RELIEVING AIRPORT CONGESTION: POLICY CHANGES NECESSARY FOR THE EFFECTIVE CONTROL OF DEMAND FOR AIRPORT RESOURCES

by

Aaron Todd Curtis

B.S.E., Princeton University

(1981)

M.S., University of Texas at Austin

(1983)

SUBMITTED TO THE DEPARTMENT OF ELECTRICAL ENGINEERING
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE
OF

MASTER OF SCIENCE
IN TECHNOLOGY AND POLICY

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
February 1990

Signature of Author_____
Department of Electrical Engineering and Computer Science
November 17, 1989

Certified by_____
Amedeo R. Odoni
Thesis Supervisor

Accepted by_____
Richard deNeufville
Chairman, Technology and Policy Program

RELIEVING AIRPORT CONGESTION: POLICY CHANGES NECESSARY FOR THE EFFECTIVE CONTROL OF DEMAND FOR AIRPORT RESOURCES

by

Aaron Todd Curtis

Submitted to the Technology and Policy Program on November 17, 1989

in partial fulfillment of the requirements for the Degree of

Master of Science in Technology and Policy

ABSTRACT

This thesis examines the effect that changing the emphasis of the federal government's approach to airport fee structures would have on congestion and flight delays at U.S. airports. Descriptions of the domestic air transportation system, the nature of federal control over airport authorities, and currently proposed technical solutions to airport congestion are given, as are queueing models that illustrate the relationship between demand for flight operations at an airport and the service delays that are experienced by the users.

Allowing local airport authorities to implement market based incentives to reduce peak demand for flight operations would better serve to allocate increasingly scarce airport resources. The changes advocated in this thesis would not require a departure from the tradition of open access to the nation's federally supported airports, but they serve to reduce the incidence and effects of airport congestion by allowing the cost of flight operations to reflect their value to the aircraft operators.

Thesis Supervisor: Dr. Amedeo R. Odoni

Title: Professor of Aeronautics and Astronautics and of Civil Engineering

3

Page

Chapter 1: Introduction and Overview

The airport congestion problem in the United States has several causes, among them the growth of passenger travel, the lack of major airport construction, the political and economic forces that limit airport development, and the limitations imposed on airport authority control over airport access. The problem to be resolved for airport operators and airport users is how airport congestion and associated problems like passenger delays can be alleviated. There are two ways this may be done, by building more airport and air traffic control capacity or by limiting or controlling demand for airport access. The common response of the federal government and airport authorities to problems caused by airport congestion is to expand the capacity of the airport and of the air traffic control system to deal with demand. However, because of the access policy in effect at most airports and the lack of effective economic incentives to discourage flight operations during peak periods of airport demand, adding capacity would not guarantee an alleviation of congestion problems in the short term. This thesis will suggest how changing the federal regulations concerning the role of airport authorities could lead to an allocation of airport resources that could supplement or replace airport expansion and air traffic capacity enhancement as methods of reducing problems caused by airport congestion.

This chapter describes how changes that have occurred in the airline industry since deregulation affect demand for flight operations at airports, the different kinds of demands for airport flight operations imposed by airport users, and the challenges facing the airport authorities that have to deal with congestion problems. Chapter 2 will look at the fundamental differences in policy between the airport authorities and the federal government. A queueing model of congestion at airports in Chapter 3 will illustrate how the congestion situation at an airport can change as capacity or demand for flight operations changes. Chapter 4 will look at the relevance that

several different programs of airport and air traffic control capacity expansion have with respect to addressing the needs of airports around the country. The final chapter will analyze the regulations controlling access and will suggest alternatives to those regulations that will allow airport authorities the flexibility to control peak airport demand without denying airport access to any aircraft operator.

1.1   Changes in Demand Since Deregulation

Since the passage of the Airline Deregulation Act of 1978, the number of passengers and passenger aircraft flight operations in the air traffic control system has continued a general upward trend. For example, from 1979 to 1987, revenue passenger enplanements of major U.S. air carriers in the 50 states increased from 296.1 to 422.7 million for an average annual increase of about 4.6%. From 1981 to 1987, commuter enplanements increased from 15.64 to 24.09 million at about a 7.5% average annual increase. Table 1.1 shows the changes in enplanements and flight operations for major air carriers and commuter and air taxi operators from 1979 to 1987.

Along with these increases in passenger enplanements and aircraft operations, there were two general changes in airline strategies, the first a move toward using hub and spoke routing systems and the second an increased use of commuter aircraft. In order to make flight operations more profitable in the increasingly competitive air transport industry, many airlines have used a hub and spoke system to increase load factors on aircraft and thus increase revenues on their flights. In hub and spoke systems, an airline's passengers are often routed to an intermediate hub airport. There, they may change planes in order to complete their flight. Doing so is more economical for the airlines, but it it has two drawbacks for passengers and airports. For the passenger, trips between cities that use an intermediate connection are longer than a non-stop flight because of the extra time

8

spent travelling to and from the hub airport and transferring at the hub airport. They are also exposed to more opportunities to experience delays en route because of the extra flight segment. For the airport, an airline's hub and spoke operation might lead to several periods in the day when many of an airline's flights are arriving or departing in a short period of time in order to facilitate an exchange of passengers at the hub. This may lead to periods when the airport is operating near its capacity to handle flight operations and thus is prone to flight delays caused by congestion. Table 1.2 indicates the magnitude of this congestion by listing the hours of delay experienced by the three largest air carriers at selected airports. These figures are from the Standardized Delay Reporting System which computes delay based on the difference between the actual and the optimal flight time rather than the difference between actual and scheduled flight time.

Table 1.1: Domestic Enplanements and Flight Operations for U.S. Carriers in the 50 States, 1979-1981 (in millions)[1]

Year	Major U.S. Air Carriers		Commuters/ Air Taxi	
	Ops	Pax	Ops	Pax
1979	5.10	296.1	---	---
1980	5.13	279.1	---	---
1981	4.94	263.7	2.34	15.64
1982	4.72	275.5	2.35	17.44
1983	4.83	301.3	2.29	15.94
1984	5.23	325.1	2.71	20.23
1985	5.48	360.7	2.76	18.85
1986	6.15	397.0	2.87	20.85
1987	6.37	422.7	2.96	24.09
Growth rate	2.8%	4.6%	4%	7.5%

---

[1] FAA Statistical Handbook of Aviation, 1987

Table 1.2 : Hours of Delay of Air Carriers and Number of Air Carrier
Operations at Selected Major Airports in 1987 [1,2]

Airport	Hours of Delay (000)	Air Carrier Operations (000)
Chicago (ORD)	100+	685.7
Atlanta	75-100	573.5
Dallas/Ft. Worth	75-100	493.6
Los Angeles	50-75	428.2
Denver	50-75	373.0
San Francisco	20-50	330.2
St. Louis	20-50	279.1
Newark	20-50	275.1
New York (LGA)	20-50	266.9
Detroit	20-50	260.1
Minneapolis	20-50	255.9
Miami	20-50	253.1
Boston	20-50	247.1
Pittsburgh	20-50	244.9
Houston (IAH)	20-50	224.7
New York (JFK)	20-50	208.7
Philadelphia	20-50	190.6

There are a number of airports that serve as a hub for one or two airlines where those hub airlines control well over half of all enplanements. Table 1.3 shows a sample of these airports and the proportion of traffic controlled by the hub airlines. As will be discussed more fully in Chapter 3, delays due to congestion are more likely to occur at times when an airport is nearing its capacity to service aircraft.

The second change in airline strategy that affects airport congestion has been the rising importance of smaller air carriers. Table 1.1 indicates that the commuter and air taxi operators, which for the most part operate aircraft with less than 60 passenger seats, have increased their number of enplaned passengers and

---

[2] FAA Plan for Research, Engineering, and Development, Jan. 1989, Vol. 1, page 3-14.

flight operations faster than the large air carriers. The most important difference between air carriers and commuters is the average number of passengers carried per flight. Using the figures in Table 1.1 for estimates of the difference, Table 1.4 gives the average passenger load of a commuter flight compared to the average load on an air carrier aircraft.

Table 1.3: Sample of Large Airports with Significant Hub Operations

Airport	Hub Airline	Total Enplanements in 1987 (millions)	Percentage of Enplanements at the Airport
Atlanta		22.65	
	Delta	12.30	54.3%
	Eastern	8.99	39.7%
Chicago		28.67	
	United	12.92	45.1%
	American	7.10	24.8%
Dallas/Fort Worth		19.90	
	American	12.29	61.8%
	Delta	5.13	25.8%
Denver		15.59	
	Continental	6.78	43.5%
	United	6.71	43.0%
St. Louis		9.73	
	TWA	8.00	82.2%
Pittsburgh		8.16	
	USAir	6.83	83.7%
Houston Intercontinental		6.95	
	Continental	5.11	73.5%

Source: FAA Statistical Handbook of Aviation, 1987.

These differences on the national level are reflected on the local level as well. In 1987 commuters represented 24.2% of all flight operations at Atlanta, but carried only 4.8% of the enplaned passengers. In the first three months of 1987 at Los Angeles, commuters represented 27.5 % of aircraft movements but carried only 2.1% of all passenger traffic [3]. For the airports, commuter aircraft represent a relatively small amount of passengers, but a significant fraction of aircraft movements. Therefore, they have a disproportionate effect on peak hour flow and delays because when all aircraft share the same runway or system of runways, it takes at least as much time to land a commuter aircraft as it does larger aircraft carrying more passengers. Chapter 2 will discuss how the federal policy of open access for all aircraft makes it difficult for airport authorities to prevent peaking of demand for flight operations and the delays that may come as a result. Chapter 3 will look at the effects commuter and general aviation aircraft have on the level of an airport's congestion.

Table 1.4: Differences Between Air Carrier and Commuter Operations in 1987

Passenger enplanements by U.S. air carriers and commuters	446.79 million
Total departures	9.33 million
Percentage of departures by commuters	30.6%
Percentage of passengers on commuters	5.4%
Average number of passengers on a commuter flight	16.3
Average number of passengers on an air carrier flight	132.7

---

[3] City of Los Angeles and City of Atlanta Airport Statistics.

1.2   General Aviation Aircraft

Deregulation of the major airlines has had no clear effect on the number of general aviation flight operations. Demand for general aviation flights varies widely among airports and these variations are a function of local economic conditions and the kind of general aviation related businesses such as flight training schools that may be located at an airport.

When it comes to general aviation aircraft, the airport authorities may not be able to single out this type of aircraft operator for any special fees or restrictions that would keep them from operating during busy periods of the day. The authority usually has no recourse but to either increase the airport's ability to handle traffic or to entice general aviation aircraft operators to use alternative facilities. As will be explained later in this chapter, airport authorities are limited in their ability to increase capacity. As for the presence of general aviation aircraft at major airports, the proportion and the number of general aviation operations is decreasing at many but not all of the largest airports. Table 1.5 shows the change in the proportion of general aviation, commuter, and air carrier aircraft at six large airports from 1983 to 1987.

Between 1983 and 1987, every one of these airports had a drop in the share of flight operations performed by commuter and general aviation aircraft. While delays associated with flight operations at a congested airport affect all aircraft using the facility during periods of congestion, the costs of these delays to the general aviation and commuter aircraft operator are relatively low because the weight based fee structure in place at most American airports insulates them from being assessed the full costs of operations during busy periods. This is due to the policies of the federal government that support the free access to any public airport by all properly equipped aircraft.

1.3   Airport Authorities

Since airline deregulation, many major airports have had to cope with significant increases in flight operations and the problems that come from airport congestion. One measure of the increase in demand for flight operations is the change in average delay time at major airports between the years 1978 and 1987. Table 1.6 gives examples of these changes at several important airports based on the Standardized Delay Reporting System

With the passage of the Airline Deregulation Act of 1978, airport authorities were put at a distinct disadvantage compared to the airlines in the area of controlling demand. Airlines were allowed to enter or exit markets or to change the nature of their operations at their discretion. Airports however were not allowed to limit passenger or aircraft movements in order to control passenger and aircraft delays. While the airport authorities had the option of expanding capacity to handle traffic, communities were and continue to be slow to approve the building of new airports or the major expansion of old ones because of concerns over noise pollution, perceived safety risks, costs, or possible lowering of property values. Even if expansion plans are approved, it may be years before runway, taxiway, or terminal expansions are completed. By the time the airport authority makes the physical changes in the airfield, the pattern and amount of airport operations may not conform to the authority's predictions. Because of the freer hand granted the airlines under deregulation, airport authorities must try to reduce problems caused by increased demand for services while having less certainty about how that future demand may change. These authorities run a greater risk of having an inappropriate and possibly an excessively expensive solution to their capacity problems.

1.4 Easing the Problems of Local Airport Authorities

The inability of airport authorities to modify demand is due to long standing federal policy concerning access to public airports. Because airport authorities are dependent on federal subsidies for airport building or for major airport improvements, they must follow the federal guidelines on airport access given under section 2210(a)(1) of the United States Code which states in part,

> (a) Sponsorship
>
> As a condition precedent to approval of an airport development project contained in a project grant application submitted under this chapter, the Secretary shall receive assurances, in writing, satisfactory to the Secretary, that-
>
> > (1) the airport to which the project relates will be available for public use on fair and reasonable terms and without unjust discrimination, including the requirement that ... each air carrier using such airport (whether as a tenant, nontenant, or subtenant of another air carrier tenant) shall be subject to such nondiscriminatory and substantially comparable rates, fees, rentals, and other charges with respect to facilities directly and substantially related to providing air transportation....

The interpretation of fair and reasonable terms has come to mean a landing fee that is based on the weight of the aircraft rather than on some other measure such as the economic value that a landing opportunity would have to other users. This traditional view of the kind of airport user fees that can be allowed has caused the local airport authorities and the federal government to not take full advantage of using economic incentives to reduce the number of airport operations at peak demand periods and in doing so reduce the incidence and duration of flight delays. The local airport authorities could use economic incentives to supplement capacity enhancement as a way to reduce congestion problems if the federal government were to make it clear that such incentives were acceptable. The argument that will

15

be made in this thesis is that enhancing an airport's capacity as a means of dealing with congestion does not allow the local airport authorities much flexibility in dealing with short term fluctuations in demand for flight operations. In addition, specifically allowing economic incentives as a means to tailor demand to more closely fit an airport's capacity would not be counter to the federal approach to airport access that is demonstrated by statutes such as section 2210(a)(1) of the United States Code. The following chapter will focus on the different goals of the federal government and the local airport authorities and how the priorities of the federal government make it difficult for the airport authorities to deal with some aspects of congestion.

Table 1.5: Proportions of Air Carrier, Commuter, and General Aviation
Flights At Selected Major Airports, 1983-1987 [4]

Airport	Year	Total Ops(000)	Air Carrier Ops (Pct)	Commuter Ops (Pct)	General Aviation Ops (Pct)
Chicago	1983	671.7	507.7 (75.6)	110.8 (16.5)	48.8 (7.3)
(ORD)	1984	713.4	597.8 (83.8)	66.0 (9.3)	45.4 (6.4)
	1985	769.9	666.2 (86.5)	59.7 (7.8)	40.5 (5.3)
	1986	794.5	705.6 (88.1)	48.7 (6.1)	36.8 (4.9)
	1987	791.9	685.7 (86.6)	69.1 (8.7)	33.7 (4.3)
Los	1983	506.1	299.3 (59.1)	141.4 (27.9)	61.8 (12.2)
Angeles	1984	543.3	323.3 (59.9)	147.2 (27.1)	68.1 (12.5)
(LAX)	1985	546.2	350.1 (64.1)	123.4 (22.6)	68.4 (12.5)
	1986	580.1	384.5 (66.3)	129.3 (22.3)	61.8 (10.7)
	1987	667.2	428.4 (64.2)	171.1 (25.6)	63.0 (9.4)
Dallas/ Fort Worth	1983	435.5	326.9 (75.1)	85.8 (19.7)	22.3 (5.1)
	1984	503.7	390.9 (77.6)	89.2 (17.7)	22.9 (4.6)
	1985	561.7	441.5 (78.6)	93.0 (16.6)	26.1 (4.7)
	1986	576.0	471.7 (81.9)	80.4 (14.0)	22.8 (4.0)
	1987	624.7	493.6 (79.0)	109.1 (17.5)	20.8 (3.3)
Denver	1983	458.1	312.4 (68.2)	70.9 (15.5)	73.2 (16.0)
	1984	488.3	327.0 (67.0)	89.3 (18.3)	70.3 (14.4)
	1985	495.3	332.8 (67.2)	104.5 (21.1)	57.2 (10.5)
	1986	524.8	373.6 (71.2)	102.4 (19.5)	46.5 (8.9)
	1987	520.9	373.0 (71.6)	105.7 (20.3)	39.5 (7.6)
Boston	1983	351.5	194.0 (55.2)	111.6 (31.8)	45.6 (13.0)
	1984	380.5	203.7 (53.5)	129.3 (34.0)	47.2 (12.4)
	1985	408.2	217.1 (53.2)	149.2 (36.6)	41.6 (10.2)
	1986	424.3	240.9 (56.8)	137.5 (32.4)	45.4 (10.7)
	1987	440.7	247.1 (56.1)	142.7 (32.4)	50.6 (11.5)
Atlanta	1983	612.8	494.5 (80.1)	79.0 (12.9)	36.7 (6.0)
	1984	689.5	547.1 (79.4)	101.1 (14.7)	39.7 (5.8)
	1985	755.8	574.4 (76.0)	143.6 (19.0)	36.4 (4.8)
	1986	787.3	578.7 (73.5)	175.1 (22.2)	31.9 (4.1)
	1987	796.9	573.5 (72.0)	192.7 (24.2)	29.1 (3.7)

---

[4] FAA Statistical Handbook of Aviation, 1983 to 1987.

17

Table 1.6: Average Aircraft Delays at Selected Major Airports
in Average Minutes per Operation,1978 and 1987 [5]

Airport	Average Delay		
	1978	1987	Increase
Atlanta	N.A.	9.1	---
Boston	6.7	8.7	21.5%
Chicago (ORD)	9.3	11.3	21.5%
Washington National	6.5	8.6	32.3%
Dallas/Fort Worth	4.6	9.4	104.4%
Los Angeles (LAX)	6.2	9.8	58.1%
Pittsburgh	5.7	5.7	0%
San Fransisco	4.5	8.8	95.6%
Detroit	4.6	6.7	45.7%
Newark	4.6	9.4	104.4%
Denver	9.2	8.1	-12.0%
System Average	5.8	7.8	34.5

[5] FAA Aviation Forecasts 1989.

Chapter 2: Airport Access Priorities of Airport Authorities and the Federal Government

2.1 Federal Priorities

Within the United States, the federal government is responsible for managing and operating the nation's airspace and airports, primarily through the Federal Aviation Administration. The FAA is also responsible for developing, deploying, and maintaining aids to navigation and air traffic control such as radars and instrument landing systems. In addition, the FAA develops the air traffic control rules and regulations under which all aircraft in the nation's airspace must operate. The FAA has three important goals with respect to civil aviation: to insure the safety of flight, to allow the expeditious movement of aircraft, and the efficient operation of the air traffic system. These three goals are balanced against the aviation development policy of the federal government, part of which has been to allow any properly equipped aircraft to use public airports.

The federal policy on airport access and development is reflected in a variety of programs and public laws. The FAA's Airport Capacity Enhancement Program is in line with the government's priority of open access at public airports. The program advocates expansion of airside facilities such as runways as the most efficient method of increasing capacity, followed by improving airspace control procedures and the use of additional equipment to support capacity enhancement. Funding of these endeavors is accomplished through the Airport Improvement Program, an offspring of the Airport and Airways Improvement Act of 1982, 49 U.S.C. §2210. Under this Act, airports that accept federal funds for the building of runways, landing systems and other airside developments must make their facilities available for public use on fair and reasonable terms. What constitutes fair and reasonable is not clearly defined in the statute, but other statutes describe the kind of terms that an airport authority may impose. In the Anti-Head Tax Act, Public Law 93-44, airport authorities are forbidden to charge

passengers a tax, fee, or head charge on an individual bases, but the authorities are allowed to levy or collect "reasonable rental charges, landing fees, and other service charges from aircraft operators for the use of airport facilities." With the passage of the Airline Deregulation Act of 1978, Public Law 95-504, the federal government began the process of ending its regulation of air carrier routes, but at the same time the Act prohibited states and other agencies that owned an airport from undertaking actions that would have the effect of regulating the routes, rates, and services of any air carrier.

Much of the legal interpretation of an airport authority's role in air transportation has centered on just what is a reasonable and fair way to allocate airport costs to the airline and airline passengers who use the airport. The Supreme Court in the case of Evansville-Vanderburgh Airport Authority District v. Delta Airlines, Inc., 405 U.S. 707 (1972), held that a $1 fee imposed on enplaning scheduled passengers was fair because the passengers were paying the fee as a way to share the cost of the services the airport provided.

In the court's majority opinion, the justices stated that the amount of tax and not the exactness of the formula used to determine the tax was the central concern. That opinion stated that a tax would not violate the commerce clause of the Constitution if it passed three tests. First, the fee could not discriminate against interstate commerce and travel or be excessive compared to the benefits received. Second, the fees must constitute a fair but not necessarily a perfect approximation of the cost for using an airport's facilities. Third, the fees could not be excessive in relation to the costs incurred by the taxing authority.

In order to preclude states from imposing head taxes that might unreasonably burden interstate commerce and partly as a result of this court decision, the Congress passed the Anti-Head Tax Act. In spite of this legislation, the Evansville tests for

fairness of an airport fee continued to figure prominently in subsequent federal court decisions.

In American Airlines v. Massachusetts Port Authority (Massport), 560 F.2d 1036 (1977), the U.S. Court of Appeals in the First Circuit held that a 52% increase in landing fees at Boston's Logan airport in 1977 was not an unconstitutional burden on interstate commerce because the fee increases were made for legitimate airport objectives. The airlines based their arguments against the fee increases on Evansville's language to the effect that a tax may not be "excessive in comparison with the governmental benefit conferred." The airlines claimed that the new landing fees violated the third Evansville test by being in excess of the benefit that the airlines were receiving. The court rejected this claim because in their words,

> we cannot see how a federal system, recognizing state sovereignty, could work on a basis of customer judgments of benefits received. A state could supply facilities which would be of critical importance to some users, of moderate convenience to others, and of marginal use to the remainder. If such taxes as landing fees were to be subject to attack from each user, depending upon the particular utility, their imposition could be a matter of endless and shifting controversy. Such an approach would subject every taxing authority to the judgments of courts as to the wisdom, the foresight, and the efficiency of its plans from the viewpoint of each affected customer.

The court did not wish to decide the precise structure of fees, but rather to allow the airport authorities to charge fees in a way that was consistent with the costs incurred by the airport with the users sharing the costs and benefits of the airport's decision.

A case where these costs were found to not bear a reasonable relation to fees was Indianapolis Airport Authority v. American Airlines, Inc., 733 F.2d 1262 (1984). There, the U.S. Court of Appeals in the Seventh Circuit held that an airport authority may not impose a cost on airline users that greatly exceeds a reasonable estimate of the costs that airlines impose on the airport. The main issue in the case was whether

the Indianapolis airport authority could disregard the revenues it obtained from airport concessionaires when setting a new fee schedule for airlines. While the costs allocated to the concessionaires, primarily car rental agencies and the parking facility, was about $1 million, the rental income was about $3.5 million. Costs allocated to the airlines was $3 million and the landing fees were calculated to yield this amount.

The court only dealt with the reasonableness of the fees charged to the airlines because the relevant federal laws covered only airline and not concessionaire fees. The court argued that because the customers of the concessionaires were airline passengers, the $2.5 million in revenues in excess of the concessionaire's allocated costs were passed on to the airline passengers. In the opinion of the court, the $2.5 million added to the $3 million in airline costs that would ultimately be passed on to the passengers results in "an exaction that is wholly disproportionate to the costs to the airport of serving the airlines and their passengers, and is therefore unreasonable under the state and federal statutes."

A June 1988 federal district court summary judgment in the first circuit by Judge Mazzone illustrated a reluctance on the part of some federal judges to take away proprietary powers from airport authorities in the area of setting fee structures. Three groups, the New England Legal Foundation, the National Business Aircraft Association, and the Airline Owners and Pilot's Association filed separate suits, later consolidated, against Massport, the authority responsible for Boston's Logan airport, as a result of the authority's proposed new landing fee schedule. The plaintiffs claimed that the new fees, the initial part of the authority's Program for Airport Capacity Efficiency (PACE), were unreasonable and would discriminate against smaller aircraft. The heart of the fee proposal was a change from determining landing fees based only on the weight of the aircraft to using the aircraft's weight and the cost per operation of providing airport services to determine landing fees. The new fee schedule increased the charge for the smallest general aviation aircraft over 300% from

$25 to over $90 while the charge for the largest aircraft went down. In the case of the 747 the fee dropped over 40%. The plaintiffs claimed that the new fees were unreasonable, discriminated unfairly against smaller aircraft, and violated the commerce and equal protection clauses of the Constitution, the Anti-Head Tax Act, the Airline Deregulation Act, and the Airports and Airways Development Act.

The district judge saw three issues before the court. First, were the fees that were assessed reasonable? Second, were they discriminatory? Third, would the fees imposed by Massport be preempted by federal law? On the first issue, the judge decided that the fee was reasonable based on the three tests of the Evansville decision. The fees were based on a uniform fair and practical standard that did not charge excessively for the benefits that were incurred. The judge also found that as in the American Airlines case against Massport, the revenues obtained by the authority were related to the costs incurred.

On the second issue, the judge held that charging higher landing fees for smaller aircraft as a way to discourage the use of Logan by these aircraft did not constitute unjust discrimination because the objectives of reducing congestion and delay were rationally related to legitimate government interest.

On the third issue, the judge saw no need for federal preemption based on the intent of the Congress to allow the proprietor to set fees. Specifically, in the Airline Deregulation Act of 1978, airport proprietors were allowed to establish landing fees so long as they were reasonable.

In the U.S. Court of Appeals in the First Circuit in August of 1989, most of the findings of the previous district court decision were reversed. Unlike Mazzone, the appeals court judges Bownes, Torruella, and Re believed that when the Department of Transportation and local airport authorities differed on policy issues concerning airport access and landing fees, the policy decision should rest with the federal agency rather than with the courts. The appeals court judges also did not disagree with the opinion

of the DOT with respect to the three issues that concerned Mazzone. On the reasonableness of the Massport fees and whether the fees were discriminatory, the administrative law judge within the Department of Transportation believed that Massport improperly allocated costs to factors other than aircraft weight and that the motive for the new fees was to drive away small aircraft. In that judge's words,

> it is difficult to walk away from the record of this case without inferring
> that the Massport PACE Plan was conceived, orchestrated and
> implemented with the principal objective of ridding Logan of small
> aircraft or severely curtailing their operations. It was a plan that went
> in search of an economic theory to justify its existence.

The administrative law judge concluded that the fees were both unfair and unreasonable, and unjustly discriminatory.

On the issue of federal preemption, both the administrative law judge of the DOT and the appeals court judges agreed that the DOT rules were supreme, and they did so for similar reasons. The administrative law judge thought that the Massport plan unduly interfered with federal control of airspace management and air traffic system access that the Congress had delegated to the FAA. The appeals court judges believed that the DOT through the FAA is charged with primary responsibility for the efficient use of the nation's airspace and that it was within the scope of the agency's mission to supervise the landing fee schemes made by the local airport authorities.

This decision of the Circuit Court does not serve as a substitute for Congressional mandate as a means to clearly define the roles and responsibilities of a local airport authority and the DOT in the area of creating solutions to the problems of airport congestion. So long as these roles and responsibilities are not made clear, legal challenges such as the ones in this case are likely to continue as congestion problems worsen at the nation's airports.

24

These cases, taken as a whole, give more concrete meaning to the fair and reasonable terms under which airports must make their facilities available for public use and also the roles played by federal and local aviation authorities. The federal court did not give to itself the role of creating the proper fee structure in these cases, but rather put itself into the position of deciding either what structure was improper or to say which organization would have the responsibility to make that decision. Evansville and the American Airlines v. Massport cases in particular imply that an airport authority is not limited to any one kind of methodology when assessing fees for the use of an airport by aircraft operators. The decision in the appeal to the Mazzone decision is particularly significant because it solidly puts the decisions of the federal authorities concerning the reduction of airport congestion ahead of the desire of an airport authority to modify demand for flight operations.

In order to deal with demands for airport services by all aircraft operators, the federal government favors the expansion of airport capacity as the best way to deal with increased demand over the long term. However, the federal government's regulations and programs do not address all of the concerns of local airport authorities. Each authority must satisfy several constituencies that may be opposed to the kinds of capacity expansion favored by the federal government. The following section will deal with airport authority priorities and how they conflict with those of the federal government.

2.2   Priorities of Local Airport Authorities

The local airport authorities that own and manage the major commercial airports are doing so primarily to serve each region's population, users of the airport, and the airport's tenants. This is true whether the authority is part of a city government such as with Los Angeles International and Atlanta Hartsfield airports, or controlled by a state or regional organization such as Massport or the Port Authority

of New York and New Jersey. Relieving airport congestion and the resulting passenger delays would affect the three groups most important to the airport authorities in different ways depending on the approach the authority uses to alleviate congestion problems.

If the authority were to follow the path most favored by the federal government, that of expanding runway capacity, aircraft operators and their passengers would be pleased with the resulting drop in delays, but the authority would not fare as well. While the increases in airport capacity may be enough to handle the peak demands on the system, during non-peak times the extra capacity would be underutilized. Any investments made by the authority in such capacity enhancements would therefore be beneficial only to that fraction of aircraft operators and their passengers that fly during peak periods. Table 2.1 gives an idea of what that fraction may be by indicating the percentage of aircraft experiencing delays of 15 minutes or more at a number of major airports from 1985 to 1987. The figures are based on the National Airspace Performance Reporting System where delay is measured as actual minus optimal flight time as in the case of the Standardized Delay Reporting System mentioned in Chapter 1. The table indicates that even if all delays were to occur due to demands at peak periods, increasing peak capacity would benefit only a small fraction of aircraft operations, and it is possible that the increased revenues may not be sufficient to cover the costs of expansion.

In addition to reducing delays for at best a small portion of all flights, adding runway capacity usually means extending the area that would be affected by aircraft noise or the other environmental side effects that would come with increasing the size of the airport. For airports in cities such as Boston, these environmental effects are the cause of strong local opposition that may make the building of any additional runways politically infeasible. At best this opposition could increase the time and expense needed to complete any major airport expansion.

26

Table 2.1: Percentage of Air Carrier Operations Delayed 15 Minutes or
More at Selected Airports 1985-1987 [6]

Airport	1985	1986	1987	Percentage of all Enplanements 1987
Chicago (ORD)	4.6	3.2	3.7	5.89
Atlanta	6.2	6.5	6.2	5.11
Los Angeles	0.8	1.1	3.3	4.55
Dallas/Ft. Worth	1.7	2.6	2.0	4.44
Denver	4.6	3.2	3.7	3.45
San Francisco	3.4	5.3	6.2	3.00
New York (JFK)	6.1	7.0	6.5	3.08
Newark	9.2	13.8	6.5	2.61
New York (LGA)	9.2	8.9	6.5	2.48
Miami	0.3	0.7	0.4	2.48
Boston	6.1	7.3	4.8	2.47
St. Louis	4.6	4.4	1.6	2.20
Detroit	2.1	1.3	1.5	2.11
Minneapolis	2.2	3.9	0.7	1.93
Pittsburgh	1.7	0.6	0.7	1.82
Washington (DCA)	2.0	3.2	2.3	1.59
Philadelphia	0.9	2.0	3.7	1.58
Houston (IAH)	0.3	0.2	0.5	1.58

Even with an increase in airport capacity that meets current demand, the airport authority and those who use the airport may not be spared future delay problems. An airport without a serious congestion problem becomes more attractive for aircraft operators who may schedule more flights throughout the day. Furthermore, airport capacity and improvements to that capacity are a function of wind and visibility conditions. An extra runway or an improved runway may add capacity under ideal conditions and may in turn lead to an increase in overall demand for flight operations. If the runway does not add sufficient capacity under all wind and visibility conditions, then during adverse weather conditions the airport may experience even higher

---

[6] Airport Capacity Enhancement Plan, U.S. Department of Transportation, 1988 , page 1-11.

average delays than before. Other methods of capacity enhancement, improving airspace control procedures and using additional equipment to enhance capacity, would not generate the environmental side effects and community opposition of runway expansion, but they suffer from some of the same drawbacks in that without any economic or regulatory incentives to modify demand, aircraft operators may take advantage of the extra capacity by simply scheduling more flights.

2.3 Conflict and its Resolution

The PACE court case involving Massport revolves around one of the most important issues facing the nation's busiest commercial airports: how to deal with increasing user demands for airport resources and the increasing delays that result from these demands. The basic conflict between the federal government and the local airport authorities on this issue stems from the differences between the freedom the users have in using an airport and the limits imposed by the federal government on an airport authority's ability to control that demand. With deregulation, air carriers were given the freedom, long enjoyed by general aviation aircraft, to change at their convenience their routes or flight frequencies. Local airport authorities on the other hand are encouraged to deal with the problems caused by increased demand by increasing capacity rather than being allowed either to limit access directly or to create economic incentives to modify demand.

To permanently resolve this conflict between the federal government and local airport authorities would require either an expansion of capacity to the point that congestion is not a problem at all, or controlling demand to the extent that facilities are no longer congested. Increasing capacity alone has its limits. As was described in the previous section, increased capacity without controls on any subsequent increases in demand may lead to a return of the same kind of delay problems that may have existed before the capacity enhancements. For controlling demand in the system, the federal

government would have to change the current access policies so that aircraft operators would either be compelled to limit their use of particularly congested airports or would have some sort of economic incentive to change their patterns of use. The rest of this thesis will further describe the nature of congestion and delays, detail steps that are being taken to alleviate airport congestion, and propose some additional methods for controlling demand.

Chapter 3, which covers elements of queueing theory as they apply to airport congestion, will illustrate how an airport near its capacity to handle aircraft operations would experience substantial increases in delays due to relatively modest increases in demand. Chapter 4 will look at the impact some planned enhancements would have on some of the nation's busier airports. The final chapter contains a proposal which could represent a way to resolve some of the conflicts between the federal and local airport authorities. It would allow the local authorities more flexibility to adapt to changing user demands while at the same time allowing the federal government to maintain its traditional role as manager of the air traffic system.

Chapter 3: Modeling Airport Capacity Using Queueing Theory

An airport's capacity is dependent on a variety of variables from noise restrictions to weather. Using simple mathematical models, one can begin to both appreciate the nature of aircraft delays and also use these models to evaluate the solutions to these problems.

Queueing theory is a branch of operations research that explores relationships between demand on a service system and delays encountered by users of that system. With respect to air traffic control, an airport that has a level of demand for service that allows all aircraft to land or take off without delay would have little need for an analysis of queueing behavior. However, most major domestic airports occasionally experience conditions such as reduced visibility or high winds that reduce the airport's ability to serve aircraft when demand for a runway is close to or exceeds the ability of that airport to accommodate the aircraft.

3.1.1 Queueing Models and Behavior

A description of a queueing system would include information on the following aspects:

1. The arrival process of new users to the system.

2. The queueing discipline or the order in which users are serviced

3. The service process.

A simplified queueing model for a single runway airport that has only arrivals can illustrate the relationship between demand for service and service delays. Assume that all aircraft have the same flying characteristics and require an amount of time to land and exit off the runway that is independent of the actions of other aircraft. Let this time be modeled by the exponential random variable $w(\tau) = \mu e^{-\mu\tau}$ for $\tau > 0$. Assume also that aircraft arrive near the airport in a Poisson manner with the

interarrival time for new aircraft in the system being distributed as another independent exponential random variable $g(\tau) = \lambda e^{-\lambda\tau}$ for $\tau > 0$. Assume also that the queueing discipline is first come first served, that aircraft remain in the queue until their service completion, and that all aircraft land successfully on the first attempt [7].

This model ignores at least four conditions that affect the ability of an airport to satisfy the demands placed on it. First, the arrival rate varies throughout the day, usually peaking for most airports in the early morning and late afternoon. Second, service rates depend very much on the weather, reaching a maximum under Visual Flight Rules (VFR) conditions when the winds are also calm and decreasing as wind velocity increases and visibility worsens. Third, actions of arriving aircraft are not completely independent of other aircraft for at least two reasons: a runway may also have aircraft competing for departure positions, and arriving aircraft may also have different flying characteristics which may force some arriving aircraft to adjust their approach in order to maintain minimum separation standards from other aircraft. Fourth, major airports usually have several runways operating at any time for arrivals, departures, or some combination of the two, so the service time for an aircraft may depend on how the system of runways is being used. Despite the limitations of the model, it is useful in illustrating the effects changes in demand for service will have on the average waiting time for a runway.

The important information that this model could provide would be the expected time a random aircraft spends waiting in queue and how that distribution changes as a function of arrival and service rates. This information can be derived for a queueing system in steady state. For the system to be in a steady state, assume $\mu > \lambda$ and define $P_n(t)$ as the probability that the system is in state n at time t, that is having n aircraft either in the queue or being served. This model is that of a birth and death

[7] Richard C. Larson and Amadeo R. Odoni, Urban Operations Research, pages 183-185, Prentice-Hall, Inc., 1981.

process in that in any infinitesimal time interval Δt, the value of the state can change by at most one. If the system is in state one or higher, it will remain in its current state with probability $(1-(\lambda + \mu)\Delta t)$, increase its state by one with probability $\lambda\Delta t$ or decrease it by one with probability $\mu\Delta t$. If it is in state zero, it can either stay in state zero with probability $(1 - \lambda\Delta t)$ or go to state one with probability $\lambda\Delta t$.

For $n > 0$, $\quad P_n(t + \Delta t) = P_{n+1}(t)\mu\Delta t + P_{n-1}(t)\lambda\Delta t + P_n(t)(1-(\lambda + \mu)\Delta t)$ (3.1)

For $n = 0$, $\quad P_0(t +\Delta t) = P_1(t)\mu\Delta t + P_0(t)(1 - \mu\Delta t)$ (3.2)

Rearranging (3.1) and dividing by Δt, one gets

$$\frac{P_n(t + \Delta t) - P_n(t)}{\Delta t} = - (\lambda + \mu)P_n(t) + \mu P_{n+1}(t) + \lambda P_{n-1}(t) \quad \text{for } n > 0 \quad (3.3)$$

As Δt goes to zero, by definition, (3.3) becomes

$$\frac{P_n(t)}{dt} = - (\lambda + \mu)P_n(t) + \mu P_{n+1}(t) + \lambda P_{n-1}(t) \quad \text{for } n > 0 \quad (3.4)$$

and from (3.2),

$$\frac{P_0(t)}{dt} = - \lambda P_0(t) + \mu P_1(t) \quad \text{for } n = 0. \quad (3.5)$$

When the system reaches steady state, $\quad \frac{P_n(t)}{dt} = 0 \quad \forall$ n and the probability that the system is in state n is the same for all time.

This implies that for state zero, $\rho P_0 = P_1$ where $\rho = \lambda/\mu$ and P_i is the limiting value of $P_i(t)$ $\forall$ i > 0. (3.6)

It can be shown by successive substitutions of (3.6) into into (3.4) that at steady state with $\mu > \lambda$, $\rho^n P_0 = P_n$. (3.7)

By definition, $\sum\limits_{n=0}^{\infty} P_n = 1$, so by using (3.6), one gets $\sum\limits_{n=0}^{\infty} \rho^n = (1/P_0)$.   (3.8)

Because $\rho < 1$, it can be shown that (3.8) reduces to $P_0 = 1 - \rho$, which implies that $P_n = (1 - \rho)\rho^n \ \forall \ n > 0$. [8]

3.1.2   Waiting Times for Service

The wait for service is dependent on the aircraft's position within the queue. If an aircraft arrives when there are no aircraft in the system, its wait until service completion will be distributed as an exponential random variable with mean $1/\mu$. However, if n aircraft are already in the system, the waiting time until completion of service for the new aircraft is now modeled by an Erlang distribution of order n+1 with mean $(n+1)/\mu$. The waiting time in the queue is Erlang of order n with mean n/μ.

The mean waiting time in queue can be given by

$$W_q = \sum_{n=0}^{\infty} P_n(n/\mu) = \rho/\mu(1-\rho) = \lambda/\mu(\mu-\lambda) \qquad (3.9)$$

By inspection, it is clear that as ρ approaches 1, the mean wait in queue grows very large. Under this model, if an airport could service 80 aircraft per hour under ideal VFR conditions and had Poisson arrivals at a rate of 64 aircraft per hour, ρ would be 0.8 and the mean waiting time given by (3.9) would be three minutes. Should the maximum service rate be reduced to 70 aircraft per hour, ρ would increase to 0.9143 and delay would go to 9.14 minutes, an over 200% increase in average delay for a 12.5% decrease in runway capacity. Without loss of generality, one may choose a time interval such that $\mu = 1$ per time period. The time in queue would be given by

---

[8] Ibid., pages 194-199.

$W_q = \rho/ (1 - \rho)$, and the relationship of W_q and ρ is given below in Figure 3.1.

If one were to define the entrance of an aircraft into an airport's service area as an arriving aircraft coming to within a given radius of an airport, then the Poisson approximation is a good one to model aircraft arrivals in the system assuming that flow control has not been exercised by ATC. Because of the numerous variables that affect aircraft behavior, once they enter an airport's service area, the Poisson model may not be as appropriate.

Figure 3.1: Variation in W_q as ρ Approaches 1
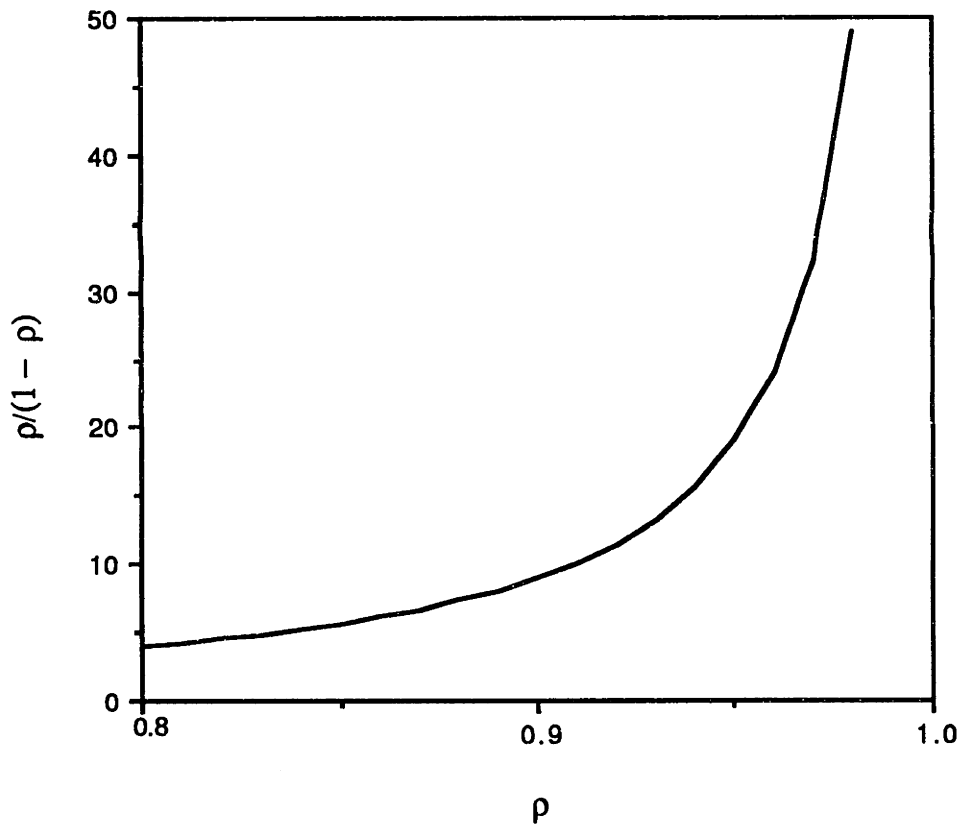
There are more general models of single server queueing behavior that assume Poisson arrivals, but make no assumption on the service probability distribution function. One of them is given by the Pollaczek-Khintchine formulas [9]. They provide W_q given only the Poisson arrival rate λ, the mean service time $E[s]$, and the variance of the service time σ^2_s. The expected time in queue in steady state is given by

$$W_q = \lambda(E^2[s] + \sigma^2_s)/[2(1 - \lambda E[s])] .\qquad(3.10)$$

The steady state condition is $\lambda < 1/E[s]$, or $\lambda E[s] < 1$

Even this model can only be considered a first order approximation for the queueing behavior of aircraft at a busy airport. However, these equations do provide a way to judge the relative merits and effectiveness of airport capacity enhancement plans.

3.2   Modelling Airport Runway Capacity

An airport's ability to serve takeoffs and landings depends on the configuration of active runways, restrictions imposed on their use, and on the weather. A comprehensive picture of an airport's capacity could come by determining both the capacity of all the runway configurations used at the airport, and the proportion of time that the airport uses that configuration.

Let there be N aircraft types with $P(i)$ $\forall$ $i \in \{1,2,...,N\}$ denoting the proportion of type i aircraft using the airport. Assuming the arrival of an aircraft does not influence the probability of a prior or a subsequent arrival of any other type of aircraft, then $p_{ij} = P(i)P(j)$ $\forall$ $i,j \in \{1,2,...,N\}$ is the probability that a type i aircraft is followed

---

[9] Ibid., pages 217-220.

35

by a type j aircraft. The elements of the NxN matrix [Tij] are the minimum separation times between aircraft of types i and j that would allow the aircraft to maintain proper physical separations where minimum separations are given by [D_{ij}]. These times and distances are determined by aircraft performance and safety considerations. The maximum landing rate is given by the inverse of the mean time between landings E[ldg] where the value is given by

$$E[\text{ldg}] = \sum_{i=1}^{N} \sum_{j=1}^{N} (T_{ij})(p_{ij}) \ . \qquad (3.11)$$

From (3.11), 1/E[ldg] would give the maximum landing rate for the runway configuration. Assuming that the minimum separations in time and distance between any two aircraft allows any of the N types of aircraft to take off safely and that one takeoff occurs between any two landings, then the maximum capacity of the runway is 2/E[ldg] operations per hour. Because of the delay characteristics illustrated in Figure 3.1, the practical runway capacity is some fraction of 2/E[ldg], usually around 80% of this rate.

3.3   Capacity Coverage Charts

With this information for each runway configuration and the proportion of time that the airport uses this configuration, one can develop a capacity coverage chart that would graphically illustrate how an airport's capacity changes under a particular weather category as wind speed and wind direction changes. In Figure 3.2, the width of each bar represents the percentage of time the airport operates with that runway configuration. The height corresponds to the number of operations per hour.

Figure 3.2: Sample VFR Capacity Coverage Chart
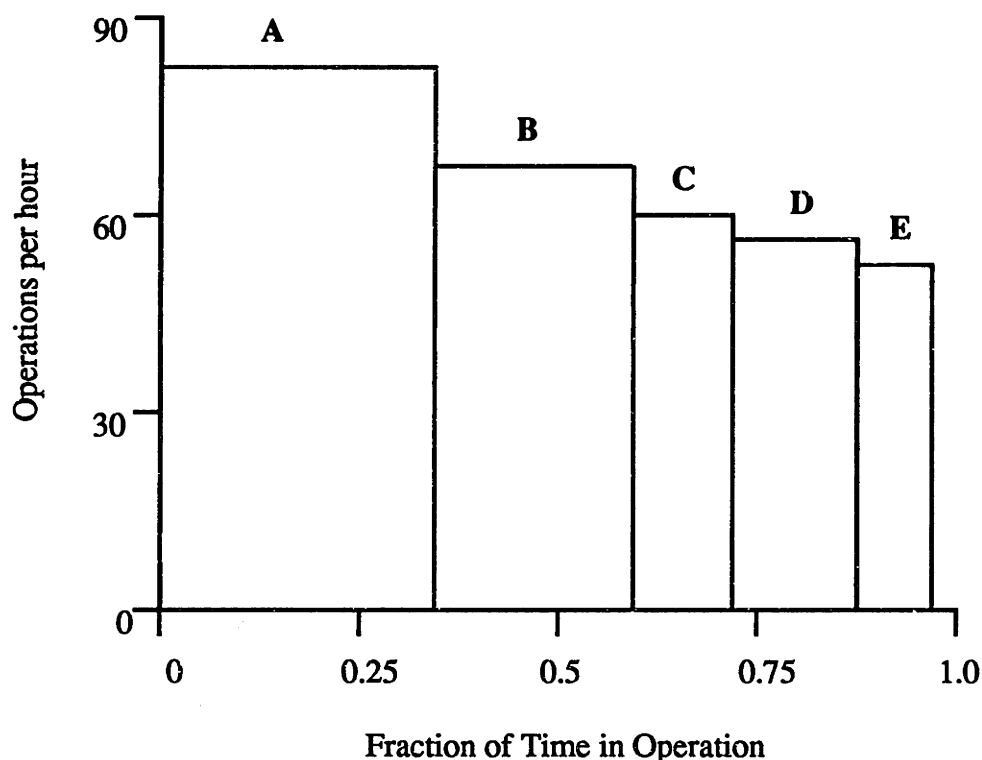
In this example, the airport's capacity would be at a maximum under condition A, which may be daylight VFR with calm winds. This chart indicates that the airport operates about 35% of the time under condition A and can handle about 83 operations per hour. As wind velocity increases and its direction varies, the capacity decreases due to less advantageous runway combinations B through E. Under strong enough winds from the right direction, the airport may be closed under VFR, in this example about 2% of the time under VFR. The widths in Figure 3.2 correspond only to the marginal availability of that runway combination, that is the percentage of time that the configuration is both feasible and has the highest capacity of the available configurations. One can also perform this analysis for all weather conditions and come up with a capacity coverage chart for all wind and weather combinations [10].

---

[10] Course notes from Planning and Design of Airport Systems.MIT, Spring 1989.

Increases in airport capacity due to such changes such as the construction of additional runways or the introduction of improved landing aids must be judged not only by how they may augment an airport's maximum capacity under ideal conditions, but also by how they may affect capacity under all wind and weather combinations. Capacity changes that would reduce the fluctuations in capacity under different weather combinations would be preferable because airlines and air traffic control authorities would encounter less variability in airport capacity. With less uncertainty about capacity, aircraft operations could be scheduled more efficiently and aircraft delays could be reduced. The capacity coverage chart is a concise display of where such changes will manifest themselves in operational conditions, and can be a very useful tool for evaluating different capacity enhancement alternatives.

For a more concrete example of how one can analyze an airport using some of the techniques of the previous sections, the estimated capacity of Atlanta's Hartsfield International Airport will be determined for different mixes of aircraft types and under different weather conditions. This will give an idea of how changing the proportions of aircraft types may change the average delay experienced by airport users.

3.4   Atlanta Airport Capacity and Possible Improvements

Atlanta's Hartsfield airport enplaned more than 5% of all passengers in the U.S. in 1986 and 1987 and is second only to Chicago's O'Hare in the number of yearly air carrier flight operations. Its delay problems are almost as significant, as illustrated in Table 1.2 and Table 1.6. The airport's Airport Capacity Enhancement Plan of March 1987 detailed the extent of the airport's past delays and projected future delay problems if no changes are made to increase the airport's capacity. Some of the important points are summarized in Table 3.1.

Table 3.1: Extent of Delays at Atlanta Hartsfield in 1986 [11]

	1986	1996
Total aircraft operations	775,000	796,500
Total delay	165,000 hours	224,000
Average Delay	12.8 minutes	16.9 minutes
Total estimated cost of delay	$247 million	$336 million

The figures for total and average delays are figured differently from those given in Table 1.2 and Table 1.6. The capacity enhancement plan of 1987 computed delays based on scheduled time and not the optimal flight time used by the FAA in the Standardized Delay Reporting System.

To reduce the extent of these delays and to deal with future demand, Atlanta's plan includes the building of a commuter runway and the reduction of commuter and general aviation aircraft operations as a means to achieve these ends. As mentioned in the last chapter, local airport authorities do not have the power to either restrict these smaller aircraft or to put into effect airport use fees to reduce demand for airport use. Some of the analytical techniques outlined earlier in the chapter will be used to compare the effectiveness of the two types of capacity enhancements.

3.4.1   Atlanta Airport Description

Atlanta's airport has four parallel runways that can each accommodate all of the types of aircraft that serve Atlanta. As Figure 3.3 illustrates, the runways are arranged in two pairs with the inner runways separated widely enough to permit independent operation. Under most conditions, all four runways are used with the outer two runways being used for arriving aircraft and the inner two for departing

---

[11] Airport Capacity Enhancement Plan: William B. Hartsfield International Airport; DOT,FAA, City of Atlanta, ATA; page 20, 1987.

aircraft. Because of the separation between the two sets of runways, the FAA can operate the Atlanta airport as though the two sets were two separate airports.

Atlanta serves as a major hub for both Delta and Eastern Airlines with the two companies accounting for almost 94% of major air carrier enplanements in 1987. The weather is well suited for these hub operations. The airport is shut down less than 1% of the time due to weather and has VFR conditions for about 90% of the year [12]. Figure 3.4 gives an approximation of the capacity coverage chart for Atlanta in 1987 based on information from the FAA in Atlanta and Atlanta's Airport Capacity Enhancement Plan.

---

[12] FAA Atlanta Airport.

Figure 3.3: Layout of Atlanta Hartsfield Airport's Runways and Terminals

26L

26R

27R

4300'

27L

Terminals

1000'

1050'

8L   8R

9L   9R
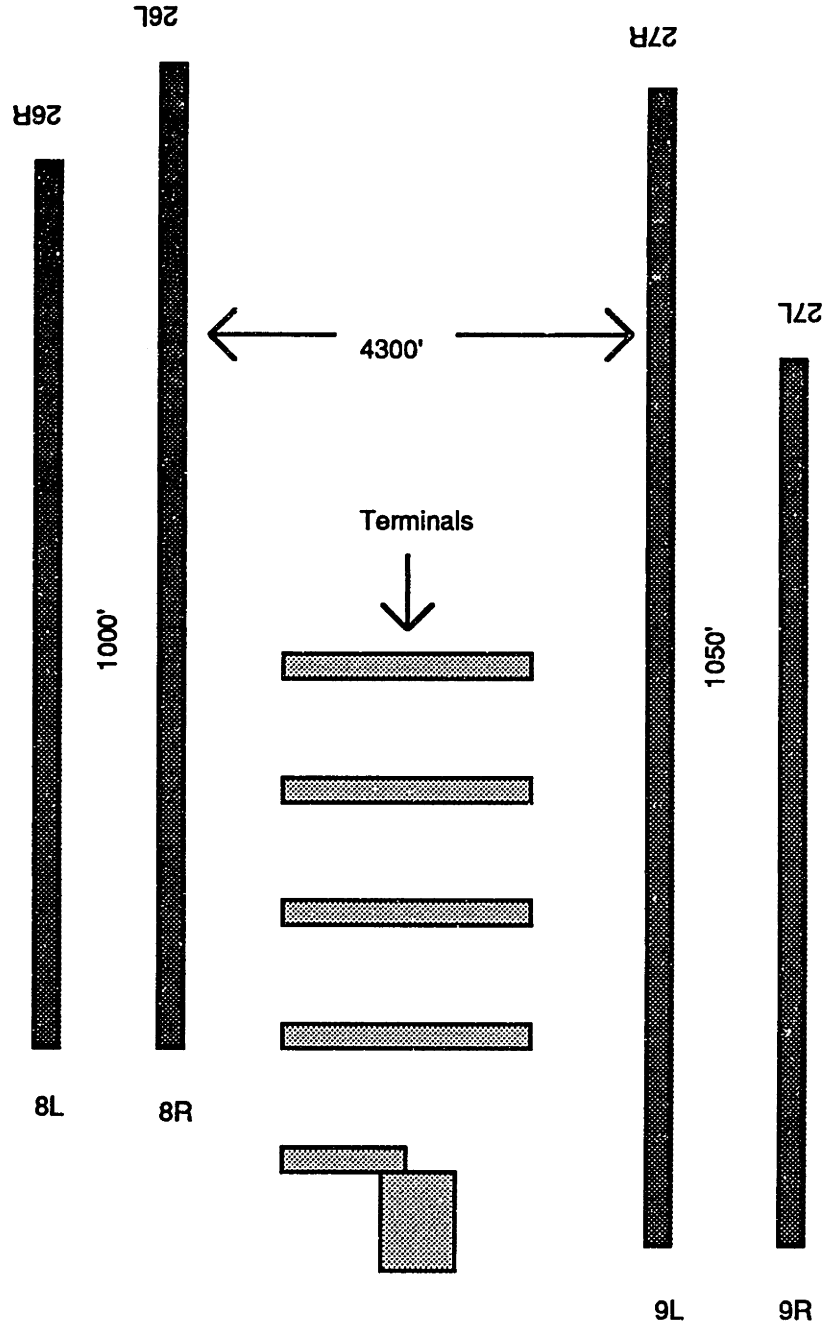
Runway Sizes: 9R-27L, 8L-26R 9000' x 150'

9L-27R 11,889' x 150'

8R-26L 10,000' x 150'

Figure 3.4: Capacity Coverage Chart for Atlanta*
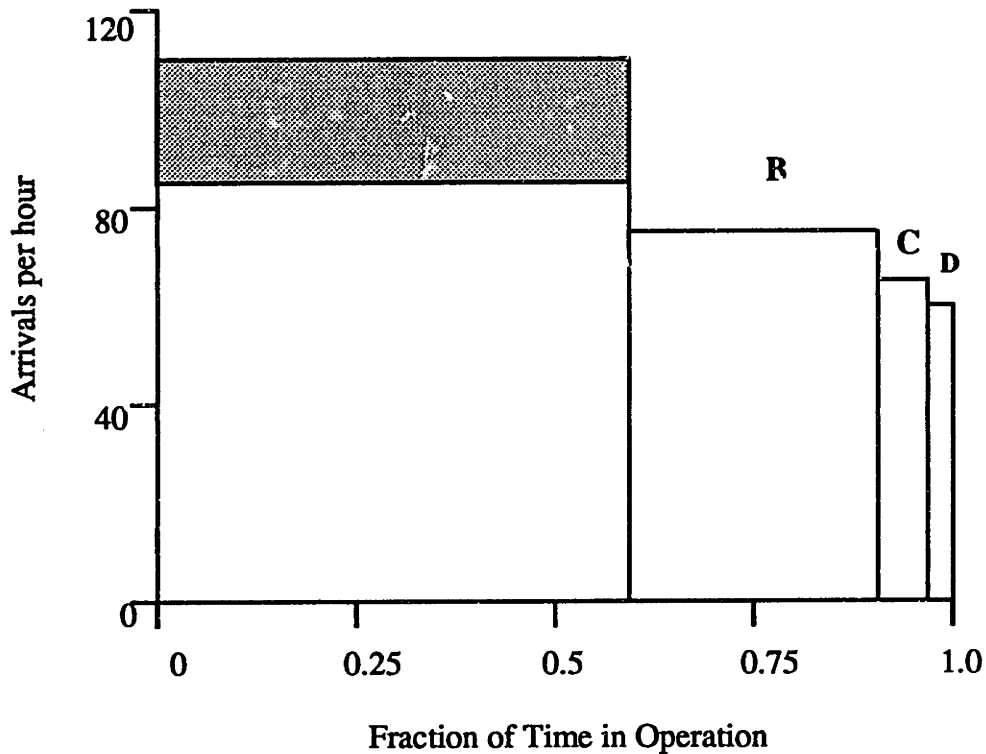
Weather Condition	Visibility/Ceiling	Arrivals per Hour
A: Visual	5nm /5000ft	85-110
B: Basic VFR	3-5nm/1000-3000ft	75
C: Category I	2nm/800ft	65
D: Category II	~1800ft RVR	60

* Four runways in operation

The number of arriving and departing aircraft in an average day in the peak month in 1986 are given by Figures 3.5 and 3.6. The peak hour for demand was from 4 to 5 p.m. with 166 total flight operations. One can also see the effect of the large hub operations of Delta and Eastern in the pattern of arrivals and departures. The four periods with the greatest number of arrivals, noon to 1 p.m., 3 to 4 p.m., 5 to 6 p.m., and 8 to 9 p.m., are immediately followed by busy periods for departures.

Figure 3.5: Hourly Variation of Demand for Arrivals in the
Average Day of the Peak Month, 1986 [13]
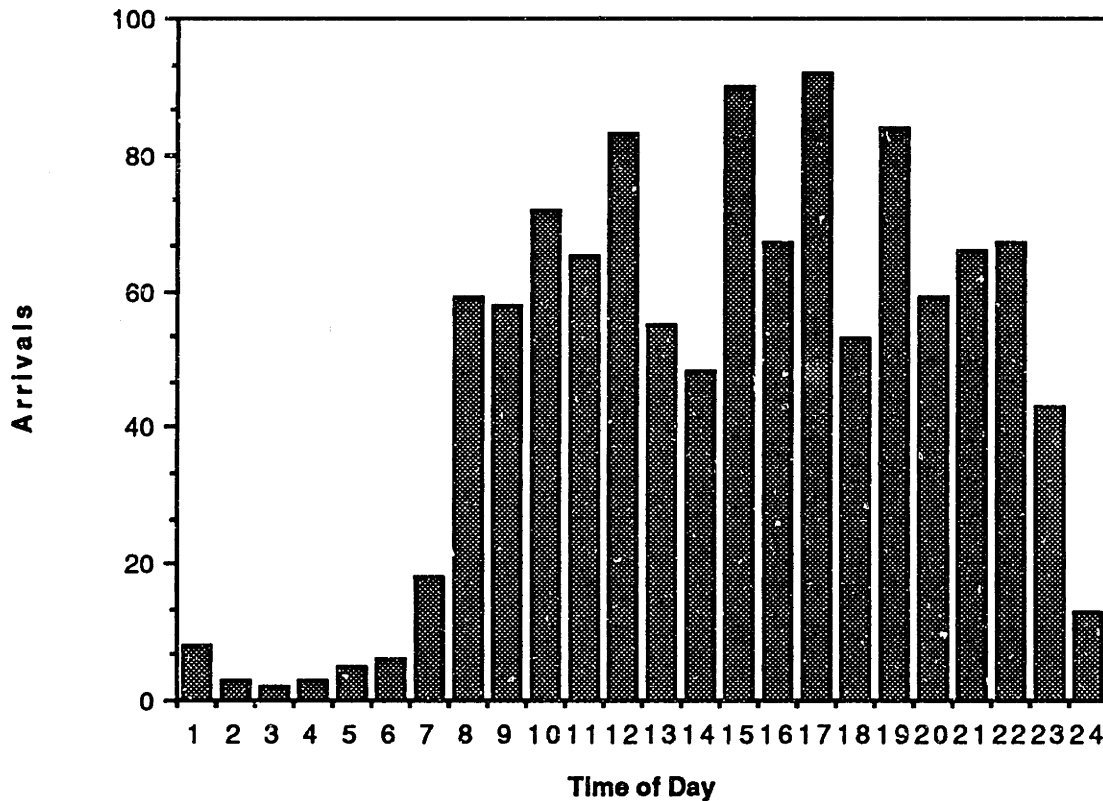
Table 1.5 indicates that Atlanta had 72% air carrier, 24.2% commuter, and 3.7%
general aviation operations in 1987. According to the FAA, most of the general
aviation aircraft had similar performance characteristics during approach and landing
as the commuter aircraft. Of the air carrier aircraft, 5.2% of the departures were
performed by wide-bodied aircraft and almost all of the rest by narrow-bodied aircraft
with approach speeds like those of the B-727 and DC-9. Using the model discussed in

[13] Airport Capacity Enhancement Plan: William B. Hartsfield International Airport, page 16.

section 3.2 of this chapter, one can estimate the capacity of Atlanta's airport given the mix of aircraft using the airport.

Figure 3.6: Hourly Variation of Demand for Departures in the Average Day of the Peak Month, 1986 [13]
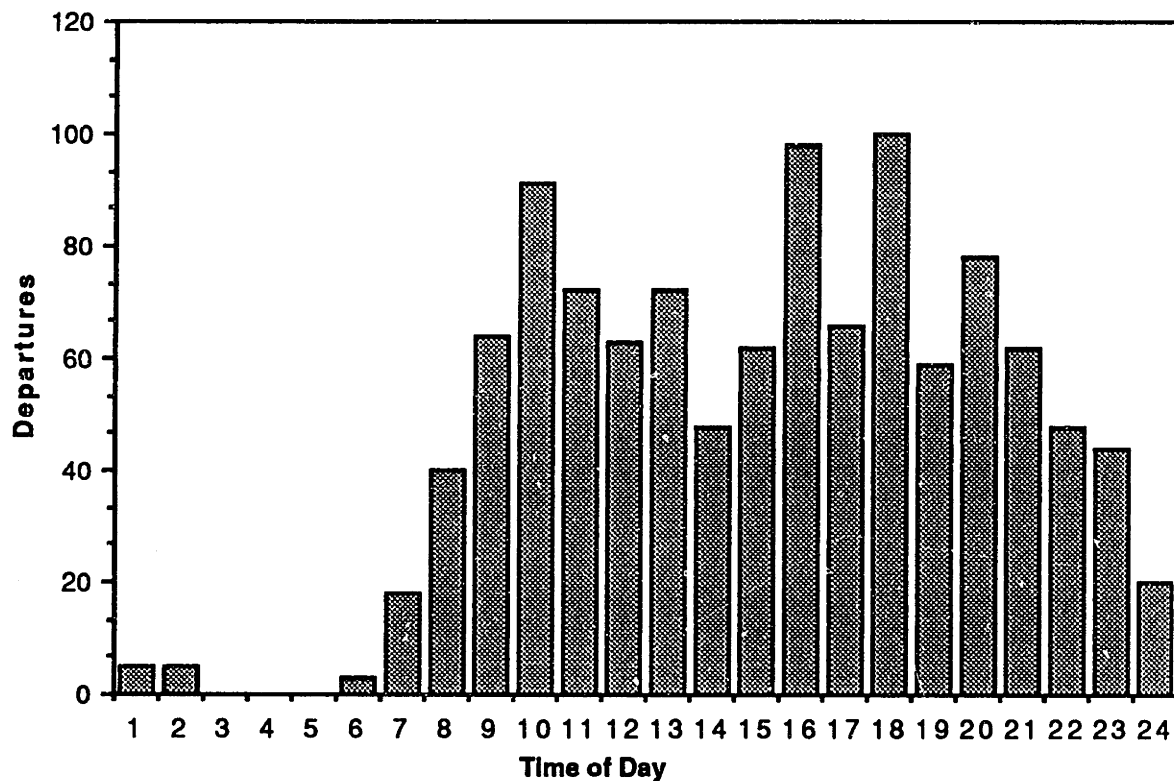
3.4.2   Modelling Atlanta's Capacity

For a simplified model of the capacity of a single runway, let there be only three types of aircraft serving Atlanta that are differentiated only by approach speeds. Type B are wide-bodied jets, type M are narrow-bodied jets, and type C are commuter and general aviation aircraft of greater than 12,500 pounds. Table 3.2 gives the p_{ij} matrix for this mix of aircraft as well as the percentage of each aircraft type $P(i)$ and their

estimated average approach speeds. It will be further assumed that the final approach path is six nautical miles long and that aircraft fly at their estimated approach speeds from the start of final approach until touchdown.

Table 3.2: Probability Matrix p_{ij} and Approach Speeds for Atlanta Aircraft

		Trail				
		B	M	C		
Lead	B	.001	.025	.010	$P(B) = 3.7\%$	$V_B = 160$ knots
	M	.025	.467	.191	$P(M) = 68.3\%$	$V_M = 140$ knots
	C	.010	.191	.078	$P(C) = 27.9\%$	$V_C = 115$ knots

The minimum distances between arriving aircraft D_{ij} are based on FAA regulations that take into account factors such as wake turbulence and visibility. Aircraft of type M and C are assumed to be between 12,500 and 300,000 pounds and those of type B are assumed to be greater than 300,000 pounds maximum gross take-off weight. Because of the number of high speed exits at Atlanta, runway occupancy times are assumed to be short enough to not interfere with arriving aircraft. If a lead aircraft i is faster than the trail aircraft j, separation time is given by

$$((6 + D_{ij})/V_j) - 6/V_i)). \qquad (3.12)$$

If the trailing aircraft is at least as fast as the lead aircraft, the separation time would be given by $\qquad (D_{ij} / V_j). \qquad (3.13)$

The D_{ij} matrices and the T_{ij} time separations for visual and basic VFR conditions are given in Table 3.3.

Table 3.3: D_{ij} and T_{ij} Matrices For Visual and Basic VFR Conditions [14]

Visual

$$D_{ij}$$

		Trail		
		B	M	C
Lead	B	2.7	3.6	3.6
	M	1.9	1.9	1.9
	C	1.9	1.9	1.9

$$T_{ij}$$

		Trail		
		B	M	C
Lead	B	60.8	111.9	165.5
	M	42.8	48.9	93.0
	C	42.8	48.9	59.5

Basic VFR

$$D_{ij}$$

		Trail		
		B	M	C
Lead	B	4	5	5
	M	3	3	3
	C	3	3	3

$$T_{ij}$$

		Trail		
		B	M	C
Lead	B	90.1	135.0	209.3
	M	67.6	77.2	127.5
	C	67.6	77.2	93.9

From equation 3.11, single runway capacity under visual conditions is 59.4 aircraft per hour, or 118.8 aircraft per hour for the entire airport. For basic VFR conditions, the figure would be 79.7 per hour for the airport. This simplified model overestimates capacity somewhat compared to the FAA figures partly because it does not take into account the small percentage of aircraft that have very slow approach speeds such as the Cessna Citation. The model also assumes maximum efficiency in the operation of the pilots and air traffic controllers.

These maximum throughput rates would increase if the mix of aircraft at Atlanta were adjusted to decrease the proportion of flights by the type C commuter

---

[14] Airport System Development, OTA-STI-231, Office of Technology Assessment, Aug. 1984, page 75.

and general aviation aircraft. Table 3.4 shows for visual conditions the current capacity given by the FAA, the capacity and queue waiting times as given by equations 3.10 and 3.11, and the capacity changes that would result under three conditions; P(C) = 20%, P(C) = 15%, and P(C) = 0%, where the proportion of type M to type B aircraft remains the same. The last would correspond to the building of a commuter runway that would be operated independently of the four current runways.

Table 3.4: Current Capacity of Atlanta and Capacity Under
Different Aircraft Mixes Under Visual Conditions

				Max Capacity (ldg/hr)	Wait (minutes) at 90% Max Capacity
	P(C)	P(M)	P(B)		
(FAA)	27.9%	68.3%	3.7%	85-110	---
Estimate with current mix	27.9%	68.3%	3.7%	118.8	5.1
Estimates with fewer type C	20%	75.7%	4.1%	123.2	4.9
	15%	80.5%	4.5%	125.5	4.8
	0%	94.6%	5.4%	138.9	4.1

The model indicates that reducing the proportion of type C aircraft by about 8% to the 20% level leads to an increase in capacity of less than 4%. A reduction to 15% leads to less than a 6% increase in maximum throughput of aircraft. Elimination of type C aircraft would lead to the greatest increase in capacity, but according to the model, it would lead to less than a 20% increase in the maximum throughput rate for larger jet aircraft. The potential increase in the number of passengers travelling through the airport may be very significant since even the smaller jet airliners have a much larger seating capacity than commuter aircraft. Even modest gains of 4% or 6%

47

in maximum aircraft throughput could lead to substantial increases in the number of passengers served.

Using the kind of capacity model presented in this chapter is one way to judge the relative merits of the options for capacity enhancement that are available to an airport authority. For the diversion of commuter and general aviation aircraft from the main runways, the Atlanta capacity enhancement plan includes a proposal for building a separate runway and terminal facility for commuter and general aviation aircraft. The plan estimates the cost in 1987 to be $100 millio . and the new facility would save an estimated $202.1 million in 1996. Other proposals by the airport authority include eliminating the peaks in airport demand for a savings of $80.5 million in 1991 and replacing one third of the commuter traffic with larger aircraft for a delay reduction worth $9.8 million in 1991. Armed with the estimated costs and benefits of several delay reduction plans, a local airport authority would have a better idea of what approach may be best for its particular situation.

The next chapter will look at several projects to reduce congestion that are under the control of local authorities or the FAA. They are all capacity enhancement measures that do not include the option of controlling peak demand or using economic incentives to reduce congestion related delays.

Chapter 4: Increases in Capacity by Changing Equipment and Procedures

The FAA is in the process of analyzing or implementing a number of ideas to reduce air traffic congestion near airports. Some of these ideas, like increasing the sophistication of airport landing aids, would be applicable at most of the nation's major airports. Others, like reducing the aircraft separation requirements during approach and landing, are smaller in scope and may have to be tailored for individual airports.

4.1   Methods of Increasing Airport Capacity

As mentioned in Chapter 2, the FAA favors increasing the capacity of the air traffic system as a means of coping with increased demand. This could entail building new airports or adding more airside capacity at existing airports, improving airspace control procedures, or using additional equipment either on the ground or in aircraft. The first and third options are quite dependent on the actions of local airport authorities, the airlines, and aircraft operators. As mentioned before, airside changes are subject to the approval of the people near the airport and the airlines serving that airport. For example, the people of Denver approved a plan to annex land in an adjoining county so that a new airport of substantially greater capacity could be built and the current airport could be decommissioned. The two major airlines at Denver Stapleton, Continental and United, are opposed to any move to a new airport, claiming that their operating costs per passenger would increase over sevenfold and that the Denver authority had greatly overestimated the future demand for airline flights through the city. Because the two airlines control over 86% of Denver's passenger traffic, they could conceivably use their commercial leverage to delay or stop the building of the new airport [15].

---

[15] *Aviation Week and Space Technology* CXXIX(11):142, 12 September 1988.

Using additional equipment to improve the effectiveness of ATC such as mode-C transponders on aircraft within a Terminal Control Area (TCA) would work best if use of the transponder were made mandatory for all aircraft in the TCA. Innovations like the Microwave Landing System (MLS) would have limited usefulness or cost effectiveness for increasing the air traffic controllers' ability to increase an airport's landing or takeoff rates unless many of the commercial and general aviation aircraft using that airport were properly equipped. Any move on the FAA's part to increase aircraft equipment requirements would probably meet organized resistance led by the major airlines and aviation lobbying groups like the Airline Owners and Pilots Association.

In the area of increasing the capacity of the air traffic system, the federal government has a freer hand in pursuing innovative strategies. While new technology is at the core of some of the methods of increasing capacity, changing perceptions of what is acceptable to the public and the FAA also plays a role. Changing long used procedures for handling aircraft is also a part of several plans that the FAA is either considering or implementing for increasing ATC capacity.

4.1.1   Enhancing Instrument Landing Systems

Proposed technological changes in instrument landing system (ILS) to increase landing capacity are a combination of two ideas: first, the development of a new instrument landing system technology and second, changing current ATC procedures to allow higher landing rates under IFR conditions on parallel or converging runways.

The first idea is incorporated in the MLS which is currently under development. Unlike the current ILS system where landing aircraft must fly above an imaginary extended centerline for several miles prior to landing, the MLS would allow aircraft equipped with MLS receivers to fly curved approaches to the runway until shortly before touchdown.

In order to take advantage of this curved approach capability and have an increased rate of aircraft landings, terminal area controllers would have to alter procedures to accommodate curved and straight approaches for several different types of aircraft. Once the MLS is installed at one or more airports, aircraft would have to be equipped with both systems to be able to perform instrument approaches at all airports. The FAA would also not be able to eliminate the current ILS systems from MLS equipped runways until the airlines and other users of instrument landing systems could incorporate the MLS into their aircraft. The MLS idea is not one that has been supported strongly by the airlines, in part because there is no clear competitive advantage in using the system unless doing so would allow an aircraft to get in more flights in marginal weather conditions. Using such a system may not be cost effective if most of their flight operations are at airports without MLS capability.

4.1.2　　　　Changing IFR Procedures

The second approach, involving the use of simultaneous ILS approaches, would not require a radical change of technologies but rather an improvement in the current ILS technology and changes in ATC procedures. Air traffic control procedures allow minimum longitudinal separations that vary from 2.5 to 6 nautical miles depending on the size of the lead and trail aircraft in order to protect the trailing aircraft from the effects of wake vortices. As of 1988, 19 major airports, including Atlanta, Dallas-Fort Worth, and the three largest New York area airports have requested or implemented reduced longitudinal separations. The improvements under IFR conditions are not large. At Newark, the estimated IFR capacity would increase from 25.3 to 26.9 aircraft per hour. Further reductions in separation standards may come as a result of

research the FAA is pursuing on the effects of wake vortices, but such reductions are not anticipated before the late 1990s [16].

Under VFR conditions, non-intersecting converging runways are often used to service independent streams of arriving aircraft. Under weather conditions which dictate the use of IFR procedures, such activities are not possible under current FAA guidelines and this can lead to severe delay problems as the service time for each aircraft waiting to land would increase. Roughly two thirds of all delays over 15 minutes are caused by adverse weather conditions, conditions often accompanied by reduced visibility, so increasing service rates under IFR conditions reduce aircraft delays at major airports in a significant fraction of these weather delayed flights.

Table 4.1 lists three of the 20 airports which the FAA has as candidates for independent IFR approaches for converging runways that can increase arrival rates up to about double of the single runway rates under IFR conditions. The FAA's goal is to be able to apply these techniques without using visual separation criteria. Research in pursuit of this goal will look at advanced cockpit avionics, more capable surveillance sensors, and new electronic navigation technology in order to implement these new procedures. The FAA estimates that implementation of these procedures would require at least five years to accomplish [17].

A similar project under development by the FAA is to implement dependent IFR approaches on converging runways. The agency has 18 candidates for this program with Boston's Logan airport being the site of a demonstration project. Table 4.2 shows that increases in IFR capacity are not as great as with independent approaches, only about 20% over single runway performance.

---

[16] Airport Capacity Enhancement Plan, U.S. Department of Transportation, 1988, pages 3-12, 1-31.

[17] Ibid, pages A-13, 3-1 to 3-3.

Currently, the FAA requires a 4300 feet separation between parallel runways for independent IFR approaches. The agency is pursuing ways to reduce this separation standard at 10 major airports to about 3000 feet. Table 4.3 indicates that such a shift would increase the number of operations performed under IFR by about 12 aircraft per hour. Aircraft may now land on parallel runways in a dependent fashion when the separation distance is between 3000 and 4300 feet so long as they maintain a two nautical mile diagonal separation distance between them.

Table 4.1: Sample IFR Capacities for Independent Converging Approaches

Airport	Runways	Capacity (arrivals/hour)		Time in Use
		Converging	Current Best	
Newark	4R,11	50.6	25.3	n.a.
JFK	13R,22L	51.0	25.5	n.a.
Oakland	27L,29	48.2	29.6	6%

Table 4.2: Sample IFR Capacities for Dependent Converging Approaches

Airport	Runways	Capacity (arrivals/hour)		Time in Use
		Converging	Current Best	
Newark	4R,11	30.3	25.3	n.a.
Boston	22L,27	38.0	26.0	4.1%
San Francisco	1R,10L	30.2	25.2	7.4*%

*Using different runway

Table 4.3: Sample IFR Capacities for Independent Parallel Approaches

Airport	Runways	Spacing	Capacity (arrivals/hour)		Time in Use
			Parallel	Current Best	
Memphis	36L,36R	3400'	49.2	35.2	8.9%
Minneapolis	11L,11R	3380'	49.2	35.5	n.a.
JFK	4L,4R	3000'	51.4	41.7	n.a.

In addition to this project, the FAA is considering allowing dependent approaches for parallel runways with as little as 2500 feet separation with the aircraft maintaining a 1.5 nautical mile diagonal separation for nine major airports, three of which are listed in Table 4.4. Currently, the FAA is evaluating the usefulness of these last two procedures at the FAA Technical Center in Atlantic City [18].

Table 4.4: Sample IFR Capacities for Improved Dependent Parallel Approaches Using 1.5 nm Diagonal Separation

Airport	Runways	Spacing	Capacity (arrivals/hour)		Time in Use
			Parallel	Current Best	
Memphis	36L,36R	3400'	40.3	35.2	8.9%
Phoenix	8L,8R	3400'	39.9	34.6	1.5%
JFK	4L,4R	3000'	45.4	41.7	n.a.

---

[18] Ibid, pages A-18,3-9.

4.2 Conclusions

Changes to the air traffic control system are evolutionary in nature due in part to the testing and evaluation that must be done to verify their applicability and safety. Because these changes cannot be implemented quickly, relatively fast changes in airline procedures or in the passenger airline fleet composition may overcome the gains that such ATC changes could make. As was the case with increasing an airport's runway capacity, an increase of an airport's IFR capacity may cause the airlines to expand service until delays become a problem once more. The actual effectiveness of these proposed changes would depend in large part on the reaction of the airlines and other airport users to increases in airport and air traffic capacity.

The improvements in capacity made by improving the capability of landing aids are largely beyond the control of individual airport authorities. In addition, the equipment and any accompanying new procedures must be put into place in many airports and aircraft in order to be cost effective for both the aircraft operators and the air traffic control authorities. This makes it difficult to tailor the solution to the unique problems faced by each airport. The next chapter contains a proposal to allow local airport authorities to control some aspects of congestion and delay by using economic incentives to reduce peak demand for airport use. The proposal is given not as a way to avoid implementing the airport and airway capacity enhancement measures mentioned in this and previous chapters, but as a way to give the airport authority the ability to tailor demand to the constraints of their airport. Such a plan would complement any increase in air traffic capacity by helping to counter bottlenecks that occur as demand for flight services exceed an airport's ability to supply that demand without major flight delays.

Chapter 5: Toward a New Policy to Reduce Airport Delays

The previous four chapters have outlined trends in demand for air service by airline passengers and aircraft operators as well as trends in delays at some of the nation's major airports. Because of the interpretation of the federal statutes that guarantee open access at fair and reasonable rates at all federally supported public airports, efforts to reduce congestion related delays have concentrated on projects that increase capacity rather than programs that focus on the modification of demand as a means to reduce congestion. The way that most local airport authorities are allowed to charge for airport use prevents them from either limiting airport access or using airport fees as a way to control congestion. As a result, aircraft operators at most public airports are charged landing fees that are insensitive to the level of demand. The local airport authorities are unable to impose congestion costs on the users, but during periods of high demand the users incur extra costs due to delays.

This final chapter presents an alternative approach to dealing with airport delays that can complement the kinds of capacity enhancements discussed in the previous chapter. This approach is one that advocates the use of economic incentives to reduce peak demand and related congestion delays. In a competitive marketplace, increased demand for a good is met by an increase in the price of that good as the market forces bring supply in line with demand. At most of the nation's major airports, increased demand for an arrival or departure opportunity does not increase the price charged for that good. The producers are limited in their ability to satisfy demand, so the consumers are forced to wait in queue until their desired good is produced.

The queues that may form would be reduced if a market mechanism could be created that would bring the demand of the good in line with the ability to create that good. Whether this kind of mechanism can be created and used to decrease congestion at major airports is the question that this chapter will try to answer. In the

context of congestion at major airports, this question brings up a two part issue: First, should local airport authorities be allowed to limit airport operations in order to control airport delays? Second, if they are allowed to do so, what form should this control take? To resolve these issues, one must define what is meant by regulation and deregulation, what alternatives to regulation exist, and what flexibility the airport authorities currently have when adjusting capacity to deal with changing demand.

5.1   Definitions

Many of the problems of airport congestion are a direct or indirect result of the changes wrought by the Airline Deregulation Act. Regulation is defined by Litan and Nordhaus as "governmental, legislative, or agency rules, having force of law, issued for the purpose of altering or controlling the manner in which private and public enterprises conduct their operations" [20]. Stone more narrowly defines regulation as "a state-imposed limitation on the discretion that may be exercised by individuals or organizations, which is supported by the threat of sanction" [21]. The two definitions imply that regulation consists of two basic activities, restrictions on activities and sanctions for operating beyond those restrictions.

The three authors further subdivide regulation into two types, economic and social. The former refers to the control of entry of firms into lines of business and the setting of prices that the firms may charge. The latter refers to those regulations that aim to correct a variety of side effects or externalities that are associated with economic activity. Social regulation, such as regulations concerning the environmental effects of enterprise, tend to extend across an array of industries. Economic regulation tends to concern a single industry. Regulation that concerns itself with controlling the

---

[20] Robert E. Litan and William D. Nordhaus, Reforming Federal Regulation, pages 5-6, Yale University Press, 1983.

[21] Alan Stone, Regulation and its Alternatives, page 10, Congressional Quarterly Press, 1982.

ways airports can manage congestion is for the most part of the economic variety. For example, controlling how an airport authority may change landing fees would be economic regulation but limiting the airport authority's right to expand its physical limits because of environmental side effects would be social regulation.

Deregulation on the other hand is defined by Brown as "the simultaneous termination of a regulatory instrument and the adoption of a non-regulatory form of intervention", or "the transfer of government control over a subject or activity from a control regime dominated by regulatory instruments to a regime that relies on non-regulatory methods of control" [22]. His definition is not one of deregulation as the termination of all forms of government intervention in an area subject to public control.

Government control over prices and routes ended as a result of the Airline Deregulation Act, but that did not mean that the airlines had carte blanche to do as they pleased in pricing or scheduling. Like other U.S. industries, the airlines were still subject to antitrust laws if they were to try and collude with their competitors for the purpose of fixing prices or restricting the freedom of another airline. The Airline Deregulation Act also did not prevent the FAA from limiting flight operations for reasons of safety or did the Act exempt airlines from noise regulations. For the airlines, the regulatory controls decreased substantially but did not disappear altogether.

5.2   Regulatory Justifications

Regulation may be a justified method of control if the free market by itself does not allow a solution to problems of efficiency, externalities, and equity that arise between involved parties. Efficiency means the maximum output for a given input of resources. For a congested airport, that output could be the number of enplaned

---

[22] Anthony E. Brown, The Politics of Airline Deregulation, page 27,
University of Tennessee Press, 1987.

passengers, seats available for passengers, or the number of flights to a destination. Efficiency could be measured by how much of the airport's resource is needed to accomplish a particular output.

An externality is a cost in a transaction that is not paid for by the parties directly involved in the transaction. An aircraft at a major U.S. airport may pay a landing fee which covers some of the airport costs, but some services like air traffic control are partly paid for out of general tax revenues. An airport that is near or beyond its capacity for handling aircraft may have many aircraft delayed for every new aircraft demanding service, but under the current fee system at most U.S. airports, the operator of this new aircraft would not have to pay any extra fee to compensate for the extra delay costs it may have caused to other operators.

Equity in this context concerns the structure by which the actors in a transaction exchange money, goods, and services. Unlike externalities and efficiency, equity decisions turn on values rather than on objective economic measurements. In the case of airport congestion, an equity concern could be whether the current airport use fee structure unfairly discriminates against a class of users. Arguments for the addition or removal of regulations that would have the result of changing the way local airport authorities and the federal government deal with airport congestion could be based on all three types of justifications, but this thesis will concentrate on the efficiency and economic externality justifications. To back an argument using these two justifications, one must first deal with the costs of regulation.

5.3   Costs of Regulation

There are three types of costs inherent in most regulatory schemes: administrative costs, compliance costs of firms or individuals, and indirect costs arising

from the regulatory program [23]. Of these three, only administrative costs can be estimated with some precision since for an airport authority or the federal government, such costs would either be explicitly funded as an independent budget item or as part of another budget item.

Compliance costs would be incurred by all aircraft operators at an airport that is under some kind of scheme to control access. For those operators of single aircraft or aircraft fleets whose schedules were not affected by the regulations, the costs would be the administrative costs plus the difference between the regulated fee and the fee that would have been in place without the regulations. For those operators that have their schedules changed, they would have the additional costs of rescheduling or cancelling flights, or the costs of moving operations to another airport. For the passenger, if the access regulations lead to a reduction of the supply of available seats the costs would include increases in ticket prices due to the airline administrative and compliance costs and to the increased value of a ticket. The indirect costs could include the negative economic impacts on the airport fixed base operators and concessions that serve aircraft and passengers, impacts such as having fewer passengers or aircraft available as potential customers.

These costs are balanced by the possible benefits of the access regulation. Reducing peak demand to the point that aircraft operators and their passengers do not face long or unpredictable delays will save on aircraft fuel costs, crew costs, and the cost of missed connections for passengers. For passengers the benefits would not be as direct. Reducing flight operations to the point that delays are much less frequent would reduce the time that the average passenger would have spent delayed in the aircraft or in the airport and would reduce the frustration that rescheduling missed flights would have caused.

_____

[23] Litan and Nordhaus, pages 18-19.

5.4   Alternatives to Regulation

The federal government and the local airport authorities have at their disposal seven alternatives to regulation as ways to intervene in a market: (1) antitrust enforcement, (2) information disclosure, (3) bargaining, (4) liability rules and private litigation, (5) public ownership or nationalization, (6) taxes and subsidies, and (7) market based incentives [24]. Of these, not all are relevant in the case of peak hour airport congestion. Airports are not experiencing congestion problems because the airport authorities are somehow restricting the aircraft's choice of airports but because a particular airport is a convenient or profitable place for the aircraft operator to land. The public and the aircraft operators already have at their disposal information that would give them an idea of how and when an airport becomes congested and how to avoid the congestion. Agreements without enforcement provisions reached through bargaining between aircraft operators and airport authorities are not a viable alternative because of the incentives for some of the profit seeking aircraft operators to ignore such agreements. Private litigation is not viable because operating an airport to the point of inconvenient delays does not justify court action since delays are not actions that are reckless or threaten the safety of airport users or the surrounding inhabitants. Further public ownership would involve taking some of the airport users out of private hands and that is out of the question as an option for U.S. airport authorities.

In conclusion, of these seven, taxes and subsidies and market based incentives are the two alternatives to formal regulation that are most applicable to dealing with the problem of airport congestion and will be looked at further in this thesis. Instituting either alternative would not be considered regulation in itself in that they lack the key

---

[24] Brown, page 25.

61

ingredient of relying on a coercive instrument to change behavior. However, instituting these sorts of reforms would require either a change in current federal regulations or a change in the interpretation of regulations that currently govern how an airport authority may control airport access.

5.5   Regulatory Agents

One relevant question in this discussion of regulation is who can set the regulations concerning airport access. The two most important groups that can do so are the federal government and the local airport authorities. Traditionally, local airport authorities have been limited in how they can control airport access. Every large commercial airport in the U.S. is dependent in some way on federal subsidies for the building or the operation of the runways, taxiways, and landing systems at the airport. In exchange for this support, airports must allow access by any aircraft and must agree to FAA regulations concerning user fees. Airports must be made "available for public use on fair and reasonable terms and without unjust discrimination " [25]. Airports receiving subsidies must spend user fees received from flight operations on capacity and operating costs and those not receiving subsidies must keep fees at a reasonable level.

In short, all airports regardless of the level of subsidies they receive must conform to federal regulations with respect to user fees. For the airports with traffic from operators of large commercial aircraft, the kind of fee structure that the federal authorities have traditionally found acceptable are weight based fees that do not discriminate by time of flight operation or the intent of the operator.

The federal government has the responsibility and the authority to regulate airport users through legislated authority given to the executive departments, and also

---

[25] 49 United States Code Annotated, §2210(a)(1) , 1989 Cumulative Annual Pocket Part, page 131, West Publishing, 1976.

through the commerce clause of the Constitution which gives the federal government the power to regulate commerce between the states. While the federal government continues to regulate safety, air traffic control, and many other aspects of civil aviation, it lost its role as a route granting authority as a consequence of the Airline Deregulation Act of 1978. The FAA has the option of limiting traffic for safety or environmental reasons and is controlling traffic at a handful of airports by strictly limiting the number of operations, but otherwise determining the level of demand for airport service is in the hands of the aircraft operators [26].

The users of the airports have varying amounts of latitude in coordinating their activities. If two or more aircraft operators are competitors, coordinating activity so as to not create an undue burden on an airport is difficult for two reasons. First, under most circumstances the practice would be in violation of antitrust statutes. While the federal government may grant exemptions in cases such as when an airport is suffering temporary capacity restrictions due to runway repairs, the local airport authorities can't offer such exemptions on their own. Second, a group of operators with some sort of agreement on scheduling cannot coerce its members to not break from such an agreement if doing so were to a member's advantage. The OPEC cartel is one such example of this situation. Even if a significant group of non-competitive airport users like general aviation operators could form such a group, without the participation of the airlines such a scheme would not be of much benefit to the non-competitive operators. The result of legal prohibitions for some users and a lack of an effective way to enforce scheduling agreements among the other users leaves airline customer or aircraft operator demand as the prime factor that determines the number of an airport 's flight operations.

---

[26] Washington National, New York La Guardia, New York Kennedy, and Chicago O'Hare.

5.6   Economics of Airport Operations

Because of the limitations of federal laws and the interpretation of what constitutes a reasonable cost to the user, airports normally charge landing fees based largely on the weight of the aircraft. This charge is the same no matter how much of the airport's resources are used to effect a flight operation or how much other airport users may be inconvenienced. During peak hours of operations, airlines and other users incur only those extra costs that may come from delays. However, each additional aircraft that operates during peak periods experiences only the effects of average delay and not the effects of the total marginal increase in delay [27]. Since an airline would experience only the average delay, measuring the costs of adding another flight to this peak period against the gain in revenue would yield a better result for the airline than if all costs were taken into account. Similarly for other types of airplane flights, the gain in convenience of peak hour operation is not offset by the full costs to the other users. The prices charged this extra aircraft is the same, so there is reduced economic incentive to fly outside of the peak hours.

Aircraft operators will vary greatly in the value they give to being able to operate without undue delay at a given time. While the recreational user or an operator of an aircraft for some non-revenue generating purpose may not put much of a value on peak hour operations, the airline operator trying to meet a schedule or the executive in a business jet flying off to close a multi-million dollar deal would be willing to pay for the privilege of flying without unnecessary delays.

Whatever value an individual operator may place on an aircraft operation, the present system does not allow the local airport authorities to charge landing fees that reflect the value of a flight operation to an aircraft operator or to increase fees to either offset the costs of congestion or as a means to discourage flight operations during

---

[27] Michael E. Levine, Landing Fees and the Airport Congestion Problem, *Journal of Law and Economics*, XII:79-108, 1969, page 90.

hours of peak demand. In spite of these limitations, airport authorities still have ways to reduce congestion. A reduction in congestion may be accomplished by increasing the capacity of the air traffic control system, a system that is funded through revenues collected by the federal government and not through airport operator funds. Other methods of expansion like the building of runways and taxiways would have to be financed in part by the airport authority, but most of these costs are also covered by federal funds.

While such expansion may be justified for reasons other than peak hour congestion, if a particular airport does experience severe delays due to peak hour demand and has no way to limit these operations, the authority may have no reasonable option but to build facilities that may accommodate peak demand, but at the same time the facilities may be relatively idle during non-peak periods. Even if the new capacity is added, the rules by which the authority can charge airlines would not change and the authority could face the same peak demand problems in the future.

As interpreted by the federal authorities, the fair and reasonable terms under which airport authorities can allow aircraft to use an airport leaves airport authorities with only less efficient options for dealing with an increase in demand in airport services. Without the options of imposing numerical caps on activities or of increasing fees to reduce demand, the airport authority can either expand the airport, or adjust to aircraft delays and live with them. If it does not expand, then in the future it will continue to face these delay problems until the aircraft operators or their customers reduce their demand for service. Given the growth of air operations and passenger enplanements at major airports over the last three decades, that is unlikely to happen. If instead the airport expands its airside capability, delay problems would be accommodated in the short term, but if growth in air operations rises or falls faster than expected, the new capability would be either inadequate or underused. The possible

results of expanding or not expanding airside capacity under different growth rates are summarized in Table 5.1.

Table 5.1: Consequences of Airside Expansion Decisions

| Airport Authority Choice | Future Delay Situation | | |
	Decrease in air operations	No change in demand	Increase in demand
Airport Airside Expansion	Excess peak capacity. New facilities not beneficial	Fewer peak delays. New capacity beneficial but not fully used	Good investment unless growth more than prediction
No airside expansion	Peak delays will decrease	Problems about the same	Problems worsen

Both choices represent risks for the airport authority. Without an ability to channel demand more evenly and to make efficient use of the airside resources, the prudent airport authority would choose to err on the safe side and expand, risking having too much rather than too little capacity to meet to future needs of the airport's service area.

5.7   Access Issues

The limits of airport authority action and the consequences for airport development brings up two basic issues that must be addressed: First, should local airport authorities have the ability to effectively limit airport access in order to decrease problems caused by aircraft delays? The answer is clearly yes. In this thesis it has been shown that without any direct or indirect controls on the time or number of aircraft operations, an airport could have a situation where users can experience significant delays due to congestion, especially during weather that can decrease

66

airport capacity. Because of the landing fee structure common to most airports, aircraft operators do not have the economic incentives to either avoid flying during busy periods or to make the most efficient use of a flight operation. By using increased fees to reduce peak demand to the point that it is far enough below the current capacity of an airport to avoid most delays, the airport will be able to adjust to short term fluctuations in demand for services and would be better able to allocate the congestion costs of airport operations to the users.

The current system of weight based pricing does not necessarily correlate with the value an aircraft operator puts on a flight operation. The operators of airline or corporate aircraft may be willing to spend extra money to to avoid congestion delays, but are unable to do so under the present system. Referring to the increases in efficiency denied airport users, Levine [28] stated that

> ... The flat-rate system of landing fees does not allow those airlines who prefer to schedule tightly and increase aircraft utilization the opportunity to use the savings possible from this method to buy the delay-free operations which are a precondition to full implementation of that policy. It delays equally long-haul passengers who have few substitutes for air travel and short-haul passengers who would otherwise use trains, buses, or private automobiles. It discourages attempts to reduce congestion, for as long as the allocation system leaves competitors free to substitute their aircraft for its own, there is no incentive for an airline to try to reduce delays by running fewer and fuller flights at peak hours or by limiting its peak-hour efforts to its highest value operations.
>
> Another aggravating factor is that, at present, neither direct nor indirect exchanges are possible because there are no property rights in airport operations. Since delay is experienced by all operators as time valued at different money rates, a system which allows conversion into a common medium, such as money, and direct or indirect exchanges would permit society to extract full value from scarce airport resources. The public commitment to

---

[28] Levine, page 92.

first come, first served operation, with landing order and delay determined by "operational," rather than economic, criteria creates enormous waste. By eliminating this waste, output can be increased, and society made better off. By redistributing income, even those who are temporarily damaged by right assignments can be made better off than before.

Since the answer to the first question was yes, the second and more basic issue that arises is as follows: How should the federal government change its regulations in order to allow the airports to have the latitude to limit airport access so as to avoid some delay problems? The development of congestion and delay problems at airports today is an indirect result of the mismatch between the freedom aircraft operators have to use an airport regardless of the delay implications for other users and the restrictions on airport authorities which prevent them from creating incentives to decrease congestion.

In short, the imbalance of freedoms of the aircraft operators and airports is the problem and correcting that imbalance rests in the hands of the federal government. This imbalance represents a stumbling block that is preventing the development of the competitive airline market which was one of the goals of airline deregulation. This stumbling block causes actions which may be socially wasteful in that resources are committed to airport expansion, air traffic control improvements, and flight delay costs that could instead be used elsewhere in the economy. The following sections will attempt to show a way to overcome that stumbling block and to answer the second question.

5.8   Proposed Policy Change

The current system of assessing airport use fees is economically inefficient because it does not provide sufficiently strong incentives to prevent problems that stem from airport congestion during periods of peak use. While the relevant federal statutes such as 49 U.S.C. §2210 do not explicitly prohibit airport fee schemes that

would bring such incentives into being, these statutes do not specifically allow them either. The interpretation of the relevant federal statutes by the federal court system also does not give either the DOT or local airport authorities a clear mandate to allow these economic incentives. For example, in the September 1989 decision of the U.S. Court of Appeals in the First Circuit mentioned in Chapter 2, the court found that the determination of the reasonableness of an airport's user fees was within the DOT's jurisdiction. The Secretary of Transportation agreed that federal law allowed an airport authority to employ reasonable landing fees or other user fees even if such fees resulted in a decline in usage by a class of user. In the case of Massport's PACE plan, the Secretary ruled that in the first phase of the plan, the allocation of airport costs was not scientifically derived and that small aircraft were burdened with a disproportionate amount of airport costs. The Secretary concluded that this kind of cost allocation violated federal guidelines for airport fees and partly as a result of this violation the Secretary did not approve the PACE plan.

The decision of the Appeals Court in the PACE case was important because it affirmed both the DOT's power in the area of approving the user fees set by local airport authorities and also the DOT's role in managing the nation's air transportation system. What the decision did not do was create a firm and unambiguous basis for federal guidelines that would specifically allow local airport authorities to modify demand using economic incentives or other means as a way of reducing airport congestion. The following policy proposal is offered as one way to allow such incentives to come into being within the current framework of federal control over the air transportation system.

The federal government should change its policies and regulations so that delay reduction and the control of congestion would clearly become allowable goals for local airport authorities when they create their fee schedules. In addition to encouraging expansion of an airport's capacity as a means of dealing with increased demand, local

airport authorities should also be encouraged to use economic incentives to modify demand to better fit the airport's resources. Rather than continue the practice of having local airport authorities recover airside expenses through fees that are based almost entirely on the landing weight of an aircraft, local airport authorities should be given explicit guidelines on how they may include congestion costs in the determination of their airport fees and in doing so make an airport usage fee more closely reflect the economic value of that flight operation. The federal government and in particular the DOT should retain its role as overseer of the national airspace system by making sure that the goals of local airport authorities do not conflict with national air transportation goals.

This proposal brings up five issues that will be addressed: (1) why this proposal is justified, (2) what kind of controls are best and why, (3) who would be affected by these policy changes and how, (4) who determines what is acceptable delay, and (5) how such a proposal could be put into place.

5.9   Justification of the Proposal

Using Stone's criteria, this change of policies and regulations can be supported by two of his three justifications, efficiency and externalities. Explicitly broadening the freedoms of the local airport authorities in the area of setting usage fees could result in greater economic efficiency through the workings of the market. Higher peak hour prices for arriving or departing aircraft would mean that those who value these operations most may continue to do so if they are willing to pay for the opportunity. This group would most likely include a high proportion of aircraft with paying passengers or other aircraft engaged in profit-oriented operations. Those that would be encouraged to fly at other times would likely consist of air carrier aircraft with relatively few passengers and most general aviation aircraft.

70

The externalities that would be eliminated are those that have been earlier described. Currently, aircraft which fly during peak periods do not have to pay for the consequences of increased delay incurred by others. Also, any aircraft operator that is delayed by the actions of other aircraft can neither receive compensation for delay costs nor pay a fee that would help to create congestion free operation for its aircraft. In a sense, the current system of weight based landing fees acts as a subsidy for some of those who wish to operate during busy periods. Incorporation of higher fees during popular periods of operation would eliminate this subsidy because the costs of a flight operation to other users would be incorporated within the usage fee.

5.10   What Are the Best Controls?

There are two basic ways to reduce congestion by exerting control over the number and type of aircraft operations allowed in a time period: regulatory methods that assign limits on the number of total aircraft that may operate in a given period and market based schemes that would have the effect of limiting operations by using economic incentives. If a scheme of the first type were to be applied to control peak usage, then it would imply that some administrative group at the local airport authority or within the federal government would decide both the proper level of traffic and the level of each type of operation that should be allowed.

There are three major disadvantages to having strict limits on the number of flight operations. First, it is difficult for an administrative group to determine a priori what the optimum amount and type of traffic should be during a given peak period. For example, to determine an optimum number of peak hour airline flights, the group should know how those flight operations may fit into the airlines' schedules, how many passengers may be served by those flights, and the schedules of the various passenger carriers. Passenger demand or an individual airline's strategy may change on a daily basis and may be quite difficult to predict over longer periods. The best laid predictions

71

may be rendered much less useful by an airline strike, the entry of a new airline, or some other unforeseen perturbation of an airline's schedule. The second major disadvantage is that an aircraft operator and its passengers may be denied a landing or takeoff opportunity even if the operator were willing to pay the full marginal costs of the increased delay that their actions may cause. Third, an airline may be willing to use up opportunities to fly at busy periods as a way to deny established competitors or new entrants the opportunity to compete fairly. Depending on the nature of the plan, one or more airlines may also collude in order to drive up the price of a flight operation.

The second type of control would be one that is based on the sixth and seventh alternatives to regulation given by Brown, taxes or subsidies and market based incentives. Together, they may be used to reduce the incidence of flight delays by encouraging traffic to operate outside of peak periods and by discouraging peak hour use by those aircraft operators who do not value peak hour operations very highly. A market based incentive could take many forms, one of which could be the use of no limits on the number of flight operations during busy periods, but with the airport authority setting prices high enough to discourage some aircraft flights and keep delays at a reasonable level. This could be combined with subsidies granted in other periods to encourage flights during non-congested time periods. During the periods of highest demand, all aircraft could be allowed the chance to purchase a flight opportunity in order to keep within the spirit of the federal laws that require fair access to all federally supported airports.

This second type of congestion control also suffers from several drawbacks. Local airport authorities would face the same problems of uncertainty regarding the actions of airlines and other aircraft operators. What may be a busy period one month may become a slack period the next month as schedules are changed to avoid higher use fees or to take advantage of subsidies. The airport authorities may have to constantly adjust fees to keep up with changing strategies. This type of control would

not necessarily guarantee that peak traffic would be reduced sufficiently to have an effect on congestion. Circumstances like a large increase in peak hour flights by an airline wishing to increase its market share or a desire by one or more airlines to maintain their schedules in spite of fee increases may effectively counter the actions of the airport authority. However, these are actions which are to be expected when market demand determines the number of flights. Subsidies may also have two undesirable side effects. First, the subsidy could be used by aircraft operators to support unprofitable flight activity. Second, subsidies may serve to attract new air traffic as well as shift traffic from periods of high demand to times of low demand. These drawbacks are also possible if control over demand were exercised by limiting the number of flight operations. However, if an airport authority were using economic incentives without any controls on when an airline may fly during the day, this use of subsidies would probably be more prevalent.

For either type of congestion control, the incentives would have to be altered for some types of traffic during times of high demand. Emergency flight operations or those involving flights to small communities under the federal Essential Air Services program should not be subject to the same criteria as normal airline or general aviation traffic. This could be done by waiving most or all of any special usage fees or by setting aside a number of landing or takeoff opportunities for such aircraft.

One problem common to both types of controls is determining the capacity of an airport. As has been discussed in the third chapter, an airport's capacity changes as a function of weather, the runway configuration, capabilities of air traffic controllers and pilots, and behavior of aircraft while on the ground or in the air. These are factors which can change by the hour, day, or season, so any determination of future capacity is inherently uncertain. This makes either type of plan imperfect with respect to finding the right peak hour capacity that would keep flight delays reasonable.

Another potential difficulty common to both of these two types of controls is the potential for abuse by the airport authority. Because the airport usually has a monopoly on the type of landing and terminal resources that the airport users desire, the airport authority could use the peak hour fees as a way to gain excessive profits from the users. There are already ample safeguards in place against price gouging by the airport authority. The fair and reasonable standard for airport use fees that currently exists under U.S.C. 2210(a)(1) would have to be interpreted differently to include the two kinds of congestion control mentioned above, but it is unlikely that the interpretation would include extra fees that are far in excess of those needed to reduce congestion. The airport authority could try such fee schemes, but affected parties like airlines or general aviation interest groups would very likely challenge such schemes in court.

This possibility of a court challenge brings up the issue of who should have the final authority to approve an airport authority's method of delay reduction. That responsibility would most likely lie within the DOT or it could be put into the hands of the local airport authorities. Allowing the federal government to have oversight responsibility would likely lead to more consistent application of new types of fee schedules. On the other hand, making the plans of the local airport authorities subject to federal approval may lead to fee schedules that submerge solutions beneficial at the local level in favor of national goals. On the other hand, if the local authorities were given a free hand in coming up with innovative incentive strategies, one could have a situation where an aircraft operator could face radically different circumstances from airport to airport: peak hour surcharges coupled with slot limitations at one airport and surcharges with no limitations at another, or open markets on peak hour flight opportunities at some airports and markets largely closed to new entrants at other airports.

If the DOT or some other part of the federal government were not the approval authority for delay reducing airport fee plans, disputes may have to be resolved using the court system as the most convenient arbiter. This would probably rekindle the kind of confusion evident in the series of cases in Chapter 2 where a variety of federal courts tried to interpret what Congress meant by a fair and reasonable airport fee. Setting up an environment where airports' congestion reduction plans would be prone to this kind of ambiguity would be detrimental to the goal of increasing the efficiency of the air traffic system and would weaken the efficiency justification for changing federal policies and regulations concerning airport access and fees. For this reason, the federal government should have the role of approving airport fee structures.

Given the drawbacks inherent to both basic methods of decreasing congestion delays, it would be better to choose the second type that emphasizes economic incentives. Of the two, it is closest to the spirit of the Airline Deregulation Act in that it opens up the airlines further to the forces of the market. At the same time, economic incentives would more closely follow the long time federal policy of open access to the nation's federally supported civil airports because no aircraft would be denied the opportunity to use any airport because of the delays it may cause.

The details of how such a control could be exerted at a particular airport is something that would depend on that airport's situation. Massport's PACE program to reduce congestion delays gives an example of how one airport's demand situation shaped the formulation of a delay reduction plan. This plan, although ultimately rejected by the DOT, was partially in effect for about six months in 1988 and was the focus of some of the court cases mentioned in the second chapter. The following critique will serve to illustrate some of the advantages and disadvantages of the two delay reduction methods discussed earlier.

5.10.1   A Critique of the PACE Program of Massport

Massport, the authority over Boston's Logan airport, developed a two phase plan to reduce peak hour delays that combined both types of delay reduction methods, quotas and economic incentives. Although their quota system did not assign strict limits on the number of aircraft that could fly during a period of high demand, that part of the plan suffered from the same kinds of drawbacks mentioned in the previous section.

In the first phase of the Authority's Program for Airport Capacity Efficiency (PACE), Massport assessed landing fees not on the basis of landing weight alone but by using a two part system which allocated fixed costs such as utilities and snow removal on a per landing basis while allocating variable costs like runway maintenance and insurance as a function of an aircraft's weight. The first phase of PACE was in effect from July 1, 1988 to December 28, 1988 and during that time the program was a significant factor that led to the reduction in both the amount of aircraft delays and in the number of general aviation and commuter aircraft operations. The key element causing these shifts was the change in the fee structure. Prior to July 1, 1988, aircraft were charged as a landing fee the maximum of either $25 or $1.31 per 1000 pounds of gross certified landing weight (GCLW). Table 5.2 gives landing fees for a variety of aircraft and the fee schedules in effect from July 1, 1988 to December 28, 1988.

Table 5.2: Logan's PACE Sample Landing Fees and Fee
Schedules July 1, 1988 to December 28, 1988

Landing Fees

Aircraft	Before Jul. 1	Jul. 1 - Sep. 30	Oct. 1 - Dec. 28
Beech 1900	25	100.45	112.37
Lear 36A*	25	101.14	112.97
MD 80	170.42	162.20	175.21
767-200	353.94	238.04	252.37
747-200	825.87	433.05	450.81

*Approximate

Fee Schedule

Prior to July 1, 1988	Minimum of $25 and $1.31 per 1000 pounds GCLW
Jul. 1 to Sep. 30, 1988	$91.78 + $0.5417 per 1000 lb. GCLW for commercial aircraft $91.78 + $0.5058 per 1000 lb. GCLW for general aviation aircraft
Oct. 1 to Dec. 28, 1988	$103.55 + $0.5512 per 1000 lb. GCLW for commercial aircraft $103.55 + $0.5091 per 1000 lb. GCLW for general aviation aircraft

Source: Massport Office of Public Affairs

The PACE fee schedule had a dramatic effect on general aviation and commuter flight operations. General aviation flight operations, involving mostly piston-engined aircraft, dropped 34% in the July to December 1988 period compared to the same period in 1987. Tables 5.3 and 5.4 indicate the changes in this period. This first phase of PACE increased the landing fee for the smallest aircraft by over 250%, but it did not as part of the plan prevent these aircraft from flying. It was only an economic incentive which helped to achieve a reduction of aircraft delays during the short time that it was in operation.

Table 5.3: Changes in Scheduled Passenger and Flight Operations
at Logan, July 1, 1988 to December 28, 1988

	Jul - Dec 1987	Jul - Dec 1988	Change
Domestic Air Carrier Flight Operations	111,854	110,021	-1.6%
Commuter Flight Operations	66,941	62,562	-6.5%
General Aviation, Military, and Other Flight operations	22,111	14,601	-34%
Total Operations	214,347	202,323	-5.6%
Domestic Air Carrier Passengers	9,564,563	9,709,458	1.5%
Commuter Passengers	712,019	704,011	-1,1%
General Aviation Passengers	45,584	34,579	-24.1%

Source: Massport Office of Public Affairs

Table 5.4: DOT On Time Performance and Ranking Sep. 1987 - Dec. 1988

	Percent On time Arrivals		Logan's Rank Among the Six NE Corridor Airports*	
	1987	1988	1987	1988
Jan	---	69.7	---	3
Feb	---	70.9	---	6
Mar	---	71.5	---	6
Apr	---	67.7	---	5
May	---	62.0	---	6
Jun	---	78.4	---	4
Jul	---	71.7	---	2
Aug	---	78.3	---	2
Sep	69.5	86.4	4	3
Oct	79.0	85.9	5	3
Nov	69.2	79.5	3	2
Dec	71.2	82.9	5	1

* Boston, Washington National, Newark, JFK, La Guardia, Philadelphia

Source: Massport Office of Public Affairs

If implemented, the second phase of the program would have involved determining what the practical capacity of the airport should have been to avoid substantial average delays at the airport for 80% of the time the airport is in operation. Once this figure were determined, some aircraft operators would be charged additional fees for landing during peak demand periods. Unfortunately, this second phase of the program had the three kinds of drawbacks associated in the previous section with imposing limits on the number of aircraft operations.

In their preferred scheme, flights the Authority considered to be of highest priority, those with the highest passenger carrying capacity potential, would not have been charged any peak hour landing fee premium. If there were still slots left during a peak period, other aircraft could bid for these slots in an auction to be held every six months. After the assignment of priority flights and the auction for non-priority slots, aircraft that later decided to fly in the peak hour could do so without penalty if it were a priority aircraft and with the imposition of an extra premium if it were an non-priority aircraft. The second phase of the PACE program was only a proposed scheme that was not implemented by Massport. However, if carried out it would have been flawed as a way to allocate capacity in peak demand periods compared to the method preferred in the previous section. In the method favored in this thesis, the users would have defined the importance and the economic value of a flight and not Massport because it would have been difficult for the Authority to be as knowledgeable as the aircraft operators about the economic value of a flight operation. For example, because the passenger carrying potential and not the number of actual passengers made an aircraft a priority flight, an arriving 747 filled with cargo would have had the same priority as one with 400 passengers. While determining an aircraft's priority by its passenger capacity may have been convenient for Massport, it is not a desirable method because it does not necessarily reflect the flight's economic value to the aircraft operator.

A related flaw is that the program does not explicitly deal with short term changes in demand and the effect it would have on peak hour delays. Eastern Airlines represented a significant fraction of Logan's traffic and their strike of 1989 is only one example of how conditions may radically change during the six month interval between auctions. Nowhere in the Massport proposal were the consequences of a large drop in demand for peak hour flight operations discussed. The operators of the smaller commuter and general aviation aircraft that may have paid for the privilege of operating during a peak hour would surely feel cheated if the projected peak hour demand did not materialize. On the other hand, an increase in peak hour operations by aircraft in the priority categories could increase delays in these peak hours without having either the operators of priority aircraft incur any congestion penalties.

If the second phase of Massport's plan had been put into action, Massport in conjunction with the DOT and the FAA would have determined some figure for hourly practical capacity, a figure that would be less than the optimum hourly VFR capacity, and Massport from this would determine how many aircraft from each category could fly. If an aircraft in a non-priority category that did not previously buy a slot decided to land or take off during a peak hour, then under Massport's proposal that aircraft would pay a premium for the operation. If actual capacity and airport demand during this designated peak period were such that the aircraft did not contribute to delay, one could argue that such a congestion related premium would be unfair to that aircraft. This represents the second kind of flaw in this method of delay control because the non-priority aircraft in this situation would be paying for delays that they did not create.

The auction method for determining the cost for non-priority use of a peak hour landing is not very robust and it is here that the third kind of flaw may show up. It is not very robust because the prices would vary only at six month intervals. Even if demand remains stable, it may take two or more auctions before the peak hour prices

80

reflect the value that the non-priority users put on those operations. The third kind of flaw may occur because in this kind of an auction, it is difficult to prevent some of the participants from colluding in order to artificially raise or lower the cost of a peak hour operation. While the airlines may face sufficient legal penalties that would discourage them from pursuing such actions, the individual aircraft owners or the agents representing general aviation aircraft operators who may bid in the auction may not be subject to these regulations and penalties.

The flaws in phase two of Massport's PACE proposal stem from the administrative nature of the plan. Massport's decisions on who would pay the peak hour fees and how those fees would be determined in general do not appear to be flexible enough to deal with changing demand for airport services. Massport set out to eliminate the biases to new entrants and other faults of the slot system in effect at La Guardia and other airports. Shortcomings like grandfathering the positions of established airlines were eliminated, but the Massport proposal still has enough shortcomings of its own to make it an undesirable model for reducing peak demand.

In contrast to the method used in Massport's PACE program, the delay reduction scheme favored in this thesis would put nearly all aircraft on an equal footing when it comes to allocating the supply of flight opportunities during periods of peak demand. The price that an aircraft operator would pay, which would include the cost to the airport for providing the airport facilities plus the market-determined surcharge for a flight operation during a peak demand time, would be based on the value an aircraft operator puts on that flight. Under the system proposed in this thesis, aircraft operators and other groups are affected in different ways by the user charges and subsequent changes in demand.

5.11   How Groups are Affected in This Proposition

If a market based, economic incentives were to be widely used as a means to modify demand and control congestion delays at an airport, the local airport authority, the aircraft operators, airline passengers, and the airport air traffic controllers would experience different kinds of gains and losses compared to keeping the current system in place.

5.11.1   The Local Airport Authority

As explained earlier, one advantage for the local airport authority is that air traffic could be controlled to prevent some of the delays that currently result from congestion during periods of high demand. Airport facilities like passenger waiting areas and short term parking would not be subject as often to surges in use by airport patrons that would result if peak delays were not reduced. Assuming that smaller capacity aircraft would be the ones most likely to change their schedules, the airport would be able to cater more to the needs of larger aircraft and their passengers.

Because aircraft operations could be more evenly spaced, the authority may not have to expand airside or terminal capacity as much in response to an increase in overall demand. Knowing that they would have the flexibility to control the pattern of demand during the day, the authority would not have to have as much excess capacity in resources such as runways, taxiways, and terminal space in order to handle peak demand. Also, the extra funds that peak hour landing fees may bring could lessen the authority's financial burden for such capital improvements.

The largest potential change for the local airport authority aside from a reduction of congestion delays may be a windfall of money. If a delay reduction program such as the one proposed in this thesis is successful, then aircraft operating during periods of high demand will pay more for their services and the extra charges would represent the value these operators give to congestion avoidance. This increase in revenue could

possibly be passed on as subsidies to encourage other aircraft operators to fly during periods of low demand or, if local circumstances permit, be used to build more airside or landside capacity at the airport. Where the money could actually go is not a direct concern of the proposal in this thesis. That decision would probably rest with the federal government.

Putting the final decision in the hands of the federal government would not mean removal of local control of extra income from an altered fee structure. Given the federal role as manager of the air traffic system, it would be able to use its unique knowledge to suggest to the local authorities how any extra income may be used to enhance airport operations. At the same time, the limits of what the local authorities can do with any extra income would be determined by the limits the federal government currently impose on an airport authority's use of airport fees.

5.11.2   Aircraft Operators

The effects on aircraft operators are different depending on the type of flying in which their aircraft are engaged. For the airlines, changing to a peak hour pricing scheme would be of direct benefit to those operating large aircraft and less benefit to those operating smaller commuter planes. An airline operating a scheduled jet aircraft with many passengers has two incentives for paying a high enough premium to operate in the peak hour. First, they have more passengers on an aircraft or in their total system among which they can spread the extra costs. Second, decreases in the frequency or length of delays saves the airline fuel, maintenance, and crew costs and would allow the airline to schedule its operations more efficiently, offsetting some of the extra peak hour flight operations charges.

Operators of smaller commuter aircraft will also have these incentives, but since the costs of operating a small commuter aircraft are much smaller than the costs for larger jets, the commuter operator may not find a peak operation as worthwhile.

However, if the commuter is in some sort of agreement to feed passengers to a larger airline, they may receive a subsidy from the airline to help offset any peak hour costs. Also commuters serving cities as part of the Essential Air Services program may also receive subsidies from the federal government or a waiver of peak hour charges in order to continue service.

General aviation operators would probably be most affected. Without paying passengers to offset increases in fees, a general aviation operator may simply choose to avoid the peak times altogether and fly either during off peak times or at another airport. The reduction in congestion would be advantageous to that portion of general aviation aircraft users, primarily business people, for whom the time saved by avoiding delays or the profits gained by operating at a peak hour is worth the expense. Other general aviation users would incur extra costs due to either an increase in airport fees or due to moving their operations to another airport.

5.11.3   Airline Passengers

The advantages for passengers parallel the advantages for the type of aircraft in which they are flying. Assuming that increases in airport fees are passed on to the airline passenger in some form, those passengers on larger jets would see a smaller average cost increase than those on smaller aircraft. In exchange for the increased ticket prices, the passengers would probably save time and avoid some of the aggravation associated with flight delays. Prices for the peak hour passenger would rise directly because of any increase in fees and indirectly because higher charges for aircraft operations may reduce the supply of flights or the number of seats per flight available to them. On the other hand, those passengers may experience a corresponding decrease in the frequency of delays that they experience.

If increasing peak hour charges are successful in reducing flight delays, passenger behavior may change as well. Peak hour arriving passengers and the people

who may greet them would tend to spend less time in the airport and spend less money on airport facilities like short-term parking. Departing passengers would also gain by having less of their time spent waiting for delayed departures. Connecting passengers would be able to reduce the time of their journeys because their airlines may be able to schedule flights more closely together and also because connecting passengers may see fewer delays caused by missed connections.

The passenger flying on a commuter aircraft would probably experience a decrease in the number of available flights to or from their destination and higher ticket prices for flights in the peak periods. If flying outside of the peak period, a passenger may still see price increases if the commuter airline wishes to spread the extra airport costs to all the passengers going through that airport. On the positive side, commuter passengers will also receive the same benefits as passengers on the larger airline, benefits such as reduced incidence of missed connections and having less time spent waiting in airports for departures.

5.11.4   Air Traffic Controllers

Using a changed airport fee structure as a way to spread out peak operations would allow the air traffic control authorities to design procedures and invest in equipment more efficiently. National growth or decline in aircraft flights will probably not be affected in any serious way by a peak hour fee system. Controllers at the level of the 20 regional Air Route Traffic Control Centers would probably not experience significant changes in traffic, but controllers at the local airport level would see differences. If an airport were to consistently keep congestion delays during peak demand periods in check, the airport controllers would not have the added problems of designing their procedures in order to handle higher levels of traffic.

For local controllers, the one advantage to having a congestion control plan in effect would be that demand for flights at an airport and the corresponding amount of

work for the controllers would probably be spread more evenly during the busy periods. This may have a positive effect on costs since more evenly spread demand would imply that extra human or material resources would not have to be expended in order to deal with very high demand peaks. On the other hand, a successful reduction of peak demand may serve as an inducement for the federal government to retard or stop developments in air traffic control that would further increase an airport's capacity.

While some members of these groups, most notably commuter and general aviation aircraft operators, would be most inconvenienced by the demand modification method favored in this thesis, on the whole the four groups mentioned stand to gain from a reduction in congestion delays. The next issue to be addressed is who should decide how much delay is acceptable, a decision which would determine who would be in charge of developing the guidelines under which economic incentives could be used to modify demand and reduce delays.

5.12   Who Determines What is Acceptable Delay?

Acceptable delay at an airport is something that would depend on the circumstances that an airport faces, circumstances that may change as a function of the season or even time of day. The local airport authority would be in the best position to know how delays affect the operation of the airport and how reductions of those delays may benefit the airport's users as a whole. Individual airport users such as airlines would know best how delays would affect their particular operations, but they have neither the local authority's responsibility to look after the needs of other airport users nor the local authority's need to respond to the demands of the local population that is served by the airport.

In the proposal of this thesis, it would be up to the federal government, most likely the DOT, to determine the specific guidelines under which an airport authority could develop economic incentives to reduce the incidence of congestion delays.

However, the federal government would not be the right choice for determining by exactly how much delay should be reduced at an airport. To have the federal government determine the proper level of delay reduction at an airport would not be consistent with the policy proposed in this thesis. One of the goals of this proposed policy change is to give the local airport authorities more options in dealing with airport congestion. In addition, without the local airport authority's detailed knowledge of an airport's needs, a federal authority would be at greater risk of coming up with delay reduction levels that are not compatible with an airport's needs.

Instead of determining acceptable delay for the local airport authority, the federal government should work instead with the local authorities to make sure that any delay reductions that may result from an airport's plans do not interfere with air transportation in a way that would not be consistent with federal mandates. This federal role would be in keeping with their current role as manager of the nation's airspace.

5.13   How The New Policy May Be Put Into Place

The federal government is the best choice for defining acceptable delay and approving an airport's plan for reducing delays using economic incentives. It already has, through the DOT, the power to enforce the proper execution of its policies as well as the ability to resolve some disputes between airport users and the airport authorities. Getting the proposed policy to the point of being a working policy of the federal government can be done using a combination of Congressional and Presidential initiative. The best model for this is probably the situation leading to the Airline Deregulation Act of 1978. Prior to the passage of that Act, economists and other advocates argued that restraints on airline competition led to a costlier service for airline customers that could be made cheaper by allowing the airlines more competitively. An argument has been made in this thesis that restrictions on the

ability of local airport authorities to modify demand prevents the nation's air transportation system from being more economically efficient and less prone to delays.

With airline deregulation, it took the commitment of several successive Presidents to the idea of deregulating the airlines to bring about the necessary changes in the executive departments such as the elimination of the Civil Aeronautics Board (CAB) and many of the functions that it performed. Along with Presidential action, there were also actions of the Congress that culminated in the Airline Deregulation Act, the Act that gave a legal basis for airline deregulation. Unlike with airline deregulation, changing the role of the local airport authorities would not require the elimination of an executive department, but it would require a commitment by the President to the idea that changing the rules that govern airport access would go a long way toward the goal of reducing problems caused by airport congestion. As with airline deregulation, a clear signal from the Congress such as specific legislation allowing airport authorities to use the reduction of congestion delays as a legitimate factor in setting airport fees would be very helpful. It would be helpful in two ways; first, it would form the basis of any new regulations that may have to be created by the DOT or some other executive department, and second, it would eliminate some of the legal ambiguity that currently exists with respect to the definition of a reasonable and fair charge for the use of an airport.

Public support played a part in allowing the executive and legislative branch to go forward with airline deregulation and it would also help these two branches of government to proceed with changing airport access policies. Prior to deregulation, the flying public often experienced the disparity of fares between between cities served by interstate airlines subject to CAB regulations and less regulated intrastate airlines like Pacific Southwest in California and Southwest in Texas. Today the flying public is exposed on a regular basis to the effects of airport congestion, and based on those

experiences they would be likely to support changes in federal policy that would lead to a reduction of the problem.

Given the recognition by the public and the users of the nation's airspace that delays related to airport congestion are a problem, it is very likely that the kind of policy changes advocated in this thesis could come into being following a path that is similar to that followed by the the policy of airline deregulation. Whether it would happen in this fashion or not happen at all is a question that can't be answered with certainty. What is certain is that delay problems due to airport congestion have not gone away on their own and are unlikely to do so in the near future.

5.14   Conclusions

Long term effects of the implementation of economic incentives to reduce congestion are dependent on several factors that may change over time. For example, the contemporary economics of airline operation often dictate the use of commuter or larger aircraft to connect two cities served by an airline through some intermediate hub airport rather than using aircraft to fly directly between the two cities. A reduction in the costs of operating an aircraft could reduce the air transportation system's reliance on large hub airports like Atlanta or Chicago and in doing so reduce these airports' congestion problems and also reduce the effects that delays at hub airports have on delays at airports elsewhere in the country. Instituting the kind of economic incentives favored in this thesis would increase the number of options available to cope with future changes in the way people fly.

One thing that the proposed policy change outlined in this chapter did not intend to do was formulate a plan to coordinate economic incentives among a system of airports. This was not done for two reasons; first, each airport that may see a need for such a fee program will have a unique set of reasons for doing so. While they may all have peaks of demand and accompanying delays, these peaks may occur twice a day as

they do at Boston's Logan airport, or several times a day as is the case with Atlanta and other major hub airports. One airport may seek to encourage general aviation aircraft to operate elsewhere while others may seek to reduce the number of small capacity commuter aircraft. The level of competition at an airport may also determine an airport's actions. If an airline with a busy hub operation also represents an important part of the airport 's revenue from flight operations, it may put the authority in a position where it may not be able to put a peak hour fee into place without risking the loss of that airline's patronage. Second, system wide coordination would mean coordination of airline schedules. Each airline has a different schedule, different fleets, different corporate strategies, and even different accounting methods. Centralized coordination of peak hour fees would mean trying to make rational decisions on fees in the system using a mass of data that may be openly available like an airline's current schedule, or largely hidden from the public like an airline's expansion plans.

Decisions at the local level to pay the peak hour fees or not would be made by the aircraft operators themselves because they are in the best position to determine what action is economically justified for them. There is no reason why this would not hold true for the system wide operation of an airline. With the multiplicity of goals and interests of each operator, adjusting fees across a system of airports to achieve some social or economic optimum for airport access would involve a level of involvement of the federal government that goes beyond the intent of the market based incentives of the proposal previously outlined in this thesis.

References

American Airlines v. Massachusetts Port Authority.
United States Court of Appeals, First Circuit, 1 September 1977.
Volume 560, Federal Reporter (second series), page 1036.

Denver Wrestles with Continental, United Over Need for New Airport.
Aviation Week and Space Technology CXXIX(11):142-144, 12 September 1988.

Anthony E. Brown.
The Politics of Airline Deregulation.
University of Tennessee Press, 1987.

Stephen E. Creager.
Airline Deregulation and Airport Regulation.
Yale Law Journal, XCIII(2):319-339, 1983.

Evansville-Vanderburgh Airport Authority District v. Delta Airlines.
Supreme Court of the United States, 19 April 1972.
Volume 405 United States Reports, page 707.

Indianapolis Airport Authority v. American Airlines, Inc.
United States Court of Appeals, Seventh Circuit, 10 May 1984.
Volume 733 Federal Reporter (second series), page 1262.

Richard C. Larson and Amedeo R. Odoni.
Urban Operations Research.
Prentice-Hall, Inc., 1981.

Michael E. Levine.
Landing Fees and the Airport Congestion Problem.
Journal of Law and Economics, XII:79-108, 1969.

Robert E. Litan and William D. Nordhaus.
Reforming Federal Regulation.
Yale University Press, 1983.

Massachusetts Port Authority.
Massport's Program for Airport Capacity Efficiency (PACE).
Massachusetts Port Authority, December 11, 1987.

Massachusetts Port Authority v. United States Department of Transportation.
United States Court of Appeals, First Circuit, 17 August 1989.
Volume 833 Federal Reporter (second series), page 157.

National Business Aircraft Association v. Massachusetts Port Authority.
United States District Court, District of Massachusetts, 29 June 1988.
Case number 88-1971.

Amedeo R. Odoni and Richard deNeufville.
Course notes from 16.781J, Planning and Design of Airport Systems.
Massachusetts Institute of Technology, Spring 1989.

Alan Stone.
Regulation and its Alternatives.
Congressional Quarterly Press, 1982.

United States Code Annotated.
Title 49: Transportation. Section 1513: State Taxation of Air Commerce.
West Publishing, 1976.

United States Code Annotated, 1989 Cumulative Annual Pocket Part.
Title 49: Transportation. Chapter 31: Airport and Airway Improvement.
  Section 2210: Project Sponsorship.
West Publishing, 1976.

United States Department of Transportation, Federal Aviation Administration.
Airport Capacity Enhancement Plan.
Report number DOT/FAA/CP/88-4. Government Printing Office, 1988.

United States Department of Transportation, Federal Aviation Administration.
Airport System Development.
Report number OTA-STI-231. Government Printing Office, August. 1984.

United States Department of Transportation, Federal Aviation Administration.
FAA Aviation Forecasts -- Fiscal Years 1989-2000.
Report number FAA-APO-89-1. Government Printing Office, March 1989.

United States Department of Transportation, Federal Aviation Administration.
The Federal Aviation Administration Plan for Research, Engineering, and
  Development, Volume 1: Program Plan.
Government Printing Office, January 1989.

United States Department of Transportation, Federal Aviation Administration.
FAA Statistical Handbook of Aviation - Calender Year 1983.
Government Printing Office, 1984.

United States Department of Transportation, Federal Aviation Administration.
FAA Statistical Handbook of Aviation - Calender Year 1984.
Government Printing Office, 1985.

United States Department of Transportation, Federal Aviation Administration.
FAA Statistical Handbook of Aviation - Calender Year 1985.
Government Printing Office, 1986.

United States Department of Transportation, Federal Aviation Administration.
FAA Statistical Handbook of Aviation - Calender Year 1986.
Government Printing Office, 1987.

United States Department of Transportation, Federal Aviation Administration.
FAA Statistical Handbook of Aviation - Calender Year 1987.
Government Printing Office, 1988.

United States Department of Transportation, Federal Aviation Administration,
  City of Atlanta, et al.
Airport Capacity Enhancement Plan: William B. Hartsfield International Airport;
City of Atlanta, March 1987.

United States President: Ronald W. Reagan.
Economic Report of the President,
  Chapter Six - Airline Deregulation: Maintaining the Momentum.
Government Printing Office, 1988.

United States, 95th Congress, second session, 24 October 1978.
U.S. Statutes at Large 92(2):1705.
Public Law 95-504: Airline Deregulation Act of 1978.

United States, 93rd Congress, first session, 18 June 1983.
U.S. Statutes at Large 87:88.
Public Law 93-44: Airport Development Accelleration Act of 1973.
  (The Anti-Head Tax Act.)