities.

Table 24.–Projected Federal Capital Expenditures on Airports Under Current Policy, 1984-89 (in millions of 1982 dollars)

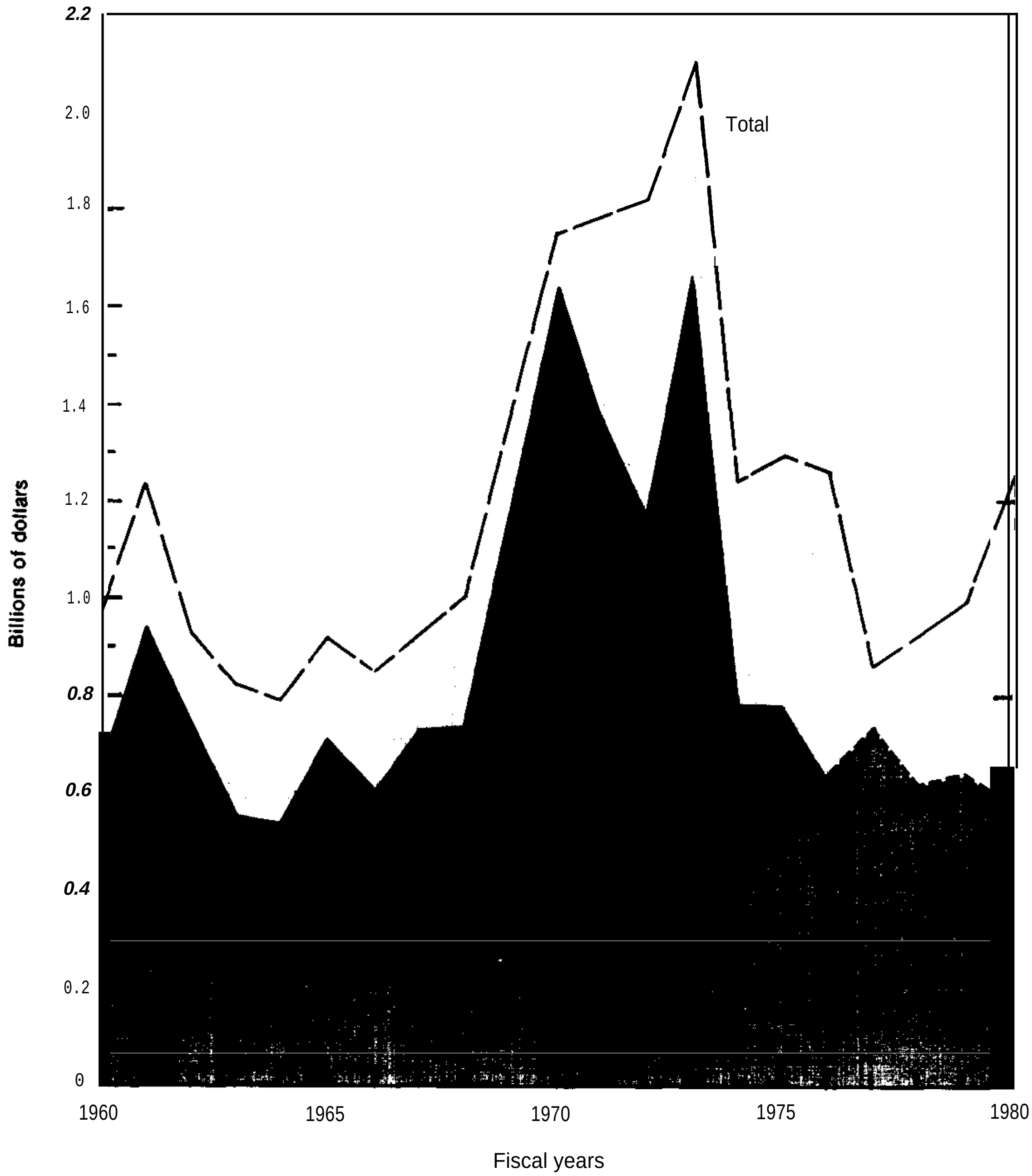
	1984	1985	1966	1967	1988	1989
Commercial:						
Large	194	188	200	207	196	200
Medium	101	98	104	108	102	104
Small	248	240	256	265	251	256
Subtotal	543	526	560	580	549	560
General aviation:						
Reliever	81	79	64	87	82	84
Other	143	139	148	153	145	148
Subtotal	224	218	232	240	227	232
Total	775	751	601	827	785	800

NOTES: Projections assume that currently authorized funding is continued through 1989 and that obligations equal new authorizations in each year. Allocation among airports is based on data supplied by FAA.
Totals may not add because of rounding and because they include 1 percent of funding used for planning.

SOURCE: Congressional Budget Office.

of total airport investment. Between 1973 and 1977, the Federal share swung from a post-1970 low of **20** percent to a high of **85** percent (see fig. 17). Such swings have resulted not from shifts in Federal outlays, which have remained relatively stable since **1970,** but from extreme changes in the mix and total volume of airport investment. Peak investment in 1973, for example, was the result of very large capital outlays by some of the largest commercial airports, which rely more on debt financing than on Federal aid for investment capital. On the other hand, many small airports, par-

Figure 17.–Federal, State, and Local Shares of Public Spending on Airports, 1960.80



SOURCES: Congressional Budget Office based on data provided by Federal Aviation Adminlstratlon (Federal outlays) and U.S. Department of Commerce, Bureau of the Census (State and local outlays).

ticularly general aviation airports, earn revenues insufficient to cover debt service; these airports tend to rely much more heavily on Federal money. In 1977, a year of low overall airport outlays in which much spending probably reflected GA airport improvements, the Federal share exceeded 80 percent. The States' share of airport investment has remained fairly stable since 1970, at about 11 percent.[3]

The Airport Improvement Program currently targets Federal funds both to commercial airports and to 2,643 general aviation facilities. Of the latter, 219 "reliever" airports are eligible for specially targeted funds that will amount to $80 million per year by 1986—a dramatic increase over the average of about $25 million per year for such airports in the period 1976-82 (see fig. 18). Federal investment in other general aviation airports also grew steadily throughout the 1970s, and under current policies, outlays in constant dollars would triple by 1987, compared to the 1980-82 level.

Demand for Airport Investment

As a result of national economic development and a general pattern of public sector subsidization of aviation activity, growth in both commercial airlines and general aviation has led to mounting airport investment needs. Since 1970, the number of GA aircraft in use grew by 63 percent (to 213,000 in 1982), and the number of hours flown increased by 67 percent. At the same time, with the introduction of wide-body jets, the number of commercial aircraft in service actually declined by 7.7 percent, from 2,690 to 2,483. As a result, general aviation now exerts particular pressure on the runways, taxiways, and other airfield components of a number of major commercial airports, often accounting for more than half of all takeoffs and landings. More frequent commercial flights at the major airports put pressure on terminals and other buildings, parking lots, and access roads.

The resulting congestion has led the Federal Aviation Administration (FAA) to project a need for substantial investment in upgrading, maintenance, and expansion. Annual airport investment demand, including work not eligible for Federal grants, will be $1.5 billion to $2 billion between 1984 and 1993, of which the Federal share—under currently defined programs—would be about $0.8 billion. This sum represents an estimated 3.3 percent of the Federal share of all public works infrastructure needs.[4] Of the $1.5 billion to $2 billion, roughly one-third would be needed to correct all present and expected deficiencies at commercial airports; two-thirds would pay for new capacity (see table 25).

[3]From data supplied by the National Association of State Aviation Officials.

[4]*Public Works Infrastructure: Policy Considerations for the 1980s*, (Washington, DC: Congressional Budget Office, April 1983).

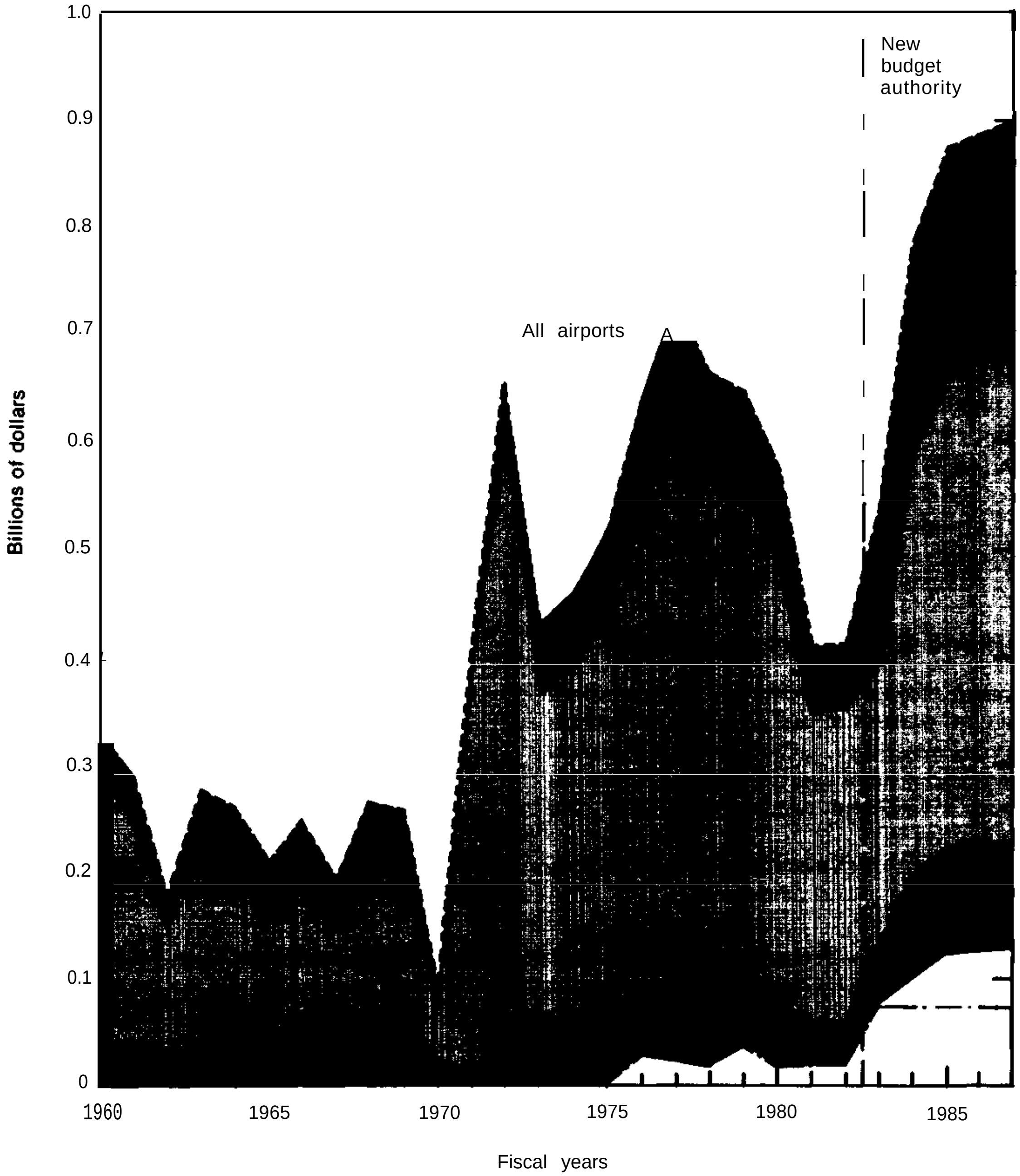
Table 25.–Projected Annual Demand for Airport Capital, by Airport Type, 1984=93

	Estimated total demand (millions of 1982 dollars)	Percent of demand: Expanded capacity	Percent of demand: Upgrading	Percent of demand: Maintenance
Commercial:				
Large	450-650	20	4	5
Medium	200-350	10	2	1
Small	400-500	15	5	5
Subtotal	1,050-1,450	45	11	11
General aviation:				
Reliever	100-150	5	2	1
Other	400-450	15	6	4
Subtotal	500-600	20	8	5
Total	1,550-2,050	65	19	16

NOTE: Includes projects not now eligible for Federal grants such as certain revenue-producing components of terminal buildings and hangars (duty-free shops, airline maintenance services, etc.). Total rounded to nearest $50 million; details may not add to totals because of rounding.

SOURCES: Congressional Budget Office reestimates of data in Federal Aviation Administration, *National Airport System Plan, Revised Statistics, 1980-1990, National Aviation System Development and Capital Needs for the Decade 1982-1991*, December 1980; General Accounting Office, *Developing a National Airport System: Additional Congressional Guidance Needed*, Apr., 17, 1979; and unpublished FAA data.

Figure 18.–Federal Capital Spending on Airports, By Type of Airport, 1960.87



NOTE: Outlays for 19S3-87 are based on authorizations in the Airport and Airway Improvement Act of 1982. Typically, appropriations and thus actual outlays are somewhat below authorized leveis.

SOURCE: Congressional Budget Office based on data provided by the Federal Aviation Administration.

FINANCIAL CONDITION OF U.S. AIRPORTS

As in any enterprise, the ability of an airport to survive without public support hinges on its financial strength. This section examines recent trends in the financial performance of major commercial airports—those with earning power sufficient to issue revenue-backed bonds. It also compares the performance of these airports with that of the other municipal enterprises competing with airports in capital markets-electric utilities, water supply and wastewater treatment projects, and turnpike, bridge, tunnel, and expressway authorities.[5] This section also assesses how the shifts resulting from Federal deregulation of the airlines might affect the financial condition of airports of various sizes.

Measures of Performance

Analysis of key financial ratios is a widely accepted method of evaluating the financial condition and performance of a single enterprise or an entire industry.[6] Many different financial ratios can be constructed, each revealing a particular aspect of business performance.

Four indicators often used by investment advisors to judge the value of a municipal enterprise to potential bondholders are: operating ratio, net take-down ratio, debt-to-asset ratio, and debt service safety margin. The first two indicate the availability of revenues beyond those needed to meet regular operating expenses:

- ***Operating Ratio***—Derived by dividing operating and maintenance expenses by operating revenue, this ratio measures the share of revenues absorbed by operating and maintenance costs. A relatively low operating ratio indicates financial strength, since it signifies that only a small share of revenue is required to satisfy operating requirements. A high ratio (close to 1) indicates that relatively little additional revenue is available for capital spending.
- ***Net Take-Down Ratio*** —Calculated as gross revenue minus operating and ***maintenance*** expenses, divided by gross revenues, the net take-down is similar to the operating ratio, but it also includes nonoperating revenues (e.g., interest income). It is a slightly broader measure of the share of airport revenues remaining after payment of operating expenses.

The second two indicators measure the ability of an airport to support existing and new borrowing for capital investment:

- ***Debt-to-Asset*** Ratio—Calculated as gross debt minus bond principal reserves, divided by net fixed assets plus working capital, an enterprise's debt-to-asset ratio measures the fraction of total assets provided by creditors. Creditors prefer low debt ratios because each dollar of debt is secured by more dollars of assets. This can be important if assets have to be sold to pay off bondholders.
- ***Debt Service Safety Margin*** —Defined as gross revenues less operating and maintenance expenses and annual debt service divided by gross revenues, this ratio measures both the percentage of revenues available to service new debt and the financial cushion to protect against unexpectedly low revenues.

Recent Trends in the Financial Strength of Airports

Overall, examination of these measures shows a trend toward improved strength in the finances of major commercial airports. Compared to the 1975-'78 period, when the operating ratio for these airports averaged 55 percent, this measure improved significantly over the subsequent 4 years, declining to 50 percent (see table 26).[7] The net

[5]The data used here, including information from airports' balance sheets and income statements, were provided by Moody's Investors Service Inc. and by the Public Securities Association. The Congressional Budget Office is alone responsible for the analysis and interpretation of these data.

[6]J. F. Weston, and E. F. Brigham, Manageti/ *Finance (New* York: Dryden, 5th ed. 1975), pp. 19-53.

[7]Although most credit analysts (including Moody's) use medians rather than averages in analyzing industry groups, CBO has found that averages give an equally meaningful measure of relative performance. This conclusion is based on an analysis of the statistical distribution of each financial ratio across individual airports. In statistical terminology, these distributions are "normal" for the in-

(continued)

Table 26.—Financial Performance of Commercial Airports, 1975-82

	Financial performance measures (in percent)[a]			
Year	Operating ratio	Net take-down ratio	Debt-to-asset ratio	Debt service safety margin
1975	51.3	55.8	25.9	18.0
1976	56.4	45.1	41.8	14.7
1977	53.7	48.8	37.7	20.9
1978	55.1	48.5	40.5	23.3
1979	51.9	52.5	47.5	30.0
1980	52.8	52.4	49.6	34.1
1981	46.9	57.1	47.6	33.6
1982	35.5	63.2	41.7	23.6
Period averages:				
1975-78	54.5	48.5	39.0	19.9
1979-82	50.2	54.2	48.1	31.6

[a]Methods of calculating performance measures are explained in the text. Data reflect averages of all commercial airports represented.

SOURCE: Congressional Budget Office, based on financial performance data from Moody's Investors Services, Inc., for 13 large, 10 medium, and 2 small commercial airports.

take-down ratio has also improved, increasing from 48 to 54 percent. This indicates a steady increase in the ability of commercial airports to service new debt from available net revenues. Indeed, major commercial airports today appear to perform on a par with other financially self-sufficient municipal enterprises, such as electric utilities, water supply systems, and sewage treatment authorities (see Box B).

Purchasers of airport revenue bonds look for assurances that an airport can generate net revenue (i.e., gross revenues net of operating and maintenance costs and debt service requirements) sufficient to pay interest over the term of the bonds and to repay the principal. Though, in comparison to other financially mature municipal enterprises, airports appear to carry high levels of debt relative to the value of their assets, net airport revenues appear relatively strong. Indeed, as shown in table 26, the debt service safety margin for major commercial airports has grown substantially since 1978, despite the increase in debt-to-asset ratios. Thus, while only 20 percent of airport revenues were available to cover the cost of new investment over the 1975-78 period, the safety margin grew to 32 percent over the years 1979-82. Moreover, in 1982, airports had a substantially higher debt service safety margin than other major municipal enterprises except perhaps highway toll facilities, for which no information is available.

'continued)

ıdustry as a whole and for different airport size categories, indicating :hat financial averages provide a meaningful basis for intra- and nter-industry comparisons. See also M. H. Ledford and P. K. Sugrue, "Ratio Analysis: Application to U.S. Motor Common Car-riers," *Business Economics*, vol. 18, No. 4, September 1983, pp. 16-54.

Effects of Airport Characteristics

Although major commercial airports as a group appear financially strong, important differences are apparent among them. These variations stem primarily from the approach to financial management and the size and economic strength of the airport service area.

Financial Management

Differences in earning power may hinge on whether an airport uses a compensatory or a residual-cost approach to financial management. While gross revenue at a compensatory airport depends largely on the volume of passenger traffic, gross revenue at a residual-cost airport may be constrained to the minimum amount needed for operations, debt service, and reserve funds established in the airport's bond resolutions. In fact, the three ratios that reflect gross revenues—operating ratio, net take-down ratio, and debt service safety margin—all show substantial differences between airports using a residual-cost approach and those using a compensatory approach.

Operating and net take-down ratios are substantially stronger at airports using the compen-

Box B.—Financial Performance of Major Public Enterprises

Operating Ratio and Net Take-Down Ratio. Major commercial airports typically use a smaller share of revenue to cover operating costs than either electric utilities or water supply and wastewater treatment authorities. However, they appear to maintain smaller operating margins than highway toll facilities.

Debt-to-Asset Ratio. Airports carry a high level of debt relative to their total assets compared with power and water authorities.

Debt Service Safety Margin. Despite their relatively high debt ratios, airports appear able to service more new debt than both electric utilities and water authorities, largely because of their lower operating and maintenance costs. Also, they have a substantially greater cushion against unforeseen shortfalls in revenue.

Median Ratios for Seven Services in 1982 (in percent)

	Financial performance measures			
Service	Operating ratio	Net take-down ratio	Debt-to-asset ratio	Debt service safety margin
Airports	56.3	48.2	48.8	28.9
Electricity:				
Generation and transmission	76.8	26.0	56.5	15.9
Distribution	79.2	23.2	35.4	14.7
Water supply	68.2	38.7	27.6	21.7
Wastewater treatment	68.3	39.3	25.0	21.2
Bridges, tunnels, expressways	47.5	64.5	N/A	N/A
Turnpikes	38.8	62.0	N/A	N/A

NOTE: This table reports medians because averages, as used in the body of this chapter, are not available for enterprises other than airports. Also, the airport data are drawn from a sample somewhat different from that used elsewhere in this report.

SOURCE: Adapted by CBO with the permission of Moody's.

satory approach (see table 27). Over the 1979-82 period, for example, operating and maintenance costs at compensatory airports absorbed only 44 percent of operating revenues, while residual-cost airports needed more than half their gross revenue just to cover such expenses. Net take-down ratios reflect the same pattern; residual-cost airports retained roughly half of their gross revenues after paying operating and maintenance costs, while compensatory airports retained 61 percent. Compensatory airports also exhibited substantially higher debt service safety margins—48 percent, as opposed to 25 percent for residual-cost airports. This indicates that compensatory airports have greater ability to finance development with retained earnings or through bond sales.

Table 27.–Financial Performance of Commercial Airports, Compared by Management Approach, 1975-82

	Averages of all Airports in category (in percent)					
	Residual cost		Compensatory		All airports[b]	
Performance measure[a]	1975-78	1979-82	1975-78	1979-82	1975-78	1979-82
Operating ratio	56.2	52.9	52.5	44.3	54,5	50.2
Net take-down ratio	46.5	51.5	53.2	60.8	48.5	54.2
Debt-to-asset ratio	*40.4*	*55.3*	*47.3*	*40.5*	*39.0*	*48.1*
Debt service safety margin	16.0	24.6	33.1	48.3	19.9	31.6

[a]Methods of calculating performance measures are explained in the text.
[b]Includes airports for which the management approach was not determined.

SOURCE: Congressional Budget Office, based on financial performance data provided by Moody's Investors Service, Inc., for 13 large, 10 medium, and 2 small commercial airports.

Airport Size

Airport size (measured in passenger enplanements) has historically been an important determinant of financial performance. Larger airports show relatively stronger performance than smaller ones. Operating ratios at large airports were 15 percentage points better than those at medium airports during the 1975-78 period and 18 percentage points better over the 1979-82 period (see table 28). Net take-down ratios and debt service safety margins reflect the same spread, while only debt-to-asset ratios are better at medium airports.

Effects of Airline Deregulation

Since deregulation of the airlines in 1978, the financial performance of large and medium airports has improved. Indeed, except for the debt-to-asset ratio at medium airports, large and medium airports show improvement on all four ratios. One plausible explanation is that many major airlines curtailed service to smaller cities, electing instead to concentrate operations on the more profitable routes serving large and medium airports. On balance, each 10-percent increase in traffic volume translates into a 2-percent improvement in operating and net take-down ratios and debt service safety margin (see app. C). Increased traffic volume at many large and medium airports since deregulation appears therefore to have improved gross revenues, yielding improvements in those indicators that turn on changes in gross revenue.

Table 28.—Financial Performance of Commercial Airports, by Airport Size, 1975-82

Performance measure[a]	Averages of all airports in category (in percent): 1975-78 before airline deregulation	1979-82 after airline deregulation
Large airports: [b]		
Operating ratio	48.0	43.3
Net take-down ratio	54.6	60.7
Debt-to-asset ratio	56.9	54.0
Debt service safety margin	20.9	34.8
Medium airports: [c]		
Operating ratio	63.3	61.7
Net take-down ratio	40.9	43.2
Debt-to-asset ratio	29.7	44.1
Debt service safety margin	17.0	25.3
All commercial airports: [d]		
Operating ratio	54.5	50.2
Net take-down ratio	48.5	54.2
Debt-to-asset ratio	39.0	48.1
Debt service safety margin	19.9	31.6

[a]Methods of calculating performance measures are explained in the text.
[b]Includes data on 13 airports.
[c]Includes data on 10 airports.
[d]Includes 2 small airports for which financial performance measures were available only for the years 1977-80. These airports have substantially better financial ratios than do the large and medium airports. As with the other airports, they also show some improvement between the two time periods.

SOURCE: Congressional Budget Office based on data provided by Moody's Investors Service.

Prospective investors in airport revenue bonds look beyond financial indicators based on gross revenues, however. In particular, they seek low debt-to-asset ratios as good cushions against possible defaults. Though gross revenues grow with increased business, so do capital needs as airports may need to expand terminals and other facilities to handle additional passengers and aircraft. Some airports, of course, have sufficient capacity to absorb significant increases in traffic with no expansion. At medium airports, however, debt-to-asset ratios have indeed increased by more than 14 percentage points between the 1975-78 and 1979-82 periods. As a result, the difference between the debt-to-asset ratios at large and medium airports has declined from 27 percentage points during the 1975-78 period to 10 percentage points between 1979-82. At the same time, the debt-to-asset ratio at large airports actually improved somewhat, from 57 percent (1975-78) to 54 percent (1979-82). Although the debt-to-asset ratio of medium airports is still better than at large airports, investors tend to be wary of worsening conditions because of the speculative factor that they introduce into a prospective investment. Whether these trends have actually diminished the investment value of medium airports is dealt with more closely later in this chapter.

The picture of small airport performance is extremely uncertain. The CBO analysis includes only two small airports, and performance indicators are available only for the 1977-80 span, rather than for the full 1975-82 period at other airports. The two small airports examined are close in size to some medium airports, indicating that they probably represent the financially stronger airports in their class. Indeed, their financial ratios are better than those of the average medium airport—perhaps an indication that smaller airports require better finances to offset the greater risks associated with their size.

Financial ratios are unavailable for the remaining 489 small commercial airports and for publicly owned GA airports. In general, it appears that the income of these airports is inadequate to support the issuance of revenue-backed bonds. Instead, to help finance capital development, many of these airports depend on government-issued general obligation bonds, local taxpayer support, and Federal grants. Revenues at some of the smaller airports are so low that they fail to cover even operating costs. However, some of these airports—especially GA airports with low user fees and aircraft parking charges—could strengthen their financial performance by introducing new or increased charges for the use of airport facilities.[8]

AIRPORTS IN THE MUNICIPAL BOND MARKET

Perhaps the stiffest test of an airport's financial strength is its success in competing with other municipal enterprises for private investment capital in the bond market. The analysis presented below points to two conclusions. First, while the financially stronger airports are the ones most active in the bond market, even financially weaker airports can attract private capital—though often they must use the taxing power of the local government as security for bond financing. Second, by comparing the cost of capital (the interest that must be paid to attract bond buyers) for airports with that of other public enterprises, it is clear that airports are generally viewed as good investments.

Role of the Municipal Bond Market in Airport Development

Between 1978 and 1982, airports raised a total of $5 billion (in 1982 dollars) in new bond financing to pay for capital improvements (see table 29).[9] Most municipal bonds are exempt from Federal income tax, a key feature that makes this financing less expensive than most other sources of private money. Predictably, therefore, the vast majority of airport debt capital is raised in the tax-exempt bond market. In 1982 alone, airports raised $1.4 billion in tax-exempt bond sales, or about 2 percent of the total volume of $79 billion in long-term tax-exempt securities sold in that year.

The 235 bond issues sold partly or wholly for airport development between 1975 and 1982 were divided more or less equally between county and municipal governments (45 percent) and port or airport authorities (43 percent). Only a small proportion (about 6 percent) of all bonds sold were issued by State governments, and about 6 percent

9 These are new bond issues only; refinancing issues are excluded.

Table 29.—Airport Bond Issues, 1978.82

	Airport bond issues (millions of 1982 dollars)[a]						
Airports by size and category	1978	1979	1980	1981	1982	1978-82	Percent of total
Commercial:							
Large	955	672	186	547	1,036	3,396	67.3
Medium	280	109	246	188	296	1,119	22.2
Small	25	134	172	70	63	464	9.2
Subtotal	1,260	915	604	805	1,395	4,979	98.6
General aviation:							
Reliever	17	1	13	0	8	39	0.8
Other	3	5	2	14	7	31	0.6
Subtotal	20	6	15	14	15	70	1.4
Total	1,280	921	619	819	1,410	5,049	100.0

[a]Excludes refunding issues.

SOURCE: Congressional Budget Office.

(14 issues) were sold by special districts and other jurisdictions (see table 30).

Effects of Airport Size and Type of Traffic

Although airports of all sizes and types participate in the bond market, larger airports do so to a greater extent than smaller ones. Among the large and medium commercial airports-together serving about nineteenths of all passenger traffic—41 (58 percent) used bond financing for capital development over the 1978-82 period (see table 31). Moreover, according to Moody's Investors Service, all large and medium airports have issued bonds at some time in the past. Although many small commercial airports also use bond financing, this group of airports participates in the bond market in only a small way, with just 50 of 489 airports (10 percent) issuing bonds over the past 5 years. The same is true of general aviation airports. Although 43 used bond financing over the past 5 years, this represents only 2 percent of all facilities in this class. However, GA reliever airports—those identified by the FAA as important in relieving congestion at major commercial airports—appear more likely than other GA airports to draw on the debt markets to finance capital improvements.

In terms of total dollar volume of bond sales, large and medium airports are by far the most prominent in the bond market. Of the total amount of municipal debt sold for airport purposes over the 1978-82 period, 90 percent was for large and medium airports, in contrast to only 9 percent for small commercial airports. GA airports accounted for a little more than 1 percent of total airport bond sales.

Table 31.—Use of Bond Market to Raise Capitai, By Airport Size and Type, 1978=82

Airports by size and category	Number of airports: Total existing	Number of airports: Issuing bonds 1978-82	Percent issuing bonds 1978-82
Commercial:			
Large	24	19	79
Medium	47	22	47
Small	489	50	10
Subtotal	560	91	16
General aviation:			
Reliever	219	9	4
Other	2,424	34	1
Subtotal	2,643	43	2
Total	3,203	134	4

SOURCES: Bond data adapted by Congressional Budget Office from Public Securities Association, Long-Term Municipal Bond File. The numbers of existing airports by size from the Federal Aviation Administration, as of February 1984.

The role of bond finance in overall investment also varies greatly according to an airport's size and type of air traffic served. Over the 1978-82 period, investment dollars raised through the bond market for large airports were three times greater than the Federal grants awarded these airports. At small airports, in contrast, Federal grants were more than double bond proceeds (see table 32). Not surprisingly, debt finance plays the smallest role at GA airports, where it has accounted for only about 10 percent of total Federal-plus-private investment over the past 5 years.l"

Although smaller commercial airports rely more heavily on Federal grants than do larger airports, they nonetheless undertake a sizable amount

[10]This excludes State and local grants and the fraction of airport investments covered by retained earnings.

Tabie 30.–Airport Bond issues, By Type of issue and Security, 1978.82

Type of issuer	Number of issues: General obligation bonds[a]	Revenue bonds[b]	Total issues	Percent of total issues
Municipality or county	60	46	106	45
Port or airport authority	19	83	102	43
State	11	2	13	6
Other[c]	9	5	14	6
Total	99	136	235	—

[a]Underlying security provided by full taxing authority of governmental unit, by full taxing authority with regard to a single revenue source, or by a single or specified tax.
[b]Underlying security provided by revenues from all airport sources, by revenues from the lessee of the proposed airport facility, or by anticipated revenues from future bond sales or grants.
[c]Special districts and other special-purpose jurisdictions.

SOURCE: Congressional Budget Office.

Table 32.-Contribution of Federal Grants and Bond Issues to Airport Investment, 1978-82

Airports by size and catagory	Percent of investment	
	Federal grants	Bond issues
Commercial:		
Large	18	82
Medium	27	73
Small	69	31
Subtotal	31	69
General aviation:		
Reliever	80	20
Other	92	8
Subtotal	87	13
Total	35	65

SOURCE: Congressional Budget Office.

of investment through the bond market. For example, while Federal matching grants to small commercial airports totaled about $1 billion (in 1982 dollars) between 1978 and 1982—requiring $100 million in local matching funds–small airports issued more than $460 million in tax-exempt bonds during the same period, more than four times the amount necessary to match Federal grants. This means that small airports as a group used more than three-quarters of their bond proceeds for investments with no Federal financial involvement. In contrast, GA airports as a group appear to raise debt capital only to the extent that, when it is combined with moneys from non-Federal sources, they can meet their Federal matching requirement.

Underlying Security of Airport Bonds

For most municipal bonds, including bonds for airport development, the bond issuer's pledge to pay interest and to repay principal is generally provided in one of two ways:

- general obligation bonds pledge the unlimited taxing power and the full faith and credit of the State, municipality, or other general-purpose government, while
- revenue bonds pledge the user fee or lessee revenues generated by the facility to be developed.

General obligation bonds are issued only by States and other general-purpose governments. Most States limit the amount of general obligation debt that a municipality may issue to a specified fraction of the taxable value of all property within its jurisdiction. In addition, many States require voter approval before issuing general obligation debt. By contrast, the volume of debt issued through ***revenue*** bonds ***is*** not included in the amount of total indebtedness subject to State debt limits, and voter approval is usually not required. Revenue bonds generally bear higher interest than general obligation bonds because they are not backed by the full faith, credit and taxing power of a governmental unit, and because the receipts from user charges are less certain than tax revenues.

In recent years, there has been a dramatic increase in the use of tax-exempt revenue bond financing. In 1982, for example, revenue bonds accounted for three-quarters of all tax-exempt bond sales, compared to about one-third in 1970. With the increasing financial pressures on local governments to reserve general obligation funding for nonrevenue-producing facilities, revenue bonds represented the vast majority—over 90 percent—of the total dollar volume of airport bond sales over the 1978-82 period (see table 33). During this period, the use of general obligation bonds for airport development was most prominent among muniapalities and counties, accounting for over half of their airport development issues—though a much smaller fraction of total proceeds. Revenue bonds predominated, however, accounting for nearly 60 percent of bonds sold by all levels of government for airport development during this period.

In addition to these two basic forms of bondholder security, a few bond issues combine sources of security to produce a hybrid bond. This device offers certain advantages, such as improved ratings and lower interest costs, without placing undue pressure on the municipal debt ceiling. In Florida, for example, the City of Tampa and Hillsborough County lent their credit to the revenue bond program undertaken to finance a new terminal at Tampa International Airport by executing standby agreements with the Hillsborough County Aviation Authority, pledging tax revenues to replenish the debt service reserve fund in the event it had to be drawn down for any reason. As further examples, the cities of Charlotte, NC, and Austin, TX, built or expanded terminal

Table 33.-Airport Bond Issues, By Type of Security, 1978-82

Airport category and bond type	Airport bond issues (millions of 1982 dollars)						
	1978	1979	1980	1981	1982	1978-82	Percent of total
Commercial airports:							
Large:							
General obligation	30	0	33	10	2	75	2
Revenue	925	672	152	538	1,034	3,321	98
Subtotal	955	672	186	548	1,036	3,396	100
Medium:							
General obligation	34	7	55	56	5	157	
Revenue	246	103	190	132	290	961	:
Subtotal	280	109	246	188	296	1,118	100
Small:							
General obligation	11	38	42	16	30	137	30
Revenue	14	96	131	54	32	327	70
Subtotal	25	134	172	70	63	464	100
All:							
General obligation	75	45	130	81	38	370	7
Revenue	1,185	871	473	724	1,357	4,609	93
Total	1,260	916	603	805	1,394	4,978	100
General aviation airports:							
Reliever							
General obligation	8	1	4	0	6	19	49
Revenue	9	a	9	0	2	20	52
Subtotal	17	1	13	0	8	39	100
Other							
General obligation	2	4	1	13	4	25	83
Revenue	a	a	a	1	3	5	17
Subtotal	2	5	2	14	7	30	100
All airports:							
General obligation	86		136	94	47	413	8
Revenue	1,194	8 %	482	725	1,361	4,634	92
Grand total	1,280	921	618	819	1,409	5,047	100

[a]Less than $0.5 million.
NOTE: Details may not add to totals because of rounding.
SOURCE: Congressional Budget Office.

facilities with general obligation bonds secured by the full faith and credit of the cities but serviced from airport revenues—so-called "self-liquidating general obligation bonds."[11]

Airport size appears to have great influence on the type of security used to back bonds. In general, the larger the airport, the less likely it is to use general obligation financing. Over the 1978-82 period, general obligation debt accounted for only 2 percent of total bond financing at the largest commercial airports, 14 percent at medium commercial airports, and 30 percent at small commercial airports. Among GA reliever airports, by contrast, some 49 percent of all tax-exempt debt capital has general obligation backing. And at other GA airports, more than 83 percent of debt finance is secured in this way.

The larger airports use relatively little general obligation financing because local governments tend to reserve such bonds for public services and facilities that cannot generate sufficient revenues to cover the costs of debt capital. Similarly, since a substantial general obligation bond issue can place enormous pressure on the debt limit and, ultimately, on the credit rating of a municipality, airport operators generally must rely on revenue bonds to finance large-scale airport improvements. During the 1978-82 period, the average size of bonds issued by large commercial airports was $49 million, compared to $26 million at medium airports, $6 million at small commercial airports,

[11]R. Bates, "Airport Financing: Whither (or Wither?) the Market?" presented at Airport Operators Council International Economic Specialty Conference, Sacramento, CA, Mar. 31, 1982.

$2.8 million at GA reliever airports, and $0.9 million at other GA airports (see table 34). Over the same period, the average size of revenue bonds issued by commercial airports was three to five times greater than the average proceeds of general obligation bonds used for commercial airports of the same size category.

Thus, revenue bonds are the dominant form of debt financing where investments are large and where revenues from airport fees and charges are sufficient to cover debt service requirements. On the other hand, at GA airports, where the average size of a bond issue is small (about $1 million), general obligation bonds far outweigh revenue bonds as a means of financing airport improvements.

The Market for Airport Bonds

The competitiveness of airports in the municipal bond market can be gauged by three conventional indicators of investment quality:

- bond ratings—a simple system used by major investor services to grade bonds according to investment quality (see Box C);
- interest costs—the interest paid by airports to attract investors relative to what other municipal enterprises pay; and
- defaults—the frequency with which a given type of enterprise has defaulted on a bond issue.

Table 34.—Average Size of Airport Bond Issues, 1978-82

Airport size and category	Average bond issue (millions of 1982 dollars): General obligation bonds[a]	Revenue bonds	Total
Commercial:			
Large	10.7	53.6	49.2
Medium	12.1	32.0	26.0
Small	3.2	9.3	6.0
Category average	5.9	36.3	26.2
General aviation:			
Reliever	3.8	2.2	2.8
Other	1.0	0.5	0.9
Category average	1.5	1.3	1.4
All-airport average . .	4.5	31.7	21.2

[a]Amounts represent the proceeds of general obligation bonds used for airport purposes. In most instances, such proceeds account for less than the full amount of the bond issue, with the balance going for other public investment purposes.

SOURCE: Congressional Budget Office.

Box C.—What Investment-Grade Bond Ratings Mean

Best Grade

Bonds rated Aaa (by Moody's) or AAA (by Standard & Poor's) are graded best. Their exceptionally strong capacity to pay interest and repay principal offers the lowest degree of risk to investors in bonds.

High Grade

Bonds rated Aa1 or Aa (by Moody's) or AA+ or AA (by Standard & Poor's) have very strong ability to pay interest and repay principal, but they are judged to be slightly less secure than best-grade bonds. Their margins of protection may not be quite so great, or the protective elements may be more subject to fluctuation.

Upper-Medium Grade

Bonds rated A1 or A (by Moody's) or A+, A, or A− (by Standard & Poor's) are well protected, but the factors giving security to interest and principal are deemed more susceptible to adverse changes in economic conditions or other future impairments than for bonds in the best and high-grade categories.

Medium Grade

Bonds rated Baa1 or Baa (by Moody's) or BBB+, BBB, or BBB− (by Standard & Poor's) lack outstanding investment characteristics. Although their protection is deemed adequate at the time of rating, the presence of speculative elements may impair their capacity to pay interest and repay principal in the event of adverse economic conditions or other changes.

NOTES: Except for the best-graded category of bonds, those bonds in each category that Moody's and Standard & Poor's believe to possess the strongest investment attributes are designated by the symbols 1 and +, respectively. The symbol − designates weaker investment characteristics in a given category.

Standard & Poor's assigns AA ratings to new issues of municipal bonds insured by the American Municipal Bond Assurance Corp. and AAA ratings to new issues insured by the Municipal Bond Insurance Association. Moody's ratings do not reflect the presence or absence of bond insurance.

SOURCES: Based on *Moody's Bond Record*, September 1982, p. 144; and *Standard & Poor's Ratings Guide*, (New York: McGraw-Hill, 1979), pp. 327-328.

Bond Ratings

For the 134 airports where new airport bonds were issued over the pasts years (including general obligation bonds used at least in part for airport development), every rated bond has received an "investment grade" from the two major investment rating services, Moody's Investors Service, Inc., and Standard & Poor's Corp. (See table 35 for ratings of the most recent airport issues.)" One explanation for these consistently good ratings is that airports expecting poor ratings do not enter the bond market.

Although investors clearly have considerable confidence in airport bonds, ratings vary between the top and medium grades. A medium grade means that rating firms see the investment as carrying a measure of speculative risk. As shown in table 35, general obligation bonds draw the best ratings. Under this form of security, ratings are determined by the economic vigor of the municipality or the entire State, and airports have little or no influence on the rating. Revenue bonds, on the other hand, draw ratings according to the fiscal vitality of the airport itself. Since more than 90 percent of all airport bonds (in terms of dollar volume) are secured with airport revenues, the cri-

[12]Note that not all traded bonds receive ratings. Of the 235 bonds used for airport purposes over the 1978-82 period, only 149 were rated. However, rated bonds accounted for more than 90 percent of the dollar volume of all airport bonds issued over the past 2 years. Rating services grade new bond issues only at the request of the issuer, and issuers sometimes choose not to seek ratings. In particular, airport bonds for relatively small investments are often sold as so-called "direct private placements," which means that the airport or municipality sells directly to an investor, usually a commercial bank or insurance company buying the bonds for its own portfolio. Although a private placement usually incurs a higher interest cost, this approach can prove worthwhile for small issues because of the high transaction costs associated with selling in the open market. (Moody's, for example, charges from $850 to $45,000 to rate a bond issue.) Over the 1978-82 period, only 8 percent of all revenue bonds issued by large airports and 13 percent of those issued by medium commercial airports were unrated. In contrast, 66 percent of revenue bonds issued by small commercial airports were unrated. All

(continued)

nonreliever GA airport revenue bonds were sold privately and without ratings. This is a reflection of the smaller average size of bond issues for small airports. For such airports, rating costs represent a greater percentage of the total bond sale.

Table 35.–Airport Bond Ratings, 1978=82

Airports by size and category and bond type	Rating received (percent)				
	Best grade (Aaa)	High grade (Aa1/Aa)	Upper medium grade (A1/A)	Medium grade (Baa1/Baa)	Not rated
Commercial					
Large:					
General obligation	33	67	0	0	0
Revenue	0	6	89	0	6
Medium:					
General obligation	50	0	50	0	0
Revenue	0	0	65	18	18
Small:					
General obligation	11	36	21	7	25
Revenue	0	4	14	7	75
All:					
General obligation	19	32	24	5	19
Revenue	0	3	49	8	40
General aviation					
Reliever:					
General obligation	0	20	20	0	60
Revenue	0	0	20	0	80
Other:					
General obligation	0	8	35	4	63
Revenue	0	0	0	0	100
All:					
General obligation	0	10	24	3	62
Revenue	0	0	7	0	93

NOTE: Data reflect ratings of the most recent issue of each bond type by all airports represented. The few airports that used both types in this period appear twice, No airport bonds rated below Baa by Moody's Investors Service were issued during 1978-82.

SOURCE: Congressional Budget Office.

teria used by investor services to rate such bonds are central to the marketability of such bonds.

Credit analysts at the major investor services rate an airport revenue bond according to a variety of factors, including the financial performance of the airport, the strength of passenger demand, and use agreements with the airlines serving the airport .13 Financial strength is viewed as a direct function of passenger demand at the airport, and credit analysts review both financial indicators and underlying patterns of passenger traffic. *[4]

Airline deregulation, which has freed air carriers from virtually all obligation to serve particular airports, has caused some shift in the relative weight credit analysts give to these different factors. In response to deregulation, the investor services today place greater emphasis on local economic strength than on airport use agreements and the financial stability of the airlines serving an airport. The rationale is that, if one airline withdraws service, a strong local economy would attract other airlines to pick up the travel business.

In view of the methods adopted by the investor services, it is not surprising that large airports—with their comparatively stronger financial showings—tend to draw the best revenue bond ratings. Over the 1978-82 period, credit analysts were far more likely to assign medium-grade revenue bond ratings to issues for medium and small airports than for large airports. In fact, over that period, not a single large airport issuing debt was rated below the upper-medium category.

Since deregulation, bond rating organizations have emphasized that passengers are an airport's true customers and that sufficient passenger demand will provide financial incentives for some airline to offer service over the long term. In particular, for origin-destination airports (those at which most passengers either begin or end their journeys) in strong travel markets, the financial failure of one carrier might have no influence on the airport bond rating. For example, when Dallas-Fort Worth Airport sold $157 million of revenue bonds in November 1982, it retained its A rating from both Moody's and Standard & Poor's despite the collapse of Braniff Airways earlier that year. Braniff had held a significant share of the Dallas-Fort Worth market and, under a residual-cost use agreement, had agreed to pay a substantial portion of the total airline share of airport costs. Moody's municipal credit report on the issue cited the bond's security provisions, the adequacy and diversity of pledged revenues, and the airport's role as one of the major facilities serving a strong Southwestern economy. The report concluded that this "combination of the sufficient revenues for all requirements and increases in scheduled commercial airline service offset the potentially adverse effects following cessation of operations this past spring of the former dominant airline serving the area. "l5

For hub airports serving large numbers of connecting flights, however, the poor financial outlook for a major airline could mean a permanent loss of patronage, with important implications for bond ratings. In May 1983, for example, Moody's revised the rating of Atlanta Hartsfield on approximately $86 million "third-lien" revenue bonds downward from A to Baal, citing as the primary reasons Eastern Airline's financial problems (reflected in a net loss of $113.8 million in fiscal year 1982), a trend of declining traffic, and reduced debt service coverage. Likewise, for the Salt Lake City Airport, Moody's downgraded its rating in

[13]Credit analysts also examine rate covenants and bond resolutions. The rate covenant is the airport's promise to establish rates, fees, and charges for the use of airport facilities, and to adjust such rates, fees, and charges from time to time so that the total airport revenue will be sufficient to meet all obligations and produce a margin of safety. The rate covenant typically requires the airport to establish rates, fees, and charges so as to provide net revenues (gross revenues less operating and maintenance expenses) at least equal to 1.25 to 1.40 times annual debt service. In other words, the airport promises the bondholder to establish a schedule of fees that provides a cushion over and above what will be required to pay operating costs and debt service. The bond resolution establishes a number of special funds and accounts to facilitate the management of bonds proceeds and revenue.

[14]In considering a particular airport project, credit analysts pay special attention to past and anticipated growth in air traffic, diversity of revenue sources, level of service, number of air carriers, and air carrier market shares. Growth is considered a critical factor because, unless capital projects are accompanied by growth in airport use, the project will dilute the airport's ability to pay principal and interest on its outstanding bonds. A diversity of revenue sources is also thought to add stability to the airport's income stream.

[15]Moody's Investors Service, Inc., *Municipal Credit Report,* for Dallas-Fort Worth Regional Airport, Texas, Nov. 10, 1982.

connection with the sale of $26 million in revenue bonds, stating that the long-term security of the bonds must be viewed with uncertainty in light of the airport's growing reliance on connecting passengers carried by the financially troubled Western Airlines.1[b] In addition, while strengthening and expansion of hub-and-spoke networks by major airlines since deregulation has improved gross revenues at some airports, the added volume of connecting traffic has also prompted the need for airport expansion programs.

In the view of the bond rating analysts, the financial picture has not improved significantly for those airports that have experienced the greatest growth in operations—and dramatic increases in debt financing requirements-since deregulation .1' For example, Standard & Poor's published credit rating on the December 1982 issue of $185 million of revenue bonds at Denver Stapleton stated that the issue is not rated higher than A " . . . because of current uncertainties surrounding future airport expansion and the substantial cost associated with whichever alternative is pursued. " Similarly, Standard & Poor's published report on the recent sale of $175 million revenue bonds for Chicago O'Hare stated that " . . . the primary concern is the magnitude of the capital program being undertaken at the airport, which is expected to cost $1.2 billion by 1990. " For this reason, the Chicago-O'Hare bond issue was also denied better than art A rating.1[8]

Interest Costs

The difference between interest costs paid by airports and by other public enterprises indicates that airports generally hold a strongly competitive position in the municipal bond market. As shown in table 36, airport interest costs for revenue bonds over the 1978-82 period were 70 "basis points" below the interest cost index for all revenue bonds. (A basis point is one one-hundredth of a percentage point.) Even general obligation bonds issued in whole or in part for airport development brought below-average interest costs over that period-perhaps reflecting that municipalities with airports tend to be economically stronger than other places.1[9]

Like municipal bonds in general, airport bonds are sold and traded at prices that reflect both general economic conditions and the credit quality of the airport or (in the case of general obligation bonds) the creditworthiness of the issuing government. Rated revenue bonds are offered for sale in one of two ways. Under competitive bidding, the airport selects the lowest bid and thus obtains funds at the lowest cost of borrowing. Under a negotiated sale, the bond purchaser consents at the outset to purchase the bonds at an agreed price.[20] In either case, the entire bond issue is usually purchased by an underwriter (commonly, an investment brokerage company) or an underwriter team who, in turn, markets the bonds to institutional and individual investors.

In deciding the price of a particular bond issue, underwriters identify a "ballpark" interest rate on the basis of general market conditions and then refine this estimate according to the credit standing of the airport in question. General market conditions represent by far the most important determinant of interest costs on airport revenue bonds,

16 Moody's Investors Service, Inc., Municipal Credit Report, for Salt Lake City, UT, Airport System, May 23, 1984. Moody's also cited the uncertainty caused by a dispute among carriers serving Salt Lake City concerning the allocation of costs for new terminal facilities at the airport-a dispute that now appears settled.

17 Cited by Ann Sowder, Smith Barney Harris Upham & Co. (formerly with Standard & Poor's), in a presentation at the 55th Annual Confenmce of the American Association of Airport Executives, Orlando, FL, June 1983.

18 Another factor in the revisionof the revision of the rating for Chicago O'Hare was evidently the reduced level of coverage on the new bonds compared to that for the airport's older revenue bond issues.

19 Comparing the indicators of overall bond market rates with those of airports is somewhat misleading, since the market indicators reflect only those bonds with 25- to 30-year maturities, whereas some airport bonds mature in less time. Over the 1978-82 period, airport bonds averaged 14.7 years in maturity. In 1981, when high interest rates caused some airports to favor shorter term bonds, the average maturity for airport bonds dropped to 10.4 years. Since bonds with longer term maturities tend to have higher interest rates than shorter term bonds, this comparison results in average interest costs for airport bonds that appear slightly lower than general market rates. CBO's statistical analysis indicates that, on average, for each 10-percent increase in market interest rates, issuers of airport bonds respond by reducing the average maturity of their issues by about 7 percent.

20 In bond industry terminology, bonds are thought of in terms of either price or bond yield (interest cost). Prices and interest cost move inversely—as prices increase, interest rates decrease, and vice versa. For simplicity, the discussion here focuses on interest costs—the airport's cost of borrowing. It is noteworthy that the underwriters typically speak in terms of dollar prices. When they say that the market is "off" or "down," they mean that dollar prices are lower and yields higher.

Table 36.—Comparison of Interest Rates for Airport Bonds and Other Municipal Bonds, 1978-82

Airports by size and category and bond type	Difference (in basis points)[a]					
	1978	1979b	1980	1981	1982	1978-82
Commercial						
Large:						
General obligation	–64	c	–109	–115	–138	–95
Revenue	N/A[d]	19	–66	–166	–12	–55
Medium:						
General obligation	–80	–45	–73	4	6	–34
Revenue	NIA	–117	–46	11	–13	–29
Small:						
General obligation	–71	–46	–50	–183	–101	–82
Revenue	N/A	–84	–189	–133	–132	–153
All:						
General obligation	–71	–46	–70	–102	–85	–73
Revenue	NIA	–29	–98	–124	–28	–68
General aviation						
Reliever:						
General obligation	76	–106	–32	c	c	3
Revenue	N/A	c	–47	c	–64	–55
Other:						
General obligation	–89	–37	–138	–46	39	–53
Revenue	NIA	c	–243	–113	–60	–107
All:						
General obligation	–48	–47	–85	–46	39	–43
Revenue	NIA	c	–145	–113	–61	–92
All ***airports:***						
General obligation	–63	–46	–73	–89	–66	–65
Revenue	NIA	–29	–103	–123	–32	–70

[a]Data reflect difference in interest rates between airport bonds and other general obligation and revenue bond issues, in basis points. (A basis point is one one-hundredth of a percentage point.) General obligation issues are compared with the average value of the Bond Buyer's Index of 20 municipal bonds during the month of issue. Revenue bonds are compared with the Bond Buyer's Revenue Bond index during the month of issue.
[b]Revenue bond figures for 1979 based on September-December only.
[c]No issue of this security in this year.
[d]N/A = Not available; the Bond Buyer's Revenue Bond Index did not start until September 1979.

SOURCE: Congressional Budget Office.

and in this respect airports have little control over the cost of capital. Airport revenue and general obligation bonds issued over the 1978-82 period followed quite closely the interest cost indicators of revenue or general obligation bonds as a whole, going from a low of 5 percent in 1978 to a high of nearly 15 percent in 1982. In fact, statistical analysis indicates that each 1 percent change in the overall market rate of interest for tax-exempt municipal bonds leads to roughly a 1 percent change in interest rates for airport bonds (see app. D). Of course, interest costs differ depending on the type of underlying security and the number of years until the bonds mature. CBO'S analysis indicates that, other things being equal, general obligation bonds for airport purposes draw interest costs that fall about 9 percent below the interest paid on revenue bonds.

Within the range of interest costs dictated by market conditions, underwriters refine their bids on airport revenue bonds on the basis of the credit standing of the individual airport. Two factors have greatest importance here: the airport's basic fiscal condition (including its prospects for traffic growth and the strength of the local economic base) and the presence of special pressures on the airport to expand capacity, thereby ***necessitating*** extensive capital development.

In general, an airport's basic fiscal condition appears to be more important than long-term airline use agreements. For example, airports using a compensatory approach to financial management—which tend to have stronger overall financial performance and shorter term use agreements than residual-cost airports—drew revenue bond interest costs that were 95 basis points below other revenue bonds over the 1979-82 period (see table

37).[21] In contrast, residual-cost airports paid only 4 basis points below other municipal revenue bonds.

On average, larger airports pay lower interest costs than smaller airports, allowing for differences in types of security and average maturities of issues.[22] However, there is considerable variation in the interest costs paid by airports of different size in the 5 years since airline deregulation. Compared to small airports, large commercial airports have generally incurred somewhat higher interest costs for new bond issues, despite their history of more favorable bond ratings. For example, in the period 1978-82, the interest on revenue bonds paid by large airports was 55 basis points less than the market average, compared to 153 basis points less for small airports. Medium airports drew higher interest costs, on average, than either large or small commercial airports-29 basis points below the market average for revenue bonds.

This pattern appears to reflect two factors. First, the market is wary of increasing expansion needs at the Nation's major hub airports and of the pressure that future investments could exert on the availability of airport revenues to service outstanding debt. Indeed, from table 36, it appears that medium airports have incurred the greatest increase in interest costs, a pattern that goes along with their mounting debt-to-asset ratios. Second, the size of the average bond issued by large airports far exceeds that of smaller ones, and underwriters' bids usually reflect an interest premium in such cases to cover the added risks of marketing such a large volume of bonds. In the determination of interest rates, such premiums alone could offset the moderately higher bond ratings achieved by larger airports.

Table 37.—influence of Financial Management Approach on Airport Bond Interest Rates, 1978-82

	Difference (in basis points)[a]		
	Residual-cost airports	Compensatory airports	Total[b]
General obligation. . . .	–37	–83	–65
Revenue[c]	–4	–95	–70

[a]Data reflect difference in interest rates between airport bonds and other general obligation and revenue bond issues, in basis points. (A basis point is one one-hundredth of a percentage point.) General obligation issues are compared with the average value of the Bond Buyer's Index of 20 municipal bonds during the month of issue. Revenue bonds are compared with the Bond Buyer's Revenue Bond Index during the month of issue.
[b]Total includes airports for which the management approach is unknown.
[c]Revenue bond figures based on September 1979-82 issues.

SOURCE: Congressional Budget Office.

Defaults

The history of an enterprise, or of an entire industry, with regard to the number of defaults is an important index of investment value. By this measure, the record of airports is particularly strong. The airport industry has never suffered a single default, a fact noted by several credit analysts in citing the premium quality of airports as credit risks. One analyst has put it as follows:

> Airport revenue bonds have a remarkable track record. In spite of recessions, inflation, oil embargoes, fare wars, deregulation, astronomical increases in the price of aviation fuel, increasingly difficult community-airport relationships, costly noise mitigation programs, slot restrictions, a controllers' strike, curfews, threats about antitrust exposure, and the like, the Nation's airports have shown that they can meet the challenges, cope with change, and consistently make payments on their outstanding debt. The industry has survived without a single default. The investment community has had its "seasoning" with airport revenue bonds. As a result of the positive experience, there is a great deal of "comfort" in airports as credit risks today .23

21 Part of this difference is attributable to revenue bonds issued by the Port Authority of New York and New Jersey. These bonds are backed by revenues from all Port Authority operations and not just airport revenues. Even excluding these bonds, however, compensatory airports had interest costs 47 basis points lower than other revenue bonds.

22 In technical terms, the elasticity of interest cost with respect to airport size averaged about –0,013 over the 1978432 period. This means that an airport with 10 percent more passenger boardings than another airport would draw about a 0.13 percent lower interest rate on its bonds.

"R. H. Bates, "Airport Financing: Whither (or Wither?) the Market?" presented at Airport Operators Council International Economic Specialty Conference, Sacramento, CA, Mar. 31, 1982.

Chapter 8

FORECASTING AND TRENDS

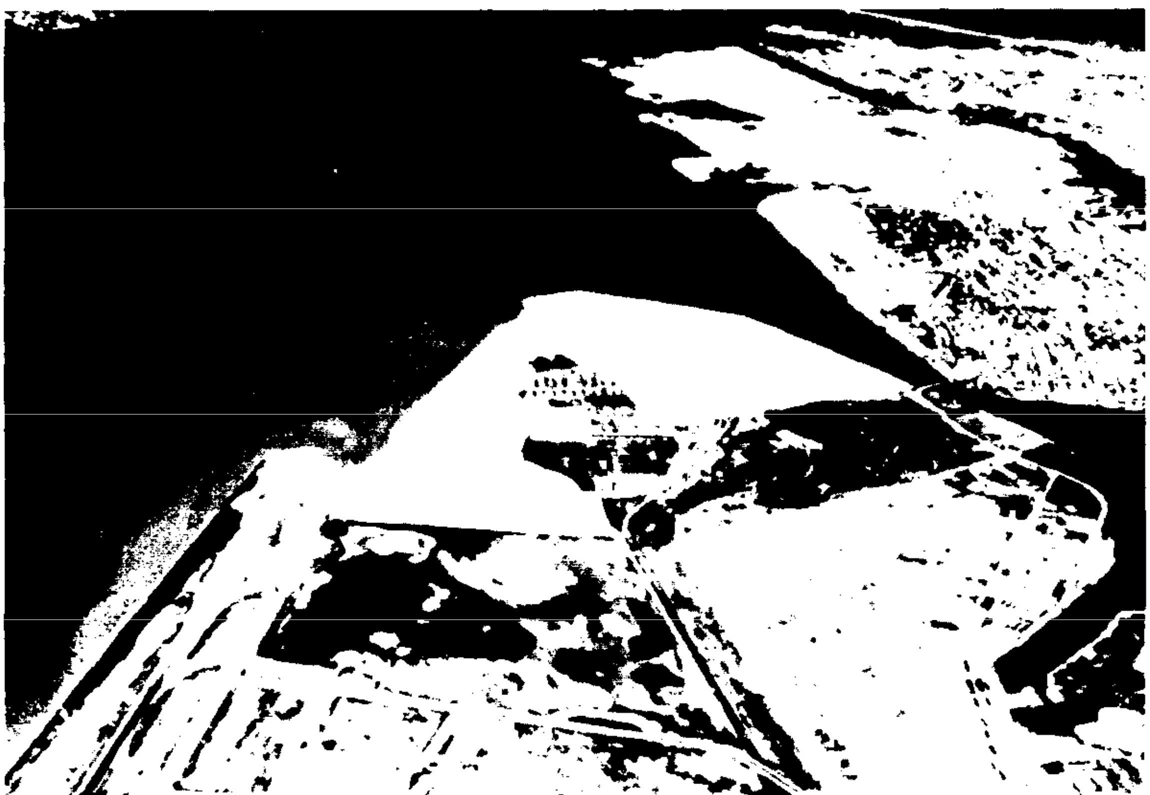


Photo cradt: Dorn McGrath, Jr.

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Chapter 8

FORECASTING AND TRENDS

Prudent management must take into account future events and conditions. Often their nature can be anticipated by analyzing events of the recent past and applying techniques to project the effects of these trends into the future. The first part of this chapter reviews forecasting techniques commonly used in aviation planning and describes their use by airport operators, air carriers, and government agencies. The second part discusses recent events and emerging trends in the aviation industry that will color future forecasts. These include the effects of deregulation, changes in route and service patterns, and the lingering effects of the air traffic controllers' strike. The final part of the chapter speculates on how these trends may affect the future needs of airports.

AVIATION DEMAND FORECASTING[1]

Methods of Forecasting

An aviation demand forecast is, in essence, a carefully formed opinion about future air traffic. Its primary use is in determining future needs or estimating when they must be met. Any of several methods may be used, with results that will vary widely in terms of scope, time scale, structure, and detail; but they have certain common features. Chiefly, forecasts are derived from assumptions about the relationship of the past and the future in that they postulate that certain measurable historical events or conditions have a causal or predictive relationship with events or conditions that will be of interest in the future, Analysis of these historical factors—usually by some sort of mathematical manipulation of data—allows the forecaster to express expectations in terms of some measure or index of aviation activity. From this initial product (e. g., expected passenger travel, cargo volume, or aircraft operations) the forecaster can derive further estimates of the nature, magnitude and timing of future needs for equipment, facilities, manpower, funding, and the like. Even though the method used may be quite rigorous and mathematically complex, forecasting is inherently a judgmental process where uncertainty abounds. The best that the forecaster can achieve is to be aware of his biases, to identify the sources of uncertainty, and to estimate the probable magnitude of error.

[1]This section is based in part on a paper prepared for OTA by David W. Bluestone, John Glover, Dorn McGrath, Jr., and Peter Schauffler.

In setting out to prepare a forecast, the forecaster has at his disposal two basic types of input data. He may choose data on aviation activity itself and use historical performance trends to project future activity. In effect, this approach assumes that the best predictor of future aviation demand is past aviation demand. Alternatively, the forecaster may choose data related to underlying economic, social, and technological factors that are presumed to influence aviation demand, treating them as independent variables that can be used to predict demand as a dependent variable. Among the factors that may be so used are:

- basic quantitative indicators, such as population, gross national product (GNP), activity of certain sectors of the economy, personal consumption expenditures, or retail sales;
- derived socioeconomic and psychological indexes, such as propensity to travel, income classifications, employment categories, educational levels, or family lifestyles; and
- supply factors, such as fare levels, aircraft characteristics (size, speed, and operating costs), schedule frequency, or structure of the air carrier industry.

The outputs of the forecast are measures of aviation activity—passenger enplanements, revenue passenger-miles, freight ton-miles, number of aircraft in the fleet, or number of aircraft operations. Other output measures, such as air carrier revenue, air traffic control (ATC) workload, and demand for airport facilities can be derived from these estimates.

The range and scope of forecasts can vary greatly, depending on the purpose they are to serve. They might include all aviation or be limited to a particular type of traffic (passenger or cargo) or a particular type of operator (scheduled air carrier, charter, or general aviation). The geographical scope may be international, nationwide, regional, or limited to a particular market or airport.

The forecasting horizon may range from a few months to 20 years, again depending on the purpose of the forecast. Airlines, for example, tend to use very short-term projections of traffic in order to estimate their financial or staffing needs on a quarterly or semiamual basis. Airport planners, on the other hand, use very long-range forecasts, on the order of 20 years, as a basis for major decisions relating to land acquisition and airport development. Between these extremes, forecasting horizons of 1,5, or 10 years are common for planning changes and improvements of airport facilities, estimating ATC workload, projecting air earner fleet requirements, and financial planning.

There are two basic approaches to aviation demand forecasting—"top-down" or "bottom-up." The top-down approach begins with the largest aggregates of economic and statistical data (usually national totals) and seeks to provide a general picture of aviation demand spanning the country and the entire system of air travel routes and facilities. Once the aggregate forecast has been developed, portions of the total volume of traffic can be allocated to specific industry segments or geographical regions based on historical shares or assumed growth rates.

The bottom-up approach, in contrast, begins with data for a specific geographic area and develops a forecast of aviation demand at a particular airport or in a metropolitan region, typically as an indicator of need for building or expanding local facilities. Where good data are available and the economy of the region is developing in an orderly way, this approach can closely approximate the reality of the area under study. In some cases, a number of such bottom-up forecasts may be combined to make a composite forecast for a larger area, but this approach of building up a regional or national aggregate from many local forecasts can lead to difficulties. For example, forecasts for some areas may be overly optimistic —often a defensive strategy designed to assure adequate future capacity. It is not unusual to find that the sum of many such bottom-up forecasts exceeds the top-down forecast for the region by a wide margin.

Whether "top-down" or "bottom-up," aviation demand forecasting as practiced today uses a wide variety of methods. The attributes, limitations, and typical applications of these methods are discussed below.

Time Trends

A simple forecasting method is the extrapolation from the past, where the forecaster assumes that major trends, such as traffic growth or market share, will continue uninterrupted and that the future will be like the recent past. Historical data for some base period are gathered and analyzed to determine a trend line, which is then extended to some point in the future, using either sophisticated mathematical procedures or simple estimation of the most likely course. This method is often used for short-term projections (1 or 2 years) where basic conditions are unlikely to change much. It is also better than no forecast at all in cases where a data base suitable for more sophisticated methods is not available. However, a basic shortcoming of trend extrapolation is that it does not take into account underlying economic, social, and technological factors that affect aviation and that are themselves subject to change.

Econometric Models

The econometric model is by far the most frequently used method for forecasting aviation demand. It is a mathematical representation of air traffic or its constituent parts and those independent variables of the national economy which are thought to influence traffic growth. Econometrics is the statistical technique used to quantify these relationships. The mathematical equations of the model relate economic factors to the level of aviation activity, based on observation of past behavior of both the economy and the aviation industry. The equations may also be constructed so as to reflect the effects of specific factors within

Photo credit: Federal Aviation Administration

Newark: the alternative to La Guardia and Kennedy

the air transportation industry itself, such as fare levels, route configurations, fuel costs, etc.

Among Federal Government agencies, both the Federal Aviation Administration (FAA) and the Civil Aeronautics Board make extensive use of econometric forecasting methods. Econometric models are also used by airlines, industry associations, and aircraft manufacturers. TWA, for example, employs a set of econometric models to forecast passenger travel industrywide and, from that, TWA’s prospective market share. The Association of European Airlines uses a mathematical model in which traffic varies directly with gross domestic product and inversely with average revenue per passenger. McDonnell Douglas, Boeing, and Lockheed all have their own versions of econometric models to project future sales of aircraft. The equations for the McDonnell Douglas model, for instance, include the ratio of long- to short-term interest rates since the cost of borrowing money has an effect on the ability of airlines to purchase aircraft.

Gravity Models

The gravity model was first developed in the sociological and marketing fields to describe various forms of human interaction. The technique was later adapted by traffic engineers to describe travel behavior. It is predicated on the assumption that travel behavior obeys a law analogous to the law of gravity, in that attraction between cities varies directly with population and inversely with distance. Thus, two large cities located near one another have a strong mutual attraction and form a very dense transportation market; small cities located far apart have little travel between them. The gravity model uses socioeconomic data for each pair of metropolitan areas to predict the level of transportation activity between them. The equations often contain terms to describe the special attractiveness of each city for different types of personal and business trips.

Although gravity models have been used extensively in highway planning, their use for aviation forecasting is limited. The State of California uses a gravity model in its State Airport System Plan in an effort to give a statewide "system view" of air transportation. The California gravity model takes into account changes in population, employment level, and income of major metropolitan areas to produce estimates of the travel that will be generated between various parts of the State. To provide consistency among plans for all transportation modes, a similar gravity model incorporating the same socioeconomic variables is used for other transportation forecasting within the State.

Scenarios

The scenario method is often used to demonstrate the variation due to differing assumptions about future conditions, thus bracketing the-range of uncertainty. The values of input variables in an econometric model, for example, are in themselves simply guesses about the future behavior of the economy. Rather than depend on a single "best" estimate of GNP in future years, the forecaster may elect to construct several scenarios to predict the behavior of the aviation industry under a range of likely economic conditions. FAA began using this method in 1976 in an attempt to describe conditions that could affect the future of air transportation, and most FAA forecasts since that time have included different scenarios incorporating divergent assumptions about the economy and the airline industry.

One of the drawbacks of the scenario method is that the range between high and low estimates can be so large that the forecast loses practical value as a guide to planning. For example, in the initial 1976 FAA study, where five scenarios were used, the high estimate of revenue passenger-miles was 2.3 times the low estimate, and the ratio of high to low forecasts of aircraft operations was 2.9.

Ratios

Some local aviation authorities and industry groups make forecasts by the relatively simple expedient of assuming a ratio between national "top-down" traffic forecasts and their own segment of traffic. This method is often used by airports that lack the funds or expertise to make independent econometric forecasts. A notable application was in 1969, when the major U.S. air carriers developed a national forecast on a consensus basis and then allocated portions of the traffic to each of 22 major air transportation hubs. The allocation, based on the historical share of national traffic captured by each hub, was adjusted by expert judgment to account for shifting patterns of airport use.

Market Surveys

This method has been used extensively by the Port Authority of New York and New Jersey for the past 25 years. The Port Authority uses in-flight passenger surveys to gather information on point of origin, choice of airport in the metropolitan area, choice of ground access mode, ground access travel time, destination, purpose of trip, and other factors that can be used to predict travel behavior and consequent demands on aviation facilities. These data are classified in a travel market model made up of over 100 socioeconomic "cells" defined by age, occupation, income, and trip purpose. The growth rate for each cell is projected by straightforward econometric "techniques.

The market survey method, while it produces a highly detailed forecast of travel, has some significant drawbacks. Data collection is complicated, time-consuming, and expensive. Since the sample is collected in a relatively brief period, it may not be truly reflective of long-term travel patterns and preferences. Airlines, which serve as collectors of the data, are reluctant for competitive reasons to relinquish control of survey results which they consider proprietary.

Judgment

To some degree, judgment enters into all forecasting. Even the most formal and scientific forecasting methods require that assumptions be made about future conditions and events. These assumptions, which represent the forecaster's basic outlook, are simply informed judgments, and they can have a powerful effect on the outcomes. Judgment also enters into the forecasting process in other ways: on the methodology to be employed, on the trends to be assumed, on the selection of years to use as a base period, on the choice of data

Photo credit: federal Aviation Administration

Commuter airline in Alaska

sources, and on likely changes in specific factors such as fuel availability, cost, and technology. At the completion of a forecast it is not uncommon to subject the results to the test of expert judgment and to adjust them in the light of what seems "reasonable."

Application of judgment has, in at least two cases, become institutionalized as part of the forecasting process. U.S. airlines generally use econometric models for traffic forecasts and fleet planning; but since they do not agree on method and initial assumptions, the Air Transport Association (ATA) develops a consensus forecast based on the judgment and practical experience of airline personnel and the ATA forecasting working group. The International Air Transportation Association (IATA) uses a modified "Delphi" technique to produce forecasts for international passenger and freight traffic. Delphi is a method for attaining consensus among experts, in this case the forecasters from participating IATA member airlines. Using this technique, initial estimates are obtained from each expert. These estimates are arranged in a composite that shows each participant how his forecast compares to the group as a whole, and each is invited to submit another forecast based on this information. After one or more rounds of comparison and feedback, judgments begin to converge, and a consensus forecast is reached.

The FAA Aviation Forecasting System

The most elaborate aviation demand forecasts produced in this country are those of the Federal Aviation Administration. They consist of national, regional, and individual airport forecasts that typically cover a 12-year period, although 20-year forecasts are sometimes prepared. These forecasts, updated and issued annually, provide the basic context for aviation demand forecasting in the United States. They are used, with a variety of specialized interpretations, by all elements of the aviation community.

In addition to the basic annual forecasts, FAA also publishes special studies and forecasts from time to time. Subjects covered recently have included air cargo activity (1979), commuter airline activity (1977 and 1981), and forecasting needs at the State level (1979). FAA has also published special "profile" reports on hourly airport activity, air carrier operations, and international passengers. In 1978, FAA began a series of individual forecasts for 24 large hub airports. These are adaptations of other FAA forecasts, with special sections on local economic growth, passenger enplanements, cargo and mail enplaned, general aviation (GA) and air carrier aircraft operations, and traffic handled by FAA towers.

FAA National Forecasts

Each year FAA publishes a national forecast entitled ***FAA Aviation*** Forecasts. The most recent edition (released in February 1984) includes detailed year-by-year forecasts from 1984 to 1995 for air carriers, air taxis and commuters, GA, and military aviation. It also contains workload forecasts for airports with FAA control towers, air route control centers, and flight service stations.

The 1984 forecasts anticipate that enplanements by major airlines will grow at an average annual rate of 4.6 percent. Larger aircraft and higher load factors will minimize actual increases in operations to accommodate this growth, with the result that FAA projects air carrier operations to grow by no more than 1.7 percent per year. Larger gains are expected for commuter carriers, whose enplanements are expected to increase by 7.4 percent per year and operations by 4.7 percent per year. GA operations are expected to increase by 6.0 percent annually. The current FAA forecasts are summarized in table 38.

Table 38.—FAA Forecasts of Aviation Activity (fiscal years)

Aviation activity	Historical 979	1982	198	Forecast 1984	1985	1995	Percent average annual growth 1979-82	1982-83	1983-84	1984-85	1983-95
Aircraft operations (millions):											
Air carrier	10.4	9.0	9.7	10.1	10.2	11.9	(4.3)	6.9	4.1	1.0	1.7
Air taxi and commuter	4.4	5.1	5.9	6.1	6.5	10.2	5.0	14.9	3.4	6.6	4.7
General aviation	51.7	34.2	35.3	38.5	42.4	71.0	10.2)	3.4	9.1	10.1	6.0
Military	2.5	2.3	2.5	2.5	2.5	2.5	(2.6)	4.9	—		
Total	69.0	50.6	53.3	57.2	61.6	95.6	(8.2)	5.3	7.3	7.7	5.0
ir carrier, domestic:											
Revenue passenger enplanements (millions)	283.4	272.8	290.3	312.7	330.0	497.8	(1.2)	6.4	7.7	5.5	4.6
Revenue passenger-miles (billions)	203.7	207.8	223.5	240.8	255.1	399.7	0.7	7.6	7.7	5.9	5.0
Commuter carriers:											
Revenue passenger enplanements (millions)	12.5	17.1	19.5	21.5	23.4	46.1	11.0	14.0	8.8	9.0	7.4
Revenue passenger-miles (billions)	1.5	2.3	2.7	3.1	3.4	7.9	15.8	16.2	2.8	0.6	9.3
Fleet:											
Air carrier	2,237	2,483	2,556	2,657	2,633	3,329	3.6	2.9	4.0	(0.9)	2.2
Commuter	1,413	1,494	1,500	1,606	1,682	2,537	1.9	0.4	7.1	4.7	4.5
General aviation (thousands)	199	213	210	207	211	287	2.4	(1.6)	(1.3)	1.9	2.6
Hours flown (millions):											
Air carrier	6.4	6.3	6.6	6.8	6.8	8.5	(0.5)	5.1	2.4	0.7	2.1
General aviation	42.3	37.8	36.6	37.6	39.1	58.4	(3.4)	(3.2)	2.7	4.0	4.0

SOURCES: 1979-83 CAB and FAA data. 1984-95 FAA forecasts.

As part of the documentation for these annual forecasts, FAA sets forth the basic assumptions concerning the industry, government, and economic environment for the forecast period. The principal indicators—gross national product, Consumer Price Index, and fuel price index—are composites of estimates obtained from four leading nongovernmental economic forecasting organizations: Chase Econometrics, Data Resources, Evans Economics, and Wharton Econometrics Associates. FAA believes that this consensus approach to formulating input assumptions lends greater credibility to the forecasts.

The air carrier portion of the forecast is developed in several steps. For airline travel, FAA first forecasts passenger yield (cost per passenger-mile) based on estimates of three independent variables: jet fuel prices, average airline wages, and available seat-miles per aircraft. The next step is to forecast passenger demand, based on GNP and yield. Third, FAA develops forecasts of aircraft operations based on load factor, average seats per aircraft, and passenger trip length, all of which are estimated in consultation with industry experts. Forecasts for itinerant operations, instrument operations, and other FAA workload measures are developed from the basic forecast of total aircraft operations, using empirically derived relationships.

Past FAA forecasts have often been criticized for inaccuracy or unrealistic assumptions about future growth of aviation. An examination of this question was made in a recent Congressional Budget Office study of FAA forecasts since 1959.[2] CBO divided the forecasts into three distinct periods (see table 39). CBO found that the forecasts performed between 1959 and 1965 were consistently low by an average of almost 19 percent. From 1966 to 1973 the forecasts swung sharply the other way and consistently overestimated the growth of aviation activity by nearly a third. From 1974 on, which coincides with the time that FAA has been using more sophisticated econometric modeling techniques, the results have been mixed, sometimes too high and sometimes too low. Overall error has averaged about 21 percent, somewhat smaller than in the previous period but still rather large for this type of forecasting. FAA forecasts for the GA sector have been especially unreliable and consistently high, sometimes by as much as 50 percent. On balance, CBO concludes that FAA's forecasts have improved substantially in the past 10 years, showing a reasonably small random error instead of the constant high or low bias that characterized forecasts of the earlier two periods.

[2] *Improving the Air Traffic Control System: An Assessment of the National Airspace System Plan* (Washington, DC: Congressional Budget Office, August 1983), app. C, p. 65.

Table 39.–Summary of FAA Forecasts, 1959-83

Periods in which forecasts made	Method	Performance 5 years ahead	Market environment
1959-65	Trend forecasting: unspecified links to economy, business cycle, population, fares, competition from other modes	Average error – 18.7 percent Worst year –32.5 percent	Expanding, prosperous economy. Rapidly growing population. Declining first-class and coach fares, (declining unit costs because of increasing use of jets).
1966-73	Trend forecasting: unspecified links to economy, business cycle, population, fares, competition from other modes	Average error +32.5 percent Worst year +58.4 percent	Softening trends in aviation activity. Increasing ticket taxes, rising fares. Forecasts made in 1969 (published January 1970) assumed 4.25 percent growth rate in 1973, to continue at that rate through decade. Inflation 2 percent per year from 1973.
From 1974	Linear econometric models	Average error +21.2 percent Worst year +34.7 percent	Airline deregulation, economic recession, fare wars, and depressed airline revenues.

SOURCE: Congressional Budget Office, *Improving the Air Traffic Control System: An Assessment of the National Airspace System Plan*, August 1983.

Terminal Area Forecasts

FAA Terminal Area Forecasts (TAFs), like FAA national forecasts, are developed annually. The TAF data base contains descriptive information and forecasts for about 4,000 airports-the 3,200 eligible for Federal aid and about 800 other public-use airports. Each airport record includes at least 5 years of historical data and a 12-year forecast of aircraft operations, broken down into air carrier, commuter, GA, and military categories. The projections for individual airports can also be aggregated to form State and regional forecasts.

The TAFs constitute a subroutine of the basic FAA "top-down" forecasts of national aviation demand. The process for developing TAFs has been refined in recent years, and they now serve as the basic frame of reference for other types of "bottom-up" forecasts undertaken by many local airport authorities and State and regional agencies. Not all local airport authorities, however, accept the validity of TAFs, which they believe do not adequately take into account the factors affecting aviation demand at the local and regional level and which are not, in their view, developed through appropriate consultation with local authorities.

The Special Problem of GA Forecasting

FAA forecasts GA demand in two segments—business aviation and personal flying. For business aircraft, the forecast is based on the real price of aircraft, interest rates, and measures of business activity such as manufacturing and retail sales. For personal flying, the factors used are aircraft price, interest rates, and GNP as a measure of income. Itinerant operations are forecast as a function of the size of the fleet and the real cost of fuel. Instrument operations are a function of fleet size. Local operations, predominantly training operations, are a function of the number of student pilots and the number of aircraft in the fleet. FAA has concluded that because of large and somewhat unpredictable oscillations in all these variables, econometric models do not produce reliable forecasts of general aviation. As a pragmatic approach, FAA uses modeling only as a point of departure to produce first approximations that are subsequently adjusted with data from periodic surveys and estimates from FU regional offices and industry representatives.

Some observers are of the opinion that FAA's general aviation forecasts are unrealistically high. For example, recent FAA forecasts estimate that the GA fleet will grow at a rate of 3.3 percent per year for the remainder of this century.[3] This means an expansion of the GA fleet from about 210,000 aircraft in 1983 to 269,000 in 1990 and 385,000 in 2000. Such a growth rate is extremely optimistic, and realizing it would require an unprecedented level of manufacture and sale in the GA aircraft industry. An increase of 175,000 aircraft in the GA fleet by the end of the century is equivalent to adding 10,000 new aircraft per year—13,000 if allowance is made for replacement of existing aircraft at the rate of 1 percent annually. When foreign aircraft sales are taken into account, the FAl forecast implies that U.S. firms would manufacture and sell about 16,000 aircraft per year between now and 2000. This seems unlikely in light of performance over the past 15 years in the GA aircraft manufacturing industry where sales (including exports) have averaged only two-thirds of this amount. A

Limitations of Aviation Demand Models

Aviation demand models can be very useful forecasting tools, but it is important to recognize their limitations. First, all models are necessarily incomplete. They attempt to reduce a large and complex system to a relatively few mathematical equations that describe the most important interactions. Many factors must be left out, either because they are difficult to formulate mathematically or because including them would make the model cumbersome and too complicated to use. There are other factors excluded not by design but by inadvertence because, with the present state of knowledge about the relationship between aviation and underlying economic and social forces, we are simply unaware of all the factors that drive demand for air transportation.

[3] *National Airspace System Plan* (Washington, DC: Federal Aviation Administration, April 1983, revised edition), p. II-2.

[4] *Aerospace Facts and Figures, 2983/84* (Washington, DC: Aerospace Industries Association, 1984), p. 33.

To guard against such structural weakness, the model builder calibrates and tests the model by inserting data from past years to see if the historical record can be accurately reproduced. If the model is well constructed and its mathematical relationships are a good representation of reality, using data from some past year in the equatiorls will yield a forecast of the aviation activity that actually occurred. Such testing *gives* the forecaster confidence that for some future **year** the model will correctly predict aviation activity if the correct ***values of input variables are used.*** Unfortunately, the correct values of input variables such as GNP or interest rates for any future year are themselves unknown, and uncertainty is simply transferred from the behavior of the aviation industry to behavior of the economy at large.

Models tend to assume that the future will be very much like the past. If the real world situation changes substantially, the model is correspondingly less accurate. Such changes might include sudden economic perturbations, such as the fuel crisis of 1973, or longer term restructuring of the market or the economy. For example, aviation models constructed to predict the behavior of a regulated industry with stable fares and routes tend to be less accurate now that price competition and freer entry into new markets are permitted. Further, because models are, at best, only partial representations of the world, it is not easy to predict which changes in travel behavior or economic conditions will be important in the future or how they should be incorporated in a model. A major problem among forecasters is discriminating among relationships that will persist and those that will not.

From this, it is clear that aviation demand models are highly influenced by underlying assumptions about economic and social trends and future conditions. The model itself may accurately depict relationships between air transportation and the state of the economy or the structure of the aviation industry, but if the assumed states of these variables at some future time are too optimistic, too pessimistic, or simply inconsistent with the course of events, the resulting forecasts can go far astray. It is probably fair to conclude that, even with the present limitations of the model builder's art, the inaccuracies due to the structure of forecasting models are generally smaller than those induced by erroneous input assumptions. An aviation demand model is no more robust than the assumptions on which it rests, and assumptions (usually a matter of expert judgment) are the most fragile part of the process.

The limitations, biases, and characteristics of a forecast may depend as much on who is doing the forecast as on the particular method being used. Airport authorities, aviation agencies, airlines, and industry associations all make forecasts to help them plan for the future and to help them justify plans and programs. There is, in many cases, a natural inclination to err on the side of optimism in order to protect the future interests of the agency producing the forecast. Thus, local airport authorities planning an expansion project may tend toward an unduly high appraisal of the overall growth prospects in the local economy and, hence, future passenger and ***cargo*** traffic. As a consequence, basing decisions to construct or expand facilities on these forecasts may lead to excess capacity or premature investment of capital. However, this may be less detrimental than relying on a forecast which is too low. Slight overcapacity and anticipation of demand is viewed by most airport planners as preferable to congestion, delay, and perhaps deterioration of service and safety.

Local forecasting may not take into account broader regional trends and conditions. The current shifts in population and economic activity

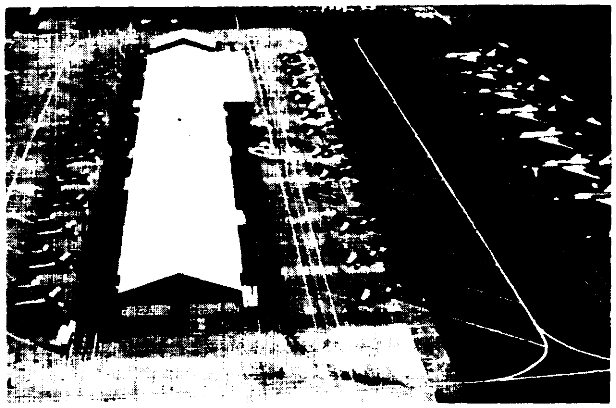


Photo credit: Federal Express

Air cargo hub

from the "Frost Belt" to the "Sun Belt" area case in point. States in the South and West are expected to experience much greater growth in aviation activity in the next few decades while communities in the North and East will tend to decline. However, this trend—with its consequences for airport planning and development—is not yet generally recognized in the forecasts prepared by "Frost Belt" communities, perhaps because they are unwilling (or find it politically unwise) to go on public record as predicting their own decline.

The tendency of the aviation community to organize categorically—air carriers, commuters, general aviation, helicopters, etc.—also influences aviation demand forecasting, both the forecasts prepared by such groups themselves and those prepared by others who seek to anticipate the demands that each sector will place on the airport and air traffic control system. All of these groups compete in some measure for the scarce resources of airspace and airport facilities, and none is prepared to concede that its own requirements are less pressing than those of others or to admit any scenario other than continued growth. As a result, each sector tends to publicize its own aspirations lest it lose out in the general competition and find its access foreclosed. With sufficient repetition and vigorous advocacy, such declarations become accepted as the reality of future demand.

For example, the President of the National Business Aircraft Association, Inc., asserted in mid-1982 that "a great pent up demand for aircraft is building all the while the recession continues. Once the general economic climate begins to improve and the price of borrowing money declines even modestly on a long-term basis, we will witness marketplace activity on a scale never before known."[5] While this bold prediction may be arguable, it reflects a natural defensive strategy. If the forecast turns out to be true, general aviation, especially business aviation, will soon become the majority user of the airport and ATC system. In this event, business aircraft operators would be unwise to allow air carriers to preempt landing slots or to accept restriction or diversion of their activities to accommodate air carriers. On the other hand, if the forecast proves too optimistic, decisions based on it could result in serious overcapacity or misallocation of resources.

No forecast is any better than its input data, and a little foreseen consequence of deregulation is that forecasting may become more difficult and less accurate in the future because of the lack of a detailed and adequately maintained data base. The Airline Deregulation Act of 1978 calls for a gradual phaseout of the Civil Aeronautics Board (CAB) by 1985. At that time, all functions of the CAB will either be eliminated or transferred to other agencies. It is still not clear how much of CAB's extensive data collecting activities will be transferred and continued. Since nearly everyone in the aviation community makes use of CAB data for forecasting purposes, the prospective loss of this resource is now the focus of extreme concern in industry and government. Not all parties agree on which parts of the CAB data base should be maintained and who should be responsible, but there is apparent consensus on at least four major points:

- CAB data have become a crucial part of the aviation forecasting process.
- Continued collection of at least the basic data on air carrier and commuter operations is vital to intelligent analysis, interpretation, and forecasting of regional and local aviation demand.
- Without such data, the reliability of forecasting for air carrier and commuter activity could decline, perhaps to a level no better than current general aviation forecasting.
- Forecasting aviation demand could become much more difficult after 1985.

The prospective loss or drastic reduction of the widely used and respected CAB data base looms as only the latest example of an unexpected major event in the uncertain world of aviation demand forecasting.

[5]John H. Winant, President, National Business Aircraft Association, Inc., remarks at a meeting of the Western Michigan Business Aircraft Association, Grand Rapids, MI, June 25, 1982.

RECENT TRENDS IN THE AIRLINE INDUSTRY[6]

Of all the forces acting on civil aviation at the present time, that which has the most profound effect—and which is perhaps the least understood in all its ramifications—is the recent deregulation of the airline industry. For 40 years, from 1938 to 1978, CAB exercised broad powers over the airline industry, controlling entry and exit of carriers, markets served, and fare structures. Although this was a period of great growth in the airline industry, the pace of change in patterns of service and airline route structure was slow because it was tempered by the regulatory process. CAB proceedings on route awards or fare changes took months or years to complete. The CAB often interpreted "public convenience and necessity" in light of the need to maintain financial stability among existing carriers. Although CAB progressively increased the level of competition, this process was usually accomplished by extending the overlap of routes and services among existing carriers.

The Airline Deregulation Act set a timetable for phasing out CAB statutory authority over a 4-year period. The major provisions of the act, effective immediately, relaxed CAB authority over routes and fares and made it easier for carriers to enter new markets or to reactivate dormant routes. Except in localities qualifying for essential air service, airlines became free to terminate service to a community by means of a simplified notice procedure. In addition, carriers were allowed to change fares within a broad "zone of reasonableness" determined by airline costs. Deregulation thus set the stage for a wide variety of changes in the way air services are offered.

While some of the effects of deregulation are now apparent, the full impact of these regulatory changes on the market cannot yet be evaluated. Air carriers have been operating in a deregulated environment for only a little over 5 years, and they are still in a "shake-down" period of adjusting to new freedoms and competitive pressures. At the same time, other major factors—escalating fuel prices, the recession, and the Professional Air Traffic Controllers Organization (PATCO) strike–have had their own effects on the airline industry, thus distorting the view of what *deregulation* has actually produced.

In general, the period 1978-81 marked a sharp increase in all airline costs, but no other cost escalated as much as fuel, which rose from $0.39 per gallon in 1978 to $1.04 in 1981. Fare flexibility provided by deregulation enabled some carriers to blunt the effects of increased fuel costs by quickly passing on the resulting higher costs to consumers. However, the deep recession, beginning with the first quarter of 1980, compounded the problem as the industry was caught in the position of needing to raise fares at a time of general economic decline.

The full effects of airline deregulation were muted if not altered by the recession, which began about 15 months after deregulation and has continued to disturb the U.S. economy. The recession has had a major effect on the airline industry, whose health has always been closely linked to GNP. In the period 1976-78, before the recession, real GNP increased by 6.7 percent per annum. During the period immediately following deregulation, GNP grew at less than 1 percent and

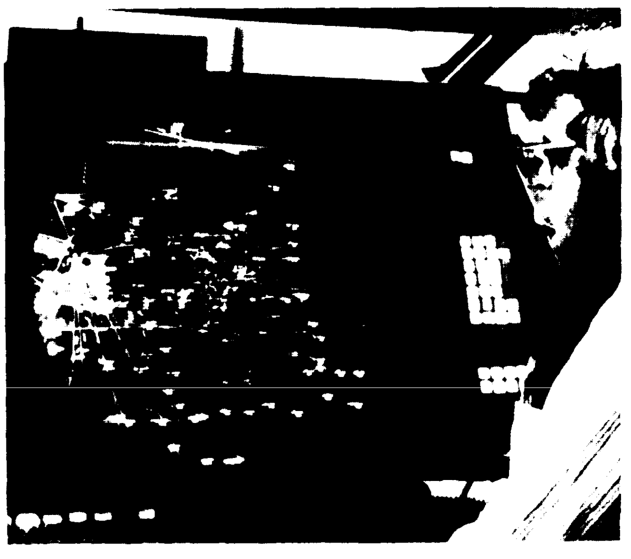


Photo credit: Federal Aviation Administration

Controller's view of a hub

[6]This section is based in part on a report prepared for OTA by Simat, Helliesen & Eichner.

actually declined during 1982. The overall economic performance of the airlines showed a corresponding slump, although some airlines fared better than others and a few even managed to increase their profitability.

Some analysts argue that service and fare stimulation following deregulation, combined with the ability to drop unprofitable routes, cushioned the effects of the recession on the air carriers. High interest rates and poor business conditions clearly blocked the start of several new carriers and indirectly provided a measure of protection for existing carriers.

In effect, the air traffic controllers' strike in August 1981 reintroduced regulatory limits on the industry. The strike led FAA to close 58 ATC towers at small airports and to impose a cap on operations at the 22 busiest airports. To allocate the hardship equitably, FAA required each airline to reduce operations proportionately at those 22 airports. An airline could exercise full latitude to select routes, so long as it had operating rights (slots) at the capped airports. Slots could be traded and, for a limited time, even sold. But if an airline did not use a slot, it was forfeited. These strike-related restrictions have since been lifted, but their effects linger. Because operating rights had considerable value in a depressed, strike-ridden market, FAA restrictions forced many carriers to hold on to slots and postpone or cancel planned route changes. Equally important, the cap on operations limited opportunities for new carriers to enter many of the major markets.

In many respects, the strike slowed the process of deregulation, but it also stimulated formation of new hub-and-spoke patterns of operation as air carriers sought to increase the number of passengers handled by using larger aircraft at the constrained airports or by transferring operations to new regional hubs at less crowded airports.

The ultimate outcome of deregulation is not yet clear. The effects apparent so far—although blurred by the impacts of increased airline costs, the recession, and the air traffic controllers' strike—suggest that profound changes are taking place in the structure and economics of the airline industry, with repercussions that may persist for several years.

Changes in Airline Industry Composition

Since deregulation, the number of airlines holding CAB operating certificates has increased tenfold. At the end of 1978, there were only 36 certificated carriers; now there are 355. To accommodate these changes, CAB has devised a new classification system that categorizes airlines as major carriers, national carriers, and large or medium regional carriers on the basis of their operating revenue. This system is not wholly compatible with two-way classification of trunk and local service carrier in use before 1978. (Table 40 compares the new and old classification systems.) For purposes of this discussion, it is more convenient to use the pre-1978 categories, augmented by two additional groups (startup jet carriers and commuter airlines) in order to show the changes that have taken place in air carrier routes and services since deregulation.

Before deregulation, the 10 trunk carriers dominated major domestic U.S. air service markets. Even today, these airlines account for about 60 percent of total domestic enplanements and an even greater proportion of revenue passenger-miles, revenue, and fleet capacity. The trunk airlines operate large fleets of jet aircraft, of which nearly 20 percent are widebody. Trunk carriers are equipped to serve primarily the long-haul markets, emphasizing direct service between most major domestic markets.

Six local service airlines operate short-haul jet service in domestic markets. In 1982, these carriers enplaned 19 percent of all domestic air passengers. Through expansion and mergers, locals have grown substantially in size and now three of these—USAir, Republic, and Frontier—are larger than some trunk carriers. Still, there are substantial differences between local service and trunk carriers. Local service carriers operate predominantly narrowbody jet aircraft, typically with 100 to 125 seats. The average stage length and passenger trip length for local service airlines is less than half that of trunk carriers.

The "startup jet carriers" include former intrastate carriers that have expanded to nationwide service since deregulation, as well as new firms that began operation since 1978. Previously, there were four intrastate carriers that provided short-

Table 40.—Domestic Airlines by Class of Carrier

New CAB classification[a]	Older classification
Major carriers (all):	***Trunk carriers (all):***
American	American
Braniff	Braniff
Continental	Continental
Delta	Delta
Eastern	Eastern
Northwest	Northwest
Pan American	Pan American
Trans World	Trans World
United	United
Western	Western
Republic	***Local service carriers (all):***
USAir	Republic
National carriers (all):	USAir
Frontier	Frontier
Ozark	Ozark
Piedmont	Piedmont
Texas International	Texas International
Air California	***Intrastate jet carriers (sample):***
Air Florida	Air California
Capitol	Air Florida
Pacific Southwest	***Charter carriers (sample):***
Southwest	Capitol
World	World
Large regionals (sample):	***New-start jet carrier (sample):***
Midway	Midway
Muse	Muse
New York Air	New York Air
Air Midwest	Pacific Southwest
Air Illinois	Southwest
Air Wisconsin	People Express
People Express	***Commuters (sampie):***
Medium regionais (sampie):	Air Midwest[b]
Aspen	Aspen[b]
Cascade	Wright[b]
Empire	Empire
Golden West	Air "Illinois
Mississippi Valley	Air Wisconsin[b]
Wright	Golden West
	Mississippi Valley

[a]Classifications are based on carriers' annual operating revenues.
[b]Certificated before deregulation.

SOURCE: Federal Aviation Administration.

haul jet services entirely within the boundaries of California, Texas, or Florida. After deregulation, these airlines obtained CAB certification and now fly interstate routes. Even though they have expanded their operations to new out-of-State markets, they retain certain pre-1978 characteristics in that they continue to serve highly competitive short-haul markets with emphasis on frequency of flights and low fares.

Several other new jet airlines have begun operation since deregulation. Some—e. g., New York Air, Midway, People Express, and Muse—are new ventures. One—Empire Airlines—is a former commuter airline that has successfully introduced jet service. Capitol Air and World Airlines are former charter operations that have inaugurated scheduled service. Typically, the startup carriers serve high-density, long-haul markets where they compete with trunk carriers, principally on the basis of low fares.

Commuter airlines usually do not operate jets, but propellor-driven aircraft with up to 30 seats. Before 1978, most commuter airlines were exempt from CAB fare and route regulation, but they were restricted to the use of aircraft no larger than 30 seats. A few—e.g., Air Midwest, Air New England, and Wright-obtained CAB certification in order to use larger aircraft or to receive subsidies for air service to small communities. As local service and trunk carriers have withdrawn from smaller markets, commuters have moved in to fill the gap. One of the earliest and most successful examples is Allegheny Airlines (now USAir), which transferred certain of its services to 12 smaller independent airlines (known collectively under the name "Allegheny Commuter") that operate under contract to USAir.

Since 1978, over 300 commuters have obtained CAB certification. They are becoming progressively integrated into the national air transportation system, providing local point-to-point service and linking small communities with the larger airport hubs. Passenger enplanements on commuters have grown rapidly, from 4.2 percent of passenger enplanements in 1979 to 6.3 percent in 1983.[7]

Changes in Route Networks

Airline deregulation has changed the national air service network from a stable system of routes served by established carriers to a fluid marketplace where carriers frequently adjust routes, level of service, and fares. The older airlines have abandoned some markets and begun service to others. New entrants have taken over some of these abandoned routes and established themselves in the dense markets where they see a competitive opportunity.

The course of the industry since deregulation has been one of uneven expansion and contraction. The principal effect on airports is that sudden and less predictable changes have taken place in the air carriers serving the airport, the level of service provided, and the facilities needed to accommodate them. Some communities have experienced a general improvement in air service since deregulation, but not all have benefited from an unregulated environment, and some have suffered almost complete loss of air service.

[7]*FAA Aviation Forecasts, Fiscal Years 1984-1995* **(Washington, DC: Federal Aviation Administration, FAA-APO-84-1, February 1984).**

Table 41 shows changes in points served by a sample of carriers between 1978 and 1981; table 42 shows the changes in service by size of city. The designations large, medium, small, and nonhub are FAA and CAB classifications based on number of passengers enplaned. Large hubs are the top 24 cities, medium hubs the next 39. There are 61 small hubs and 461 nonhubs.[8]

Most of the established carriers added and deleted service points frequently during this period. Air California and Air Florida, no longer restricted to intrastate traffic, expanded the number of points served. The Allegheny Commuter system of USAir abandoned 23 stations and added 30. American Airlines moved into Braniff's market, adding 12 stations in the Texas, Louisiana, and Alabama markets. Frontier Airlines discontinued service to 28 nonhubs and small hubs and branched out to other small cities and a few large hubs. Piedmont pursued the same strategy, adding seven large cities and two high growth areas in Florida, while deleting 16 small hubs and nonhubs.

Competition has been intense in certain high growth markets. For example, cities like Phoenix with substantial population growth have attracted new carriers. Traffic growth at Orlando, which is now served by 10 carriers as opposed to 4 before deregulation, is a product of both economic development (Disney World and Epcot) and a surge of discretionary travel stimulated by lower fares.

For the most part, trunks and local service carriers dropped short-haul markets. Between 1978 and 1981, the number of trunk airline flights to markets with stage lengths under 200 miles dropped by 44 percent. Local carriers followed suit by reducing short-haul departures by 35 percent and more than doubling flights in the range of 500 to 1,000 miles. Some of the short-haul market has been picked up by the commuter carriers.

The emerging pattern is one of increased activity at large and medium airports and eroding service at the smallest nonhub airports, as shown in table 43. Confirmation of this pattern can be found in data on changes in aircraft departures

[8]*FAA Statistical Handbook* **of** *Aviation, Calendar Year 1982* **(Washington, DC: Federal Aviation Administration, December 1982).**

Table 41.—Changes in Stations Served by Air Carriers, 1978-81

Carrier	Stations served in: 1978	1981	Stations Added	Deleted
Air California	10	14	7	3
Air Florida	11	18	9	2
Allegheny Commuter	49	56	30	23
American Airlines	45	61	24	8
Braniff Airways	37	34	5	8
Capitol International Airways	0	4	4	0
Continental Airlines	30	46	17	1
Delta Air Lines	71	71	10	10
Eastern Airlines	66	70	15	11
Frontier Airlines	87	78	19	28
Jet America Airlines	0	2	2	0
Midway Airlines	0	12	12	0
Muse Air	0	2	2	0
New York Air	0	13	13	0
Northwest Airlines	31	36	5	0
Ozark Airlines	47	48	11	10
Pacific Southwest Airlines	13	15	5	3
Pan American	34	21	2	15
People Express Airlines	0	10	10	0
Piedmont Airlines	48	40	9	17
Republic Airlines	114	104	15	25
Republic Airlines West	46	37	4	13
Southwest Airlines	9	14	5	0
Texas International Airlines	34	32	12	14
Trans World Airlines	37	50	17	4
United Airlines	83	77	10	16
USAir	54	58	16	12
Western Airlines	31	27	5	9
World Airways	0	5	5	0
Total	**987**	**1,055**	**300**	**232**

SOURCE: *Official Airline Guide*, "Report on Airline Service, Fares, Traffic, Load Factors, and Market Shares," Report #21, June 1982.

Table 42.—Comparison of Hubs Served by Selected Carriers, 1978 v. 1982 (second quarter)

Carrier	Large hubs 1978	1982	Change	Medium hubs 1978	1982	Change	Small hubs 1978	1982	Change	Nonhubs 1978	1982	Change	Total 1978	1982	Change
American Airlines	13	12	+8	20	24	+4	8	12	+4	0	0	0	41	57	+16
Continental Airlines	11	8	−3	10	15	+5	4	4	—	1	0	−1	26	27	+1
Delta Air Lines	20	22	+2	17	22	+5	19	20	+1	11	5	−6	67	69	+2
Eastern Airlines	19	23	+4	20	26	+6	21	19	−2	4	2	−2	64	70	+6
Frontier Airlines	5	12	+7	9	9	—	5	11	+6	47	25	−22	66	57	−9
Northwest Airlines	11	17	+6	3	3	—	5	6	+1	1	5	+4	20	31	+11
Ozark Airlines	7	13	+6	7	7	—	5	7	+2	23	9	−14	42	36	−6
Pan American	12	12	—	5	2	−3	8	2	−6	0	0	—	25	16	−9
Piedmont Airlines	4	13	+9	9	11	+2	10	7	−3	20	9	−11	43	40	−3
Republic Airlines	19	23	+4	14	17	+3	25	22	−3	86	54	−32	144	116	−28
Trans World Airlines	15	18	+3	12	13	+1	4	6	+2	0	0	—	31	37	+6
United Airlines	18	20	+2	19	24	+5	21	17	−4	19	6	−13	77	67	−10
USAir	9	15	+6	13	14	+1	8	9	+1	17	8	−9	47	46	−1
Western Airlines	8	9	+1	5	8	+3	2	2	—	9	5	−4	24	24	—

SOURCE: Civil Aeronautics Board, *Competition and the Airlines: An Evaluation of Deregulation*, app. D, December 1982.

Table 43.—Aircraft Departures by Hub Size (June 1, 1978, and June 1, 1982)

Hub size[a]	Number of communities	Departures per week[b] June 1978	Departures per week[b] June 1982	Increase or decrease	Percent change
Departures by hub size:					
Large	1923	60,384	63,825	3,441	5.7
Medium	36	23,076	25,480	2,404	10.4
Small	66	13,788	14,115	327	
Nonhub	504	28,575	25,239	(3,336)	(1::;)
Total	629	125,823	128,659	2,836	2.3

Distribution of departure changes by hub size:

Change	Number of hubs: Large	Medium	Small	Nonhub	Total
Increase	18	23	30	200	271
No change	0	0	1	12	13
Decrease	5	13	35	292	345

[a]Hub classification based on data for year ended Sept. 30, 1982.
[b]Includes departures to all destinations by all carriers listed in the *Official Airline Guide*

SOURCE: *Official Airline Guide*, June 1, 1978, and June 1, 1982.

for all commercial service airports, shown in table 44. According to CAB, over 292 nonhub cities lost service from 1978 to 1982.[9] In some instances, localities dropped by larger carriers have received replacement service from commuter airlines. As a result, the average size of aircraft serving these points is smaller, and the number of seats available per departure has declined.

Medium hubs appear to be the main beneficiaries of increased air carrier activity. Two factors appear to account for this trend: the air traffic controllers' strike, which limited access to many large airports, and the growth of regional hubbing. As shown in table 45, departures from medium hubs to other medium hubs increased by 30 percent between 1978 and 1982. Departures from medium hubs to small or large hubs have also increased. By contrast, flights between large hubs have declined.

Formation of New Hubs

Air traffic has increased at airports in several medium-size cities as a result of moves by trunk airlines and local service carriers to consolidate their operations in hub-and-spoke route systems. (A diagram of a typical hub-and-spoke structure is shown in fig. 19.) The basic strategy is to establish one airport as the hub into which traffic from other cities is fed along radial routes. Flights by a carrier into and out of the hub are closely scheduled in "complexes" or "connecting blocks" of approximately 30 to 45 minutes so as to facilitate transfers and minimize passengers' waiting time. For the air carrier, the chief advantage is that service can be provided between smaller cities and along thinly traveled routes more economically than if they were connected by direct flights.

Hubbing is not new. Delta established a hub at Atlanta long before deregulation, and hubbing has been the core of Delta's operating and marketing philosophy for years. The same principle of tight control of traffic feed through a single point was applied over 20 years ago by United in Chicago and USAir in Pittsburgh.

Deregulation, however, has added impetus to the practice of hubbing by allowing airlines almost complete freedom to set up new routes and service points. Many local carriers, no longer satisfied to feed traffic to the trunk carriers, have taken the opportunity to establish their own regional hubs—e.g., Piedmont at Charlotte, Dayton and, most recently, Baltimore; Republic at Memphis; and Western at Salt Lake City.

By setting up a hub at an underutilized airport (usually in a medium-size city), a carrier can avoid the congestion encountered at major airports and reduce operating costs, while at the same time creating markets in surrounding cities where it might

[9]*Report on Airline Service, Fares, Traffic, Load Factors and Market Shares* (Washington, DC: Civil Aeronautics Board, June 1982), table 15.

Table 44.—Weekly Departures and Seats, by Hub Size, 1978-83

	Weekly data						Percent change					
	6/78		6/82		6/83		6/78 to 6/82		6/82 to 6/83		6/78 to 6/83	
	Number	Percent of system	Number	Percent of system	Number	Percent of system	Ratio	Average annual rate	Annual rate	Rate change in 1983	Ratio	Average annual rate
Large hubs:												
Departures	58,886	47	61,545	[illegible]	70,371	[illegible]	4.5	1.1	14.3	13.1	19.5	3.6
Seats	6,672,500	59	[illegible]170,320	[illegible]	8,270,855	[illegible]	7.5	1.8	15.3	13.3	24.0	4.4
Seats/departure	113.3	—	116.5	[illegible]	117.5	[illegible]	2.9	0.7	0.9	0.2	3.8	0.8
Medium hubs:												
Departures	23,032	18	25,394	20	28,982	20	10.3	2.5	14.1	11.3	25.8	4.7
Seats	2,264,932	20	2,368,046	20	2,731,820	21	4.6	1.1	15.4	14.1	20.6	3.8
Seats/departure	98.3	—	93.3	—	94.3	—	(5.2)	(1.3)	1.1	2.4	(4.1)	(0.8)
Small hubs:												
Departures	12,613	[illegible]	[illegible]	[illegible]	14,240	[illegible]	1.2	0.3	11.6	11.3	12.9	2.5
Seats	1,073,643	[illegible]	[illegible]	[illegible]	[illegible],061,216	[illegible]	(6.3)	(1.6)	5.4	7.1	(1.2)	(0.2)
Seats/departure	85.1	—	[illegible]	—	74.5	—	(7.3)	(1.9)	(6.4)	(4.6)	(12.5)	(2.6)
Nonhubs:												
Departures	31,479	25	28,911	22	31,253	22	(8.2)	(2.1)	8.2	10.5	(0.7)	(0.1)
Seats	1,332,488	12	1,156,734	10	[illegible],194,757	9	13.2)	(3.1)	3.3	6.6	(10.3)	(2.2)
Seats/departure	42.3	—	40.0	—	38.2	—	(5.4)	(1.4)	(4.5)	(3.1)	(9.7)	(2.0)
Total:												
Departures	126,010	100	128,609	100	144,846	100	2.1	[illegible]	12.6	12.1	14.9	[illegible]
Seats	11,343,563	100	11,701,435	100	13,258,648	100	3.2	[illegible]	13.3	12.4	16.9	[illegible]
Seats/departure	90.0	—	91.0	—	91.5	—	1.1	[illegible]	0.5	0.2	1.7	[illegible]

SOURCE: Civil Aeronautics Board, "Report on Airline Service, Fares, Traffic, Load Factors, and Market Shares," table [illegible] June 1982, and table 18, June 1983.

Table 45.—Changes in Weekly Departures Between Major Categories of Airports

Item	Percent change (June 1978 to June 1982)
Between large hubs and:	
Large hubs	(11.5)
Between medium hubs and:	
Large hubs	6.5
Medium hubs	30.4
Between small hubs and:	
Large hubs	(5.8)
Medium hubs	11.2
Small hubs	(12.0)
Between nonhubs and:	
Large hubs	(9.4)
Medium hubs.	(12.1)
Small hubs	(25.5)
Nonhubs	(28.4)

SOURCE: *Official Airline Guide*. City categories are based on July 1982 hub classifications. Only nonstop flights between cities are counted. Nonhub departure statistics include 11 communities which lost service between June 1978 and the enactment of the Deregulation Act in October 1978.

not otherwise be practical to offer frequent air service, or any service at all. Further, by choosing an airport that is not extensively served by competing carriers, the hubbing carrier maintains control over traffic; passengers who arrive on the carrier's flights will depart on one of its connecting flights, not on a competitor's.[10] In general, carriers setting up new regional hubs have concentrated on serving the traveler flying less than 1,000 miles, a group which may represent as much as two-thirds of the domestic market.

Hub-and-spoke operations seem to be increasing even at large airports, such as Chicago, Atlanta, Denver, and St. Louis. Since deregulation, most of the trunk carriers have increased the number of markets served nonstop from large hubs. Ninety-nine percent of Continental's departures (before the airline filed for bankruptcy) fed the Houston and Denver hubs. In 1979, Delta operated nonstop flights from Atlanta to 59 cities; today it is serving 72, having added routes to the Caribbean as well as stations in the West and South. United's schedule shows a net gain of 16 points served nonstop from its Denver hub. In 1981, TWA dropped direct service from its St. Louis hub to Atlanta, Toledo, and Knoxville but added direct service to Des Moines, Houston, Little Rock, San Diego, San Antonio, and Chicago. However, some observers believe that this type of route experimentation and readjustment may not signal a long-term trend. They expect that, as air traffic increases generally, the disadvantages of hub-and-spoke operation at the largest airports will outweigh the advantages, and some air carriers will divert their activity to medium hubs.

Air cargo carriers are also turning to hubbing. In 1972, Federal Express adopted the hub-and-spoke strategy for fast delivery of air cargo under 70 pounds. The site selected, Memphis, is centrally located with a modern airport that is relatively uncrowded and practically never shut down by weather. Between 11:00 p.m. and 4:00 a.m. each day, Federal Express flights converge on Memphis from all over the country, unloading as many as 80,000 packages, which are sorted and reloaded on flights to destination cities within a 4-hour period.

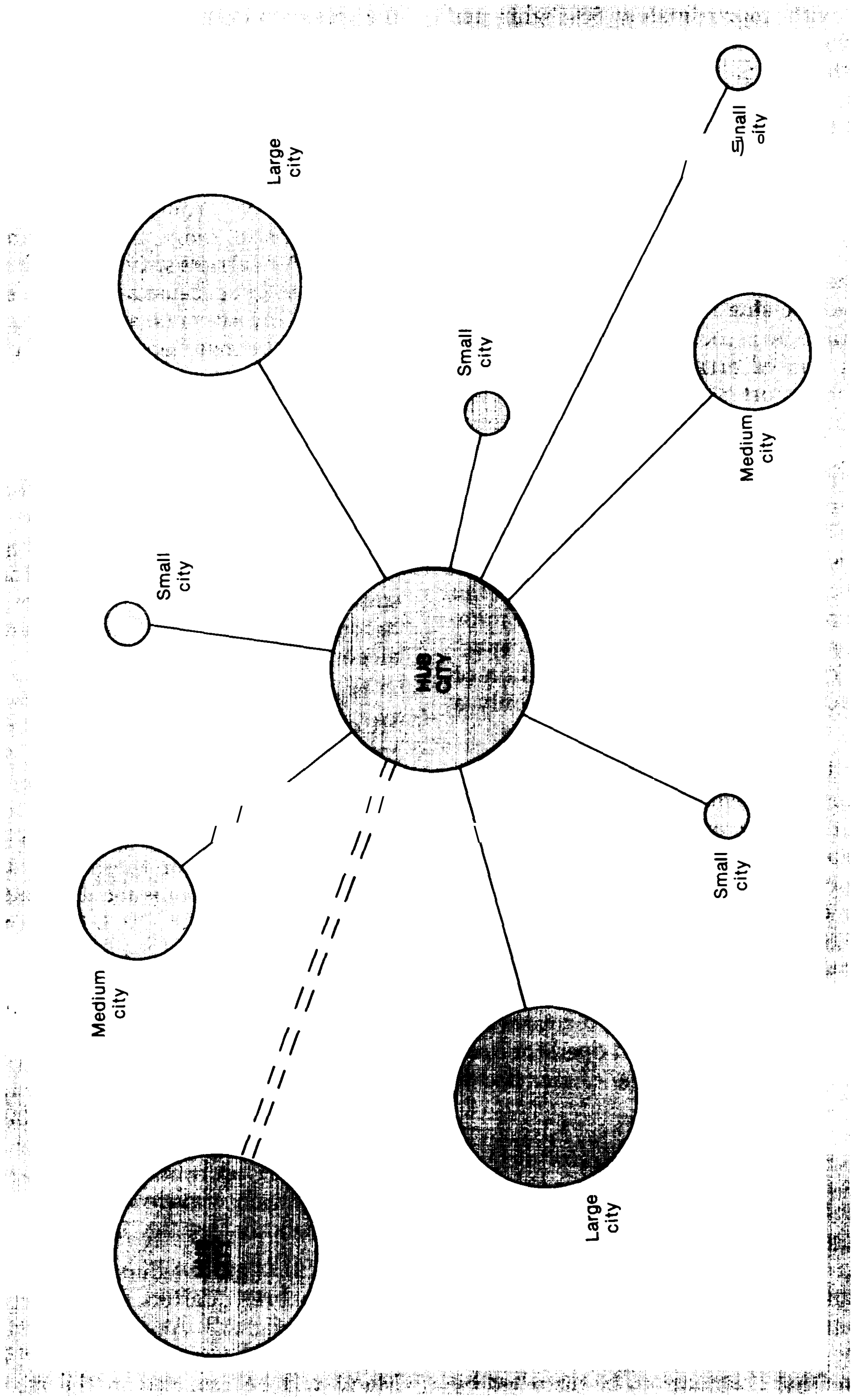
Other cargo carriers have likewise adopted the hubbing concept, especially for the overnight delivery and small package segments of their business. For example, Flying Tigers has converted its Chicago storage facility into an overnight sorting center. Emery Air Freight, a large freight forwarder that now operates an aircraft fleet, has built an overnight sorting center in Dayton.

Selection as the site of a new hub can be a boon to the local airport in terms of growth in traffic and revenue. For example, since Piedmont established a hub at Charlotte, the increased traffic volume has made it possible for the airport management to reduce landing fees for all airport users and still enjoy higher revenues. Other aspects of airport operation at Charlotte have benefited as well. Income from parking and concessions is now 20 percent ahead of forecasts, and the airport has recently built a new 10,000-ft runway and a $64 million terminal. Similarly, Piedmont's Midwestern hub in Dayton appears to be revitalizing an airport which had lost service after deregulation.

Western Airlines embarked on development of a major hub in Salt Lake City in direct competition with carriers serving regional and transcontinental markets through Denver and Dallas/Fort Worth. Western currently offers nonstop service

[10] A hub-and-spoke system offer benefits apart from the marketing advantages. Crew expenses, maintenance costs, and other costs of terminal operations can be significantly reduced, and labor stability can also be markedly improved by selection of an effective hub.

Figure 19.—Hub-and-Spoke Route System



SOURCE: Office of Technology Assessment.

to 33 cities, with approximately 86 flights per weekday. Largely as a result of Western's hubbing, traffic through Salt Lake City has increased dramatically. Domestic enplanements are up 13 percent from 1981, and departures have increased by 25 percent. Salt Lake City Airport has responded by raising $30 million in bonds to expand the terminal and to build Western a new eight-gate concourse.

On the other hand, becoming a new hub may prove a mixed blessing for an airport. The pattern of operations associated with hubbing—many closely spaced arrivals and departures—means that the airport is extremely busy for brief periods but practically idle the rest of the time. This peaking effect is illustrated in figure 20, which is a partial listing of Western Airlines' arrivals and departures at Salt Lake City. In fact, peaking is even more severe than the figure shows since there are other airlines that rely on connections with Western or that operate flights at the same time as one of Western's connecting banks. These extreme traffic surges strain airport capacity and may create the need for construction of additional facilities that are needed for only a small part of the day.

Where the hubbing carrier dominates airport use, the airport management may find itself at the mercy of that carrier's operating and expansion plans. For example, while Piedmont's establishment of a hub at Dayton has led to a doubling of air carrier operations there, it also made the airport management dependent on one carrier for half its revenues. Construction of new facilities, needed solely to accommodate the highly peaked pattern of service of a single carrier, increases that dependency and leaves the airport operator open to great financial risk should the carrier decide to move elsewhere.

Other adjustments may lie ahead for airports that serve as national or regional hubs. It is not yet known if there are minimum requirements for a hub to operate successfully or whether the operation of several hubs in the same region will lead to an oversupply of air services in certain markets. The pattern of hubbing will probably endure, but the fluidity of a deregulated market, especially one that continues to be distorted by the recession and the lingering effects of the air traffic controllers' strike, makes the future difficult to predict.

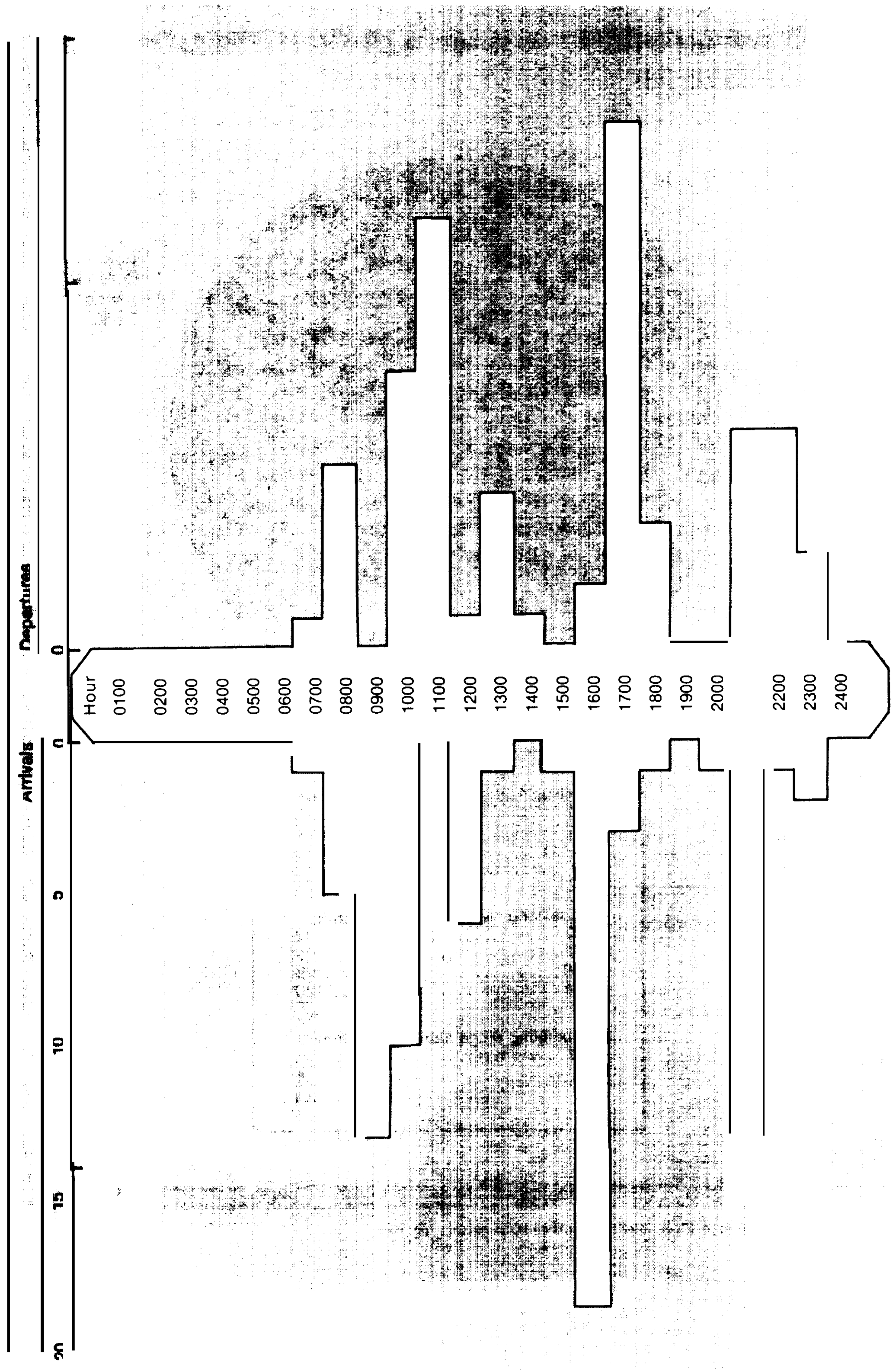
Aircraft Equipment

The key to economic efficiency for an aircraft is operation on a route to which it is well suited in terms of size, range, and performance characteristics. Air carriers strive to use their equipment in this way; but because aircraft are expensive and long-lived investments, available equipment cannot always be matched to routes and traffic volume as well as one would like. It is especially difficult now, when service patterns and markets are in flux. The efficiencies attainable through the use of larger aircraft may not be available if the economics of hub-and-spoke operation and increased competition among carriers argue for the use of smaller aircraft. As carriers begin to replace their present fleets with aircraft that are better suited to current market conditions, aircraft size becomes an important factor in assessing future airport capacity needs.

The aircraft that now make up the U.S. jet fleet are of three major types. Narrowbody short- and medium-range aircraft, like the DC-9, B-727, and B-737, constitute about 75 percent of the fleet. These aircraft, which seat 100 to 150 passengers, are used primarily for flights with stage lengths under 1,000 miles or those with several intermediate stops. Medium- and long-range widebody aircraft such as the DC-10, L-1011, or B-747 make up about 18 percent of the jet fleet. These aircraft, seating 250 to 400 passengers, are most efficiently operated on heavily traveled long routes of more than 1,500 miles, but they can be (and have been) used effectively on shorter routes of sufficiently high density. Long-range narrowbody aircraft like the DC-8 and B-707, with 140 to 180 seats, make up only about 7 percent of the fleet and are usually operated on routes over 1,500 miles which are not densely traveled enough to warrant use of a widebody (see fig. 21 and table 46).

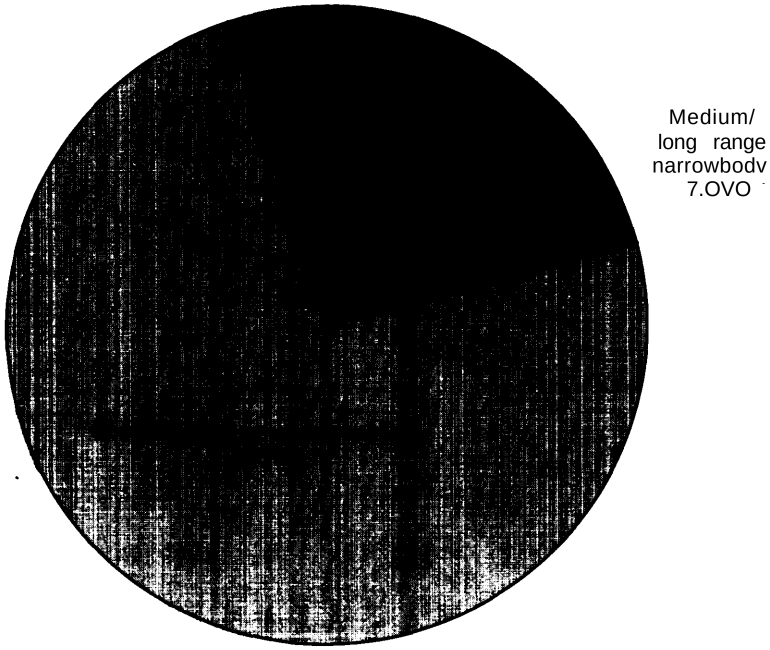
The short- and medium-range aircraft which make up three-quarters of the fleet vary widely in age (see fig. 22). About 60 percent are over 10 years old, and 40 percent are over 15 years old. Many will be replaced in the next few years,

Figure 20.—Western Airlines Activity at Salt Lake City



SOURCE: Western Airlines

Figure 21.–Composition of U.S. Commercial Jet Fleet, 1982



Short/medium range narrowbody aircraft:

B-727	1,012
B-737	238
BAC-111	26
DC-9	473
	1,749

Medium/long range widebody aircraft:

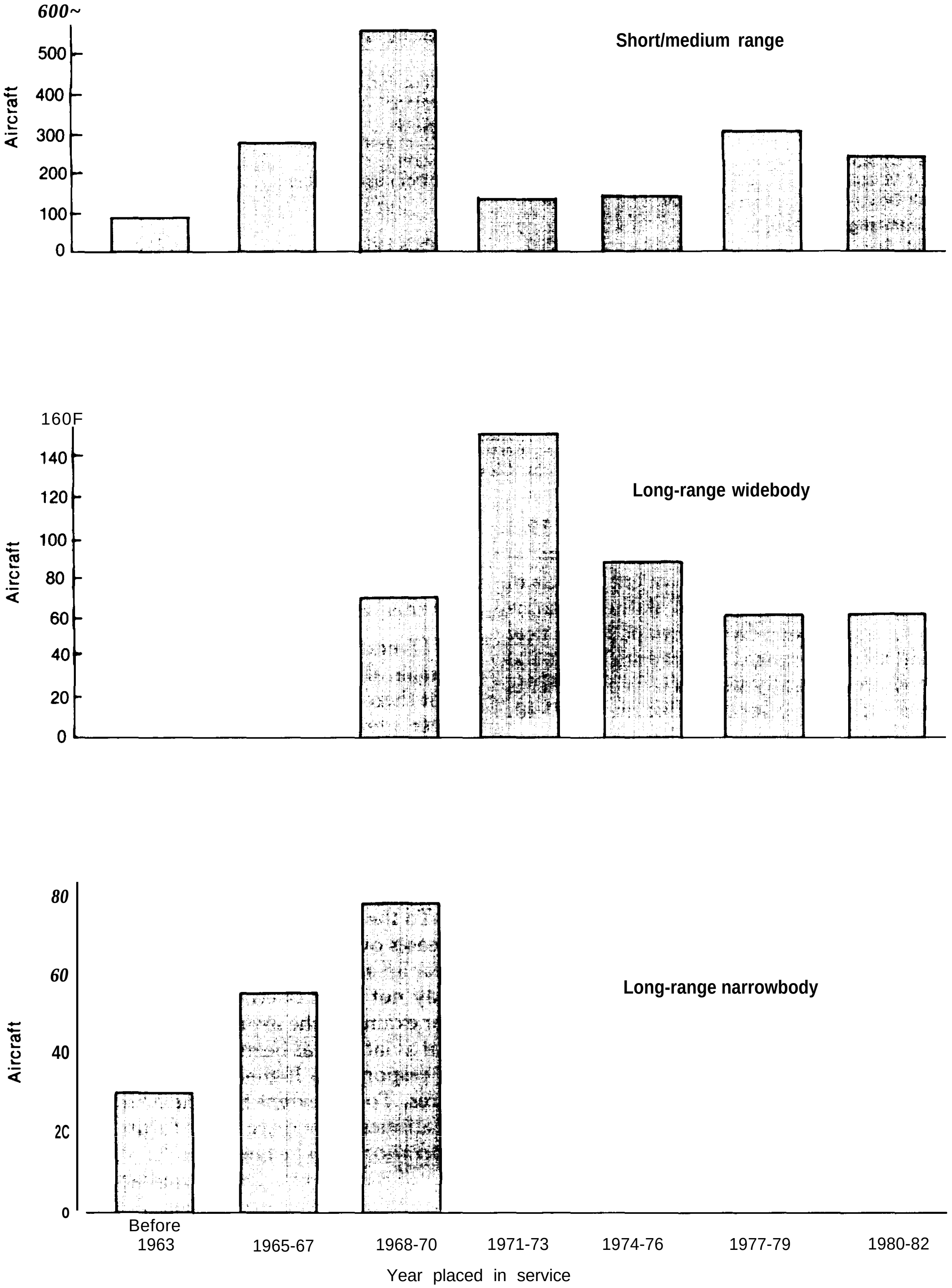
A-300	25
B-747	128
DC-10	159
L1011	~
	429

Medium/long range narrowbody aircraft:

6-707	71
DC-8	90
	161

SOURCE: Commercial Aircraft Fleet Databank, Lockheed-Georgia Co., July 1982.

Figure 22.—Age of Aircraft in Service in U.S. Commercial Jet Fleet (different scales)



SOURCE: Commercial Aircraft Fleet Databank, Lockheed-Georgia Co., July 1982.

Table 46.—Present and Future Commercial Jet Aircraft

Current generation			Next Generation		
Manufacturer	Designation	Seats[a]	Manufacturer	Designation	Seats[a]
Short/medium-range narrowbody					
Boeing	B-727-1OO	70-131	Airbus Industrie	A-320	150
Boeing	B-727-200	120-175	Boeing	B-737-300	132-148
Boeing	B-737-200	115-130	Boeing	B-757	186-220
Fokker	F-28	65-85	British Aerospace	BAE-146-200	82-109
McDonnell Douglas	DC-9-1O	90	Fokker	P-332	110
McDonnell Douglas	DC-9-30	115	McDonnell Douglas	MD-80	167
McDonnell Douglas	DC-9-50	139			
Medium/long-range widebody					
Aribus industrie	A-300	220-300	Airbus Industrie	A-31O	205-265
Boeing	B-747-1OO	374-452	Boeing	B-747-300	530
Boeing	B-747-200	374-500	Boeing	B-767-200	210-255
Lockheed	L-101 1	256-400	Boeing	B-767-300	270
McDonnell Douglas	DC-10-IO	250-380			
McDonnell Douglas	DC-10-4O	250-380			
Medium/longwange narrowbody					
Boeing	B-707-120	125			
Boeing	B-707-320	120-189			
McDonnell Doualas	DC-8-62	189			

[a]The number of seats on any given model of aircraft may vary according to cabin configuration, mix of first class and coach accommodations, and seat pitch.

SOURCE: Simat, Helliesen & Eichner, and *The Airline Handbook, 1983-1984* (Cranston, RI: Aerotravel Research, December 1983).

largely with aircraft like the B-757 (195 seats), DC-9-80 (155 seats), and the B-737-300 (140 seats)—all of which are bigger than equivalent models in common use today (see table 46). Although some manufacturers are considering production of new short- and medium-range aircraft with about 100 seats, they are generally viewed as replacements for aircraft of yet smaller size, like the DC-9-1O.

A somewhat opposite trend is expected in the long-haul segment of the fleet. The long-range narrowbody jets are 13 to 20 years old. They are technologically obsolete, fuel-inefficient, and noisy by present FAA standards. Most will be retired from service within the next 5 years, although it is possible that some could be refitted with new engines to extend their economic lifetime a bit longer. There is no new narrowbody aircraft in design or production which is an exact equivalent. Instead they will be replaced either with current generation widebodies or new models like the B-767 or the A-31O.

Most long-range widebody aircraft now in the fleet are expected to remain in service for several more years, but they too will eventually be replaced. Except for a stretched version of the B-747, which Boeing expects to produce for use on heavily traveled long-haul routes, most new widebodies for domestic use will be smaller than existing models. Aircraft such as the B-767 and A-310, which seat between 230 and 270, are typical of this new generation of long-range aircraft.

Overall, the average size of the jet fleet may remain about the same, or perhaps decrease slightly, but there will be a greater range of sizes. Today's fleet averages 150 seats within a range of 85 to 400; the future fleet might be as much as 10 percent smaller and made up mostly of aircraft in the 100- to 250-seat range, but with some much larger aircraft with 500 seats (or even 700 to 800 seats for a full upper deck 747) operating on dense routes.

To the extent that the demand for air travel increases over the coming years, airports will clearly bear an additional burden. However, this burden may not be as onerous as it would first appear. For example, the average load factor in commercial aviation has been rising over the past 5 years in response to higher operating cost and lower fares. To the extent that the average load factor continues to increase in the future, fewer aircraft operations will be needed to handle a given number of passengers. Or, viewed another way, the growth of aircraft operations will not be as rapid as the growth in passenger enplanements. If, however, the number of competitors increases in certain high-density markets, the average number of passengers attracted by each competitor will thereby be reduced. In this case, the total number of flight operations would be likely to increase as carriers favored smaller aircraft and placed emphasis on frequency of service and price competition.

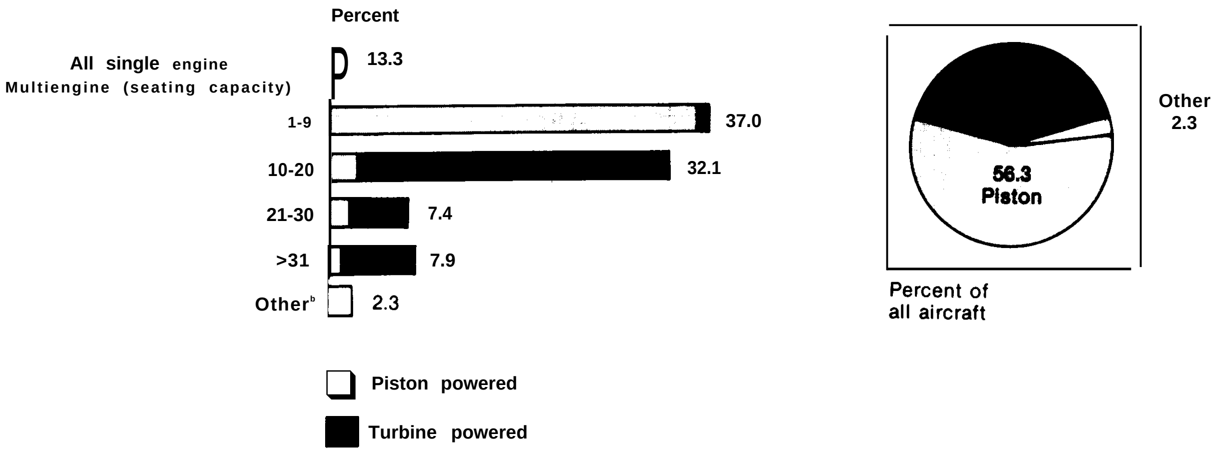
The next generation of short- and medium-range aircraft—workhorses of the current jet fleet—are likely to have an additional 20 to 30 seats per aircraft. This should translate into a reduction of 20 percent or so in the number of operations needed to carry a given volume of passengers. On the other hand, the average size of aircraft on long-haul routes will probably decrease over the next decade as more carriers compete for the market. While this might lead to an increase in the number of operations, there is reason to believe that reduction in aircraft size could also augur a change in the structure of airline networks.

The present generation of widebodies proved economical only in service between major hubs. Many passengers had to be routed through these hubs in order to take advantage of the attractive economics afforded by widebodies. Bringing these people into and out of large hubs often created additional and unnecessary aircraft operations that contributed to the delay and congestion at these airports. If airlines choose to utilize the new generation of smaller (but economical) long-range aircraft to provide direct service in lower volume markets or in connecting flights to smaller hubs, the burden of increased passenger enplanements will be shifted away from presently congested major hubs.

The aircraft used by commuter carriers are almost entirely propellor-driven, with either piston or turbine engines. Although they range in size from **6** to **60** seats, over 80 percent seat **19** or fewer passengers (fig. 23). Federal regulations—which limited the size of commuter aircraft to a maximum of **19** seats before 1972, 30 seats in 1972, and 60 seats since 1978—dampened the interest of U.S. manufacturers in building small transport aircraft.11 Consequently, few U.S. firms now pro-

[11] See *Impact of Advanced Air Transport Technology, Part III—Air Service to Small Communities* (Washington, DC: U.S. Congress, Office of Technology Assessment, OTA-T-120, February 1982).

Figure 23.—Composition of Commuter Aircraft Fleet, 1981[a]



[a]Passenger aircraft only
[b]Hellcopter and let.

SOURCE: Regional Airlines Association Annual Survey, 1981.

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duce small transport aircraft, most of which are imported from Canada, Brazil, and the Netherlands. With the progressive lifting of restrictions on the size of aircraft that commuters may operate, the average size of aircraft in the commuter fleet has increased from about 10 seats in 1970 to about 15 in 1980. This growth trend is likely to continue, and many of the new commuter aircraft entering the fleet over the next decade will be in the 30- to 60-seat range.

The growth of commuter airlines will have important implications for future airport needs. The commuter airline fleet tripled between **1970** and **1981,** with much of the growth occurring since deregulation (table 47). FAA forecasts that by 2000 the commuter fleet will triple again, reaching about 4,500 aircraft .12 While many of these will be used in air service to small communities, where major air carriers do not find it profitable to operate, a large number will also converge at hub airports to feed passengers to larger carriers. Many of these operations will be at busy airports where it will be hardest to accommodate them at gates and in terminal facilities. Further, the mixing of large jet and small propellor-driven aircraft in the same traffic stream will add a burden to air traffic control and could aggravate congestion and delay both in the airspace and on the airport surface. A partially offsetting factor is that the average size of commuter aircraft will probably increase. Thus, while commuter operations will grow, they will not be as great as they would be if aircraft size were still restricted by a regulatory ceiling of **19** or **30** seats.

Table 47.—Aircraft Operated by Commuter and Regional Airlines, 1970-81

Year[a]	Aircraft in service	Percent annual change
1970	687	
1971	782	14
1972	791	1
1973	885	12
1974	997	13
1975	1,073	8
1976	1,009	– 6
1977	1,119	11
1978	1,200	7
1979 (est)	1,350	12
1980[b]	1,606	19
1981[b]	1,743	8

SOURCES: [a]Civil Aeronautics Board, *Commuter Air Carriers Traffic Statistics*, fiscal years 1970-79.
[b]Regional Airlines Association, *Annual Survey of U.S. Commuter and Regional Airlines*.

12 National Airspace System Plan (Washington, DC: Federal Aviation Administration, April 1983, revised edition), p. II-2.

IMPLICATIONS FOR AIRPORT DEVELOPMENT

There is almost universal agreement that air traffic will continue to increase throughout the rest of this century and that some forms of growth could lead to serious congestion and delay in the national airport system. There is considerably less agreement about how much traffic will grow and how it will be distributed across airports and among sectors of civil aviation. Of the two questions, distribution is probably the more important, since it will determine which airports are affected and what measures can be taken to deal with the congestion and delay that could result. If, for example, traffic continues to concentrate at airports that are already severely congested or at those now approaching capacity limits, there is a legitimate fear that major hubs will be caught in a form of "gridlock" that will spread throughout the national airport system. On the other hand, if traffic patterns change and new growth occurs not at the airports now saturated but at other airports with adequate reserve capacity, the system can absorb a large amount of new traffic without an appreciable increase in local or general congestion and delay. Between these extremes are other possibilities, each with differing consequences for various types of airports and classes of airport users.

If aviation demand grows at the rate foreseen by FAA, delay will increase at high-density airports—perhaps intolerably—and could even spread to other airports that are now relatively free of congestion. Congestion would be especially severe if traffic were to concentrate at a few large hubs, so severe that air carriers would probably seek to avoid escalating delay costs by shifting their centers of operation to other airports. Some carriers might shift to other suitable large hubs, but more likely the move would be to medium airports with adequate facilities and ample surplus capacity—in effect breaking the pattern that now exists at airports such as Atlanta or Chicago and selecting a site where the rehubbing carrier would be the principal, if not the only, major airline at the site. The current trend toward hub-and-spoke route structure and the present inclination of airlines to purchase short- and medium-range narrowbody aircraft seem to indicate the likelihood of rehubbing. If so, the area of greatest interest over the next decade or so could be medium hubs, where the influx of traffic may necessitate rapid, but selective, expansion of airport facilities.

The prospect of extensive rehubbing at medium airports does not necessarily imply that these airports will face a capacity crisis like that of some major hubs today. If the medium airports that are to serve as new hubs are chosen wisely and if the practice does not lead to abuse,[13] they offer a large capacity reserve. The key is how the airlines respond in a deregulated environment where they may compete in a variety of ways, some of which might offer a short-term advantage but at the cost of an unbalanced use of the airport system as a whole. The full implications of rehubbing are by no means clear. On one hand, rehubbing seems to be an attractive way to absorb growth in demand and provide air transportation service while avoiding the delay costs of a large multi-airline hub. On the other hand, we have too little experience with the dynamics of an unregulated air travel market to know how many new, smaller, single-airline hubs are economically practical.

h this setting, the reliever concept is of great potential value. By shifting GA traffic away from centers of air carrier operation while still allowing GA adequate access to major metropolitan areas, relievers offer important advantages. There is the advantage of allowing each sector of civil aviation to grow without impediment to the other. This would not only reduce delay and its associated costs for all users of metropolitan airports, it would also have important collateral effects on airport efficiency (through segregation of dissimilar types of traffic) and on airport expansion costs. It may be less costly to upgrade one or two reliever airports to handle more traffic than to expand the major air carrier airport to absorb the same amount. If general aviation—especially business aviation—grows as much as FAA projects, it is clear that some way will have to be found to serve this segment of civil aviation.

For the reliever concept to work, however, it will not be sufficient simply to push GA traffic off to some other airport in the metropolitan area. For GA to accept this diversion and to embrace the reliever concept, the alternate airports must provide facilities and services appropriate to GA needs and of quality comparable to that of the major airport. This implies not only adequate runways, aprons, navigation aids, and ATC services, but also facilities for aircraft storage and maintenance and landside connections to activity centers in the metropolitan area. The reliever thus needs to be a mirror of the air carrier airport, not just another place to land.

Both these observations suggest the need to think of airports as a system, not as separate parts. The recently enacted Airport Improvement Program makes it clear that such a broad view is needed in order to determine how to make good use of the infrastructure already in place and how to fit new demand into an existing system that has large unused capacity overall, even though it is congested at a few points. This implies that a strategy of restructuring airport use through adjustment of operational patterns and judicious improvement of existing airports may be a less expensive and more manageable alternative than continuing to build new facilities in response to demand wherever and whenever it occurs.

[13]One form of abuse might be too heavy concentration of traffic at the new site by the rehubbing carrier. Another might be transfer of operations by other airlines to the same airport in an effort to compete for transfer passengers or to cash in on the traffic boom.

Chapter 9

AIRPORT SYSTEM PLANNING

Photo credit Dorn McGrath, Jr

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AIRPORT SYSTEM PLANNING

Given the high cost and long leadtime for building or improving airports, planning is key in determining what facilities will be needed and in creating programs for providing them in a timely manner, while making wise use of resources. Planning for airport development requires more than simply scheduling the capital improvements to be made. Airports are public entities, whose managers interact with many other public and private stakeholders. Airport development plans affect other aspects of community life—e.g., through the land dedicated to aviation use or the noise or automobile traffic that the airport generates. The need for aviation development must thus be weighed against other societal needs and plans. Further, planning cannot be done for one airport in isolation; each airport is part of a network which is itself part of the national transportation system. For these reasons, airport planning involves government at all levels, as well as other public and private organizations.

Determining need and programming development at individual airports has become formalized in a process called airport master planning. While master planning in the full sense is practiced primarily by large airports, even the smallest must make use of some elements of the process to prepare for future change. At a level above airport master planning is regional system planning, which is concerned with development of all airports in a metropolitan area. It often involves difficult political decisions on development priorities among competing airports. In some cases, this responsibility is assumed by a regional or metropolitan planning agency, but many State governments have also taken on the task of developing a coordinated system plan for airports serving not only major metropolitan regions but also outlying small communities and rural areas within the State. In some cases, State agencies prepare these plans themselves; in others, they provide technical assistance and review for local planning bodies. The role of the Federal Government in airport planning includes a broad range of activities. The most comprehensive activity is the National Airport System Plan of the Federal Aviation Administration (FAA), which summarizes the development needs of roughly 3,200 airports across the country. At the other extreme, FAA has responsibility to approve, on a project-by-project basis, specific development projects for which airport sponsors are seeking Federal funds.

This chapter describes airport planning at various levels, with emphasis on the planning process and the problems facing airport planners in general. The final part of the chapter looks more closely at airport system planning from a national perspective and addresses issues that FAA will need to consider in preparing a new comprehensive planning document—National Plan of Integrated Airport Systems—called for in the Airport and Airway Improvement Act of 1982.

THE PLANNING PROCESS

Airport Master Planning

At the local level, the centerpiece of airport planning is the master plan—a document that charts the proposed evolution of the airport to meet future needs. The magnitude and sophistication of the master planning effort depends on the size of the airport. At major airports, planning may be in the hands of a large department capable of producing its own forecasts and supporting technical studies. At such airports, master planning is a formal and complex process that has evolved to coordinate large construction projects (or perhaps several such projects simultaneously) that may be carried out over a period of 5 years or more. At smaller airports, master planning may be the responsibility of a few staff members with other responsibilities who depend on outside consultants for expertise and support. At very small airports, where capital improvements are minimal or are made infrequently, the master plan may be a very simple document, perhaps prepared locally but usually with the help of consultants.

While there is considerable variation in the content of the master plan and how it is used, its basic products are a description of the desired future configuration of the airport, a description of the steps needed to achieve it, and a financial plan to fund development. The master planning process consists of four basic phases: 1) airport requirements analysis, 2) site selection, 3) airport layout, and 4) financial planning.[1]

The first phase, requirements analysis, specifies new or expanded facilities that will be needed during the planning period. This involves cataloging existing facilities and forecasting future traffic demand. The planner compares the capacity of existing facilities with future demand, identifying where demand will exceed capacity and what new facilities will be necessary.

The process of relating future demand to existing facilities and estimating the nature and size of needed improvements is complex. It requires detailed forecasts, since sizing depends not only on the number of passengers and aircraft in future years but also on the type of the traffic. For example, traffic consisting mainly of transfer passengers imposes requirements that are different from those where the majority of traffic is origin and destination passengers. Sizing of facilities is also affected by the distribution of activities throughout the day and by the size and operating characteristics of aircraft serving the airport. This process is simplified by the use of standard relationships between general measures, such as annual enplanements, and specific measures, such as peak-hour passenger demand.

The second phase, site selection, is most important in the construction of a new airport. When considering the expansion of an existing airport, there is usually less choice about where to locate new facilities. Requirements for safety areas and clear zones around existing runways and taxiways, for example, mean that much apparently "vacant" land at airports cannot be used for other purposes. New facilities can be located only in places where they, and the traffic they generate, will not interfere with existing facilities. The site selection phase for a new airport requires an in-depth analysis of alternative sites, looking closely at such factors as physical characteristics of the site, the nature of surrounding development, land cost and availability, ground access, and the adequacy of surrounding airspace. The final choice of one site over others is often quite subjective. For example, there is probably no objective way to compare the disadvantages of increased noise in some part of the community with the advantages of improved air service for the metropolitan area as a whole. The "right" choice depends on how decisionmakers weigh various criteria, and it is often a political, rather than a technical, choice.

In the third phase, airport layout, the locations of planned new facilities are mapped on the airport site. In this phase, the planner also looks at how the airport will fit into the surrounding community. A land use plan is usually prepared at this point to show existing and proposed residential, business, and industrial development around the airport and expected levels of aircraft noise. It shows areas which must have protected airspace and those where building height limitations will have to be imposed. In addition, the effect of the airport on highway and public transportation systems transit is analyzed. This step is important not only for the safety and operational efficiency of the airport and its compatibility with the surrounding community, but for the effect on the level and structure of airport operating costs. Failure to recognize the relationships between airport configuration and ongoing costs can have lasting effects on the economy of the airport and its revenue-earning potential.

The fourth and final phase, financial planning, is an economic evaluation of the entire plan of development. It looks at the activity forecasts of the first phase from the point of view of revenues and expenditures, analyzing the airport's balance sheet over the planning period to ensure that the airport sponsor can afford to proceed. A corollary activity in this phase is preparation of a financial plan, which specifies the funding sources and

[1]This discussion draws heavily from ch. 4 of Norman Ashford and Paul H. Wright, *Airport Engineering* (New York: Wiley-Interscience Publications, John Wiley & Sons, 1979). This work, in turn, is but a slightly updated version of the classic text on airport planning and design, Robert Horonjeff, *Planning and Design of Airports*, 2d ed., McGraw-Hill Series in Transportation (New York: McGraw-Hill, 1975).

financing methods for the proposed development—the portions that will be funded through Federal grants-in-aid, the size and timing of bond issues, the revenue from concessionaire rents, parking fees, landing fees, and so on.

The steps outlined above often require several years to complete, and at most airports, master planning is an ongoing and continuous process. By the time the master plan has been drawn up, much of the information may be outdated, and compilation must begin again. Thus, it is common for master plans to be wholly or partly updated on a cycle of 3 to 5 years.

The master plan is most applicable to a rather narrow planning problem, the development of a single airport. Planning of a regional airport system, which addresses problems of a broader scope, contains many elements in common with the master planning process. However, regional planning is usually less concerned with the details of siting facilities at a particular airport than with the adequacy of service in a given geographic area and the roles of different airports in meeting future needs. While the master planning process is fairly standardized, at least at larger airports, regional planning procedures vary widely among local, regional, State, and Federal agencies.

Regional Airport Planning

Regional airport planning takes as its basic unit of analysis the airport hub, roughly coincident with the boundaries of a metropolitan area. The planner is concerned with *air* transportation for the region as a whole and must consider traffic at all the airports in the region, both large and small. The practice of regional planning is relatively new and has been instituted to deal with questions of resource allocation and use which often arise when the airports in a region have been planned and developed individually and without coordination among affected jurisdictions. Regional planning seeks to overcome the rivalries and the jurisdictional overlaps of the various local agencies involved in airport development and operation. The goal is to produce an airport system that is optimum with respect to regionwide benefits and costs.

Thus, regional airport planning addresses one critical issue usually not dealt with in an airport master plan: the allocation of traffic among the airports in a region. This can be a sensitive subject. Questions of traffic distribution involve political as well as technical and economic issues, and they can greatly affect the future growth of the airports involved. One airport may be quite busy while another is underutilized. If traffic were to continue growing at the busy airport, new facilities would have to be constructed to accommodate that growth. On the other hand, if some of the new traffic were diverted to an underutilized airport, the need for new construction might be reduced and service to the region as a whole might be improved.

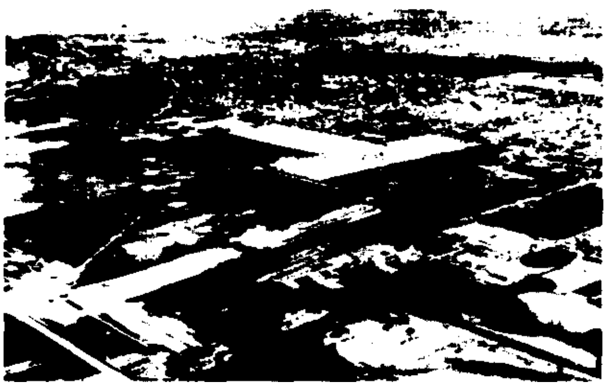
Although *a* planning agency may decide that such a diversion is in the interest of a metropolitan region and might prepare forecasts and plans showing how it could be accomplished, it may not necessarily have power to implement these plans. Where airports are competitors, it is probably not reasonable to expect that the stronger will voluntarily divert traffic and revenues to the other. The planning agency would likely have to influence the planning and development process at individual airports so that they will make decisions reflecting the regional agency's assessment of regional needs.

One way to influence planning decisions is through control over distribution of Federal and State development grants. Before 1982, regional agencies served as clearing houses for Federal funds under the review process required by Office of Management and Budget Circular A-95. While the award of Federal airport development funds depended mainly on FAA approval of the airport sponsor's application, the A-95 process required that designated regional agencies review projects before the grants were awarded. In particular, the regional agencies were required to certify that the planned improvement was consistent with Federal regulations-for example, environmental regulations.

In July 1982, the President issued Executive Order 12372, outlining a new policy for intergovernmental review of direct Federal grant programs. The purpose of the new policy is to "strengthen

1929

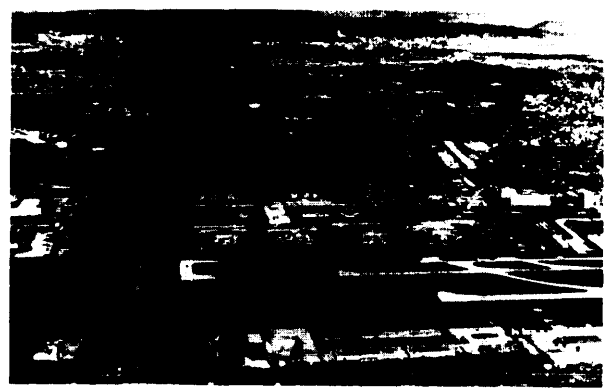
1939



1949

1959

1969



1979

Photo credit: Dorn McGrath, Jr.

50 **years** of **development at Los Angeles International** Airport federalism by relying on State and local processes for the State and local government coordination and review of proposed financial assistance and direct Federal development. . . .“ The intent is to give additional weight to the concerns of State and local officials with respect to federally funded development. State and local governments are encouraged to develop their own procedures (or refine existing procedures) for reviewing development plans and grant applications. Under the new policy, agencies are to certify that Federal spending is consistent with State and local objectives and priorities, instead of certifying that State and local projects comply with Federal guidelines, as they did formerly. Federal agencies, such as FAA, are expected to accommodate recommendations communicated through the State review process or to justify refusal to do so.

Some States may choose to continue using the same regional planning organizations as review agencies, while others may create new procedures and new agencies. The Executive order discourages “the reauthorization of any planning organization which is federally funded, which has a federally prescribed membership, which is established for a limited purpose, and which is not adequately representative of, or accountable to, State or local elected officials. ” However, States may choose to retain the same regional agencies-they were established under State law in the first place —but to change their function to reflect accountability to State and local rather than Federal officials. It is still too early to tell how these changes in the review procedure will affect the ability of regional agencies to influence airport planning decisions.

Much of the regional agency’s success may depend as much on negotiation and persuasion as on legal or budgetary authority. Often compromises can be reached on a voluntary basis. For example, the Regional Airport Planning Commission has been working with the three San Francisco area airports to help each develop a “noise budget” to comply with California’s strict environmental laws. Because noise is directly related to the level of aviation activity, the noise budget plan, when completed, will affect future traffic allocation among the airports. Its implementation will most likely require some diversion of new traffic growth from busy San Francisco International to the other bay area airports.

Even where airports in a region are operated by the same authority, allocation of traffic between airports may still be difficult. For example, the Port Authority of New York and New Jersey can implement its planning decision to increase activity at Newark by instituting differential pricing, improved ground access, or other measures to increase use of that airport. Implementation of the policy, however, depends not just on control of airport development expenditures but also on the ability to influence the activities of private parties—the air carriers and passengers.

Regional airport planning authorities may also, if they have planning responsibility for other transportation modes, plan for the airport as part of the regional transportation system. When multimodal planning responsibility resides in one organization, there is greater likelihood that the planning agency will consider airport needs in relation to other forms of transportation in the region. Also, the regional agency may undertake to improve coordination between the various modes, so that, for example, airport developments do not impose an undue burden on surrounding highway facilities or so that advantage can be taken of opportunities for mass transit. For this to happen, however, two conditions are necessary: regionwide authority and multimodal jurisdiction.

State Airport Planning

According to the National Association of State Aviation Officials (NASAO), there are 47 State aviation agencies that carry out some form of airport planning. In 39 States, these agencies are subdivisions of the State Department of Transportation (DOT); in the others, they are independent agencies. Several States have an aviation commission in addition to an aviation agency. The commissions are usually appointed by the Governor and serve as policymaking bodies. State involvement in airport planning and development takes several forms: preparation of State airport system plans, funding of local master planning, and technical assistance for local planning. Table **48**

Table 48.—State Funding of Airport Planning

State	Fiscal year	Amount
Arizona	1983	$ 60,000
Arkansas	1982	1,255,200
Connecticut	1982	100,00
Florida	1982	250,000
Georgia	1982	20,000
Hawaii	1982	160,290
Illinois	1983	31,000
Kansas	1982	9,445
Louisiana	1982	180,000
Maine	1982-83[a]	18,240
Maryland	1982	102,875
Massachusetts	1982	18,525
Michigan	1982	145,000
Mississippi	1983	10,000
Montana	1982	26,000
Nebraska	1982	7,750
New Hampshire	1982-83[a]	30,000
New York	1983	33,000
North Dakota	1982~	25,000
Pennsylvania	1982	68,340
Rhode Island	1981-82[b]	225,000
South Carolina	1982	124,000
Tennessee	1982	13,000
Utah	1982	45,000
Vermont	1982	15,500
Virginia	1982	51,700
Total[c]		$3,024,865

[a]Biennial appropriation.
[b]Calendar year.
[c]In addition to the States listed, North Carolina appropriated $191,000 (biennial, 1982-83) and Wisconsin $64,200 (1982) for planning purposes as part of grants for specific airport improvement projects.

SOURCE: National Association of State Aviation Officials.

shows the level of State funding of local planning efforts in 1982-83 as reported by NASAO.

Airport planning at the State level involves issues that are somewhat different from those of local or regional agencies. State governments are typically concerned with developing an airport system that will provide adequate service to all parts of the State, both rural and metropolitan. Development of airports is often seen as an essential tool for economic development or overcoming isolation of rural areas. Some State aviation agencies, in Ohio and Wisconsin for example, have set a goal to develop at least one well-equipped airport in each county. Usually the allocation of traffic between airports serving the same community is not at issue. Rather, the issue is deciding how to allocate airport development funds among candidate communities and to maintain a balance between various parts of the State.

To understand the main features of State airport plans, OTA reviewed a sample of 16 State airport plans and conducted telephone interviews with 30 State agencies. The review focused on three areas: the circumstances of preparation, major elements of content, and the planning process. A summary of the 16 plans reviewed by OTA is shown in table 49.

Before 1970, very few States conducted extensive or systematic airport planning. An important stimulus to State agencies to initiate comprehensive planning efforts was provided by the Airport and Airway Development Act of 1970, which set aside 1 percent of airport aid moneys from the Trust Fund for this purpose each year. Most States applied for these funds promptly and typically spent from 1 to 4 years in developing State Aviation System Plans (SASP) under guidelines issued by FAA, although a few took considerably longer. Most of the States sought assistance from outside consultants in some phase of the planning activity. Among the States surveyed by telephone, approximately one-third have kept their plans up to date with additional Federal grants or State funding.

State plans typically encompass a planning period of 20 to 30 years; the year 2000 is a common planning horizon. Planning periods are normally divided into short-, medium-, and long-term segments (usually 5, 10, and 20 years, respectively). In each case, estimates of future needs have been developed by comparing existing facilities with projections of future traffic.

The major feature of the plans, and by far the bulk of each document, is a detailed listing of the actions planned by class of airport and type of improvement. The types of improvements most commonly cited are land acquisition (new sites or expansion of existing airports); pavement repair or improvement (runways, taxiways, aprons, roads, parking); installation of lighting and landing or navigation aids; and building construction (terminals, hangars, administrative facilities).

Of the 16 plans reviewed, 14 include a statement of priorities for investment based on the relative value of projects in meeting objectives of the system plan. The three dominant criteria identified by most of the States were: 1) correcting a condition related to operational safety, 2) preventing deterioration of existing facilities, and 3) ad-

Table 49.—Review of State Aviation Plans

		Preparation						Elements of plan				Coordination, review, and implementation			
[redacted]		When	How long	Latest	How planning	Contractor	Planning		Estimated costs[a]	Funding sources	Financing	Priorities & schedule	Integration with other plans[b]	External review[c]	Implementing parties identified
Arizona	State DOT	1978	d	1983	ADAP[e]	d	1979-2000	Funding	351	Yes	Yes	Yes	Yes	Yes	Yes
Indiana	State DOT, Division of Aeronautics	1971	3 years	1981	1971-HUD funds; 1981-ADAP	Yes	1981-2000	No State funding	600	Yes	Yes	Yes	Yes	None indicated	Yes
Maryland	State DOT, State Aviation Administration	1975	2 years		ADAP and State funds	Yes	1975-2000	Funding	144	Yes	Yes	Yes	Yes	None indicated	Yes
Massachusetts	Department of Public Works, Aeronautics Commission	1973	4 years	1983	ADAP	Yes	1983-2000	None	83	Yes	Yes	d	Yes	None indicated	No
Michigan	State DOT, Aeronautics Commisson	1974	2 years	None	ADAP	Yes	1975-95	None	685	Yes	Yes	d	Yes	Yes	Yes
Minnesota	Department of Aeronautics	1974	1 year	1982	ADAP	1974-yes 1982-no	1982-2000	None	365	Yes	Yes	d	d	yes	Yes
Missouri	State DOT	1978	2 years	None (forecasts revised m 1981)	ADAP	Yes	1978-2000	No State funding	40	Yes	Yes	Yes	Yes	Yes	No
Nevada	Public Service Commission	1975	d	d	ADAP	d	1975-95	None	344	Yes	Yes	Yes	Yes	Yes	Yes
North Carolina	State DOT	1979	6 years	None	ADAP	Yes	1979-2000	None	420	Yes	Yes	Yes	Yes	Yes	No
Oklahoma	Aeronautics Commission	1979 (based on 1975 data)	2 years	None	ADAP and Ozarks Commission	Yes	1979-2000	None	163	Yes	Yes	Yes	Yes	Yes	Yes
Oregon	State DOT, Aeronautics Commission	1974	d	d	ADAP	d	1975-90	None	73	Yes	Yes	Yes	Yes	Yes	Yes
Pennsylvania	State DOT	1980	3 years	None	ADAP	Yes	1980-2000	None	259	Yes	Yes	Yes	Yes	Yes	No
South Dakota	State DOT, Division of Aeronautics	1979	4 years	None	ADAP	Yes	1977-97	None	80	Yes	Yes	Yes	Yes	Yes	Yes
Virginia	State Corporation Commission, Division of Aeronautics	1975	d	None	ADAP	Yes	1975-1995	None	251	Yes	Yes	Yes	Yes	Yes	Yes
Washington	Aeronautics Commission	1977	3 years	1981	ADAP	Yes	1981-2000	None	430	Yes	Yes	Yes	Yes	Yes	Yes
Wisconsin	State DOT	1976	d	Update now m progress	ADAP	Yes	1975-95	None	333	Yes	Yes	Yes	Yes	Yes	No

[a]For latest update, in dollars of that year.
[b]Including State or regional transportation or economic plans.
[c]By State or regional agencies or local authorities.
[d]Not determined.
[e]Program Planning Grant under the Airport Development Aid Program (Public Law 91-258)

SOURCE: *Office of Technology Assessment.*

dition of airfield capacity to accommodate growth in demand.

While there are surface similarities, SASPs vary greatly in scope, detail, expertise, and planning philosophy. One State agency director freely admitted that the State system plan was basically a wish list, prepared primarily because planning funds were available and the State DOT required it. He indicated that the plan was out of date and would not be updated in the foreseeable future because it has little relevance to the agency's actual activities. On the other hand, several State agencies regard the SASP as a valuable working document that is kept current and serves as a guide in programming and distribution of State funds.

In many States, programming of funds is somewhat separate from the system planning process. While the SASP may have a long planning horizon of 20 years or more, the actual award of grants to complete particular projects is on a much shorter time scale. Some State agencies have developed methods for keeping current files on local airport projects planned for the near term (say 3 years). When airports apply for State aid (or request State assistance in applying for Federal aid) the SASP is used to assign priority for grant award as funds become available. As a rule, only a fraction of the projects outlined in the SASP are undertaken.

Each State plan reviewed by OTA tabulated estimated costs of recommended improvements and identified funding sources. Funding is almost universally identified as the primary constraint on implementation of the SASP, and nearly all contain a caveat about the availability of funds. While other factors (e.g., noise or availability of land) may have been considered in the planning process, they are seldom cited in the documents themselves.

In all States, some sort of consultation, coordination, or review by persons outside the State aviation agency, is part of the planning process. Often these are regional economic development or planning agencies created by State government. In many cases, airport planning is part of a general transportation planning process, but methods of interaction and feedback among the modal agencies and between the State and regional agencies are described only vaguely.

Some State agencies are involved in master planning activities for local airports, especially rural or small community airports that do not have the staff to carry out master planning on their own. State agencies may provide technical assistance or actually develop local master plans. Some States also participate in airport planning for major metropolitan areas, although most leave this responsibility with the local airport authority or a regional body. In recent years, State participation in planning at the larger airports has shown some increase, a trend that may be bolstered by current Federal policy that earmarks a share of annual Trust Fund outlays for State aviation planning.

National Airport Planning

Airport planning at the national level is the responsibility of FAA, whose interests are to provide guidance for development of the vast network of publicly owned airports and to establish a frame of reference for investment of Federal funds. These interests are set forth in the National Airspace System Plan (NASP), a document required under the Airport and Airway Development Act of 1970. The NASP is a lo-year plan that is periodically updated by FAA, most recently in 1980.

The NASP is not a plan in the fullest sense. It does not establish priorities, lay out a timetable, propose a level of funding, or commit the Federal Government to a specific course of action. Instead, it is merely an inventory of the type and cost of airport developments which might take place during the planning period at airports eligible for Federal assistance. It is a tabular, State-by-State presentation of data for individual airports, listed in a common format, indicating location, role, type of service, and level of activity (enplanements and operations) currently and for 5 and 10 years in the future. Projected costs of airport needs in five categories-land, paving-lighting, approach aids, terminal, and other—are shown, also at intervals of 5 and 10 years.

Estimates of need contained in the NASP are developed by comparing FAA national and terminal area forecasts to the present capacity of each airport. Much of the initial determination of need and the regular updating is performed by FAA regional offices, which monitor changes and developments being carried out at the airports. The NASP is not a simple compilation of local master plans or State Airport System Plans, although FAA does draw on these documents as sources in forming judgments about future needs and prospective airport improvements.

The NASP is not a complete inventory of airport needs. The plan contains only "airport development in which there is a ***potential*** Federal interest and on which Federal funds may be spent under the Airport Development Aid Program (ADAP) and the Planning Grant Program.'" There are two necessary conditions in the test of potential Federal interest. First, the airport must meet certain minimum criteria as an eligible recipient for Federal aid, and second, the planned improvement at that airport must be of a type that is eligible for Federal aid. Eligible projects include such projects as land acquisition for expansion of an airfield, paving for runways and taxiways, installation of lighting or approach aids, and expansion of public terminal areas. Improvements ineligible for Federal aid are not included in the NASP—e.g., construction of hangars, parking areas, and revenue-producing terminal areas that airports are expected to build with private, local, or State funds. Thus, the total of $12.67 billion in estimated airport needs listed in the NASP for the 1980-89 period may somewhat underestimate total airport need. The estimated cost of improvements by general categories of eligible project is shown in table 50.

On the other hand, the NASP probably overstates the amount that will actually be spent on airport improvements over the 10-year period. Many of the projects whose costs are included in the NASP will not receive Federal funds and many will not be undertaken at all. Inclusion in the NASP does not necessarily represent Federal agreement to fund a project or local commitment to carry it out. It is merely FAA's best estimate of likely future need. The goal of the NASP is to set forth ". . . the type and estimated cost of airport development considered by the Secretary to be necessary to provide a system of public air-

'*National* Airport System *Plan, Revised Statistics,* 1980-1989 (Washington, DC: Federal Aviation Administration, n.d.), p. iii.

Table 50.—Estimated Cost of Improvements by General Categories

Service level	Land	Paving lighting	Approach aids	Terminal	Other	Total cost[a]
0 to 5-year period (millions of dollars):						
Air carrier	$1,144	$2,322	$ 93	$888	$ 768	$5,216
Large hubs	(573)	(903)	(14)	(453)	(454)	(2,397)
Medium hubs	(220)	(460)	(7)	(222)	(94)	(1,003)
Small hubs	(188)	(362)	(20)	(130)	(68)	(768)
Nonhubs	(163)	(597)	(52)	(83)	(153)	(1,048)
Commuter service	90	208	11	0	33	343
Reliever	349	297	29	0	61	736
General aviation	809	1,293	102	0	237	2,441
Total[a]	$2,393	$4,120	$235	$888	$1,100	$8,736
Percent of total	27%	47%	3%	10%	13%	100%
6- to 10-year period (millions of dollars):						
Air carrier	$423	$1,572	$39	$538	$200	$2,772
Large hubs	(71)	(715)	(8)	(294)	(116)	(1,204)
Medium hubs	(297)	(218)	(5)	(109)	(32)	(662)
Small hubs	(35)	(294)	(8)	(69)	(25)	(431)
Nonhubs	(20)	(344)	(18)	(66)	(27)	(475)
Commuter service	9	91	7	0	13	120
Reliever	71	157	12	0	18	257
General aviation	59	615	43	0	64	781
Total[a]	$561	$2,434	$102	$538	$295	$3,931
Percent of total	14%	62%	3%	14%	7%	100%

[a]Figures may not add due to rounding.

SOURCE: Federal Aviation Administration, National Airport System Plan, 1980 revision.

ports adequate to ***anticipate and meet*** the needs of civil aeronautics . . .“ If and when local sponsors are ready to undertake projects, they must apply for Federal funds.

The 1980 NASP relates airport system improvements to three levels of need: Level I—maintain the airport system in its current condition, Level II—bring the system up to current design standards, and Level III—expand the system.[3] In 1980, the estimated cost of completing the NASP was $12.67 billion between 1980 and 1989. Of this amount 16 percent was for maintaining the system, 18 percent for bringing the system up to standards, and 66 percent for expanding the system. The distribution of the projected needs for different classes of airports is shown in table 51.

The classification by three levels of need is a refinement added to the latest version of the NASP. It moves in the direction of assigning priorities to different types of projects instead of the earlier practice of presenting needs as a single sum. FW selected this presentation because previous lump sum projections “often did not lend themselves well for use in establishing the funding levels of programs intended to implement their broad findings.” The three-level system was developed as a guide to Congress, illustrating how “alternative levels of funding . . . can be based on relating NASP development needs to three levels of program objectives.”4

The classification system is somewhat misleading because it is not as hierarchical as it might appear, and the placement of a type of improvement at a particular program level does not necessarily reflect the priority that will be given a given project. High-priority projects—i.e., those which FAA and a local sponsor agree must be carried out as soon as possible—may not necessarily correspond with “Level I“ needs in the NASP. An expansion project (Level III) at an extremely congested and important airport might be more urgent than bringing a little-used airport up to standards (Level II). Thus, if available funds were limited to 34 percent of total need (the amount needed to cover Levels I and II) it would not be possible, nor would FAA intend, to carry out only Level I and II projects and leave a vital Level III project unfunded. In any given year, the actual grants awarded are used for some projects in each program level.

[3] Maintaining the system includes such projects as repaving airfields and replacing lighting systems; bringing the system up to standards involves such projects as installing new light systems and widening runways; expanding the system includes construction of new airports or lengthening runways to accommodate larger aircraft.

[4] *National Air-port System Plan, Revised Statistics, 1980-1989,* op. cit., p. 6.

Table 51.—National Airport System Plan: System Needs by Program Objectives, 1980=89 (total costs In 1978=79 billions of dollars)

	Level 1: Maintain existing system	Level 11: Bring airports up to standards	Level Ill: Expand system	Total
Air carrier	$1.28	$1,21	$5.50	$7.99
Commuter service	0.11	0.11	0.24	0.46
Reliever	0.13	0,25	0.62	1.00
General aviation	0.52	0.75	1.95	3.22
Total	**$2.04**	**$2.32**	**$ 8.31**	**$12.67**
Percent	**16%**	**18%**	**66%**	**100%**
Level I	**$2.04**			
Level II (includes Level I)		**$4.36**		
Level III (Includes Level I and II)			**$12.67**	

Level I. Sixteen percent ($2.04 billion) of total development is related to maintaining the condition of the system; i.e., implementing special programs involving safety and security in which the FAA has special responsibilities and assuring the physical integrity of existing airports by reconstructing and rehabilitating pavements and lighting systems.

Level II. Bringing existing airports up to current design standards comprises 18 percent ($2.32 billion) of NASP costs and includes projects such as paving, extending, widening, strengthening, and lighting existing runways; providing taxiways and clear zones when they are absent; and other work related to the present use of the airport.

Level III. Expanding the airport system includes development to accommodate the increased volume of passengers and aircraft projected for the decade, upgrading airports to accommodate larger aircraft and longer nonstop flights, and constructing new airports. Development oriented toward expanding the system comprises 66 percent ($8.31 billion) of total 10-year needs.

SOURCE: Federal Aviation Administration, National Airport System Plan, 1980 revision.

The NASP has been criticized for drawing the Federal interest too broadly and for being more of a "wish list" than a planning document. Critics have claimed that it is merely a compilation of improvements desired by local and State authorities and that it does not represent a careful assessment of airport development projects that truly serve national airport needs as distinct from those that are primarily local or regional in character. It is true that the plan includes many very small airports of questionable importance to the national system of air transportation. The criteria for inclusion in the NASP are minimally restrictive. The principal ones are: 1) that the airport has (or is forecast to have within 5 years) at least 10 based aircraft (or engines), 2) that it be at least a 3&minute drive from the nearest existing or proposed airport currently in the NASP, and 3) that there is an eligible sponsor willing to undertake ownership and development of the airport. Clearly there are many airports that meet these minimum criteria. As of the beginning of 1984, there were 3,203 airports qualifying for inclusion in the NASP—roughly a minimum of one airport per county.

Paradoxically, the NASP has also been criticized for just the opposite reason: it is too exclusive, in that it reflects only FAA's interpretation of national importance and not those of State or regional planning agencies. There are about 1,000 airports, not listed in the NASP, that are integral parts of State and regional development plans; and their exclusion means that sponsors or State planning agencies cannot expect Federal aid for developing these facilities. Table 52 shows a comparison of the airports included in NASP and in State system plans. Only in three cases (Florida, Iowa, and New York) does the NASP include more airports than the State plan.

GENERAL PROBLEMS IN AIRPORT SYSTEM PLANNING

Airport planning, as practiced today, is a formalized discipline that combines forecasting, engineering, and economics. Because it is performed largely by government agencies, it is also a political process, where value judgments and institutional relationships play as much a part as technical expertise. On the whole, airport planners have been reasonably successful in anticipating future needs and in devising effective solutions. Still, mistakes have been made—sometimes because of poor judgment or lack of foresight and sometimes because of certain characteristics of the planning process itself. In effect, the process and the methods employed predispose planners toward solutions that may be "correct" for a single airport but perhaps not for the community, region, or airport system as a whole. As a result, airport plans may take on a rigidity that is inappropriate in light of changing conditions or a narrowness of focus that does not make best use of resources.

Demand as an Independent Variable

A major problem in the planning process at all levels is the tendency to treat demand as an independent factor. Planners forecast future demand and then use those forecasts to justify the need for facilities, to frame their design, and to ascertain whether there will be sufficient revenue to pay for them.

Basic economics indicates that supply and demand exist in an equilibrium relationship that is mediated by price. When prices fall, demand increases; when prices rise, demand falls. The system is in equilibrium when price reaches a level where supply exactly equals demand. This basic relationship holds for airport supply (capacity) and demand, as in other market situations. Price in this case includes not only monetary transactions but also the speed and convenience of air transportation and the cost of delay. The planning process, however, does not typically approach airport needs from a market perspective.

The predisposition to treat demand as an independent variable in the planning process is illustrated by FAA's guidelines to airport planners on how to make forecasts in support of master plans (written in 1971 but still current). After attributing the then current "airport crisis" to low forecasts in the past, the guidelines instruct plan-

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Table 52.-Comparison of National and State Airport System Plans, 1982

State	Total airports	Airports in SASP[b]		Airports in NASP	
		Number	Percent	Number	Percent
Alabama[a]	193	84	44	72	37
Alaska[a]	689	c	—	275	40
Arizona	224	94	42	56	25
Arkansas[a]	105	86	82	66	63
California[a]	297	297	100	220	74
Colorado	312	83	27	56	18
Connecticut[a]	28	26	93	16	57
Delaware	37	4	11	4	11
Florida[a]	514	105	20	126	25
Georgia[a]	125	136d	109	111	89
Hawaii	51	17	33	16	31
Idaho		160	82	38	19
Illinois[a]	&	113	13	94	
Indiana	365	92	25	82	; ;
Iowa	355	80	23		26
Kansas	376	111	30	: ;	24
Kentucky[a]	115	73	63	54	47
Louisiana	292	95	33	60	21
Maine	160	47	29	34	21
Maryland	49	39	60	31	63
Massachusetts[a]	216	36	17	32	15
Michigan[a]	291	166	64	104	36
Minnesota[a]	597	141	24	83	14
Mississippi[a]	166	78	47	75	45
Missouri[a]	393	131	33	100	25
Montana		119	63	72	38
Nebraska[a]	; $	121	37	76	23
Nevada	128	46	36	27	21
New Hampshire[a]	52	12	23	12	23
New Jersey	271	67		40	
New Mexico	156	60	: :	44	; :
New York	486	81	17	91	19
North Carolina[a]	286	112	39	78	27
North Dakota[a]	555	85	15	50	9
Ohio	674	126	19	105	
Oklahoma	292	174	60	104	:
Oregon[a]	410	89	22	62	15
Pennsylvania[a]	161	195d	121	91	
Rhode Island	20	6	30	6	X
South Carolina[a]	82	65	79	53	65
South Dakota	162	84	52	55	
Tennessee	82	g l d	111	78	z
Texas[a]	500	292	58	226	45
Utah	89	51	57	39	44
Vermont	63	23	37	13	21
Virginia[a]	205	77	38		
Washington[a]	322	191	59	:	: ;
West Virginia	90	c	—	30	33
Wisconsin[a]	421	111	26	84	20
Wyoming	105	42	40	29	28
Totals	13,136	4,634	35	3.599	27

[a]State counts used.
[b]SASP = State Airport System Plan; NASP = National Airport System Plan.
[c]No State plan.
[d]Includes planned new airports.

SOURCE: National Association of State Aviation Officials.

ners not to consider possible constraints on aviation demand in developing forecasts, except in certain limited cases. Rather, it advises the planner to focus on the "total demand potential" of the airport:

> In the [planner's] development of [airport activity] forecasts, an ***unconstrained approach*** is usually the best approach . . . .
>
> The "unconstrained" forecast represents the potential aviation market in which all of the basic factors that tend to create aviation demand are used, ***without regard to any constraining circumstances . . .*** that could affect aviation growth at any specific airport or location. Using this approach, it is possible to determine the theoretical development needs in accordance with the total demand potential. For an airport serving an exceptionally high activity metropolitan area, however, potential constraints and alternative methods to reduce them should be considered (emphasis supplied).[5]

It is particularly noteworthy that the document instructs planners to consider constraints on demand solely for the purpose of finding ways to reduce them.

Treatment of demand as an independent variable is rooted in the practice of civil engineering when designers have to plan facilities for events totally beyond their control. In designing a flood control project, for example, the demand on the facility is purely a function of natural forces over which the planner can exercise no control. Demand on an airport, however, is not an uncontrollable natural phenomenon; it responds to changes in the price of using the airport. For example, there is presumably some set of market conditions under which no one would fly between the hours of 5 and 7 p.m., even though this is currently the period of peak demand. Alternatively, if adequate facilities are not provided, some demand will be suppressed. No such similar responsiveness exists in the natural demand placed on flood control facilities.

The costs of sizing the system to serve peak-period demand are very high. To the extent that passengers are willing to bear that cost, the investment in facilities to accommodate this demand is a good use of economic resources. Yet, the structure of the entire system is based on the premise that the passengers are willing to bear the cost, and they are rarely given a choice to save money by altering the time of day at which they choose to fly. While airlines sometimes provide discounts to night passengers or to those flying in slack travel seasons, these are exceptions. Usually, the price of traveling at the peak period is no more than at offpeak periods.

The lack of incentives for traveling during off-peak periods is to some extent a problem reaching beyond airport planning per se. If airport sponsors choose not to institute peak-hour prices, planners have littIe choice but to accommodate that decision. At the same time, however, the planning process often fails to identify alternatives to sizing facilities for unconstrained peak load. In some cases such alternatives may be preferable or, at the very least, worthy of consideration in the planning process.

Plans as Advocacy Documents

While the airport planning process may take into account the desires of the community served by the airport, the master plan itself often has a distinctly advocative flavor. This is perhaps best illustrated in a passage from the introduction to FAA's guidelines to airport planners on master planning:

> . . . This advisory circular recommends procedures to be followed in making the master plan study of the individual airport and suggests methods of coordinating, organizing, and presenting the master plan document so that it will be a viable tool for the ***promotion*** of airport improvements (emphasis supplied).[6]

Such use of the master plan raises some disturbing questions about the process. Should the planning process plan be a medium for promoting a particular plan for airport development, chosen by the planner or airport operator, who usually has a vested interest in building or expanding the airport? Or should it present a set of optional development paths for community decisionmakers? If advocacy of development is an appropriate use

[5] ***Airport*** **Muster Plans, Advisory Circular AC 150/5070+5 (Washington, DC: Federal Aviation Administration, 1971), pp. 11, 13.**

[6] **Ibid., p. 3.**

of the master plan, then should not some forum be available to weigh airport development against other community needs and to integrate airport projects with other community plans?

In practice, the political body with jurisdiction over the airport performs this oversight function, but it is hampered by planning documents that presuppose the desirability of airport expansion. The master plan is often quite thorough in presenting alternative forms of expansion and in arraying the pros and cons of each. It is usually silent on the more fundamental questions of whether any improvement should be undertaken and what options there are besides airport development.

Lack of Integration Among Plans

Airport planning at local, regional, State, and Federal levels is not well coordinated and integrated. To some extent, this arises naturally from different areas of concern and expertise. At the extremes, local planners are attempting to plan for the development of one airport, while FAA is trying to codify the needs of several thousand airports which might request aid. Local planners are most concerned with details and local conditions that will never be of interest to a national planning body.

The lack of common goals and mutually consistent approach is also evident between Federal and State planning. Over 10 years ago, the Federal Government recognized the need to strengthen State system planning and provided funds for this purpose under ADAP, and nearly all the State Airport System Plans have been prepared with Federal funding. However, it does not seem that FAA has always made full use of these products in preparing the NASP. The State plans contain many more airports than the NASP, and the priorities assigned to airport projects by States do

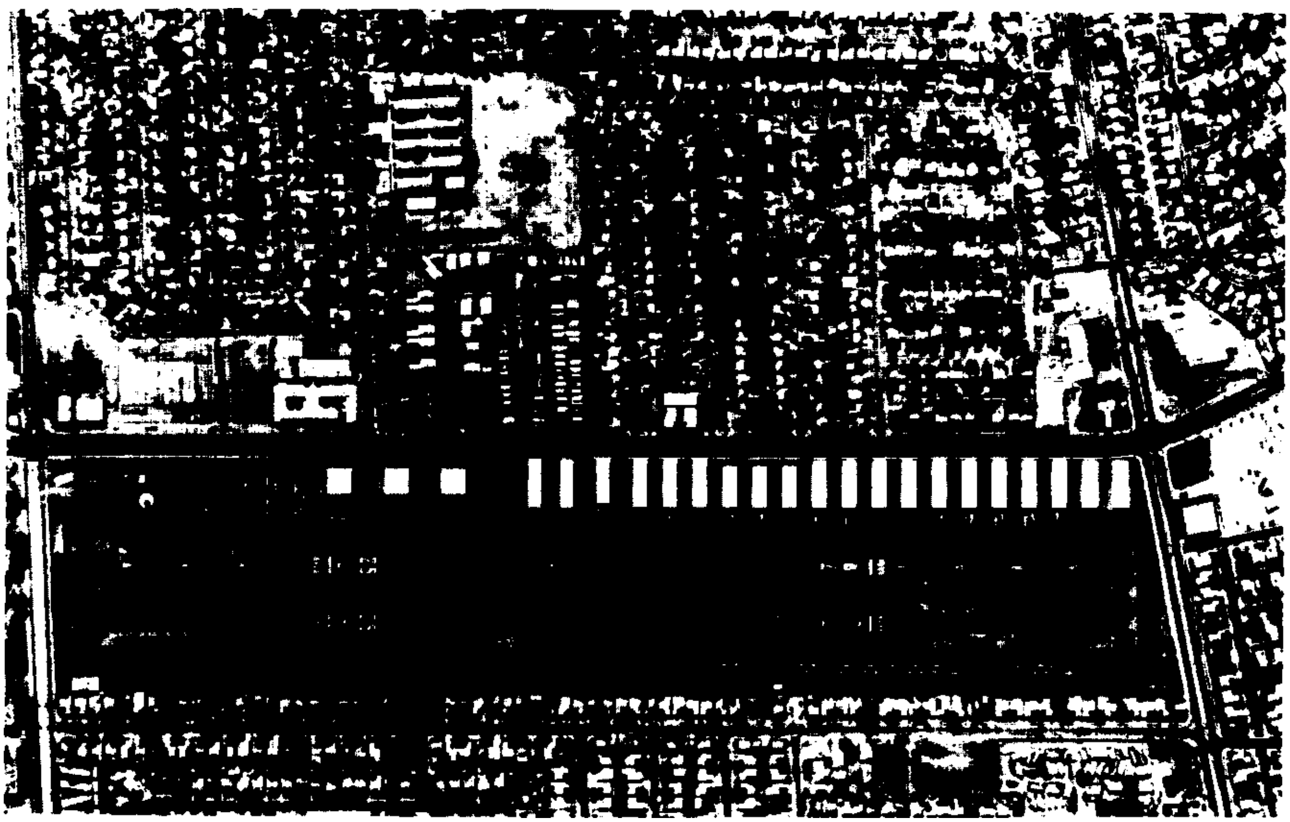

Photo credit: Aviation Division, County of Los Angeles

Urban encroachment at a GA airport

not always correspond to those of the NASP. While it is probably not desirable, or even possible, for the NASP to incorporate all elements of the State plans, greater harmony between these two levels of planning might lead to more orderly development of the national airport system.

There is also a lack of coordination between airport planning and other types of transportation and economic planning. This is particularly evident in the case of land use, where airport plans are often in conflict with other local and regional developments. Even though the airport authority may prepare a thoroughly competent plan, lack of information about other public or private development proposed in the community (or failure of municipal authorities to impose and maintain zoning ordinances) allows conflicts to develop over use of the airport and surrounding land. This problem can be especially severe where there are several municipalities or local jurisdictions surrounding the airport property.

An additional problem is the lack of integration of airport planning with that for other modes of transportation. An airport is an intermodal transportation center, where goods and people transfer between the ground and air modes. It forms an important link in the total transportation system of a region. The ground transportation system providing access to the airport can be a significant contributor to congestion, delay, and the cost of airport operation. Yet, airport operators have little authority or influence over decisions on transportation beyond the airport property line.

At the national level, there is also a lack of integrated planning within FAA. There does not seem to be close coordination between FAA's National Airport System Plan and the National Airspace System Plan. While the two plans are based on the same aviation demand forecasts, they have not been brought under a common schedule. Nothing has been published to show how the airport improvements contained in one plan will interact with air traffic control (ATC) improvements proposed in the other.

NATIONAL PLAN OF INTEGRATED AIRPORT SYSTEMS

The Airport and Airway Improvement Act of 1982 (Title V, Public Law 97-248) reflects a strengthened congressional commitment to airport planning. At the regional and State levels, the law dedicates 1 percent of Federal airport development funds for planning, with availability contingent on a demonstrable (not demonstrated) ability to conduct regional planning. As such, the new law provides an opportunity for State governments and regional agencies to institute or expand their planning efforts.

The Congressional Mandate

The act calls for refinement of the national airport planning process by instructing the Department of Transportation to develop a National Plan of Integrated Airport Systems (NPIAS) by September 1984. The description of this plan in the legislation makes it clear that the intent is to expand and improve planning at the national level. Specifically, the act calls for "integrated airport system planning," which it defines as:

> . . . the initial as well as continuing development for planning purposes of information and guidance to determine the extent, type, nature, location, and timing of airport development needed in a specific area to establish a viable, balanced, and integrated system of public-use airports.[7]

Planning includes identification of system needs, development of estimates of systemwide development costs, and the conduct of such studies, surveys, and other planning actions, including those related to airport access, as may be necessary to determine the short-, intermediate-, and long-range demands that the airport must meet.

The policy declaration points out several ways in which the planning effort is to be "integrated." It states that:

[7]Public Law 97-248, Title V, §503 (a) (7).

> . . . it is in the national interest to develop in metropolitan areas an integrated system of airports designed to provide expeditious access and maximum safety. . . . [and it is in the national interest to] encourage and promote the development of transportation systems embracing various modes of transportation in a manner that will serve the States and local communities efficiently and effectively.[8]

From this it is evident that the legislation requires a plan which is "integrated" in two ways: 1) geographically, in the sense that all airports in a region are to be considered together; and 2) intermodally, in the sense that planning for the aviation should be part of the planning for the regional transportation system as a whole. The requirements of the act will bring FAA's airport planning process into closer relation with metropolitan and regional transportation planning than ever before.

Desirabie Features of NPIAS

The NPIAS is not scheduled for publication until September 1984, and it is not yet clear how FAA will respond. Certainly the task will require either major modifications of the planning process that has produced the NASP or development of a completely new planning tool to respond to the intermodal and regional aspects of the congressional mandate. As an aid to Congress in evaluating the plan when it is released, OTA offers the following general comments about features that would be desirable in an integrated national airport plan.

Comprehensiveness

First of all, the NPIAS should be truly national in scope. A national plan may not need to include every airport in the country, but it should explicitly define the interest of the Federal Government with respect to airports of all sizes and purposes. The current NASP has been criticized both for being too broad and for being too exclusive. On the one hand, many airports are included in the NASP are of scant importance to the national system of air transportation. On the other hand, the NASP excludes about 1,000 airports that are part of State Airport System Plans or that may otherwise have some regional importance. The difficulty might be traced to the fact that airports are either "in" or "out" of the NASP. A comprehensive system plan may have to define a hierarchy of Federal interest, specifying different degrees of importance and eligibility for funding.

A complete plan will thus have to start with a careful definition of a national airport system and the airports that make it up. It is entirely possible that the degree of Federal interest will not be the same for all types of airports, depending on their size, mission, and locale. In some cases, airports may be of only local or regional importance and of no direct interest to the Federal Government. However, if the plan is to be comprehensive, these airports should be identified and perhaps earmarked for consideration in State or regional plans.

Comprehensiveness also requires that the NPIAS address all types of development. Some types of improvements, particularly those to be made with Federal funds, will be of chief concern. However, in the interest of completeness, the plan will have to assess total airport system costs, not just those eligible for funding through the Airport Improvement Program. Further, a complete plan will have to consider, from the viewpoint of total system costs, where there are more cost-effective alternatives to investment in new or expanded facilities. In addition to projects for accommodating growth, it will be necessary to consider methods for directing and managing demand growth to fit within existing capacity.

Integration

The act specifically calls for integrated region-wide planning, but formulation of the NPIAS affords FAA the opportunity to integrate the planning process even further by developing a cohesive and hierarchical planning system in which regional or statewide system planning activities are meshed into airport planning at the national level. Further, this broader concept offers the opportunity to devise a system for coordinating airport planning more closely with system planning for other modes of transportation, at both the regional and national level.

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[8]Public Law 97-248, Title V, $502 (a) (9) and $502 (b).

It is especially important that the NPIAS seek to integrate airport planning with two other major FAA planning efforts—the National Airspace System Plan (NAS Plan) and the National Airspace Review (NAR). Initial funding for the NAS Plan was also approved in the 1982 Airport and Airway Improvement Act. This plan, published in early 1982, outlines FAA's future improvements to the en route and terminal area ATC systems over the next 10 years. The NAR is a 42-month study of air traffic procedures, begun in June 1982 as a joint undertaking of FAA and aviation industry representatives. Its objectives are to improve the efficiency of traffic flow in the airspace system by revising regulations and instituting new procedures that reflect technological improvements in aircraft and air traffic control.

The three segments of the aviation system—airports, ATC facilities, and airspace use procedures—need to be developed in coordination. Piecemeal development could lead to inefficiencies, bottlenecks, and misdirected investment. For example, it would probably be a waste of resources to add runway capacity at an airport if the ATC system cannot be upgraded to handle the additional traffic in that area until several years later. Conversely, there is little advantage in seeking to move traffic more expeditiously between airports only to have it encounter delays in the terminal areas where improvements have not yet been scheduled or implemented. Integrated development of airports, ATC facilities, and air traffic procedures will be necessary to obtain maximum benefit from any one of the parts and to ensure cost-effective investment.

Priorities

Another important consideration will be the identification of priorities for implementation and

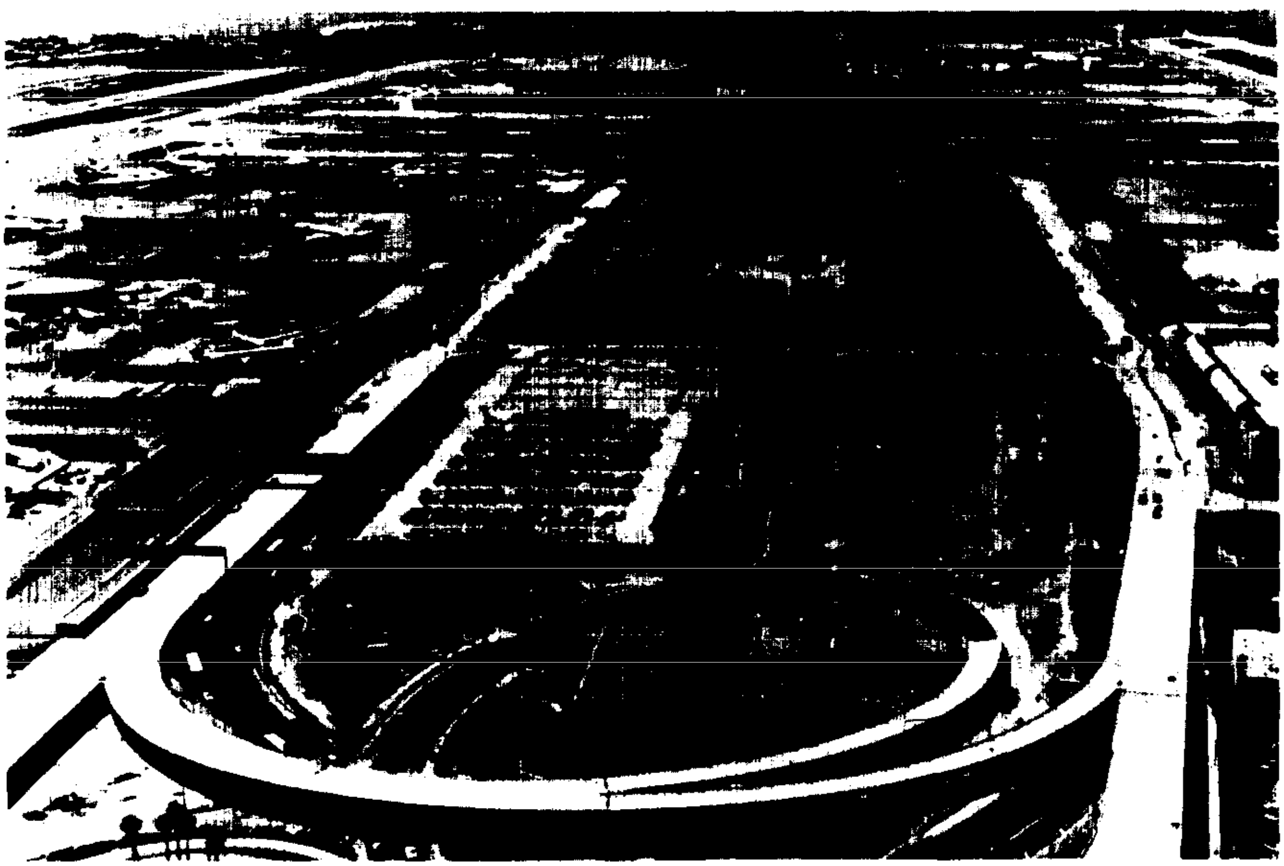

Photo cradlt: Faderal Aviation Admlnlstratlon

Recently completed airfield, terminal, and landside expansion at Los Angeles International Airport funding by class of airport and type of need. FAA attempted in the latest version of the NASP to classify needs according to three levels of program objectives: 1) maintain existing system, 2) bring airports up to standards, and 3) expand the system. Within these levels, gross estimates of needs for each class of airport (air carrier, general aviation, etc.) are made. While this classification system represents a good start, it is still not fully satisfactory. The NPIAS plan should include a scheme for relating specific types of airport projects to systemwide objectives and assigning priorities to specific projects. Such priorities could aid FAA in evaluating the systemwide effects of specific program actions and serve as a guide in the distribution of capital development funds.

Multiple Planning Horizons

Another desirable characteristic of the plan would be the use of multiple planning horizons. Development of airports is an ongoing process and a given plan of improvements often takes a number of years to complete. The large-scale investments are often "lumpy," and a period of intense development and heavy investment at an airport may be followed by a lull of several years. The use of several planning horizons-perhaps of 5, 10, and 20 years—would aid in integrating short-term improvements into smoother long-term investment paths at each airport. It would also help to relate improvements at individual airports to broader system goals. Given the uncertainties of forecasting, long-range projections are subject to greater error and therefore must be treated more flexibly. Procedures for periodic revision and updating of the plan would allow for these longer-range projections and decisions to be reviewed and adjusted. Use of multiple planning horizons is already a a characteristic of the NASP, which sets out airport-by-airport needs on a 5- and 10-year basis. The horizon might usefully be extended to 20 years, with the latter 10-year period intended as no more than an approximation (or "early warning") of long-range trends and need.

Time phasing of improvements is an important feature that has been missing in previous FAA airport system plans. As a general rule, planned airport developments should be related to an overall schedule determined by forecasted growth, expected leadtime, and relationships with the elements of the NAS Plan and the NAR. The development schedule for all parts of airspace system—airports, ATC facilities, and air traffic procedures—should be tied together in a common planning framework. For example, if under the NAS Plan an airport is to receive ATC improvements that will increase airside capacity, this should be reflected in the airport system plan as it may dictate other terminal or landside improvements. Conversely, in planning ATC improvements to increase capacity, implementation should be scheduled first at those airports where they will have the most beneficial effect.

It may be well, insofar as possible, to build these schedules around "trigger events." For example, instead of scheduling improvement at some airport for a particular year, implementation might be made conditional on passenger enplanements or aircraft operations reaching some specified level. This approach has two advantages. It provides protection against the inevitable inaccuracy of forecasts, and it allows flexibility in matching improvements with need.

Coordination and Review

There will be a need for periodic review and update. To see that the broadest range of interests are taken into account, the initial planning and the review process should be conducted in cooperation with State, regional, and local planning authorities and with the aviation community at large. The consultative planning technique recently employed by FM in the National Airspace Review and the Industry Task Force on Airport Capacity Improvement and Delay Reduction has been useful not only in helping FAA recognize and accommodate diverse interests, but also in enriching the planning process. Involvement of other planning agencies and private organizations representing airport users in a continuing dialogue will ensure that improvements contemplated in the NPIAS are in harmony with user needs and the objectives of State, regional, and local aviation agencies.

Chapter 10

POLICY CONSIDERATIONS

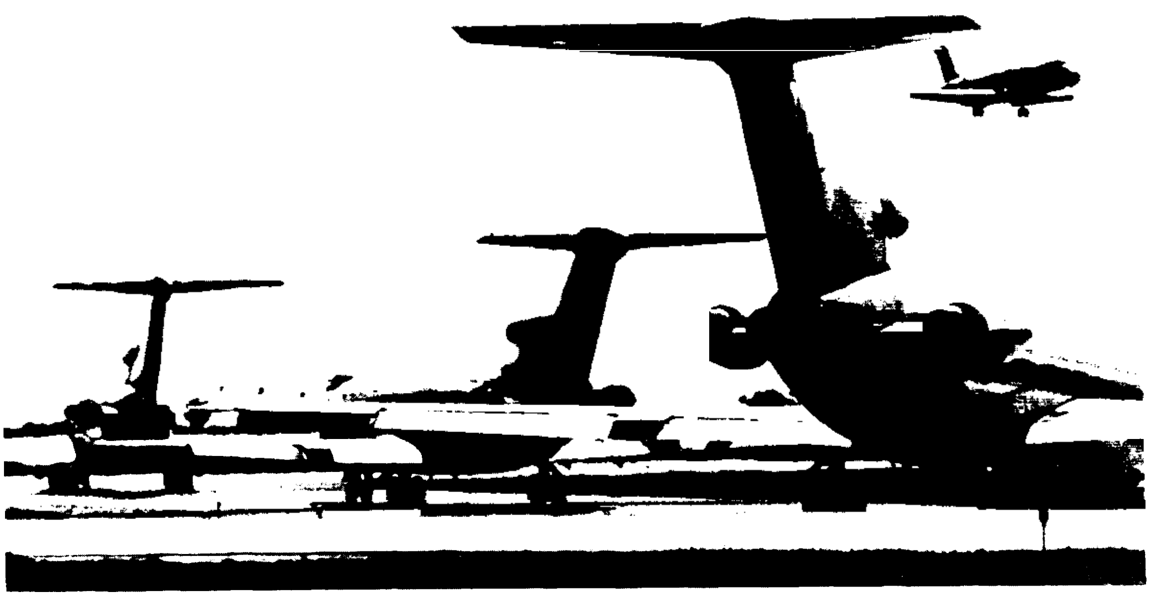

Photo credit: Federal Aviation Administration

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POLICY HISTORY

The Air Commerce Act of 1926 marked the beginning of Federal regulation of air traffic and aviation safety. At the time the law was enacted, aviation was an infant industry. There was a widely held view that aviation was hazardous, and some doubted that the airplane would ever have much commercial importance. There were others, however, who recognized that benefits, both commercial and military, might accrue to the Nation if safety could be improved and the manufacture and use of aircraft were fostered and encouraged. Direct subsidy to the aircraft manufacturing and air transportation industries was thought inappropriate, but Congress did empower the Department of Commerce to chart the airways, to maintain navigation facilities, and to act in other ways to promote air commerce. A year before, in the Airmail Act of 1925, Congress had authorized the Post Office Department to contract for domestic mail service, thereby giving impetus to formation of airlines and providing an important source of operating revenue for the new industry.

The 1926 legislation included no provision for Federal involvement in airport development. In the debate leading to passage of the Air Commerce Act, Congress considered but rejected the idea that airports were a matter of Federal interest. It was thought that airport development should be left to local initiative and that Federal policy toward airports and airways should be analogous to that for ports and waterways:

> The Federal Government established and maintained lighthouses, dredged channels, and furnished weather forecasts; it left to municipalities, however, the establishment and control of port facilities. It followed, therefore, that while the Government should chart airways, provide airway lights for night flying, maintain emergency fields, and furnish weather reports to pilots, it would leave to municipal authorities the control of airports. In other words, airways were like channels or harbors; airports were like docks.[1]

On this line of reasoning, the 1926 Act contained a specific prohibition against Federal involvement in the construction of airports, thereby establishing the "dock" concept, which remained Federal policy until 1940.[2] However, when the Civil Aviation Act was passed in 1938, Congress began to reconsider airport policy. The principal purpose of the 1938 Act was to establish a new independent agency, the Civil Aeronautics Administration (CAA), to be responsible for economic regulation of air carriers. There was no authorization of airport aid, but neither was it prohibited. Instead, the act directed the CAA Administrator to survey airport facilities and to make a recommendation to Congress about the advisability of Federal Government participation in airport construction and maintenance. Before this study and recommendation could be acted upon, World War II began in Europe; and Congress, taking the view that development of a strong system of airports was vital to national defense, appropriated $40 million for construction and improvement of 250 airports.

National defense, or national security, became the major rationale for Federal participation in airport development from that time forward. Federal assistance to airports continued through the war years; and, after the war, Congress appropriated a total of $500 million over 7 years in the Federal Airport Act of 1946. The 1946 Act was the first legislation to deal specifically with civil airport development, and part of its justification was that a strong system of municipal airports would be of vital importance in a war or other

1 U. S. Senate, Report to Accompany H.R. 4209, "Department of Transportation and Related Agencies Appropriation Bill, 1982," Report No. 97-253, p. 10.

[2]It was perhaps due to the dock analogy that the term "airport" came into common use. Before that time, airports were generally referred to as airfields or aerodromes.

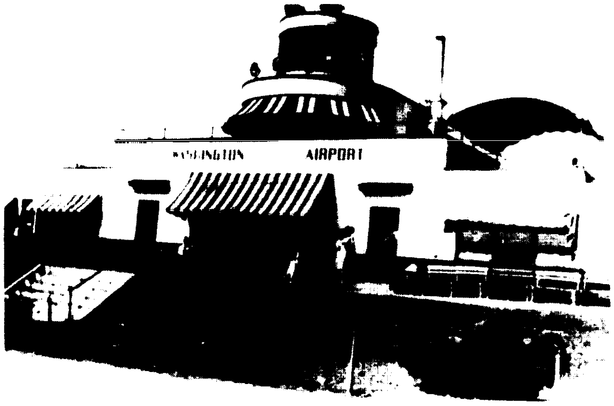


Photo **credit: Federal Av/atlon Administration**

Then . . .

national emergency. The act provided capital grants in the form of matching funds to encourage State and municipal initiative in building and improving publicly owned airports. This program of aid, financed from the General Fund, continued until **1969.**

During the period 1946-69, Congress took another significant step when it reorganized the Federal Government agencies responsible for regulating air transportation and administering aviation programs. The Federal Aviation Act of 1958 transferred responsibility for the technical aspects of air traffic control (ATC) and aviation safety to the newly created Federal Aviation Agency— later Federal Aviation Administration (FAA) leaving economic regulation to the CAA, which was renamed the Civil Aeronautics Board (CAB). The act contained a statement of policy indicating that Congress retained its traditional view that promotion of safe and efficient civil aviation was in the national interest, and national defense remained a dominant theme. The FAA Administrator was, among other things, charged with:

- the regulation of air commerce in such a manner as to best promote its development and safety and fulfill the requirements of national defense;
- the promotion, encouragement, and development of civil aeronautics; and
- the control of the use of the navigable airspace of the United States and the regulation of both civil and military operations in such airspace in the interest of the safety and efficiency of both.[3]

To carry out the responsibilities of managing the airspace, FAA also received authority to approve the siting of airports and to administer Federal funds for airport development.

FAA came into existence at a time of great change in the aviation industry. Traffic growth was placing excessive demands on both the ATC system and airports. By 1958, the major airlines were beginning to replace their aging equipment with jet aircraft, which offered much greater operating efficiency, higher speed, and better service to the traveling public. The advent of jets, however, placed great pressures on the airport system. Because of speed, size, and weight of jet aircraft, runways, taxiways, and aprons had to be redesigned, and passenger terminals had to be modified or rebuilt to handle jet aircraft and the larger volume of passengers per flight. While jets were first used only in a few high-density, long-haul markets, it was apparent after a few years that they would be economical for use throughout the system and that hundreds of airports would have to be upgraded or stand in danger of losing air service.

The expansion and modernization of many airports was paid for by local airport sponsors with help from funds available under the Federal Airport Act. However, the amount of aid available

[3]**Federal Aviation Act of 1958, Public Law 85-726, Aug. 23, 1958.**

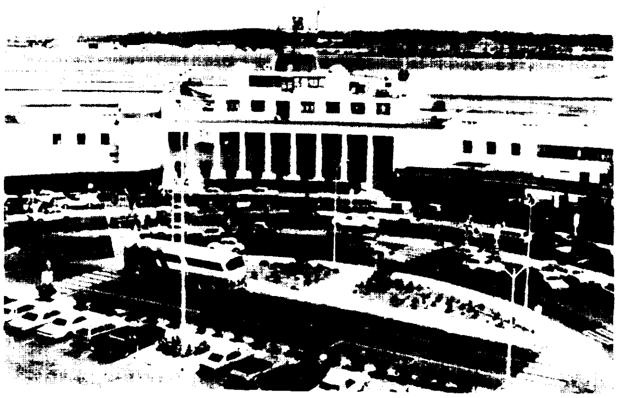


Photo credit: Federal Aviat/on Administration

. . . and now

under the act was small (about $75 million per year), and Congress was becoming increasingly uncomfortable with what amounted to direct subsidy of the aviation industry through General Fund appropriations. Congress responded to these concerns with the passage of the Airport and Airway Development Act of 1970 and a companion revenue bill.

The 1970 Act established the Airport and Airway Trust Fund and levied an airline ticket tax, general aviation (GA) fuel tax, and other user fees to provide revenue. The user-supported Trust Fund ended the need for airports and the ATC system to compete with other national priorities for appropriations from the General Fund. Part of the Trust Fund was used to pay for the modernization of the ATC system, a program which FAA had started in the late 1960s. In addition, the Trust Fund supported the Airport Development Aid Program (ADAP), which provided grants to assist airport operators in funding capital projects. Between 1971 and 1980 the Trust Fund received approximately $13.8 billion, of which $4.1 billion was invested in the airport system through ADAP grants.

Passage of the Air Cargo Deregulation Act of 1976 and, more importantly, the Airline Deregulation Act of 1978, signaled an end to the 40-year history of economic regulation of the airline industry. The deregulation of airlines was part of a general trend gaining momentum in the 1970s to reduce Government regulation of private industry. By this time, many observers in Congress and elsewhere had begun to doubt that Federal regulation was encouraging orderly competition and had come to suspect that the regulatory process was imposing unnecessary costs and creating distortions in the marketplace. Even before Congress passed the deregulation acts, CAB itself had conducted a number of experimental reductions of certain types of regulation in order to encourage competition. With the 1978 Act, the market was opened to new firms, and carriers gained much greater freedom to enter or leave markets, to change routes, and to compete on the basis of price. The 1978 Act also called for the "sunset" of the CAB by the end of 1984, with transfer of its few remaining essential functions to other agencies.

Deregulation has had a profound effect on the airport system. Once air carriers were permitted to change routes without CAB approval, they dropped many unprofitable points, confirming the fears of some opponents of deregulation that air service to small communities would suffer. Service to some smaller cities continued under the "Essential Air Service" provisions of the Deregulation Act, which provides subsidies (through 1988) to the last carrier in a market so as to prevent selected cities from losing service altogether. In many cases, small commuter carriers entered the markets abandoned by larger carriers. In addition, the airlines' new freedom has greatly changed their relationships with airport operators, who can no longer depend on the stability of the earners serving the airport and who must accommodate new entrants.[4]

One of the major issues affecting airport development, especially since the beginning of the jet age, has been aircraft noise. FAA has responsibility for regulating aircraft noise—in the Federal Aviation Regulations Part 36 (1969) and Part 91 (1976)—and for establishing procedures for airspace use. However, the Federal Government has not taken on the task of directly regulating the noise level at a given airport; this is considered the province of the airport operator. The Aviation Safety and Noise Abatement Act, passed by Congress in 1979, was intended to "provide assistance to airport operators to prepare and carry out noise compatibility programs. " It authorizes FAA to help airport operators develop noise abatement programs and makes them eligible for grants under ADAP.

The Airport and Airway Development Act expired in 1980 and Congress did not agree on reauthorizing legislation until passage of the Airport and Airway Improvement Act of 1982. During fiscal years 1981 and 1982 the taxing provisions of the Trust Fund were reduced, and revenues were deposited in the General Fund and the Highway Trust Fund. However, Congress continued

[4] *Air Service to Small Communities* (Washington, DC: U.S. Congress, Office of Technology Assessment, OTA-T-170, February 1982).

Photo cradlt: Federal Av/ation Admlnlstratlon

The continuing problem of noise

to appropriate airport aid—$450 million for each of the 2 years. At least part of the delay in passing new legislation was due to the debate over "defederalization," an action which would have made the Nation's largest airports ineligible for Federal aid on the grounds that they were capable of supporting themselves financially. Defederalization was dropped from the final version of the legislation, but Congress directed the Department of Transportation to study the matter further and to report at a later date.

The 1982 Act reestablished the operation of the Airport and Airway Trust Fund (with a revised schedule of user taxes) and authorized a new capital grant program, called the Airport Improvement Program (AIP). In basic philosophy, AIP is similar to the previous ADAP. The principal changes are in the formula for distribution of airport aid and in the criteria of eligibility. Overall, the Airport and Airway Improvement Act of 1982 authorizes a total of $4.3 billion in airport aid for fiscal years 1983 through 1987.

ASSESSMENT OF FEDERAL AIRPORT POLICY

In large measure, the system of airports that we have in the United States today owes its existence to Federal policy, whose express purpose has been to foster the development of civil aviations In the earliest years of civil aviation, the Government's actions were confined to subsidy of aircraft manufacturers through military purchases and indirect support of aircraft operators by airmail contracts. Since airports were regarded as essentially local enterprises, they did not receive Federal aid. But from the beginning, civil aviation was perceived as an adjunct to military aviation in providing national defense, and in the World War II era this became the rationale for direct Federal Government assistance to civil airports. In the years after 1945, the Federal Government took an even more important step in sup: porting the civil airport system when it turned over to local authorities hundreds of airports that had been built and operated as military installations but were then deemed surplus. This infusion of capital facilities not only expanded the airport network serving commercial aviation, it also encouraged the purchase and use of GA aircraft by assuring ample landing facilities within reach of nearly everyone in the country.

By 1960, this divestiture of military holdings had largely run its course, and the emphasis of Federal policy shifted to upgrading and expansion of major airports to accommodate jet aircraft and to alleviate problems of congestion and delay in airline traffic that were beginning to emerge. Smaller airports were not neglected, however. Between 1960 and 1970, $510 million—about 20

5 For example section 305 of the Federal Aviation Act of 1958, which established the Federal Aviation Administration, states that "the Administrator is *empowered and directed to* encourage *and foster* the development of civil aeronautics and air commerce in the United States and abroad" (emphasis supplied).

percent of all Federal expenditures for airport capital improvements—were directed to small communities and to improving the quality of GA facilities. In addition to construction and improvement of runways and airfield facilities, the Federal Government aided general aviation in other ways. The network of Flight Service Stations was expanded, and the number of airports with FAA-operated control towers grew substantially, with nearly all of the additions coming at smaller airports. Safety of civil aviation was an important motivating factor, but so too was the desire to establish and maintain an extensive system of well-equipped airports serving all classes of civil aviation, providing readily available commercial air transportation and operating bases for aircraft used for business purposes and private flying.

The passage of the Airport and Airway Development Act of *1970* institutionalized Federal airport aid by establishing the Airport and Airway Trust Fund, supported by user fees, which provided a dedicated source of revenue for capital improvement. This act not only committed Federal support to the airport system, it also gave the Federal Government a strong, perhaps dominant, voice in how that system would develop. By identifying the kinds of airports eligible for capital grants, by specifying the types of projects that would be supported, and by establishing formulas for Federal, State, and local funding, the Airport Development Aid Program effectively set the pattern of airport development for the *1970s.* After a brief period of uncertainty in **1980-82**, when Congress allowed the legislative authorization of ADAP to lapse, previous Federal policy on airport development was reaffirmed in September **1982** with passage of the Airport and Airway Improvement Act of **1982**, which established the Airport Improvement Program.[6]

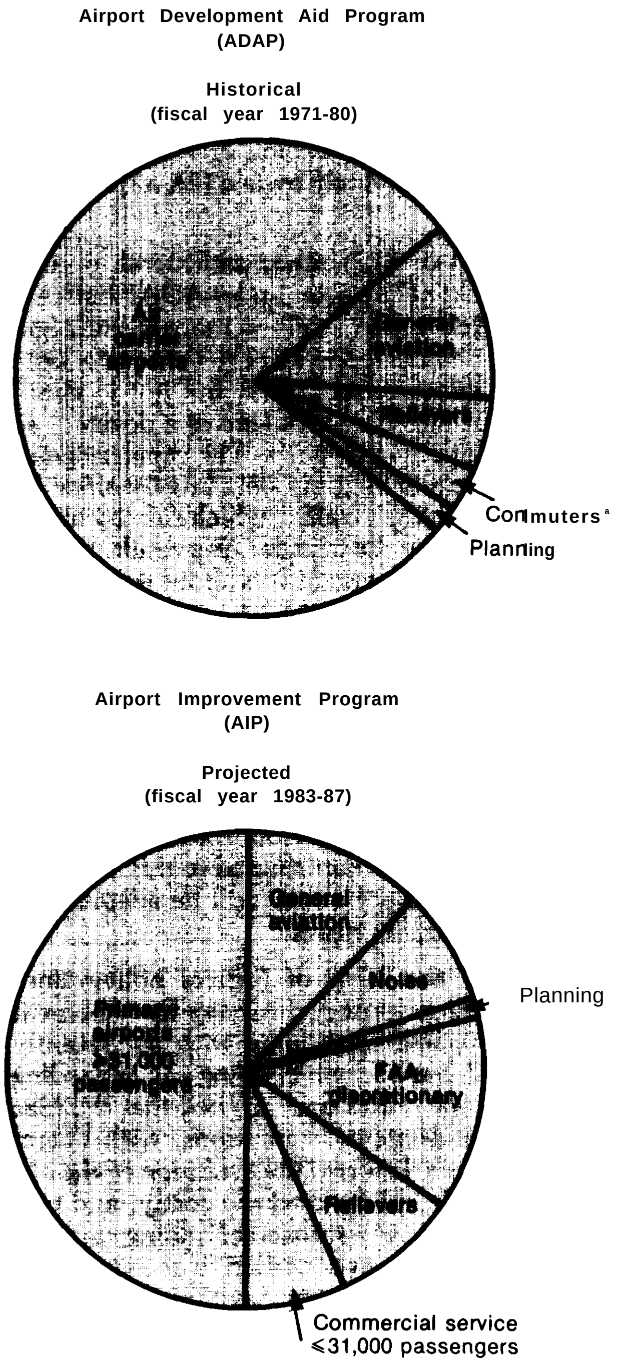
AIP preserved the general approach to airport aid established under ADAP, with certain revisions to correct what were perceived as imbalances in the allocation of funds and to adjust the shares paid into the Trust Fund by various classes of airport and airspace users through ticket and fuel taxes. The principal differences between ADAP and the new AIP are in the proportion of Federal aid to be allocated to air carrier, reliever, and GA airports, the earmarking of *8* percent for noise projects, and extension of Federal aid for the first time to privately owned GA airports (see fig. *24).*

Investment of $4.1 billion in Federal moneys for airport capital projects under ADAP between **1971** and 1980 and $7.9 billion more in State and local funds enabled the airport system to keep abreast of construction needs, but not to eliminate the chronic delay problems at a dozen *or so* major metropolitan airports. The capacity gains achieved at major airports were largely offset by growth in passenger traffic, which rose by about 75 percent during the decade. As a result, the situation at these airports now is about the same as it was in the late 1960s. If FAA forecasts are correct, however, capacity problems may emerge at more airports in the next 10 to *20* years, possibly affecting as many as 60 air carrier airports by the end of the century. There may also be a shortage of facilities for general aviation in major population centers, notably in the Sun Belt States of the South and West. It is therefore appropriate to ask how past policy has contributed to this situation and whether present policy will be adequate to deal with emerging needs.

Certainly, the focus of Federal policy since passage of the Airport and Airway Development Act of 1970, and continuing with the recently enacted AIP, has been on building and expanding airports. Some critics have argued that the bias toward capital-intensive solutions, with liberal Federal aid, has distorted the evolution of the airport system. It has favored the costly, and perhaps self-defeating, approach of adding capacity wherever and whenever needed to accommodate demand. But new capacity inevitably begets new demand, which creates need for more capacity, and so on in an escalating spiral. Limitations on land available for airport expansion or building new airports, steady encroachment of urban development around airports, and community opposition to airport noise make adding capacity an

6 Section 502 of the act finds and declares that "continuation of airport and airway improvement programs and more effective management and utilization of the Nation's airport and airway system are required to meet the current and projected growth of aviation and the requirements of interstate commerce, the Postal Service, and the national defense." 96 Stat. 671, Title V, sec. 502(a)(2).

Figure 24.—Distribution of Airport Aid Funds Under ADAP and AIP



[a]Fiscal year 1987-80 data only.

SOURCE: J. J. Corbett, "Reflections on the New Airport/Airway Trust Fund Law," *Airport Services Management*, vol. 22, No. 9, September 1982.

increasingly expensive and difficult solution. The alternative urged by critics of present policy is to encourage demand-management techniques that would promote fuller and more efficient use of the infrastructure already in place. These critics would redirect policy away from large capital projects and toward a combination of managerial, operational, and market-oriented approaches to channel new growth to fit within the ample capacity now available in the airport system as a whole.

Another criticism of past and present policy is that it has concentrated almost exclusively on airside capacity-runways, taxiways, and other such airfield facilities. Most FAA studies of capacity have limited their concern to aircraft delay (or even more narrowly, air carrier delay), and the calculation of benefits has been confined largely to air carrier fuel and labor savings and more efficient aircraft utilization. In part, this may be a methodological limitation. It is considerably more simple and straightforward to calculate aircraft delay costs than to quantify the intangibles of terminal and landside delay —e.g., what is the economic value of convenience or passenger time? On the other hand, FAA has traditionally interpreted aviation policy in such a way that the agency's interest is closely circumscribed about the airfield and aircraft operations, leaving responsibility for other parts of the airport to the site manager or to other agencies of government.

Delays in terminals and on landside access roads are widespread and probably account for more of the increase in passenger travel time than delays in aircraft departures and arrivals. By concentrating on expanding the airside, the Federal Government has placed on airports almost the whole burden of keeping pace with terminal and landside improvements. A broader targeting of Federal funds, it is argued, will be needed to deal with all forms of delay associated with air transportation. An extension of this argument is that Federal policy should broaden its sphere of concern to encompass the airport as part of the overall urban or regional transportation system. Indeed, the new AIP legislation charges FAA with responsibility to develop a National Plan of Integrated Airport Systems, which implies not only integration of planning and development for all airports within a region or the Nation but also integration with other modes of transportation.

Another way in which Federal policy-or at least FAA interpretation of Federal policy-has been faulted is that it has led to an overly broad definition of what constitutes airports of national importance. The last edition of the National Airport System Plan contains 3,159 airports that are eligible for Federal aid. Preliminary indications are that the new National Plan of Integrated Airport Systems now being prepared by FAA will contain even more—3,203 as of the beginning of 1984 and 3,639 by 1995. Most of these airports are small general aviation facilities serving only a relatively few aircraft. While there is a distinction between eligibility for Federal aid and actual receipt, the existence of a trust fund and a Federal policy that seeks to spread aid broadly to all classes of airports has created a very large roster of airports competing for a share of Federal moneys, with each believing that it can and should receive support for capital projects. At the national level, this leads to inflated estimates of "needs," which exert pressure for more and more Federal outlays in a continuing program of airport building and expansion. A more restrictive definition of the Federal Government's interest may be necessary to clarify the distinction between those airports that serve a nationwide air transportation function and those that serve purely local and specialized needs that are national only in an aggregate sense.

A somewhat different criticism that *is* partially contradictory to the argument above is that Federal aid has favored air carrier airports while neglecting the needs of other users of the airspace, chiefly those who frequent GA and reliever airports. To some extent, the provisions in AIP to increase that share allocated to general aviation are a response to this criticism. However, this argument is not simply a plea for more aid to general aviation. Rather, it is directed to the larger issue of financial self-sufficiency. Some contend that Federal aid should be targeted toward those airports that do not have adequate revenues or access to debt capital in the private market. The largest airports, which collectively serve almost

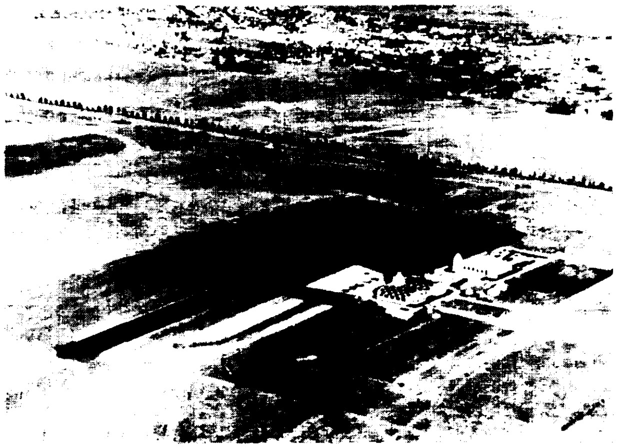


Photo credit: Los Angeles Department of Airports

Mines Field, L.A. Municipal Airport in 1929

90 percent of air travelers, are, ***or*** could be, virtually self-supporting.[7] If so, these critics maintain, it is not an appropriate use of Federal moneys (even perhaps moneys from a dedicated trust fund) to help those that can help themselves. This is the argument of those who would defederalize large and medium airports, and it has found favor both among small airport operators (who see it as an opportunity to obtain more Federal aid) and those who seek market-oriented solutions that would reduce the Federal budget.[8]

The defederalization argument, however, also embraces a more fundamental economic concern —economically efficient pricing of airport facilities and services. Economists contend that Federal policy which supports capital improvements by grants from a trust fund and which is predicated on unrestricted airport access for all users on demand, when coupled with local airport practice of residual-cost pricing as a method of setting landing fees, encourages supply-oriented solutions to congestion and delay. The alternative favored by economists is pricing the use of airport facilities according to the marginal cost that

[7]This point is addressed at length in ch. 7.

[8]A market approach attempts to simulate the operation of a largely unregulated market by utilizing the price mechanism to control the quantity demanded. This approach is used by government in a number of areas; e.g., the Federal Government auctions the right to cut timber or to drill for offshore oil. See D. Koran and J. D. Ogur, *Airport Access Problems: Lessons Learned From Slot Regulation by the FAA*, Bureau of Economics Staff Report to the Federal Trade Commission, May 1983.

such use imposes on the airport operator and on others who seek to use the airport at the same time. At the local level, this implies airport use fees based on the cost incurred to provide a given amount of capacity. At the national level, the implication is twofold: 1) Federal aid should be given only to the extent that local resources are insufficient and that it is in the national interest to provide, and 2) local airport authorities should be given the freedom to impose user fees that are consonant with market forces. Thus, they would argue that Federal policy-explicitly by the "first-come, first-served" principle and by prohibition of facility user charges (head taxes) and *implicitly* by its silence on the question of efficient pricing as a means to increase airport revenue—distorts the market in the direction of unnecessary Federal subsidy and capital-intensive approaches to increase supply rather than modulate demand.

This brief critique of past and present Federal policy points to a basic issue. In promoting aviation by providing abundant capacity at low cost to airport and airspace users, has the Federal Government in effect subsidized airlines, general aviation, aircraft manufacturers, and local development? The evidence suggests that the answer is yes. But the more important question is motive, not effect. In the earliest days of aviation, the aim of Federal policy seems to have been to foster a fledgling industry for reasons of national defense and development of an economically valuable new mode of transportation. Without this support, aviation might have lagged or withered altogether. In the years after World War II, the rationale of civil aviation as a buttress of national defense became less important, and considerations of the national economy and regional development came to predominate. They still do. Aircraft manufacturing and the aviation industry are important contributors to the balance of trade. Available, efficient, and low-cost air travel stimulates all sectors of the economy. An airport is an important economic resource to a community, both in and of itself and because it can be used to leverage additional highly desirable development. In this sense, aviation is a general boon to the economy, and it can be argued that the Federal Government's policy is amply justified.

On the other hand, aviation is no longer immature, underdeveloped, and struggling. Despite vicissitudes that affect it along with the rest of the economy, aviation is a robust industry that is capable of supporting itself. Is, therefore, a strong Federal presence still required? Perhaps yes, perhaps no. But it is certainly not inappropriate to reexamine the nature of the social and economic contract between the Government and the aviation community to see if mutual interests could be better served in other ways.

ALTERNATIVE FEDERAL AIRPORT POLICIES

While there are many aspects of Federal policy that affect airport system development, there is perhaps none so powerful as that pertaining to funding of capital improvements or expansion of airport facilities. The policy options considered here therefore concentrate on the rationale of the Federal funding program and the amount of capital aid to be provided. Four policy alternatives are presented:[9]

- ***Defederalization***— withdrawal of Federal aid for those airports capable of self-support (essentially all large airports and most medium airports) in the expectation that they will be able to finance their own capital improvements through retained earnings and issue of revenue bonds.
- ***Selective Federal*** Aid—based on a more restrictive definition of Federal interest in airport development, aid only to those airports that provide commercial air service and to a selected set of GA airports whose function is to relieve congestion at commercial service airports in major metropolitan areas.
- No ***Federal*** Aid—return to the "dock" policy, under which Federal interest in civil aviation would be limited to airways, navigational aids, air traffic control, and safety and no Federal aid would be provided for airport

[9]The first three of these policy alternatives are also examined by CBO in *Financing U.S. Airports in the 1980s,* April 1984.

development on the grounds that such facilities should be built and maintained by the municipalities whose economic interests they serve.

- State Administration—transfer to State governments of responsibility y for administering a federally funded airport aid program composed of formula grants to commercial service airports based on passenger enplanements and block grants to be distributed on a discretionary basis by State aviation agencies.

In advancing these options, OTA does not contend that present policy is unsatisfactory or that it would be an inappropriate course for future years. The present Airport Improvement Program, tempered by the previous 10 years of experience with ADAP, seeks to provide a balanced and sufficient program of aid that is consistent with the approach to fostering civil aviation that has prevailed since the 1960s. However, as the foregoing policy assessment has brought out, there are some fundamental questions that are worth reexamining.

The rationale of the options presented here is that, if it is desired to redirect Federal airport policy, there are three basic avenues that might be taken. The first, embodied in the defederalization option, is that the primary test to be applied in the distribution of aid to airports is financial self-sufficiency. The second line of departure from present policy is that a more restrictive definition of Federal interest could be applied. Two options of this sort are considered: selective aid only to those airports that serve to make up a national air transportation network and-more restrictive still—aid for navigation and air traffic control but not to airports themselves. The third shift of policy, State administration, would not affect the amount and type of airport aid afforded under current policy, but it would place responsibility for distribution of this aid in the hands of State and local agencies instead of the Federal bureaucracy. None of these options would change the present method of support for ATC system modernization or for funding FAA operational and maintenance activities. FAA's regulatory and safety functions related to airport operation would likewise be unaffected.

It should be noted that, while these options are discussed as though they were independent and mutually exclusive choices, this is simply an analytical convenience. A revised Federal airport policy might well combine features of two or more of these options, either in the interest of addressing several perceived shortcomings of present policy or in an attempt to mitigate adverse impacts that might result from adoption of any one option in pure form.

It should also be noted that not all of the concerns about the adequacy of the airport system voiced in this report are explicitly addressed in the policy options. For example, the need for and application of new technology to alleviate airport congestion or to reduce delay do not specifically motivate any of the policy choices. It is assumed that needed technological improvements or procedural changes in air traffic control would be made under all options, whether by FAA or by local airport authorities. However, since the rate of adoption might be influenced by the availability of funds and the priorities of the agency responsible for financing, the effect of funding policy on the adequacy of the airport system is considered as a possible impact in the discussion of each option.

Similarly, the issue of noise is not addressed in any of the policy options. The responsibility and liability of various parties in protecting communities from the adverse effects of airport noise is an important question—perhaps the thorniest facing civil aviation today—but its resolution lies largely outside the realm of topics treated in this report. It is a legal issue that will turn mainly on what the courts determine to be the joint and several responsibilities of airport operators, airspace users, and Federal, State, and local governments in dealing with the problem.

Finally, the matter of local airport managerial practice and pricing policy is not a direct concern shaping any of the policy choices, although some might lead to more economically efficient pricing of airport services. Chapters 2, 5, and *6* have dealt with the importance of the contracts and working arrangements between airport managers and and airport users, with the effects of different approaches to pricing the use of facilities, and with the general issue of economic approaches to managing demand for airport services. These are thought by OTA to be matters of local policy that lie somewhat outside the focus of Federal concern, although it is recognized that the Federal Government has a responsibility to assure that enterprises receiving grants are properly managed. The extent to which Federal policy on financial aid or on administration of the airport aid program might affect local management, pricing, and financing mechanisms is treated as one of the possible effects of each option.

Funding Under Current Policy

In the 5 years from 1978 to 1982, funds from all sources invested in airport improvements averaged $1.8 billion annually. Of this, about $1 billion was raised through bond sales, mainly revenue bonds issued by large and medium airports. Federal grants for airports of all sizes amounted to slightly less than $0.6 billion per year, with State aid making up the remainder (table 53).

While the Federal Government contributed about one-third of the total invested, the share varied considerably in relation to airport size. For large airports, the Federal contribution typically made up a little over 15 percent of all investment; for medium airports, about 25 percent. At small commercial airports, Federal funds made up two-thirds. For GA airports, Federal money was typically 90 percent or more of all investment. In general, the degree of Federal participation in capital projects reflected the earning power and borrowing capacity of the airports receiving grants.

Table 53.—Sources of Airport investment Funds, 1978-82 (millions, 1982 dollars)

Airport category	Bond sales	Federal aid	Percent Federal aid
Large[a]	$ 689	$144	17
Medium[a]	224	75	25
Other commercial service[a]	93	164	66
Reliever	8	63	89
General aviation	6	104	95
All airports	**$1,020**	**$570[b]**	**36**

[a]Large airports enplane more than 1 percent of all passengers; medium more than 0.25 percent. The other commercial service category includes 210 small primary airports (0.01 to 0.25 percent of annual enplanements) and 279 non-primary airports enplaning at least 2,500 passengers annually.
[b]In addition, States provided about $200 million per year in aid, primarily for small airports.

SOURCE: Office of Technology Assessment estimates based on CBO data on bond sales and FAA data on Federal airport aid.

Table 54 is an estimate of future demand for airport investment capital over the 10-year period 1984-93. Large and medium airports, which handle about 90 percent of passenger traffic, account for the bulk of the anticipated investment—$650 million to $1 billion annually, or roughly the same level as in recent years. An additional investment of $400 million to $450 million is expected at small commercial airports. The demand for capital by reliever and GA facilities is estimated to run between $500 million and $600 million annually.l”

Also presented in table 54 are currently authorized annual outlays under AIP and estimates of bond sales that could be expected if historic borrowing patterns were to continue. It appears that this combination of public and private financing (which is roughly the same as that over the past few years) would be adequate to cover the projected investments for airports as a whole, but with considerable variation by airport size and class.

In general, these figures suggest that current policy and the funding level authorized in AIP

[10]*Financing U.S. Airports in the 1980s* (Washington, DC: Congressional Budget Office, April 1984), p. 81.

Tabie 54.—Projected Airport Capitai Needs and Sources of Funds (millions, 1982 dollars)

Airport category	Annual needs (1984-93)[a]	Annual Federal aid[b]	Bond sales[c]
Large[d]	&50-$6&l	$260	$ 669
Medium[d]	200-350	80	224
Other commercial service[d]	400-450	85	93
Reliever	100-150	60	8
General aviation	400-450	95	6
Other federal aid[e]	—	160	–
All airports	**$1,550-$2,050**	**$800**	**$1,020**

[a]Projections provided by CBO. Low estimates are derived from FAA National Airport System Plan; high estimates are from preliminary unpublished needs analysis for National Plan of Integrated Airport Systems
[b]Assumes that AIP outlays and the distribution formula currently authorized through 1987 are continued.
[c]Based on average annual sales for 1978-82.
[d]Large airports enplane more than 1 percent of all passengers; medium more than 0.25 percent. The other commercial service category includes 210 small primary airports (0.01 to 0.25 percent of annual enplanements) and 279 non-primary airports enplaning at least 2,500 passengers annually.
[e]Made up of $108 million for discretionary grants, $64 million for noise projects, and $8 million for planning.

SOURCE: Office of Technology Assessment, based on CBO and FAA data.

would be adequate to meet airport proposed airport investments over the coming 5 to 10 years. However, this statement is valid only for airports in the aggregate. There are imbalances between projected needs and available resources for certain classes of airports, with some—particularly the small airports—facing a possible shortfall of investment capital and larger airports appearing to enjoy virtual financial self-sufficiency. Thus, there are several options that might be pursued, either to alter the amount of Federal airport aid overall or to adjust the distribution of these grants among various classes of airports. These options are examined below.

Defederalization

The term "defederalization" was coined a few years ago when proposals were raised in Congress to discontinue Federal aid to those airports capable of self-support.[11] The airports targeted for defederalization were large and medium airports — those handling more than 1 percent and those handling between 0.25 and 1 percent of annual passenger enplanements, respectively. Advocates of defederalization pointed out that Federal aid has formed one-quarter or less of the capital budget of such airports and that they are, for the most part, capable of supporting themselves financially. They have demonstrated that they can raise private funds in the bond market to pay for capital improvements and that they can generate sufficient revenues to cover their operating expenses and debt service.

Withdrawal of Federal aid from these airports was been seen by supporters of defederalization as a method of holding the line on Federal airport development expenditures and freeing funds to aid smaller airports and to improve the ATC system. According to one supporter:

> we can concentrate limited Federal funds on those airports that are least able to raise revenues on their own and on the development of the airways system, in-flight air traffic control systems, navigational aids, and landing systems.[12]

With the loss of Federal funds, deregulated airports would have to finance capital improvements through retained earnings and debt financing. In many cases, these airports might find it necessary to increase user fees or to float larger or more frequent bond issues.

Effects on the Federal Budget

Assuming that all 71 large and medium airports were no longer to receive Federal aid, Federal outlays for airport development could be cut to about half what they are under current policy. As shown in table 55, average annual Federal

[11] See, for example, S. 1648, the Airport and Airways System Development Act of 1979, 96th Congress.

[12] Senator Nancy L. Kassebaum in the U.S. Congress, Senate Committee on Finance, "Airport and Airway Tax Measures," hearings on S. 1047 and S. 1272, July 21, 1981, 97th Congress.

Table 55.–Federal Airport Aid (Defederaiization Poiicy)

Airport category	Number of airports	Average annual expenditures (1985-89) (millions of 1982 dollars)	
		Present policy[a]	Defederalization[b]
Large[c]	24	280	—
Medium[c]	47	80	—
Other commercial service[c]	489	85	120
Reliever	219	80	115
General aviation	2,424	95	130
Other Federal aid	—	180d	75[c]
Totals	**3,203**	**800**	**440**

[a] Assumes that AIP outlays and the distribution formula currently authorized through 1987 are continued.
[b] Assumes currently authorized levels of aid plus equal distribution of $108 million in discretionary grants for airport catefories that remain eligible for Federal aid.
[c] Large airports enplane more than 1 percent of all passengers; medium more than 0.25 percent. The other commercial service category includes 210 small primary airports (0.01 to 0.25 percent of annual enplanements) and 279 nonprimary airports enplaning at least 2,500 passengers annually.
[d] Made up of $108 million for discretionary grants, $64 million for noise projects, and $8 million for planning.
[e] Grants for noise projects and planning at currently authorized levels.

SOURCE: Office of Technology Assessment

outlays for airport development during the period 1985-89 would fall from $800 million to approximately $440 million. This could amount to a savings of about $1.8 billion in Trust Fund expenditures over the 5-year period.

The defederalization option presented here also assumes that funding for small commercial service, reliever, and GA airports would remain at the level authorized under current policy. In addition, these airports might receive a larger share of the $108 million in discretionary grant moneys than they do now. In table 55 it is assumed these discretionary funds are distributed equally among the three classes of airports that remain eligible for Federal aid, but some other distribution might also be appropriate. Presumably, expenditures for airport noise abatement would remain roughly the same as under present policy, with some funding still available for noise projects at large and medium airports.

If Federal outlays for airport development were cut back to $440 million per year, it would be possible to reduce the taxes needed to sustain the Airport and Airway Trust Fund. The Congressional Budget Office, on the basis of information from FAA and the Office of the Secretary of the Treasury (Office of Tax Analysis), estimates that receipts from the airline ticket tax will average about $2.6 billion per year for 1983 through 1987. A reduction of $360 million in annual airport grants from the Trust Fund is equivalent to roughly one-eighth of this amount—or about 1 percentage point of the 8-percent airline ticket tax.[13]

Effects on Airport Financing

Large and medium airports have been especially successful in funding capital projects through the tax-exempt bond market. On average, large and medium airports raised slightly over $900 million per year in the bond market between 1978 and 1982. This was supplemented by about $220 million in Federal aid. If Federal funds were unavailable, it is possible that some improvement projects would not be undertaken, and that the demand for capital would be somewhat smaller than under current policy. It is more likely, however, these airports would attempt to replace lost Federal funds through larger or more frequent bond sales. While it is difficult to determine how much more the airports would seek to raise, it could be an additional $100 million to $200 million annually.

Defederalized airports might find that the cost of borrowing money would increase for two reasons. First, they would be competing more vigorously for larger sums of money. Second, they would have lost the more or less guaranteed infusion of Federal funds and might therefore appear to investors as more risky investments. However, in light of airports' strong financial position and blemish-free record in the bond market, it is unlikely that their ability to raise capital would be greatly affected.

Smaller commercial service airports, which have annual capital needs of about $400 million to $450 million, could be expected to raise about $90 million from bond sales (judging from their performance in 1978-82) and might receive up to $120 million in Federal grants, depending on how discretionary funds are allocated. This would leave an unfunded need of between roughly $200 million and $250 million. It is assumed that GA and reliever airports would receive the same aid as under present policy, plus perhaps as much as an additional $70 million in discretionary moneys. These airports might be the biggest gainers from a defederalization policy.

Effects on Airport Users

Defederalization would make large and medium airports more dependent on revenue-bond financing. One source of income commonly used to guarantee payment of these bonds is airport use fees charged the airlines. Thus, one effect of defederalization might be to change the balance of power between airlines and airport management in decisions on capital investment. At about half of the large and medium airports, airlines now exercise control of investments through majority-in-interest clauses and other features of airport-airline use agreements, and airport operators have often found that Federal grants were almost the only funds that they could use for projects which the airlines were unwilling to support.

[13] *Improving the Air Traffic Control System: An Assessment of the National Airspace System Plan* (Washington, DC: Congressional Budget Office, August 1983).

If Federal moneys were unavailable, airport operators might have considerably less latitude in managing their capital budgets. On the other hand, defederalization could encourage airport managers to discontinue or weaken majority-in-interest clauses when airline use agreements come up for renewal. It is difficult at this point to assess which way the balance would shift.

If operators of large and medium airports were to offset the loss of Federal funds by increasing user charges, the general effect of deregulation on users of those airports would be higher fees for landing, leasing of space, and airport services. All classes of users—business aviation, GA, and airlines—might find it more expensive to operate at defederalized airports. For airlines, much of this expense would be passed on to passengers in the form of higher fares.

Some proponents of defederalization argue that defederalized airports should be given the power to levy a passenger facility charge (PFC) or head tax in order to supplement their present revenues. Even if permitted, many airports might not choose to institute a head tax. Others, however, insist that some such mechanism for raising additional funds is necessary if they are to give up Federal assistance. If head taxes were widely adopted, airline passengers would face a second form of increased travel cost.

Serious questions have been raised about the feasibility and advisability of implementing local passenger facility charges.[14] Four issues are of particular concern:

- How and by whom should fees be collected and how could the confusion caused by different rates at different airports be avoided or managed?
- Should diversion of head tax revenues to nonairport uses be prevented?
- How can head taxes be instituted in the face of such obstacles as long-term use agreements that prohibit the establishment of new fees?
- What can be done about airports where the head tax may not be feasible?

If the Federal Government chooses to allow head taxes, guidelines for their application would have to be established. For example, to prevent double charges, it would be necessary to determine whether the tax should be levied on arriving or departing passengers. So, too, would it be necessary to decide whether transferring passengers should be taxed and, if so, whether at the same rate as origin-destination passengers.

The most likely means of collecting a PFC would be through a unit charge collected by the travel agent or other ticket seller in much the same way that the Federal head tax for international departures is now collected.[15] Because the management of airline reservations is highly computerized, it should be possible to work out an automated accounting system for charging the proper fee to each passenger and dispersing revenues to the airports. Such a system would be more complex than the current system of collecting a Federal tax from all passengers, but is certainly within the scope of current technology and practice. The details would have to be worked out carefully to avoid an undue administrative burden on airlines and travel agents.

Another possibility would be a charge assessed against the airline, rather than the passenger, based on airline passenger counts at the airport. This is a common means of collecting passenger facility charges at European airports today, and the Federal international departure tax is now levied on airlines on the basis of passenger counts. A third choice would be to have the airports themselves collect head taxes, but there is evidence that this method of collection would be more costly and less efficient than either of the others.[16]

A much more difficult issue is whether Federal guidelines should be established to prevent diversion of airport revenues to other, nonaviation, purposes. While it is quite common in other countries to treat airports as revenue producers for municipal or national governments, it has generally

[15] William R. Fromme, *The Airport Passenger Head Tax: Analysis of Its Potential Impact*, final report to the U.S. Department of Transportation, February 1984.

[16] For detailed analysis of the practical problems of collection and the options discussed here, see Thompson and Crenshaw, *Airport Passenger Facility Charges*, final report to the U.S. Department of Transportation, February 1984.

not been the custom in the United States to divert aviation taxes to nonaviation uses, and some regard the practice as improper. It was, in fact, the problem of diversion that caused the Federal Government to forbid airports to impose head taxes in 1973. The problem might be solved by Federal legislation requiring that passenger facility charges reflect actual costs and that proceeds be used only for airport purposes.

A few airports have introduced clauses in newly negotiated use agreements that specifically protect management's right to levy a head tax in the event that such charges become legally permissible. However, Airport Operators Council International estimates that at least *20* of the top 70 airports could not impose a PFC because of their existing use agreements. Federal legislation could override these agreements.

Even if the Federal Government grants them the authority, airport operators will have to decide for themselves whether the head tax option is a realistic alternative for financing airport development. Managers of several major airports have stated publicly that they would not impose a PFC even if it were allowed. For those unable or unwilling to use head taxes, the most likely alternative would be to increase landing fees and concession rents.

If all large and medium airports were defederalized, and all elected to replace all lost Federal aid with PFCS, the cost of the average airline ticket would increase by about **$1.50.** Since the average ticket now costs about $100, this would not raise the price of air travel appreciably. If the Federal Government were to reduce the present 8-percent passenger ticket tax by 1 percentage point, the added cost of head taxes would be largely offset.

Effects on Airport System

The defederalization policy could have an effect on demand at large and medium airports. Higher landing fees charged to raise additional revenue might discourage use of these airports by general and business aviation. If so, there could be some decrease in congestion and delay, but the effect would be highly localized and it is difficult to gauge what the implication might be for the airport system as a whole.

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Because of the unavailability of supplementary Federal aid, additional funds for improvements at large and medium airports would have to be raised privately. The need to rely entirely on debt financing might cause airport operators to defer some projects or to scale them down to essentials. Overall, defederalization could increase the likelihood that only those investments which are truly needed and ***economically justified*** would be undertaken. The type of investments most likely to be eliminated or drastically reduced would be those that do not generate revenue or provide direct financial benefit to airport users.

Selective Federal Aid

A criticism of present airport funding policy—at least as reflected in the criteria applied by FAA in formulating the National Airport System Plan (NASP),—is that the Federal interest is drawn too broadly and unselectively. At one extreme, about three-quarters of all Federal aid under ADAP went to air carrier airports—many of which appear to be capable of financing investments from airport revenues and borrowing in the private money market. AIP reduces this share to half, but this amount may still be high.

At the other extreme, Federal aid is accorded to many small GA airports that do not serve a national transportation function—at least if this function is defined as contributing directly to commercial air travel. The grants that such airports receive are typically small—most are under $200,000 and many are $50,000 or less. In the aggregate, they were about 12 to 15 percent of all Federal aid under ADAP and would continue at this level under AIP.[17] The criteria for eligibility applied to GA airports are such that virtually any publicly owned aviation facility in the United States could expect to receive Federal aid.[18] Many are very small, serving a dozen or so based aircraft that are used either for instruction, aerial work, private business purposes, or recreational flying. As a rough estimate, these 2,424 GA airports probably serve less than half of the private and business aircraft in this country.[19]

The rationale of the selective aid policy is that much more stringent criteria of eligibility should be applied to airports receiving Federal assistance. Two tests would be applied: 1) Is the airport incapable of obtaining adequate investment capital through its own means? and 2) Does the airport contribute to a national system of commercial air transportation? By these standards, only the 560 commercial service airports[20] and the 219 GA airports designated as relievers would receive capital aid, and only to the extent that they were unable to finance investments from their own resources. In effect, the Federal Government, through the Airport and Airway Trust Fund, would become either the lender of last resort or an outright grantor in those cases where repayment seemed impractical and it was in the public interest to sustain the facility as part of the air transportation network. Airports not meeting these criteria (virtually all the 2,424 GA airports in the NASP today) would not be eligible for Federal grants, and it would become the responsibility of State and local governments ***and the users of these airports*** to provide capital funds. The funds now earmarked in AIP for noise projects and airport planning grants to States ($64 million and $8 million per year, respectively) could still be made available for airports of any size or purpose.

In a sense, the selective aid policy would create for airports an analog of the present highway system, with a Federal component (airports of national interest akin to the Interstate Highway System) and a State and local component (smaller airports serving local needs as do State, county, and city roads). The Federal interest would be centered on those airports deemed essential to interstate transportation; State and local interests would be similarly defined. While this distinction is not clear-cut, neither is it in the highway system, and yet it serves as a workable way to differentiate Federal, State, and local responsibilities. Unlike the highway system, however, there would still be a very large number of privately owned airports (over 10,000), about 20 percent of which are open to public use.

Effects on the Federal Budget

This more restricted definition of the Federal role in airport development would considerably reduce the annual expenditures under AIP in 1983-87. Even if the full $108 million in discretionary funds were to be added to the amount that small commercial service and reliever airports now receive under present policy and if noise and planning grants were unchanged, aid would amount to $345 million per year, slightly over 40 percent of the presently authorized level (table 56). Small commercial service airports would receive about $140 million per year (the $85 million authorized in AIP for this purpose plus perhaps half of the $108 million now earmarked for discretionary grants). Relievers could receive as much as $130 million annually (the $80 million or so now available under AIP and up to $50 million of discretionary funds). Noise and planning grants would

[17]By formula, AIP allots 12 percent of Federal airport aid directly to GA airports in 1983-87. Some of the additional 13.5 percent in discretionary grants may also be awarded to GA airports.

[18]By FAA criteria, a GA airport is eligible for inclusion in the NASP if it: 1) is included in an accepted State or regional airport system plan, 2) serves a community more than 30 minutes from another existing or proposed airport in the NASP, 3) has or is forecast to have within 5 years 10 based aircraft (or engines), and 4) has an eligible sponsor willing to undertake ownership and development of the airport.

[19]Most of the 65,000 business and executive aircraft and many of the 95,000 privately owned aircraft operated for personal use are based either at commercial service airports or at reliever airports around large metropolitan areas.

[20]Airports regularly served by at least one airline or commuter carrier and enplaning more than 2,500 passengers annually.

Table 56.–Federal Airport Aid (Selective Aid Policy)

Airport category	Number of airports	Average annual expenditures (1985-89) (millions, 1982 dollars) Present policy[a]	Selective aid[b]	Defederalization[b]
Large[c]	24	280	—	—
Medium[c]	47	80	—	—
Other commercial service[c]	489	85	140	120
Reliever	219	80	130	115
General aviation	2,424	95	—	130
Other Federal aid	—	180[d]	75[e]	75e
Totals	**3,203**	**800**	**345**	**440**

[a]Assumes that AIP outlays and the distribution formula currently authorized through 19877 are continued.
[b]Assumes currently authorized levels of air plus equal distribution of $108 million in discretionary grants for airport categories that remain elibible for Federal aid.
[c]Large airports enplane more than 1 percent of all passengers; medium more than 0.25 percent. The other commercial service category includes 210 small primary airports (0.01 to 0.25 percent of annual enplanements) and 279 nonprimary airports enplaning at least 2,500 passengers annually.
[d]Made of up $108 million for discretionary grants, $64 million for noise projects, and $8 million for planning grants.
[e]Grants for noise projects and planning at currently authorized levels.

SOURCE: Office of Technology Assessment.

presumably remain at the levels presently authorized.

There would be a substantially increased burden on State and local governments, who would find themselves pressured to pickup roughly $95 million per year in GA airport funding that would no longer be available from the Federal Government. In partial recompense, however, the additional $55 million in Federal aid for small commercial service airports available under this policy might diminish the need for State outlays in this area.

Further relief to the States might still be necessary, and one way to accomplish this would be to turn back some portion of Trust Fund revenues to the States, at least on an interim basis, to ease their transition to greater funding responsibilities. Another way would be to transform some of the Federal taxes on aviation into State taxes. The aviation fuel tax is such a possibility. The Federal taxes now levied on aviation gasoline and jet fuel are expected to bring in an average of about $150 million annually through 1987. A one-third reduction in these taxes at the Federal level, with a corresponding increase in State levies would provide about **$50 million** more to the States that could be used for airports no longer receiving Federal support. The impact of this action on the Trust Fund would be negligible. It would reduce Trust Fund revenues by about 1.5 percent.[21]

[21]*Review of the FAA 1982 National Airspace System Plan* (Washington, DC: U.S. Congress, Office of Technology Assesment, OTA-STI-176, August 1982), pp. 34-35.

Effects on Airport Financing

For large and medium airports, the effects of a selective aid policy would be the same as under a defederalization policy. Large and medium airports no longer eligible for Federal aid would be required to finance capital improvements through a combination of operating revenues and borrowing from private sources. Also as in the case of defederalization, the selective aid policy would not entirely eliminate Federal funds for large and medium airports. If it is assumed that about $65 million to $70 million per year would still be set aside for noise-related projects, a substantial share would probably go to large and medium airports as it does now under current policy.

Small commercial service and reliever airports could find their financial situation somewhat eased. If the present $108 million in discretionary funds were added to the grants they now receive, a larger amount of Federal aid would be available to these airports under selective aid than under either present policy or the defederalization option. If discretionary funds were split evenly, commercial service airports would find the $85 million now accorded them under present policy increased to as much as $140 million under selective aid.

Small commercial service and reliever airports might also be in a better position to raise more capital on their own by virtue of their inclusion in a more selectively defined Federal airport system. This action by the Federal Government, which could be interpreted as a commitment of continued support, might enhance the credit-worthiness of these airports in the eyes of potential investors in bond issues.

General aviation airports excluded from the Federal system under the selective aid policy would have to turn to other sources of capital. Since they are for the most part publicly owned, their first resort would be to their parent municipal or county government and then to their State. If aid could not be obtained from these sources (and perhaps even if it were), GA airports would have to turn to their users to cover some portion of capital investments. Higher landing fees, tie-down charges, and hangar rentals would be the most probable course, both to generate needed capital and to demonstrate to public or private parties that the airport operator is making a best effort to be self-supporting.

In most circumstances, the operator of a GA airport would probably face higher than average borrowing costs. In fact, debt financing would probably be feasible only for the larger GA airports, those with a sufficient number of based aircraft and a high enough level of operations to assure investors that debt could be serviced from revenues. Revenue-bond financing for smaller GA airports would be difficult, and for the very smallest virtually impossible. For such airports, the most likely recourse would be financing through general obligation bonds issued by the municipality or State.

One way to provide assistance to marginally profitable GA airports would be to establish a Federal revolving fund, which would make capital improvement loans available at low interest, or no interest. Some States (e.g., Idaho, Minnesota, and Nebraska) now have such revolving funds for special purposes such as installation of lighting and navigation aids or hangar construction. Setting up a revolving fund at the Federal level would entail a one-time appropriation (perhaps from the current Trust Fund surplus). Thereafter, it would operate at little or no cost to the Federal Government or to Trust Fund contributors except for administrative expense and forgone interest (if money were loaned below the prevailing market rate).

Effects on Airport Users

For major, national, and larger commuter airlines, the effects of the selective aid policy would be like those of defederalization, at least for their activities at large and medium airports. Landing fees and other use charges at these airports would probably rise as managers sought to generate new revenue to offset the loss of Federal funding. In some cases, airlines with a majority in interest at these airports might seek a stronger voice in investment decisions since they would be asked to underwrite a greater share of capital improvements, either directly through participation in the financing or indirectly through higher airport use fees. Small commuter airlines serving a large or medium airport might find it harder to protect their interests since they would generate relatively little revenue for the airport (even though paying higher use fees) and thus could not exert much influence on decisions related to investment or access to facilities. In contrast, commuter airlines would probably find their situation at smaller commercial service airports somewhat improved. The increased amount of Federal funding available for these airports would, over time, raise the quality of facilities and services at these sites, but probably not the cost paid by users in the form of landing fees or rents.

Business and corporate aircraft operators would almost certainly encounter higher use fees at airports not receiving Federal funds-either the large and medium airports expected to be self-supporting or the GA airports excluded from the Federal system. This would be an incentive for business and corporate aircraft to use reliever airports—which are precisely for this purpose-but it could, in turn, cause pressure on reliever airport operators to upgrade their facilities to be more nearly on a par with commercial service airports.

Thus, a somewhat unexpected result of the selective aid policy could be a more marked differentiation among airports and types of users—with air carriers predominating at large and medium commercial service airports and business aviation gravitating to relievers in major metropolitan areas. This stratification might also lead to each class of user paying a share of cost closer to that which they actually impose on their airports of choice.

The other major segment of general aviation—those who operate light aircraft for personal or recreational purposes—would also be likely to incur higher airport use costs under this policy. At "off-system" GA airports, they would have to pay more in order to support these facilities or lose them. This might cause some GA operators to gravitate to nearby relievers or medium and small commercial service airports with capacity to accommodate them. But even at many of these airports, user charges might be higher than they are today. Since this segment of general aviation is quite sensitive to factors of cost and convenience, the longer term result might be a dampening of personal GA. This type of flying probably would not diminish absolutely (unless the costs increased drastically), but the rate of growth might be substantially slower than it has been in the past 20 years.

Effects on the Airport System

The primary effect of the selective aid policy on the airport system would be to create a more coherently organized system—due in part to a clearer delineation of the Federal interest and a more tightly focused program of support for public air transportation. The airports receiving federally administered funds would be those serving virtually all airline passengers and air cargo movement and those private parties with a strong business or personal interest in operating aircraft. Discretionary use of airports and airways would not be discouraged, but it would be channeled to a "second-tier" network of GA airports. The adequacy and health of the GA airport network would be determined largely by the willingness of discretionary flyers to pay the costs of maintaining and operating facilities provided for their use.

From the combination of more narrowly targeted Federal support, user fees more in line with the cost of providing service, and stratification of airport use by type of aircraft might come certain operational benefits. To the extent that the traffic mix became more homogeneous—especially at large and medium airports-delays due to the disparity of aircraft performance characteristics would be reduced.. Adjustment of user fees, if prompted by the motive of recovering cost in proportion to the burden imposed on the airport to provide the type and amount of service demanded, might also help to relieve congestion in several ways. They could provide capital needed for new facilities; they could serve to redistribute demand to offpeak periods; and they could induce diversion of some users to reliever airports or alternative, less congested sites.

The chief negative impact of this policy is its potential effect on general aviation, particularly the portion using airports that would be excluded from the Federal system. The financial condition of many of these airports is weak today, and they might become weaker without Federal support. The loss of adequate and convenient landing sites or the higher cost of using GA facilities could constrain the growth of personal and recreational flying. On the other hand, some of the past growth of this sector has been inspired by Federal programs which provided up to 90 percent of the capital investment at GA airports. To this extent, general aviation is a product of a Federal policy that has subsidized the ownership and operation of aircraft for private purposes. If GA operators prove unwilling to bear a greater share of the costs at the airports they patronize, it may be an indication that their demand for facilities is more induced than real.

No Federal Aid

This option represents a return to the "dock" policy that prevailed in the years before World War II. It postulates that airport owners, principally municipalities or States, would assume full responsibility for capital improvement of airports. The Federal Government would provide no grant funds for this purpose and would concern itself only with support of air navigation—airways and air traffic control, including installation and maintenance of control towers and landing aids at airports.

As described earlier in this chapter, present Federal policy on airport development has evolved gradually over the past 40 years. The original Federal view was that airports, like water ports, should be matters of local concern. Municipalities were expected to build and maintain port or airport facilities because these investments yielded primarily local or regional economic benefits. The Federal role was to maintain the waterways and airways and to provide navigation systems, thereby serving the national interest of facilitating interstate commerce and contributing indirectly to the well-being of communities linked by the waterway or airway systems.

A return to the dock policy is by no means a suggestion that the current and past policies of directly aiding airports have been a mistake. Direct Federal support has been crucially important to the development of the national airport system. The national defense considerations during World War II and the need for airport modernization at the beginning of the jet era were pressing problems at the time. In retrospect, the decisions to provide Federal funds for airport development constituted sound public policy for that time since they served the long-term Federal interest of fostering and encouraging the growing air commerce and aircraft manufacturing industries.

It is possible, however, that the goals of these Federal programs have been achieved. An extensive, modern airport infrastructure is now in place. The aircraft manufacturing industry has matured. Public transportation by air is no longer a fledgling industry—it has been the dominant mode of long-distance travel for many years. If the goals of the program of Federal assistance to airports have been achieved, then it might be argued that the program should be terminated and that outlays from the Airport and Airway Trust Fund should be limited to those needed for modernization, operation, and maintenance of the ATC system.

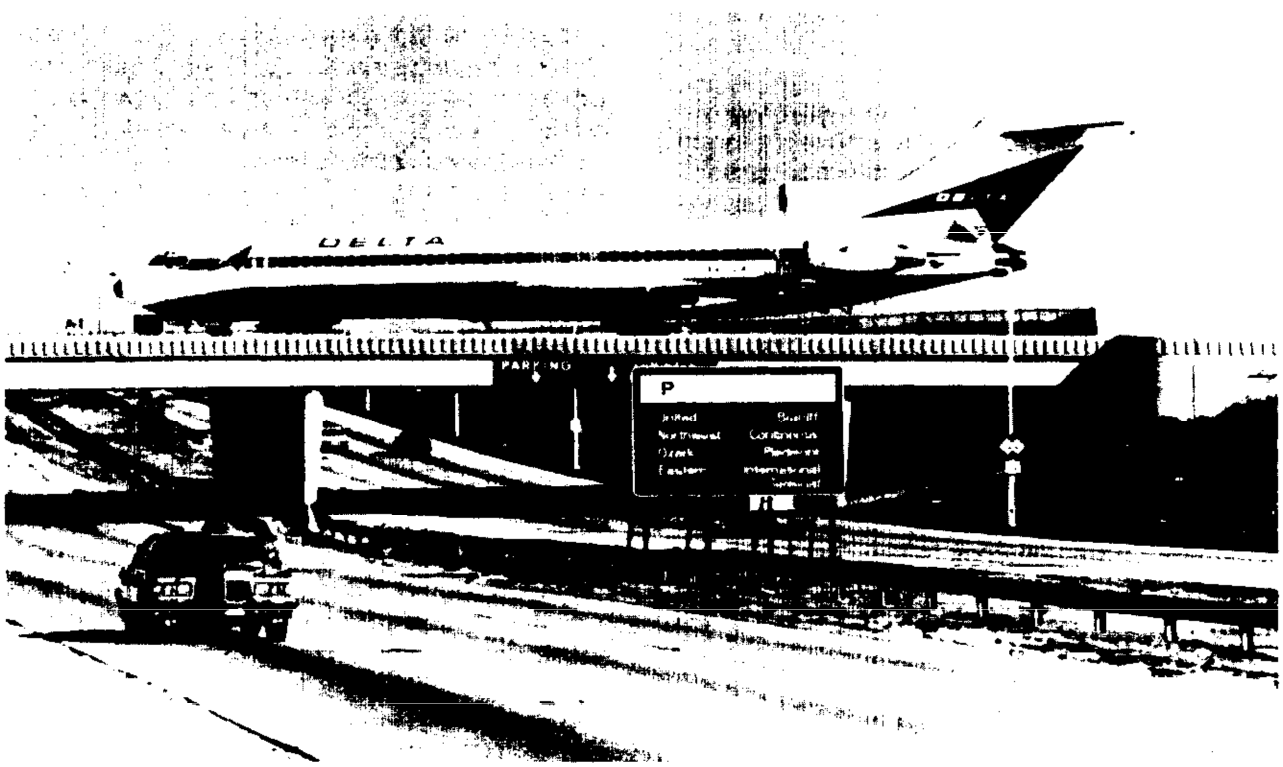

Photo credit: Federal Aviation Administration

Meeting of modes

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Effects on Federal Budget

This option would eliminate all Trust Fund expenditures for airports, which amounts to $800 million per year under present policy. Aviation user taxes could be reduced to the level necessary to cover the capital and operating costs of the airways and ATC system. The passenger ticket tax, for example, could be reduced from 8 to 5.5 percent.

Effects on Airport Financing

Airport sponsors would have the responsibility of raising all funds needed for capital projects. Some improvements would be funded with retained earnings or moneys borrowed from private investors through revenue bonds or other indentures. Airports might have to increase user fees to makeup for lost Federal funds. Some less efficient or low-traffic airports could have difficulty raising capital and might remain unimproved or close altogether.

Another possible source of funding would be State or local authorities. Some States, for example, might elect to provide assistance to airports unable to raise the capital needed for improvements. Local governments might choose to assist their airports as well. Airports provide many benefits to the local economy: they provide jobs and attract industry to a region, in addition to linking the community to the outside world. To the extent that a community wished to preserve these benefits, the local government might choose to allocate local tax revenues to assist the airport, or it might use its general obligation bonding authority to borrow funds for airport use. If the community were unwilling to provide assistance, this might be taken as an indication that the economic benefits of the airport were not worth the cost .

While the return of financing responsibility for airports to State and local government might pose hard choices in some communities, it would not be disastrous in the aggregate. The Federal share of airport expenditures is $800 million per year, out of the total of $53.4 billion per year spent by Federal, State and local governments on major infrastructure programs.[22] Of this annual expenditure, about half (a little over $25 billion) is spent by States and localities. Even if States and municipalities assumed responsibility for the entire $800 million formerly provided in Federal grants, their annual capital expenditure would increase by only about 3 percent. In fact, however, State and local governments would probably have to raise not over half this amount since, under current policy, approximately $400 million of Federal outlays go to large and medium airports which appear capable of raising adequate capital without local or State participation.

Effects on Airport Users

A basic effect of this policy might be to bring the price of airport services more closely into line with the cost of providing those services. Faced with the need to generate investment capital, airports of all sizes would have to increase existing user fees, or perhaps introduce new ones. Air carriers and general aviation, as the primary beneficiaries of airport service would have to pay higher airport use fees, except perhaps in cases where the locality chose to provide some sort of subsidy. With increased dependence on bond financing at air carrier airports, airlines might be expected to underwrite a larger share of airport costs.

Effects on Airport System

This policy—like the selective aid policy described earlier—might also lead to a two-tier airport system composed of roughly 500 commercial service and 200 reliever airports supported by a mixture of private funding and State and local aid and 2,000 to 3,000 GA facilities that would have to rely on the patronage of private owners of based and itinerant aircraft. Some communities might choose to support such GA airports as a matter of local pride or as a spur to local economic development. Those airports not receiv-

[22] *Public Works Infrastructure: Policy Considerations for the 1980s* (Washington, DC: Congressional Budget Office, April 1983), p. 9. The CBO analysis projects that, under current policy, Federal, State, and local investment for all public works will total $53.4 billion per year for the period 1983-90: highways ($27.2 billion), public transit ($5.5 billion), wastewater treatment ($6.6 billion), water resources ($4.1 billion), municipal water supply ($7.7 billion), air traffic control ($0.8 billion), and airports ($1.5 billion). All figures are in 1982 dollars.

ing community support might face great difficulty surviving on user fees and rents alone, which might be an indication of their marginal economic value to civil aviation.

Because it would create a situation where airports might have to compete on the basis of price, this policy could also lead to a "free market" in airports, with cities vying for business and users shopping for the best price and service. Airports have already begun to compete for air carrier service since airline deregulation, and the end of Federal funding for airports might lead to an intensification of this trend.

The effects of this policy would probably vary greatly by region. The greatest possibility of negative impact would be in sparsely populated States, where there is not a sufficient base of aviation activity to support many low-volume airports.

State Administration

The essential feature of this policy is that it would change the way in which the airport funding program is administered. It differs from present policy in that responsibility for distribution of Trust Fund moneys and for management of grant applications and awards would be transferred from the national to the State level. State aviation agencies or departments of transportation would, in effect, replace FAA as the administrator of airport aid.

The Federal Government would not need to divorce itself entirely from airport capital assistance. For reasons of efficiency and national uniformity, the Federal Government could continue to collect the present taxes that support the Airport and Airway Trust Fund, and the congressional process of authorization and appropriation of Trust Fund outlays for airports would remain unchanged. However, administration of grants and exercise of discretionary authority in distributing that part of the Trust Fund now allotted to airports would no ***longer*** be carried out by a central Federal agency. Instead, these responsibilities would devolve to the States, much as they now do in the administration of the Highway Trust Fund.

There are several ways to implement such a policy, and that outlined here is intended only as an illustration of the concept, not a specific formulation of how a State-administered program should work. In spirit, this policy is an application of New Federalism, a concept whose stated purpose is to "restore the balance of responsibilities within the Federal system and to reduce decision, management, and fiscal overload on the Federal Government."[23] Simply stated, it would place greater authority at the State level for decisionmaking on the delivery of capital funds. This policy option is prompted by three criticisms of the way in which the Federal airport program is now administered. First, the present program is encumbered by a growing number of categorical grants, conditions, and regulations. Second, a central Federal bureaucracy is not always responsive to local needs and circumstances; and the interests of aid recipients might be better served by State governments, which are closer to these concerns, more accessible, and capable of acting more promptly. Third, the present division of responsibility between Federal and State agencies results in neither being able to deal with airport planning, development, and funding problems as a whole.

In the illustrative example presented here, Trust Fund outlays for airports would remain at the level now authorized under AIP—an average of $800 million per year. Half of this sum would be distributed directly to individual commercial service airports as pass-through grants based on passenger enplanements. The other half would be distributed to the States in the form of block grants based on various indicators of aviation activity (number of airports, aircraft registrations, fuel sold, area, population, and the like). State aviation agencies or transportation departments would have full discretionary authority to allocate this half of Trust Fund outlays among airports in the State.

The Federal Government might choose to retain some authority to set capability standards for State agencies and to draw guidelines for the States in determining eligibility for award, purpose of expenditure, and degree of local participation; but this is not an essential feature of the

[23]Executive Office of the President, "White House State of the Union Fact Sheet," Washington, DC, Jan. 20, 1982, p. 17.

policy. The Federal Government would retain all functions related to safety, operational procedures, and airport certification. All ATC facilities (including those at airports) would continue to be installed and operated by FW.

Effects on the Federal Budget

This policy option would have no effect on the Federal budget since it would amount to a transfer (or revenue turnback) of Trust Fund tax revenues to the States. It would result in no financial gain or loss either at the Federal level or for the States individually and collectively.

Since Congress would still exercise control over Trust Fund outlays through its authorization and appropriation powers, the amount could be adjusted to any level deemed appropriate. Because of the responsibility vested in the States, the congressional process might be amended to include periodic consultation with the States about the magnitude of needs and the most pressing priorities. FAA might play a role in this, acting either as a clearinghouse for State assessments of their needs or as an independent advisor on the condition of the airport system nationwide and on the total capital investment required over any given period.

Effects on Airport Financing

Although the total funding for airports would not change from that available under present policy, the distribution of grants by class of airport would probably be somewhat different. Table 57 shows the breakdown that would occur if commercial service airports received half of annual Trust Fund outlays prorated by an enplanement formula and if the other half were distributed in equal parts to small commercial service, reliever, and GA airports. The distribution of the discretionary half could vary considerably from State to State. The equal three-way split shown in Table 57 is an approximation of how States in the aggregate might choose to act, based on the way that they have historically supported various classes of airports.

For commercial service airports, especially large and medium airports, the principal effect of this policy would be an assured and essentially predictable source of income that would be entirely under the control of the airport manager. The total amount available to large and medium airports might be slightly less than it is under present policy since it would be strictly limited to enplanement allotments. (These airports receive about the same enplanement money today plus a share of discretionary FAA grants for noise projects and other purposes.) Small commercial service airports, on the other hand, would probably receive more than they do under present policy. In addition to annual enplanement distributions amounting to about $45 million, these airports might receive about one-third of State discretionary awards ($133 million). This total of $178

Table 57.–Federal Airport Aid (State Administration Policy)

		Average annual expenditures (1985-89) (millions, 1982 dollars)				
			State administration			
Airport category	Number of airports	Present policy[a]	Enplanement[b]	Block grant[c]	Selective aid[d]	Defederalization[d]
Large[e]	24	280	280	—	—	—
Medium[e]	47	80	75	—	—	—
Other commercial service[e]	489	85	45	133	140	120
Reliever	219	80	—	133	130	115
General aviation	2,424	95	—	133	—	130
Other aid	—	180[f]	—	—	75[g]	75[g]
Totals	3,203	800	800		345	440

[a]Assumes that AIP outlays and the distribution formula currently authorized through 1987 are continued.
[b]Assumes that half the current level of aid would go to large, medium, and other commercial service airports based on enplanements, with large airports receiving 70 percent, medium 20 percent, and other commercial service 10 percent.
[c]Assumes that States will distribute block grants about equally among the other commercial service, reliever, and general aviation categories.
[d]Assumes currently authorized levels of aid plus equal distribution of $108 million in discretionary grants for airport categories that remain eligible for Federal aid.
[e]Large airports enplane more than 1 percent of all passengers; medium more than 0.25 percent. The other commercial service category includes 210 small primary airports (0.01 to 0.25 percent of annual enplanements) and 279 nonprimary airports enplaning at least 2,500 passengers annually.
[f]Made up of $108 million for discretionary grants, $64 million for noise projects, and $8 million for planning.
[g]Grants for noise projects and planning at currently authorized levels.

SOURCE: Office of Technology Assessment.

million per year under the State administration policy would be double the $85 million allocated to them by the present AIP distribution formula.[24]

Reliever and GA airports would also be likely to receive more funding under the State administration policy than they do today. This is somewhat conjectural, however, since there is no way to predict how States might choose to allocate discretionary funds. Distribution of $133 million per year to each of these two classes of airports assumed for illustrative purposes is by no means assured. Still, it seems reasonable to conclude that GA airports, at least, would fare better under State administration. State agencies have historically shown strong interest in GA airports, and more than half of all State-supplied airport funds typically go to such small facilities.

This policy might benefit general aviation airports in another way. At present, there are about 1,000 more airports in the aggregate of all State Airport System Plans than there are in the National Airport System Plan.[25] It seems likely that an airport program administered by the States would include all publicly owned airports within their boundaries and that the 1,000 or so not now eligible for Federal assistance would receive some part of State discretionary grants.

State administration might also have two favorable effects on all types of airports. First, availability of a substantial sum of money under State agency control might make it easier for some airports to obtain aid since they would have to compete for funds only with other airports in the State and not those in a region or the country as a whole. Second, grant applications and funding awards might be processed more promptly under a State-administered program than they are by FAA, which has jurisdiction over the entire country. State agencies and local airport authorities often complain about delays in securing FAA approval or in obtaining funds after grants are approved. By distributing these FAA functions to State agencies, this policy could afford airport operators more ready access to funding authorities, quicker administrative action, and less delay in the delivery of funds after the decision has been made.

Effects on Airport Users

For the users of airports now eligible for Federal grants, there would probably be little or no change under the State administration policy. At large and medium commercial service airports, the funds available for capacity-related improvements would be about the same as under present policy. Users of reliever and small GA airports could find these facilities improved due to the greater amount that might be awarded under State-agency administration. Overall, this policy would be unlikely to affect airport congestion and delay, except insofar as increased funding for reliever airports could hasten the expansion or upgrading of these facilities.

Effects on the Airport System

As postulated here, State administration would not alter the amount of funding available for airport development, but it would radically shift the present balance by allotting funds in roughly equal amounts among the five classes of airports. This would be achieved by reducing slightly the share for large and medium airports (compared to the present AIP formula) and reallocating these funds to the other three classes, along with that portion of Trust Fund outlays now reserved for FAA discretionary grants. In effect, this policy would devote half of annual Trust Fund outlays to airports serving airline passengers and the other half to those serving general aviation (with some degree of overlap of these two functions at many commercial service airports). Thus, this policy reflects the view that air transportation is of two kinds, with each entitled to more or less equal Trust Fund support. On one hand, there are common carriers providing public air transportation. On the other, there are those who use the airspace and airport system for private business and personal purposes that may also provide public benefit. By providing aid in an evenhanded way, this policy affirms the importance of both to interstate commerce and the public welfare.

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[24]Primary commercial service airports enplaning between 0.25 and 0.01 percent of total annual passengers are collectively entitled to about $45 million under the current AIP authorization. Nonprimary commercial service airports (those with less than 0.01 percent but at least 2,500 passengers annually) are allotted 5.5 percent of Trust Fund outlays, which amounts to $45 million per year under present authorizations for 1983-87.

[25]In 1982, the State Aviatjon System Plans contained a total of 4,634 airports; the NASP had 3,599. *NASAO Databank 1983* (Washington, DC, National Association of State Aviation Officials, March 1983).

Appendixes

Appendix A

ACRONYMS AND ABBREVIATIONS

ADAP — Airport Development Program
AERA — Advanced En Route Automation
AIP — Airport Improvement Program
AOCI — Airport Operators Council International
ARTS — Automated Radar Terminal System
ASDE — Airport Surface Detection Equipment
ASR — Airport Surveillance Radar
ATA — Air Transport Association
ATC — air traffic control
ATCRBS — Air Traffic Control Radar Beacon System
AWOS — Automated Weather Observation System
CAA — Civil Aeronautics Administration
CAB — Civil Aeronautics Board
CAPIS — Customs Accelerated Passenger Inspection Service
CBO — Congressional Budget Office
CDTI — Cockpit Display of Terminal Information
CNEL — Community Noise Equivalent Level
dB — decibel
dBA — decibel (A-weighted)
DOT — Department of Transportation
EPNdB — Effective Perceived Noise Decibels
FAA — Federal Aviation Administration
FAR — Federal Aviation Regulations
FBO — fixed base operator
FHWA — Federal Highway Administration
FIS — Federal Inspection Service
FY — fiscal year
GA — general aviation
GNP — gross national product
GTW — gross takeoff weight
IATA — International Air Transport Association
ICAO — International Civil Aviation Organization
IFM — Integrated Flow Management
IFR — Instrument Flight Rules
ILS — Instrument Landing System
IMC — Instrument Meteorological Conditions
JAWOS — Joint Automated Weather Observation System
JAWS — Joint Airport Weather Studies
LLWSAS — Low Level Wind Shear Alert System
Ldn — Day-Night Average Sound Level
MLS — Microwave Landing System
Mode S — Discrete Address Secondary Radar System (with data link)
NAR — National Airspace Review
NAS — National Airspace System
NASA — National Aeronautics and Space Administration
NASAO — National Association of State Aviation Officials
NASCOM — National Airspace Command Center
NASP — National Airport System Plan
NEF — Noise Exposure Forecast
NEXRAD — Next Generation Weather Radar
nmi — nautical mile
NPIAS — National Plan of Integrated Airport Systems
OSEM — FAA Office of System Engineering Management
PANCAP — Practical Annual Capacity
PATCO — Professional Air Traffic Controllers Organization
PFC — passenger facility charge
PGP — Planning Grant Program
PHOCAP — Practical Hourly Capacity
PMS — Performance Measurement System
ROT — runway occupancy time
SASP — State Aviation System Plan
SDRS — Standard Air Carrier Delay Reporting System
SMSA — Standard Metropolitan Statistical Area
STOL — Short Takeoff and Landing (aircraft)
TAF — Terminal Area Forecast
TAGS — Tower Automated Ground Surveillance System
TCAS — Traffic Alert and Collision Avoidance System
TMS — Traffic Management System
TPX-42 — Military Radar Beacon Decoder
UHF — Ultra High Frequency (radio)
UMTA — Urban Mass Transportation Administration
VAS — (Wake) Vortex Advisory System
VFR — Visual Flight Rules
VHF — Very High Frequency (radio)
VMC — Visual Meteorological Conditions

Airport Designators

The Federal Aviation Administration and the ***Official Airline Guide*** employ a standard three-letter abbreviation to identify commercial service airports. The identifiers for large airports—those enplaning 1 percent or more of airline passengers in 1982—are listed below.

ATL	— Atlanta, William B. Hartsfield International
BOS	— Boston, Logan International
DAL	— Dallas, Love Field
DCA	— Washington National Airport
DEN	— Denver, Stapleton International
DFW	— Dallas-Fort Worth Regional
DTW	— Detroit, Metropolitan Wayne County
EWR	— Newark
HNL	— Honolulu International
IAH	— Houston Intercontinental
JFK	— New York, John F. Kennedy International
LAS	— Las Vegas, McCarran International
LAX	— Los Angeles International
LGA	— New York, La Guardia
MCO	— Orlando International
MIA	— Miami International
MSP	— Minneapolis-St. Paul
MSY	— New Orleans International, Moisant Field
ORD	— Chicago, O'Hare International
PHL	— Philadelphia International
PHX	— Phoenix, Sky Harbor International
PIT	— Greater Pittsburgh International
SEA	— Seattle-Tacoma International
SFO	— San Francisco International
STL	— St. Louis (Lambert) International
TPA	— Tampa International

Appendix B
SURVEY OF CURRENT AIRPORT FINANCIAL MANAGEMENT PRACTICES

The data on the financial policies and practices of **60** large and medium airports used in this study were gathered in a survey conducted by CBO in the summer of 1983. These data are summarized in the following table, which lists the airports surveyed in rank order of passenger boardings (enplanements) in calendar year 1982. It gives each airport's size (in terms of passenger boardings), type of public operator, and financial management approach (see ch, **6).** It also undicates whether or not the airport has a use agreement containing a majority-in-interest clause, the terms and expiration dates of current use agreements (if any), and any recent, ongoing, or planned changes in financial management or related developments.

Table B-1.—CBO Survey Data on Financial Management Practices at 60 Large and Medium Commercial Airports, 1983 (Numbers of enplanements in 1982 in parentheses)

Financial Management Approach	Majority-in-Interest Clause	Term and Expiration Date of Use Agreement	Recent or Planned Changes
HARTSFIELD ATLANTA INTERNATIONAL (17,653,400), Run by city			
Residual cost, but terminal concession revenues shared by city and airlines	Yes (all capital projects involving increase in landing fee)	30 years (2010)	Basic landing fee will be renegotiated in 1991
CHICAGO-O'HARE INTERNATIONAL (17,428,127), Run by city			
Residual cost	Yes	35 years (2018)	Allocation of costs, majority-in-interest clause revised in new agreement; clause protecting right to levy passenger facility charge included
LOS ANGELES INTERNATIONAL (15,758,082), Run by semi-autonomous department of the city			
Residual cost	No, but airlines must approve debt financing exceeding $515 million limit in use agreements	30 years (1992); 40 years (United and American)	Terminal leases of five years or less where possible, except when airlines make extensive capital commitments (terminal modifications by United and American Airlines); shorter-term, more compensatory agreements anticipated after 1992

(Continued)

Table B-1 .—CBO Survey Data on Financial Management Practices at 80 Large and Medium Commercial Airports, 1983 (Numbers of enplanements in 1982 in parentheses) (continued)

Financial Management Approach	Majority-in-Interest Clause	Term and Expiration Date of Use Agreement	Recent or Planned Changes
NEW YORK--JOHN F. KENNEDY INTERNATIONAL (12,490,411), Run by port authority			
Compensatory	None	25 years (2004)	JFK and LaGuardia are leased from New York City; city's share of these airports' net revenues will rise from 60 to 75 percent in 1985
DALLAS-FORT WORTH REGIONAL (12,401,626), Run by both cities			
Residual Cost	None	40 Vears (2014)	None reported
DENVER-STAPLETON INTERNATIONAL (1 1,608,458), Run by city/county			
Compensatory	None	28 years (1992)	May move to annual adjustment of fees and rental rates next year (currently adjusted biennially)
SAN FRANCISCO INTERNATIONAL (9,915,042), Run by city/county			
Residual cost	Yes, but can only defer for six months	30 years (201 1)	Current revenue may not be used to fund capital development over $2 million in any one year. City must exercise best efforts to issue revenue bonds to finance capital development
MIAMI INTERNATIONAL (9,256,017), Run by county			
Residual cost, but some properties excluded from revenue base in calculating residual cost	Yes (except $1 million Discretionary Fund and projects supported by revenues not counted in revenue base)	25 years (1987)	Month-to-month leasing of terminal space when leases expire or new space added. Last year, moved from three-year to annual rent adjustments
NEW YORK--LAGUARDIA (9,235,150), Run by port authority			
Compensatory	None	Being negotiated (25-year lease expired in 1980)	Airport seeking shorter-term (ten-year) lease. LaGuardia and JFK are leased from New York City; city's share of net revenues will rise from 60 percent to 75 percent in 1985

(Continued)

Table B-1 .—CBO Survey Data on Financial Management Practices at 80 Large and Medium Commercial Airports, 1983 (Numbers of enplanements in 1982 in parentheses) (continued)

Financial Management Approach	Majority–in-Interest Clause	Term and Expiration Date of Use Agreement	Recent or Planned Changes
BOSTON LOGAN INTERNATIONAL (7,934,881), Run by port authority			
Compensatory	None	No use agreements	Short-term leases will be developed in an effort to maintain flexibility in terminal space allocations
HONOLULU INTERNATIONAL (7,533,909), Run by state			
Residual cost	None	30 years (1992)	Last year, created minimum landing fee for airlines and raised inter-island carriers' fee; interest from bond proceeds now to be used for capital development rather than credited to airlines
HOUSTON INTERCONTINENTAL (6,371,546), Run by city			
Compensatory	No	28 years (1997)	Much future capital development planned
WASHINGTON NATIONAL (6,333,478), Run by federal government			
Compensatory, but FBO revenues credited to landing area	No	Ten years (1984)	None reported
IAMBERT-ST. LOUIS INTERNATIONAL (5,962,71 8), Run by city			
Compensatory	Yes	40 years (2005)	Terminal rentals will be adjusted annually as leases expire (currently adjusted every two years)
NEWARK (N. J.) (5,817,050), Run by port authority			
Compensatory	None	25 years (1998)	Moving to shorter-term building leases, as possible. City's share of net revenues will rise from 60 percent to 75 percent in 1986
MINNEAPOLIS-ST. PAUL INTERNATIONAL (5,337,845), Run by airport authority			
Residual cost (airfield); terminal, compensatory	Yes, for airfield area only	27 years (1989)	None reported

(Continued)

Table B-1.—CBO Survey Data on Financial Management Practices at 60 Large and Medium Commercial Airports, 1983 (Numbers of enplanements in 1982 in parentheses) (continued)

Financial Management Approach	Majority-in-Interest Clause	Term and Expiration Date of Use Agreement	Recent or Planned Changes
	GREATER PITTSBURGH INTERNATIONAL (5,029,694), Run by county		
Residual cost	None	Two years (1983) + 1-year renewal option (1984)	Majority-in-interest clause deleted in new agreement; clause added protecting airport's right to levy passenger facility charge if law permits
	SEATTLE-TACOMA INTERNATIONAL (5,012,249), Run by port authority		
Residual cost; terminal, compensatory	Airport Affairs Committee reviews and approves capital projects	32 years (2001); month-to-month	Will offer month-to-month tenants five-year "rollover" leases (five years with three five-year renewal options)
	DETROIT METROPOLITAN WAYNE COUNTY (4,935,203), Run by county		
Residual cost	Yes (except for airport Discretionary Fund projects)	(2009)	None reported
	LAS VEGAS--MCCARRAN INTERNATIONAL (4,655,484), Run by county		
Compensatory	None	No use agreements (ordinance)	None reported
	PHILADELPHIA INTERNATIONAL (4,403,541), Run by city		
Residual cost	Yes (can disapprove any project with life of more than five years, costing over $100,000)	32 years (2006)	None reported
	PHOENIX SKY HARBOR INTERNATIONAL (4,007,579), Run by city		
Compensatory	None	No use agreements (ordinance)	Might move in future to some form of lease/use agreement to protect airporl in post-deregulatory environment

(Continued)

Table B-1.—CBO Survey Data on Financial Management Practices at 80 Large and Medium Commercial Airports, 1983 (Numbers of enplanements in 1982 in parentheses) (continued)

Financial Management Approach	Majority-in-Interest Clause	Term and Expiration Date of Use Agreement	Recent or Planned Changes
TAMPA INTERNATIONAL (3,861,509), Run by airport authority			
Residual cost	Yes, but no clear direct veto power; excludes Discretionary Fund and all projects in Master Plan	30 years (1999)	None reported
ORLANDO INTERNATIONAL (3,383,495), Run by airport authority			
Residual cost	Yes	28 years (2008)	Developing 1400-acre industrial park to maximize revenues
NEW ORLEANS INTERNATIONAL (3,020,438), Run by city			
Residual cost	Yes (except small Discretionary Fund)	20 years (1992)	None reported
CHARLOTTE-DOUGLAS INTERNATIONAL (2,860,092), Run by city			
Compensatory	Yes, airfield only (projects that will increase airline fees)	25 years (2004)	Revenues have increased since Charlotte became Piedmont's major hub
SAN DIEGO INTERNATIONAL (2,818,374), Run by port authority			
Compensatory	None	15 years (1994); month-to-month (new entrants)	Term shortened for recent entrants
SALT IAKE CITY INTERNATIONAL (2,703,003), Run by city (in process of forming airport authority)			
Compensatory	Yes (approve capital projects over $50,000; one signatory airline suf- ficient to approve)	25 years (2003)	Revenues have grown because of hub operations, but bond rating fell due to Western's financial problems and cost allocation dispute over terminal development project (now resolved)
CLEVELAND HOPKINS INTERNATIONAL (2,656,252), Run by city			
Residual cost	Yes (except Discretionary Fund); can disapprove projects over $250,000 (1976 dollars), but city can override airlines after projects have been disapproved twice	30 years (2005)	None reported

(Continued)

Table B-1.—CBO Survey Data on Financial Management Practices at 60 Large and Medium Commercial Airports, 1983 (Numbers of enplanements in 1982 in parentheses) (continued)

Financial Management Approach	Majority-in-Interest Clause	Term and Expiration Date of Use Agreement	Recent or Planned Changes
KANSAS CITY INTERNATIONAL (2,623,808), Run by city			
Compensatory	Yes, for airfield capital projects (except Discretionary Fund)	28 years (1998)	None reported
MEMPHIS INTERNATIONAL (2,290,930), Run by airport authority			
Residual cost	Yes, all projects over $5,000 (except Discretionary Fund)	30 or more years (1999)	Growth of Federal Express has helped offset loss in commercial air carrier landed weights; landing fees and rentals reduced recently
BALTIMORE-WASHINGTON INTERNATIONAL (2,269,164), Run by state			
Compensatory (modified; space rentals set too low to recover costs)	Yes (projects over $25,000)	15 years (1993) plus ten-year renewal (2003)	None reported
PORTLAND (ORE.) INTERNATIONAL (1,928,054), Run by port authority			
Residual cost	Yes (except Discretionary Fund)	20 years (1991)	None repofied
SAN ANTONIO INTERNATIONAL (1,776,650), Run by city			
Compensatory	None	Eight years (1984)	New agreement being negotiated probably will be very similar to existing one
I(AHULUI (MAUI) (1,670,782), Run by state			
Residual cost	None	30 years (1992)	None reported
GREATER CINCINNATI INTERNATIONAL (1,663,686), Run by airport authority			
Residual cost	Yes (all projects over $50,000, except Discretionary Fund)	30 years (2002)	Concession revenues have increased since Cincinnati became a hub for Delta

(Continued)

Table B-1.—CBO Survey Data on Financial Management Practices at 60 Large and Medium Commercial Airports, 1983 (Numbers of enplanements in 1982 in parentheses) (continued)

Financial Management Approach	Majority-in-Interest Clause	Term and Expiration Date of Use Agreement	Recent or Planned Changes
	MILWAUKEE--GENERAL MITCHELL FIELD (1,61 1,100), Run by county		
Residual cost	Yes, but can only defer projects for 2 years (projects over $100,000, or several adding up to $200,000)	25 years (2010)	Went to long-term residual cost agreement to finance new terminal, to be completed in 1985
	PALM BEACH INTERNATIONAL (1,607,760), Run by county		
Residual cost	None	17 years (1984)	Airport seeks compensatory approach, much shorter term for new agreement. Major improvements to begin in 1985
	SAN JOSE MUNICIPAL (1,520,519), Run by city		
Residual cost	None	30 years (2009); three to five years (new entrants)	Moving to shorter-term agreements for recent entrants and adjusting terminal rental rates upwards, as possible
	INDIANAPOLIS INTERNATIONAL (1,383,01 1), Run by airport authority		
Compensatory	None	One to five years (ordinance); some carriers operating without agreement	Ratemaking subject to challenge in litigation pending in U.S. Circuit Court of Appeals, Seventh Circuit
	PORT COLUMBUS INTERNATIONAL (1,315,612), Run by city		
Residual cost (airfield); terminal--concession revenues go to airport	Yes, airfield only (projects over $25,000)	25 years (2000)	None reported
	OKLAHOMA CITY--WILL ROGERS WORLD (1,302,459), Run by city		
Compensatory (modified; airlines do not contri - bute to most capital development)	None	30 years (1997); one to five years (new entrants)	Rates negotiated by supplemental agreements every five years. New entrants are offered one-year agreements until expiration of five-year cycle

(Continued)

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Table Bo1.—CBO Survey Data on Financial Management Practices at 80 Large and Medium Commercial Airports, 1983 (Numbers of enplanements in 1982 in parentheses) (continued)

Financial Management Approach	Majority-in-Interest Clause	Term and Expiration Date of Use Agreement	Recent or Planned Changes
	RENO CANNON INTERNATIONAL (1,281,393), Run by airport authority		
Residual cost	Yes, but airport can override after two deferrals	17 years (1996)	Short-term lease and use agreement now available
	TULSA INTERNATIONAL (1,274,199), Run by airport authority		
Residual cost	Yes (projects over $400,000; except Discretionary Fund)	30 years (2008)	None reported
	ALBUQUERQUE INTERNATIONAL (1,269,279), Run by city		
Compensatory	None	Renegotiating; last agreement two to five years (1981)	New agreement will resemble previous one
	WINDSOR LOCKS (CT.) --BRADLEY INTERNATIONAL (1,232,669), Run by state		
Compensatory	Yes (airfield projects over $250,000, terminal projects over $75,000)	30 years (201 1)	None reported
	SACRAMENTO METROPOLITAN (1,227,096), Run by county		
Residual cost	Yes, but can only defer projects for two years (projects over $100,000; except Discretionary Fund)	Five years (1986)	Term, rate-setting practices, and majority-in-interest clause altered in new agreement
	Washington, D. C.--DULLES INTERNATIONAL (1,207,343), Run by federal government		
Compensatory (but FBO revenues credited to landing area)	None	10 years (1984)	None reported

(Continued)

Table B.1.-CBO Survey Data on Financial Management Practices at 80 Large and Medium Commercial Airports, 1983 (Numbers of enplanements in 1982 in parentheses) (continued)

Financial Management Approach	Majority-in-Interest Clause	Term and Expiration Date of Use Agreement	Recent or Planned Changes
NORFOLK INTERNATIONAL (1,1 96,286), Run by port authority			
Residual cost	Yes, can request cost justification, and arbitration if not satisfied, for any item in capital budget	25 years (1999)	None reported
NASHVILLE METROPOLITAN (1,1 53,019), Run by airport authority			
Residual cost	Yes (projects over $20,000)	30 years (2005)	None reported
AUSTIN--MUELLER MUNICIPAL (1,1 15,992) Run by City			
Compensatory	Not formal, but implied in lease for projects for which airline rates amortize airport costs	Five years (1988)	Term shortened and ratemaking approach changed in new agreement (effective 1 March 1983)
JACKSONVILLE INTERNATIONAL (1,008,891), Run by port authority			
Compensatory (modified)	None	20 years (1990)	None reported
LIHUE (KAUAI) (995,512), Run by state			
Residual cost	None	30 years (1992)	None reported
EL PASO INTERNATIONAL (994,102), Run by city			
Residual cost	None	Renegotiating; last agreement 20 years (1982)	None reported
ONTARIO (CAL) INTERNATIONAL (989,024), Run by semi-autonomous department of the city of Los Angeles			
Residual cost	None	Five years (1985)	Landing fees same as Los Angeles International; *only* Southern California airport with capacity to expand

(Continued)

Table B-1.—CBO Survey Data on Financial Management Practices at 60 Large and Medium Commercial Airports, 1983 (Numbers of enplanements in 1982 in parentheses) (continued)

Financial Management Approach	Majority-in-Interest Clause	Term and Expiration Date of Use Agreement	Recent or Planned Changes
RALEIGH-DURHAM (941,005), Run by airport authority			
Compensatory	None	No use agreements	None reported
LOUISVILLE--STANDIFORD FIELD (922,009), Run by airport authority			
By negotiation (noncompensatory, but not residual cost)	None	Renegotiating; last agreement 30 or more years (1983)	Airport seeks shorter term, fully compensatory terminal, residual cost airfield in new agreement
TUCSON INTERNATIONAL (900,547), Run by airport authority			
Residual cost	Yes, projects over $35,000 (except Special Reserve Fund) and next year's budget	30 years (2006)	$60 million terminal expansion project under way, to be completed in April 1985
OMAHA--EPPLEY AIRFIELD (848,257), Run by airport authority			
Compensatory	No	Year-to-year (1984)	Major terminal expansion project will begin in 1984
COX DAYTON INTERNATIONAL (806,464), Run by city			
Residual cost	Yes, projects over $10,000 (except Discretionary Fund)	23 years (1996)	Traffic has increased significantly since Dayton became hub for Piedmont. Terminal apron overlay project to begin in 1984; possible terminal expansion in 1985

SOURCE: Congressional Budget Office

Appendix C

IMPACT OF MANAGEMENT APPROACH AND AIRPORT SIZE ON AIRPORT FINANCIAL PERFORMANCE

The analysis in chapters 6 and 7 divides airports into the three size categories (large, medium, and small) based on passager enplanements. Such divisions, though useful, are necessarily arbitrary, and should be understood to carry the caution that slight changes in definition can shift conclusions regarding the effect of airport size on financial performance. A similar caution should be applied in assessing the relative shifts in financial performance between large and small airports following Federal deregulation of the airlines, at which time major air carriers curtailed service to some small airports in favor of the larger facilities serving more profitable routes.

To overcome the problems created by arbitrary distinctions in airport size, the Congressional Budget Office has related airport financial data to airport size as a continuous variable. The statistical results are reported in table C-1 and interpreted numerically in table C-2. As shown in table C-2, the approach to financial management and the volume of traffic served by the airport bear significantly on financial performance.

Effect of Management Approach

Airports that use the compensatory approach have net take-down ratios better, on average, by 24 percent than residual-cost airports, and debt service safety margins more than twice as good. There are two possible interpretations of this result, however. One is that the added earning power possible with the compensatory approach improves an airport's financial performance. A second is that only those airports in the strongest travel markets turn to the compensatory approach

Table C-1 .—Ordinary Least Squares Regression Estimates for Airport Financial Performance, Pooled Cross-Sections, 1975-82

	Log Operating ratio	Net Log take-down ratio	Log Debt-to-asset ratio	Log Debt-service safety margin
Constant	5.894	1.883	1.647	1.334
	(29.22)	(8.770)	(3.192)	(3.223)
Financial management approach (1 = compensatory.	–0.101	0.218	–0.145	0.791
	(- 1.873)	(3.873)	(– 1.096)	(7.575)
Log of Enplanements:				
1975 ratios	–0.238	0.253	0.182	0.184
	(-9.081)	(8.752)	(2.423)	(3.300)
1976 ratios	–0.229	0.228	0.244	0.124
	(-9.099)	(8.148)	(3.657)	(2.400)
1977 ratios	–0.231	0.229	0.233	0.167
	(-9.280)	(8.596)	(3.636)	(3.277)
1978 ratios	–0.230	0.299	0.249	0.179
	(-9.036)	(8.483)	(3.864)	(3.472)
1979 ratios	–0.235	0.238	0.274	0.206
	(–9.493)	(9.055)	(4.315)	(4.092)
1980 ratios	–0.237	0.240	0.272	0.217
	(-9.456)	(9.016)	(4.221)	(4.271)
1981 ratios	–0.241	0.243	0.257	0.207
	(–9.791)	(9.316)	(4.080)	(4.126)
1982 ratios	–0.261	0.242	0.282	0.173
	(–9.933)	(9.104)	(3.033)	(3.402)
R'	0.588	0.579	0.272	0.569
F value	12.760	12.985	2.701	12.320

NOTE: "t-ratios" are given in parentheses. Logs are natural logs.

SOURCE: Congressional Budget Office.

in the first place. Both explanations may apply to some extent.

Debt-to-asset ratio appears not to be affected by management approach—i.e., no statistically significant relationship is apparent. This is not surprising, as management approach itself need not influence the actual level of investment. There is also no statistically significant relationship between management approach and operating ratio.

Effect of Airport Size

Airport size has a measurable influence on financial performance. As shown in table C-2, the elasticity of airport size with respect to an airport's operating ratio lies at about –0.24. This means that each 10-percent increase in the volume of traffic improves the airport's operating ratio by **2.4** percent. Conversely, each lo-percent fall in traffic volume causes an estimated **2.4** percent deterioration in operating ratio. Similar relationships emerge for the other financial indicators shown in table C-2.

Table C-2.—Estimated Impact of Approach to Financial Management and Airport Size on Airport Financial Performance (95 percent confidence Intervals In parentheses)

	Operating ratio	Net take-down ratio	Debt-to-asset ratio	Debt-service safety margin
Percentage differences in financial performance at compensatory relative to residual-cost airports	−9.61	24.35	−13.47	120.49
	(±10.56)	(±11.03)	(±25.88)	(±20.46)
Elasticity with respect to number of enplaned passengers:				
1975	−0.24	0.25	0.18	0.18
	(±0.05)	(±0.06)	(±0.15)	(±0.11)
1976	−0.23	0.23	0.24	0.12
	(−0.05)	(+0.05)	(±0.13)	±0.10)
1977	−0.23	0.23	0.23	0.17
	(±0.05)	(±0.05)	(±0.13)	(±0.10)
1978	−0.23	0.23	0.25	0.18
	(±0.05)	(±0.05)	(±0.13)	(±0.10)
1979	−0.13	0.24	0.27	0.21
	(±0.05)	(±0.05)	(±0.13)	(±0.10)
1980	−0.24	0.24	0.27	0.22
	(±0.05)	(±0.05)	(±0.12)	(±0.01)
1981	−0.24	0.24	0.26	0.21
	(±0.05)	(±0.05)	(±0.12)	(±0.10)
1982	−0.26	0.24	0.28	0.17
	(±0.05)	(±0.05)	(±0.18)	(±0.10)

SOURCE: Table C-1.

Appendix D

FACTORS AFFECTING AIRPORT COSTS OF CAPITAL

The statistical (regression) analysis summarized in table D-1 attempts to quantify the effects of four factors on interest costs paid by the issuers of airport bonds: general market conditions, type of security used to back airport bonds, numbers of years in which bonds mature, and airport size (in terms of numbers of passenger enplanements).

The results indicate that interest costs and market conditions are proportional; a l-percent change in market interest costs yields roughly a l-percent change in airport interest costs. Issuers of general obligation bonds, on average, obtain 8 percent lower interest costs than issuers of revenue bonds (see table D-2). Further, the regression provides statistical confirmation of the typical bond yield curve, with longer-term issues requiring higher interest rates. As the average maturity of the bond increases, so does the average interest paid, with a lo-percent increase in maturity resulting, on average, in a 1.1-percent increase in the interest rate over this period. The analysis also shows that, after adjustments are made for these other factors, the larger the airport, the lower the interest rate, On average, 10 percent more enplanements results in a 1- to I. S-percent decrease in interest.

Table D-1 .—Ordinary Least Squares Regression Estimates, Pooled Cross.Section: 1978-82

	Log interest cost
Constant	–0.174 (–1.105)
Log of Bond Buyer's 20 Bond Market Index	0.992 (14.355)
Bond security (general obligation = 1)	–0.088 (–4.520)
Log of average maturity	0.111 (6.739)
Log of enplanements:	
1978	–0.0146 (-2.844)
1979	–0.0117 (–2.208)
1980	–0.0123 (–2.421)
1981	–0.0113 (–1.988)
1982	–0.0156 (–2.783)
R'	0.896
F value	125.576

NOTE: "t-ratios" are given in parentheses. Logs are natural logs.

SOURCE: Congressional Budget Office.

Table D.2.—Estimated Impact of Market Interest Rates, Type of Security, Average Maturity, and Airport Size on Airport Cost of Capital, 1978-82
(95 **percent confidence intervals in parentheses)**

	Interest cost
Elasticity with respect to market interest rates	0.99 (*0.14)
Percentage difference in interest costs of general obligation versus revenue bonds	–8.4 (+3.8)
Elasticity with respect to average maturity of issues	0.1115 (*0.0324)
Elasticity with respect to number of enplaned passengers:	
1978, .,	**−0.0146 (±0.0100)**
1979	**−0.0117 (±0.0103)**
1980	**−0.0123 (±0.0099)**
1981	**−0.0113 (±0.0111)**
1981	**−0.0156** (* O.O11O)

SOURCE: Table D-1.

Appendix E

AIRPORTS IN THE MUNICIPAL BOND MARKET: A REGIONAL ANALYSIS

This appendix summarizes the participation of airports in the municipal bond market by FAA region over the 1978-82 period (see table E-1) and charts regional differences in interest rates paid on airport bonds relative to other municipal bonds (table E-2).

The FAA breaks down regions as follows:

- New ***England Region:*** Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont.
- *Eastern Region:* Delaware, District of Columbia, Maryland, New Jersey, New York, Pennsylvania, Virginia, West Virginia.

Table E.l.—Bond Issues for Airports by Region, 1978-82

Region	Number of issues	In millions of 1982 dollars: Average size of issue	In millions of 1982 dollars: Value of issues	Percent of total: Number of issues	Percent of total: Value of issues
New England:					
General obligation	3	0.4	1.1	1.3	a
Revenue	1	100.2	100.2	0.4	2.0
Subtotal	4	25.3	101.2	1.7	2.0
Eastern:					
General obligation	7	8.2	57.3	2.9	1.1
Revenue	21	14.9	312.4	8.8	6.2
Subtotal	28	13.2	369.7	11.8	7.3
Southern:					
General obligation	9	9.2	82.4	3.8	1.6
Revenue	34	44.0	1,496.8	14.3	29.7
Subtotal	43	36.7	1,579.2	18.1	31.3
Great Lakes:					
General obligation	43	4.3	185,1	18.1	3.7
Revenue	17	10.3	174.6	7.1	3.5
Subtotal	60	6.0	359.6	25.2	7.1
Central:					
General obligation	13	1.9	25.2	5.5	0.5
Revenue	8	12.9	103.4	3.4	2.0
Subtotal	21	6.1	128.6	8.8	2,5
Northwest Mountain:					
General obligation	4	2.3	9.2	1.7	0.2
Revenue	15	21.1	315.8	6.3	6.3
Subtotal	19	17.1	325.0	8.0	6.4
Western Pacific:					
General obligation	5	5.5	27.3	2.1	0.5
Revenue	20	52.7	1,053.6	8.4	20.9
Subtotal	25	43.2	1,080.9	10.5	21.4
Southwest:					
General obligation	7	3.2	22.5	2.9	0.4
Revenue	30	35.9	1,077.1	12.6	21.3
Subtotal	37	29.7	1,099.6	15.5	21.8
Alaska[b]:					
General obligation	1	3.0	3.0	0.4	0.1
All regions:					
General obligation	92	4.5	413.0	38.7	8.2
Revenue	146	31.7	4,633.8	61.3	91.8
Total	238	21.2	5,046.8	100.0	100.0

[a]Less than 0.05 percent.
[b]No revenue bonds issues for this region.

SOURCE: Congressional Budget Office.

Table E-2.—Differences in Interest Rates Paid on Airport Bonds Relative to Other Municipal Bonds by Region, 1978-82 (in basis points)

Region	1978	1979	1980	1981	1982	1978-82
New England:						
General obligation	–58	a	– 122	a	a	–79
Revenue	NIA	a	a	a	22	22
Eastern:						
General obligation	a	– 4	a	–57	–18	–26
Revenue	N/A	a	–47	–469	–36	– 137
Southern:						
General obligation	–71	–51	–95	a	a	–70
Revenue	NIA	– 101	– 156	–77	8	–63
Great Lakes:						
General obligation	–75	–36	–43	–75	–54	–59
Revenue	NIA	a	–223	–74	– 142	– 154
Central:						
General obligation	–88	–32	a	– 153	–81	–94
Revenue	N/A	a	a	22	a	22
Northwest Mountain:						
General obligation	– 102	–69	a	a	–237	–119
Revenue	NIA	N/A	– 102	a	–37	–53
Western Pacific:						
General obligation	93	a	– 109	–115	– 138	–35
Revenue	NIA	64	17	– 8	–15	5
Southwest:						
General obligation	a	–70	–46	a	– 8	–49
Alaska:						
General obligation	a	a	a	a	–42	–42
Revenue	NIA	a	a	a	a	b
Total:						
General obligation	–63	–46	–73	–89	–66	–65
Revenue	NIA	–29	– 103	– 123	–32	–70

NOTES: Data reflect difference in interest rates between airport bonds and other general obligation and revenue bond issues, in basis points. General obligation issues are compared with the average value of the Bond Buyer's Index of 20 municipal bonds during the month of issue. Revenue bonds are compared with the Bond Buyer's Revenue Bond Index during the month of June. Revenue bond figures for 1979 based on September-December only. N/A = data not available

[a]No issues with this security in this **Year.**

[b]No issues with this security in this **region.**

SOURCE: Congressional Budget Office.

- ***Southern Region:*** Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, Puerto Rico, South Carolina, Tennessee, Virgin Islands
- ***Great Lakes Region:*** Illinois, Indiana, Michigan, Minnesota, North Dakota, Ohio, South Dakota, Wisconsin.
- ***Central Region:*** Iowa, Kansas, Missouri, Nebraska.
- *Northwest Mountain Region:* Colorado, Idaho, Montana, Oregon, Utah, Washington, Wyoming.
- *Western Pacific Region:* Arizona, California, Guam, Hawaii, Nevada.
- *Southwest Region:* Arkansas, Louisiana, New Mexico, Oklahoma, Texas.
- *Alaskan Region:* Alaska.

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