Managing Demand To Reduce Airport Congestion and Delays

JOHN B. FISHER

Delays caused by airport and airway congestion are spreading throughout the national air transportation system, and the FAA's estimates of passenger growth indicate that the situation will continue to deteriorate unless prompt actions are taken. The most often mentioned solution to the imbalance between the demand for airport services and the available supply is to build new airports, but airport construction is an expensive and lengthy process. Therefore, the government's Airport Capacity Enhancement Plan and an Industry Task Force have recommended several system enhancements to boost capacity. However, the recommended enhancements will not provide enough capacity to accommodate the forecast growth in traffic. Consequently, it appears that airport congestion and delays will continue unless efforts are undertaken to manage demand. To that end, peak/off-peak landing fees are suggested, combined with passenger surcharges to moderate the demand for services during peak periods at severely congested airports.

The Federal Aviation Administration (FAA) estimates that over the next 12 yr, passenger enplanements in this country will grow about 4.5 percent annually (*1*, p. 46), and that the number of air carrier operations will increase about 2.3 percent annually through 1999 (*1*, p. 5). However, Federal Aviation Administrator Allan McArtor has stated that there already are "more aircraft in the system than the country's runways can handle" (*2*). Consequently, delays have become frequent and persistent occurrences. In June 1987, the Air Transport Association (ATA) estimated that U.S. airlines were incurring total delays averaging 2,000 hr per day, which is equivalent to grounding an airline with 250 jets (*3*). The overcrowding has become so severe that future demand at most major airports will be satisfied only at the cost of even greater delays (*4*, pp. 2–19).

Forecasts of demand at Boston's Logan Airport indicate that, in the absence of supply enhancements, the average delay during instrument meteorological conditions could rise from 60 min/passenger in 1988 to 100 min/passenger by 1990 and to almost 3 hr/passenger by the turn of the century (*5*, p. 15). Moreover, the congestion-delay problem, which has been concentrated at a relatively small number of airports, is expected to spread throughout the system. Based on FAA estimates, all but seven large hubs and almost half of all large and medium hubs will be suffering from severe airside congestion by the turn of the century (*6*, p. 2).

Because of the severity of the problem, airport congestion and delays have received a great deal of consideration, and this paper presents yet another perspective. The first part of the paper focuses on the factors that have contributed to the worsening of congestion and delays, the second briefly reviews the potential for and limits to enhancing system capacity, and the third discusses techniques for bringing demand in line with the available supply. In the final section of the paper, a combination of economic techniques for managing demand is recommended as a remedy to airport and airway congestion and delays.

THE SPREAD OF CONGESTION AND DELAYS

The search for remedies logically begins with an identification of the forces behind the problem of airport congestion and delays. Over the past 5 yr, increasing numbers of passengers and airplanes have been funneled into fewer and fewer airports. Between 1983 and 1987, annual passenger enplanements rose 40 percent to 447 million, and the number of scheduled aircraft departures increased by 31 percent to 6.5 million, but the number of airports receiving scheduled commercial air service declined 2.5 percent, from 854 to 834 (*7*, *8*). The decline in the number of airports receiving scheduled service has contributed to congestion and delays, but the problem is much more complex than is implied by these figures.

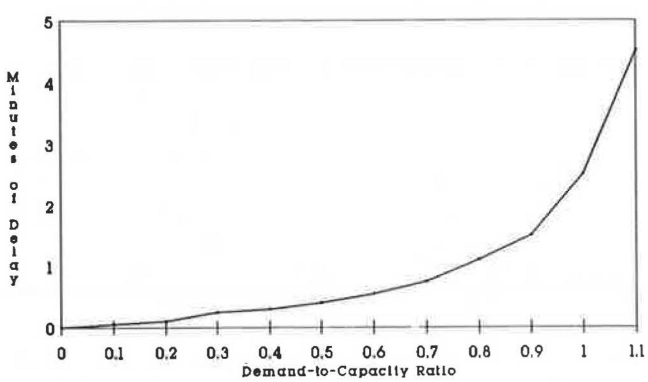
Congestion and delays occur whenever airport demand exceeds the system's capacity. However, the relationship between the demand for and the supply of airport capacity can change drastically in a very short period of time because of weather changes, equipment outages, or air traffic control procedures. Table 1 shows the peak scheduled demand and maximum hourly capacity under instrument flight rules (IFR) and visual flight rules (VFR) conditions at 18 primary commercial airports. At 14 of the 18 airports, the peak level of scheduled demand equals or exceeds 75 percent of maximum capacity under instrument meteorological conditions. At seven of the airports, the peak level of scheduled demand actually exceeds maximum capacity under IFR conditions. Experience has shown that an airport becomes congested and delays start accumulating whenever demand exceeds 75 to 80 percent of the available supply (*9*, p. 8) and that the length of the average delay grows at an increasing rate as the ratio of demand to supply approaches 100 percent (see Figure 1). Therefore, the

Department of Marketing, School of Business, Ohio State University, Columbus, Ohio 43210. Current affiliation: Capacity and Air Service, Port Columbus International Airport, 4600 International Gateway, Columbus, Ohio 43219.

TABLE 1 MAXIMUM HOURLY CAPACITY AND PEAK NUMBER OF SCHEDULED AIRLINE OPERATIONS PER HOUR AT SELECTED AIRPORTS

	Maximum Hourly Capacity			
Airport	IFR Conditions	VFR Conditions	Peak Number of Scheduled Airline Operations	Ratio (%)
Boston Logan	100	110	89	89
Cleveland	51	72	36	71
Washington National	65	85	51	79
Denver Stapleton	66	140	108	164
Detroit Metro	120	120	98	82
Newark	102	111	78	77
Houston International	92	116	53	58
New York Kennedy	68	90	85	125
Los Angeles International	124	131	137	110
New York La Guardia	66	78	68	103
Miami	110	128	95	86
Minneapolis/St. Paul	80	104	84	105
Chicago O'Hare	212	212	153	72
Philadelphia	76	110	82	108
Pittsburgh	110	120	91	83
San Francisco	65	85	51	79
St. Louis	73	90	95	130
Tampa	105	120	35	33

NOTE: Maximum hourly capacity is total number of operations/hr based on a 50-50 arrival and departure mix, 1984 data.
IFR conditions: instrument flight rules apply.
VFR conditions: visual flight rules apply.
Peak number of scheduled airline operations/hr based on November 1987 weekday service, as published in the *Official Airline Guide*.
Ratio is peak number of scheduled airline operations divided by maximum hourly capacity in IFR conditions.
Source: FAA.



SOURCE: *Airport Capacity and Delays.* Advisory Circular AC150/5060-5, FAA, U.S. Department of Transportation, Sept. 23, 1983.

FIGURE 1 Nonlinear relationship between average delay per aircraft and demand-to-capacity ratio.

solution to the congestion-delay problem is to minimize the ratio of demand to capacity, but there is much controversy over which part of the ratio should receive the higher priority.

Many economists have focused on the need to reduce demand because congestion and delays affect both long-haul passengers, who have few substitutes for air travel, and short-haul passengers, who have many (*10*, p. 92). This conflict between the travel needs and options of short-haul versus long-haul travelers is nowhere more apparent than at Boston's Logan Airport. According to the August 1, 1988 *Official Airline Guide*, there were 11 daily scheduled arrivals into Logan from airports within the Boston metropolitan statistical area. In addition, there were a total of 44 scheduled daily arrivals from four resort areas within the state of Massachusetts, and 16 scheduled daily arrivals from one out-of-state city just 55 mi away. These 71 flights represent only about 13 percent of Logan's scheduled daily arrivals, but they contribute to congestion and delays by competing with long-distance flights for limited airport access. Some experts have argued that existing runway capacity would be better used if some of the demand from short-haul users could be reduced.

Other observers blame the frequent imbalances between airport supply and demand on the fact that no new airports have been built in the past 15 years. Cries to build more airports make good headlines, but they ignore the complexities of new-airport development. For example, aviation demand is generally concentrated around large urban areas. The 20 largest metropolitan statistical areas in the United States account for approximately 60 percent of the domestic-origin and domestic-destination passenger traffic, even though the 20 most populous cities represent only 40 percent of the total U.S. population (*11*). If new airports are to be built near the major metropolitan areas that generate passenger demand, the challenge will be to find large sections of affordable and environmentally acceptable land.

Even when suitable sites can be identified, mustering support for new-airport development has proved to be difficult. Air carriers have been among the most outspoken advocates of airport construction, yet some airlines are opposing proposals for new airports in Chicago and Denver. The city of Denver has had to seek help from a federal court to enlist United and Continental airlines as backers of a proposed airport (*12*), and *Airline Business* has reported that United is opposing efforts to build a new airport in Chicago (*13*).

Not only have some airlines been slow to support new-

TABLE 2 SCHEDULED DAILY DEPARTURES AT SELECTED HUB AIRPORTS (*15*)

		Number of Scheduled Daily Departures		
Airport[a]	Carriers[b]	January 1983	January 1988	Percent Increase
STL	TW and OZ	250	312	25
ATL	DL and EA	546	724	33
DEN	CO, FL and UA	314	453	44
LAX[c]	AL, DL, UA, and AA	237	380	60
DFW	AA, DL and WA	331	537	62
SFO	UA, PS and AL	122	239	96
ORD	UA and AA	331	658	99

NOTE:
[a]Airport identifier codes: STL = St. Louis, ATL = Atlanta, DEN = Denver, LAX = Los Angeles International, DFW = Dallas/Ft. Worth, SFO = San Francisco, and ORD = Chicago O'Hare.
[b]Carrier identifier codes: TW = TWA, OZ = Ozark, DL = Delta, EA = Eastern, CO = Continental, FL = Frontier, UA = United, AL = USAir, AA = American, WA = Western Airlines, and PS = Pacific Southwest.
[c]1983 data include scheduled departures of airlines later acquired by major carrier.

TABLE 3 TOTAL OPERATIONS AT SELECTED AIRPORTS

	Total Takeoffs and Landings		Percent of Operations at All Tower Airports	
Airport	Fiscal 1978	Fiscal 1987	Fiscal 1978	Fiscal 1987
ORD	754,986	796,609	1.12	1.31
ATL	543,951	801,833	0.81	1.31
LAX	528,540	655,189	0.79	1.07
DEN	468,575	521,608	0.70	0.86
DFW	398,644	609,300	0.59	1.00
Totals	2,694,696	3,384,539	4.01	5.55

NOTE: Airport Identifier Codes: ORD = Chicago O'Hare, ATL = Atlanta, LAX = Los Angeles International, DEN = Denver Stapleton, and DFW = Dallas/Ft. Worth.
Source: FAA.

airport development, but some deregulated carriers have adopted operating practices that actually contribute to congestion and delays. Eleven times per day in the spring of 1986 American Airlines scheduled 30 flights into its Dallas hub within a 15-min period (*14*). The tight scheduling of connecting complexes at airline hubs makes for efficient use of equipment and minimizes passengers' scheduled travel time, but it also fosters congestion whenever delays in one connecting bank spill into the next complex, thereby creating a chain reaction that can have a long-lasting impact.

The airlines continue to add flights into and out of their hub airports because each additional spoke results in a geometric increase in the number of potential passengers. In 1983, there were only 11 cities where a single carrier had more than 100 daily departures. By February 1988, there were more than 24 cities with a single carrier offering at least 100 daily departures (*15*). The extent to which some airlines have increased their scheduled daily departures at their hub airports is shown in Table 2. The flights have been added at airports that have been classified as severely constrained, and there have not been increases in airport capacity comparable to the increases in the number of scheduled departures by the hub carriers.

The growth of hub-and-spoke route networks has resulted in a significant concentration of airline operations at a relatively small number of commercial airports. Table 3 shows that in fiscal 1978 the combined number of operations at Chicago O'Hare, Atlanta, Los Angeles International, Denver Stapleton, and Dallas/Ft. Worth accounted for 4.0 percent of the total operations at all tower-controlled airports. In fiscal 1987, the number of operations at the same five airports, which are major airline hubs, had increased by 25.6 percent and accounted for 5.6 percent of total operations at tower-controlled airports.

Growth in the number of hub carrier operations adds to congestion and typically increases the carrier's market share, both of which impose costs on society. According to a report released by the Congressional Budget Office, "There is ample statistical evidence that, other things being equal, passengers in more concentrated markets pay higher fares, and that the greater a carrier's share of total traffic at an airport the higher the fare it is able to charge" (*16*, p. 34). Market concentration also raises the possibility that the hub airline can exert undue influence on airport authorities. Senator John C. Danforth (R-Mo.) has said that "Trans World Airlines dominate[s] enplanements [at St. Louis] . . . and ha[s] a strong voice in determining whether the airport should expand" (*17*).

The post-deregulation business practices of the major airlines have contributed to congestion and delays. On the other hand, some of the major airlines have realigned their schedules in attempts to reduce congestion and delays. For instance, in July 1987 American Airlines claimed it had rescheduled 1,537 of its 1,600 daily departures. Moreover, one airline executive confided that he felt the airlines had gone just about as far as they could to reduce congestion and delays (personal communication). Nevertheless, the number of scheduled operations at many congested airports still exceeds capacity limits under certain conditions, and the FAA's forecasts indicate that even more passengers and airplanes will be demanding access to the overcrowded system.

TECHNIQUES FOR BUILDING SUPPLY TO MEET DEMAND

All potential remedies to the congestion and delay problem seek to equate the supply of airway and airport services with their demand. To that end, the FAA's Airport Capacity Enhancement Plan has identified three approaches to expanding system capacity: airport improvements, airspace procedure improvements, and aircraft improvements (*4*, p. xii).

Airport improvements are appealing long-term solutions to the problem of congestion and delays because of the nonlinear relationship between the length of delays and the demand-to-capacity ratio. It was stated earlier that as airport demand approaches capacity, the length of the average delay grows at an increasing rate. Conversely, according to the plan, "each one percent increase in capacity lowers the costs of delay by [about] five percent" (*4*, pp. 4–11), and the Industry Task Force on Airport Capacity Improvement and Delay Reduction noted that "the construction of new airports and runways is still the best way to increase airport capacity" (*18*). However, the five new airports and 32 new runways called for in the report will cost an estimated $34 billion, will take years to construct, and must overcome many political and environmental hindrances. Therefore, until new airports and runways can be added, other capacity enhancements are needed, and the Airport Capacity Office has funded the development of airspace procedure and aircraft improvements.

The proposed operational improvements to increase system capacity are relatively inexpensive and fairly easy to implement. On the other hand, operational improvements to system capacity are frequently site specific, and until the numbers and experience levels of air traffic controllers are restored to pre-strike levels, operational techniques such as "simultaneous operations on converging runways," "reduced spacing," and "simultaneous operations on intersecting wet runways" must be meticulously tested and selectively implemented. In addition, the Industry Task Force estimated that all such procedures combined will increase system capacity by a total of about 20 percent (*6*, Attachment 16), and the benefits of the added capacity probably will be short-lived.

Domestic enplanements are forecast to grow about 4.5 percent annually through the remainder of this century (*19*), and according to the Industry Task Force, the implementation of operational improvements will not significantly relieve severe congestion at a number of hard-core problem airports, which will continue to inconvenience up to 50 percent of the traveling public and impose large delay costs (*6*, Attachment 6). Therefore, it appears that if congestion and delays are to be reduced, user demand must be moderated.

TECHNIQUES FOR BRINGING DEMAND IN LINE WITH CAPACITY

Some industry observers have commented that demand management techniques are admissions that the air traffic control system has failed to handle the demand placed upon it. It is true that an air traffic control system that handled a then-record 240 million scheduled enplanements and 4.9 million scheduled departures in 1978 is probably feeling the strains of 447 million scheduled enplanements and 6.6 million departures 10 yr later (*7*). It also is true that some demand management techniques are arbitrarily imposed caps limiting access to severely overcrowded airports, but other types of market-based demand management techniques may provide long-term remedies that are consistent with existing government policy, efficient, nondiscriminatory, and cost-effective.

Demand management techniques do not attempt to expand airport capacity, but they can postpone the need for expansion by promoting more intensive and more economically efficient use of the existing capacity (*9*, p. 1). Techniques for managing demand are generally classified in two groups, administrative techniques and economic techniques, both of which attempt to equate demand with supply by limiting the number of operations that will be permitted access to the airport. The techniques are distinguished by their approaches to allocating access to scarce airport and airway services.

Administrative Techniques for Managing Demand

Administrative techniques for managing demand traditionally have involved the imposition of slot quotas. Determining an airport's hourly slot quota (defined as the number of scheduled takeoffs and landings that the airport will handle during any given hour) is the sole prerogative of the federal government and is based on the capacity of the airport. Fluctuations in supply and demand make it difficult to ascertain a desirable quota level, as evidenced by the FAA's recent decision to reduce the hourly capacity limits at Chicago O'Hare (*20*). It is even more challenging to allocate the slots equitably among the many competing users.

To promote equity at airports where slot quotas have been instituted, the government traditionally has relied on the administrative technique of designating a portion of an airport's slot quota for each of the different categories of users, such as incumbent carriers, new entrants, and general aviation. The allocation of the slots to each user within a category is then determined by another set of administrative techniques. For instance, the government has granted antitrust immunity for airline scheduling committees to negotiate among themselves the allocation of slots set aside for incumbent carriers, and the government frequently relies on a first-come-first-served reservations system to allocate the slots set aside for general aviation users.

Administrative techniques ensure that the number of scheduled operations does not exceed a predetermined level, creating an artificial equilibrium that can be used, in the short term, to alleviate congestion and delays. The Massachusetts Port Authority (Massport) has estimated that "if the number of peak period operations at Logan were reduced 20 percent, the duration of the average delay would decrease by 80 percent, thereby reducing delay by 50 minutes for each of 7,000 passengers" (*5*, p. 20).

Administrative techniques limit overcrowding, but they have several serious shortcomings. First, they are short-term solutions that ignore the reality of inadequate supply. The imposition of quotas masks changes in the actual market demand for access to a slot-controlled airport, and the lack of information on true market demand makes planning for future capacity enhancements more difficult.

Second, airport congestion and delay is a local phenomenon, albeit with nationwide consequences, and the federal government has taken the position that the initiative for airport policies equating capacity and demand is vested in the communities that own and operate the airports (*4*, p. xiii). However, the federal government specifically prohibits local airport authorities from independently imposing a ceiling on the number of operations for the purpose of reducing or eliminating congestion, and local authorities are prohibited from distributing landing and takeoff rights (*21*).

Third, the quotas are arbitrarily determined. There is no mechanism, other than administrative trial and error, to ensure an efficient allocation of the slot quota. Even the most ingenious allocation of slots cannot anticipate all of the changes in demand that will occur among the different categories of users and among the users within each category.

Fourth, administrative techniques tend to preserve the status quo of airline market shares. Quotas can limit the potential for new entry and can result in anticompetitive agreements among the incumbents. The lack of competition in some administratively constrained markets has resulted in average fares 20 percent higher than fares in other markets (*22*), which is a compelling reason to regularly consider "a change in slot allocations" (*17*). However, reallocating slots is a perplexing task. Efforts to reduce congestion at one airport cannot be considered in isolation but must be analyzed with due consideration of the impact on operations at other airports with which the airport is linked (*9*, p. 31).

Finally, the allocation of slots is complicated by the increasing use of feeder agreements at hub airports. In many smaller communities, a commuter carrier operating under a feed agreement with a major carrier has replaced the major carrier's jet service with high-frequency service in smaller equipment. This arrangement has benefited the commuter carrier, the communities receiving higher-frequency service, and the major carrier who relies on the commuter's feed traffic. However, it has also resulted in a surge in the number of operations at many hub airports. Nationwide in 1987, commuter carriers accounted for approximately 6.5 percent of total domestic enplanements but 55.7 percent of all air carrier operations (*23*).

It has been argued that because it takes so many commuter flights to equal the passenger load of one large commercial jet airplane, the number of passengers that an airport could serve would be increased if slots were reallocated from the commuter carriers to the major carriers. Moreover, reallocating slots from commuter carriers to major carriers probably would reduce the amount of feed traffic for the hub airline, which in turn would conceivably weaken the hub airline's competitive position relative to the other airlines at that airport. However, reallocating commuter slots also means a reduction in service to small communities and an economic hardship for the commuter carrier whose livelihood is tied to the amount of feed traffic carried to the major's hub.

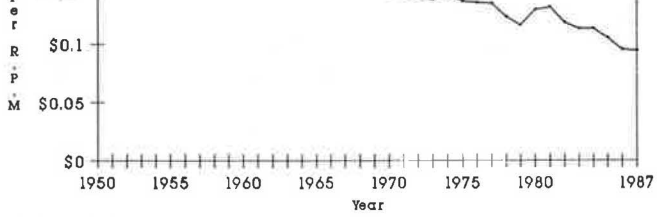
It is worth noting that small-community air service is not a purely economic issue. It has been, and continues to be, primarily a social issue. Congress closely monitors air service to small communities and has been forthcoming with money to ensure its continuance. Reducing commuter slot allocations, which reduces small-community access to the national aviation system, seems to run counter to the desires of Congress.

Administrative techniques will always be vulnerable to attack on the equity issue because the allocations are arbitrary. There is no opportunity for the haves and the have-nots to express the relative value of slots. In addition, administrative techniques are stopgap measures that neither increase supply nor reduce the true underlying demand. They are not long-term solutions to airport congestion and delays. A better, long-term approach is to adopt pricing mechanisms that automatically bring demand in line with the available capacity.

Economic Techniques for Managing Demand

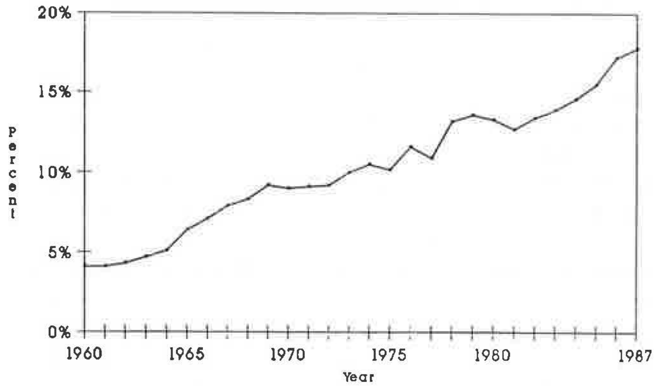
The boom in air travel and the resultant congestion and delays can be attributed, in part, to two divergent trends in the pricing of air transportation services. Airline fares, expressed in constant dollars, have been on a downward trend for the past 30 yr (see Figure 2). The steady decline in fares has fostered rapid growth in air travel, which in turn has stimulated demand for airport and airway services.

A Gallup survey conducted for the ATA indicates that the percentage of the adult population that had flown during a given year increased from 25 percent in 1977 to 30 percent in 1987 (*24*). Figure 3 shows that as fares have declined, the percentage of intercity passenger miles traveled by air has increased from 10.9 percent in 1977 to 17.8 percent in 1987. The rate at which intercity travelers are abandoning their automobiles and other modes of travel is increasing (*25*).



SOURCE: Air Transport Association

FIGURE 2 Revenue per revenue passenger mile for scheduled U.S. operations stated in constant dollars.



SOURCE: Air Transport Association

FIGURE 3 Percent of all intercity passenger miles traveled by air.

Between 1981 and 1987, air's share of intercity passenger miles rose 6 percentage points. In recognition of this trend, American Airlines Chairman Robert Crandall has noted that although flying has become commonplace and affordable, "unfortunately the air traffic control system simply was not built to handle the resulting volumes of traffic" (*26*).

Air travel has become affordable because the monetary price of airport and airway access has not been adjusted upward in proportion to the increased demand for services. In economic parlance, higher traffic volumes resulting from lower real airline fares have shifted the demand curve for airport services upward along a fixed supply curve. In an open market, each upward shift in the demand curve would result in a new and higher equilibrium price, equating airport supply with demand. However, increases in the monetary price for airport access apparently have lagged behind the upward shifts in the true equilibrium prices, resulting in artificially low prices and demand in excess of supply.

At least one observer has noted that the major reason for the disparity between the industry's needs and the industry's ability to provide for them is the failure of present arrangements to perform the major function of a properly working price system (*10*, p. 95). Some airports are attempting to reduce congestion and delays with pricing mechanisms. The techniques used and their long-term prospects for easing congestion and delay are analyzed in the following sections.

Slot Sales

Slot sales/auctions is a hybrid approach to allocation that combines features of both administrative and economic techniques for allocating airport demand. An airport's quota of slots is administratively determined, but instead of relying on administrative techniques to allocate the quota among user groups, the slots are exchanged in an open-market system whereby any person can buy, sell, lease, or trade the airport operating rights granted by the government, with prices to be determined by the forces of supply and demand (*27*). Michael E. Levine Associates has noted that a "properly designed and operated [auction process] is clearly superior to the present system for allocating scarce airport capacity" and has a number of advantages, including user determination of each slot's worth and long-term local control. The local airport authority would be able to maintain some measure of control by buying, selling, and trading slots for its own account; and the open-market exchange of slots would provide planners with information on the level of demand for airport services and revenues for airport expansion (*28*). Despite the advantages of slot sales over administrative techniques of allocation, there are problems with slot sales that limit their appeal.

Arbitrary administrative decisions have to be made on a variety of complex economic issues, including the number of slots to allocate per time period per day; the length of time each operating right is valid; the takeoff, landing, and taxiway rights associated with each slot; and the process for distributing the initial allocation of slots. In addition, a decision has to be made on the use-or-lose requirements for each slot, the procedures for recalling an underused slot, and the use of proceeds that accrue to the airport authority as a result of its slot market activities. It was stated earlier that administrative techniques lack a mechanism that ensures an efficient allocation of slots. Similarly, there is no assurance that the number and nature of the slots made available for sale are the most desirable or the most effective.

A second shortcoming of slot sales is that access to the airport is controlled by a potential user's ability to identify persons holding an operating right at the desired time and by the buyer's ability to then offer a price that induces the seller to part with the operating right. There is concern that the allocated operating rights, which are valuable assets, might be hoarded by financially strong buyers, thereby blocking airport access to potential users. A dominant carrier would be tempted to accumulate a large proportion of the available operating rights and redistribute them according to its own needs and those of its feeder carriers. Carriers who might otherwise offer competing service may have trouble garnering sufficient slots, particularly if the service involves more than one slot-controlled airport. In general, "the difficulties in using slot [sales] to ration capacity grow exponentially as the number of slot-restricted airports increases" (*16*, p. 67). The problems arising from an arbitrary determination of the number of slots to offer for sale and the potential for abuse in the slot market suggest that slot sales are not the most efficient or effective technique for allocating scarce airport resources.

Peak/Off-Peak Pricing

An economic technique that has received considerable attention by economists and that some airports have instituted is peak/off-peak pricing. The appeal of peak-hour pricing is its simplicity. A surcharge is imposed on peak-hour operations to induce some users to go elsewhere during the peak period or to use the airport at a less congested time.

Peak/off-peak pricing is not inconsistent with the government's free-market philosophy of deregulation. Moreover, peak/off-peak pricing can satisfy each of the following requirements for an efficient and effective remedy to congestion and delay:

- It does not compromise safety;
- It is not inherently discriminatory against any user group;

- It is not incompatible with other approaches for reducing congestion and delays;
- It does not conflict with other airport objectives, such as noise control;
- It does not favor any political constituency;
- It is fiscally sound;
- It is effective as both a short-term and a long-term approach; and
- It is well-grounded in theory and backed by actual experience.

Nevertheless, actual adoption of peak/off-peak pricing has been limited.

Much of the economic literature on peak-period pricing theory does not recognize the unique operational considerations of the aviation industry. For instance, some airports have unique congestion and delay problems that cannot be addressed by pricing. New York's Kennedy Airport suffers from peak congestion between 3:00 p.m. and 10:00 p.m., which is a function of the rigid curfews at foreign airports in different time zones. Pricing techniques will not have much effect on congestion and delays arising solely from the operational constraints associated with foreign flights.

Furthermore, in cases where peak-hour surcharges have been imposed, the airlines have demonstrated low cross-elasticities of demand between peak and off-peak periods (*29*). The airlines' unresponsiveness is not surprising because the peak-hour surcharges have been relatively small compared with the total costs of operating a flight. Landing fees usually account for less than 5 percent of an airline's total operating expenses, and changes in other costs can either offset or dilute the effect of higher landing fees. The optimum fare schedule needed to shift commercial airline operations away from peak periods to off-peak periods is not known (*30*) and is difficult to calculate.

Most applications of peak-hour pricing have been designed to encourage certain types of users to relinquish airport access in favor of other types of users. In such cases, the peak-hour surcharge is set high enough to discourage flights by the targeted user groups but not so high as to impose a significant financial burden on high-value users (typically defined as flights with large payloads). However, economic theory suggests that unless the peak-hour surcharge reflects the true value of airport access during the peak period, long-term airport demand will not be reduced. Users who place a relatively low value on access to the airport will go elsewhere or use the airport at other times to avoid the surcharge. However, if the surcharge is below the true market value of airport access during the peak period, users who place a higher value on airport access will continue to increase their demand during peak periods, and the problem of congestion and delays will not have been alleviated.

Peak-hour surcharges that are not equal to the true market value of airport access are discriminatory because there is no rationale for the price chosen other than to exclude a particular user group. At equilibrium, the true market value of airport access equals the marginal cost of providing that access. The marginal cost of airport access is the sum of the incremental cost of each operation plus a provision for the social costs each operation imposes on others (*31*). The latter set of costs includes the cost of noise pollution suffered by airport neighbors and delay costs incurred by others waiting to use the airport at the same time. Of course, it is extremely difficult to identify the incremental cost of each airfield operation or to impute a dollar figure of the intangible costs arising from each user's access. Fortunately, the theoretical value of marginal cost pricing is not compromised by an iterative series of administrative "best-guesses" to find the optimal price.

Peak/off-peak pricing based on marginal costs allows a local airport authority to establish an equitable price for airport access that all potential users can choose to accept or not at any time during the day. Unlike slot sales, there is no separate operating right that must be acquired, and a potential user does not have to find a seller with a slot at the desired time. The airport is a willing seller to all potential users at the equilibrium price.

Those who object to the theory behind peak-hour pricing often do so on the grounds that the price for airport access should only reflect the tangible costs of providing the service. This attitude presumably stems from the long-standing practice of granting open and equal access to all potential users on a first-come-first-served basis. Unfortunately, whenever demand is rising and capacity is fixed, allocation is inevitable if the price, including social costs, is not allowed to rise in response to higher demand.

Direct Passenger Surcharges

Demand for airport access ultimately is derived from a traveler's decision to use air transportation to reach a desired destination. Obviously, there would be no demand for airport and airway services from the airlines if potential travelers chose not to fly. Yet nearly all of the literature on reducing airport congestion and delays focuses on methods of altering demand by the airlines.

Economic techniques, such as peak/off-peak pricing, indirectly attempt to alter a passenger's travel behavior by imposing costs on the airline. The airline then is supposed to pass the costs on to the passenger, thereby causing the desired change in travel behavior. However, the airline decides to what extent it will pass along to the passenger the price of access to the airport at peak periods. There is no direct link between the airport authority that is trying to control congestion and the passenger who is the true source of that congestion. Consequently, an airport authority has to rely on the airline to communicate to the passenger in the form of higher fares the cost of congestion. The possibility that the airline may choose not to pass along all of those costs indicates the inherent inefficiency of indirect methods of controlling travel behavior.

Moreover, airside congestion is just one facet of the congestion and delay problem. Landside and terminal congestion are quite severe at some airports. Of 33 airports surveyed by the Industry Task Force in 1982, 36 percent cited runway capacity problems, 39 percent cited taxiway capacity problems, 48 percent cited terminal capacity problems, 58 percent cited airport gate problems, and 58 percent cited terminal curbside problems (*6*, Table 1). Shortages of terminal capacity and airport gate and terminal curbside problems are caused by too many people seeking access to the air transportation system, not too many airplanes seeking such access.

The airlines have done a commendable job of making air travel commonplace and affordable. However, as American Airlines' Crandall has noted, at the present time the national airspace system cannot accommodate all of the passengers who want to take advantage of the services being offered by the airlines. Therefore, until the system's capacity can be expanded, congestion and delay could be reduced by controlling the level of underlying demand from potential travelers.

Controlling the demand for airport services could be achieved with passenger surcharges that encourage travel by alternative modes, provide incentives to travel by air at off-peak times, and promote the choice of flights connecting at less congested airports. For example, all tickets for travel during peak periods would be subject to surcharges regardless of the routings. Passengers would have a clear choice, pay a surcharge to travel at peak periods or avoid the surcharge by scheduling trips during off-peak periods. Furthermore, any itinerary that included flights connecting at congested airports would incur additional surcharges for each connection. Again, passengers would have a clear choice; flights that involve a connection at a congested airport would be subject to a connecting surcharge. The connecting surcharge would apply only to flights involving a connection at a congested airport, and would be in addition to any peak-period surcharge that might apply. Travelers living in a city with a congested airport would not be subject to the connecting surcharge unless their travel plans involved connections at other congested airports.

Of course, not all travelers will have access to flights that do not involve a connection at a congested airport. For example, travelers from small communities whose only air service is provided by a commuter airline tied to a major carrier's hub operation could be exempted from the connecting surcharge at the hub airport. Travelers in larger markets who currently do not have a choice of flights that would allow them to avoid the connecting surcharge might see the situation change after imposition of the surcharge. Theoretically, airlines would have an incentive to begin offering nonstop flights or flights connecting at uncongested airports, because neither type of flight would be subject to the connecting surcharge. Other things being equal, airlines offering flights exempt from the connecting surcharge would have a competitive advantage over airlines whose flights would be subject to connecting surcharges.

The proposed passenger surcharges would be levied on the true source of air service demand, which could affect the demand for airport services by reducing the overall level of air travel demand, shift demand from peak to off-peak periods, and offer connecting passengers an incentive to travel through less congested hub airports. There are other advantages to passenger surcharges: they can be quickly adjusted in response to long-term or short-term changes in capacity and demand, they do not compromise safety, and they are compatible with other techniques for reducing congestion and delay. The surcharges could be adjusted to reflect differences in congestion at various hub airports and by time of day. A connecting surcharge may also provide an incentive for the hub airlines to shift some of their connecting flights to less congested airports, such as Omaha, Columbus, Indianapolis, and Birmingham.

The degree to which passenger surcharges would achieve the desired results is a function of two factors. First, potential passengers must be informed of the existence and nature of the surcharges. Second, methods must be developed so that passengers pay the surcharge when purchasing their tickets or confirming their reservations (*32*). Fortunately, the availability of computerized reservation systems and established procedures for collecting the government's 8 percent tax on airline tickets provide many of the necessary apparatuses by which the passenger surcharges could be implemented. Moreover, the growing importance of travel agents for preparing itineraries and distributing tickets would facilitate the dissemination of information about the surcharges. In particular, the surcharges could be programmed into the airlines' computerized reservation systems so that the surcharges would be displayed on a travel agent's computer terminal whenever a potential passenger inquired about travel alternatives.

Passengers who have grown accustomed to traveling on attractive discount fares may resent the imposition of user surcharges, but there is a compelling economic argument for the surcharge. Under the present allocation system, passengers randomly "pay" for the imbalance between supply and demand by being subjected to delays of indeterminate frequency and duration. A monetary surcharge theoretically would reflect the cost that the user is imposing on the overcrowded system. Travelers who value the speed and convenience of undelayed air travel would be offered the opportunity to express monetarily the worth of less congested travel. Of course, the peak-period surcharge could be avoided by the choice of travel during less congested off-peak periods, and the connecting surcharge could be avoided by the choice of flights that connect at less congested airports. Moreover, passengers would benefit with the introduction by airlines of competing service that would not be subject to the additional surcharge, such as nonstop service or flights connecting at uncongested airports.

The airlines that have lowered fares to attract customers are bound to object to the imposition of a passenger surcharge that raises the cost of air travel. Indeed, a stated intention of the passenger surcharge is to reduce passenger demand for air travel because the airlines' low fares have attracted more passengers than the system, whose capacity is temporarily fixed, can handle. Furthermore, some carriers have invested millions of dollars to develop their hub operations at what are now congested airports. However, the proposed surcharges are designed to offer lucrative incentives for passengers to choose competing flights that do not involve a connection at those congested hub airports.

Not only will the surcharge affect demand for some airlines' services, but the major airlines will be asked to bear a large portion of the costs of implementing the surcharges. For example, their computerized reservation systems will have to be programmed to calculate and display the proposed surcharges, and the airlines will be responsible for collecting the surcharges. Clearly, the airlines have legitimate reasons to oppose the surcharges.

On the other hand, there are undesirable social costs (i.e., higher fares and undue influence over airport authorities) associated with the preeminent market positions of some airlines at their major hubs. Therefore, it is reasonable to question who will benefit if major hub airports are enlarged. At a time when many commercial airports are underused, is there any justification for enlarging congested hub airports just to handle the peak demands from airlines that continue to expand their hub operations? A passenger surcharge, designed to reduce the total amount of air travel and to divert some of the remaining traffic through less congested airports at off-peak times, might lessen the need to expand the major hub airports.

Some industry analysts believe economic incentives will not be effective because airline schedules are based on the needs of business travelers, whose travel behavior is relatively insensitive to changes in price. However, price-sensitive discretionary travelers will alter their travel patterns if confronted with out-of-pocket surcharges, and airline loads will be affected by the loss of those discretionary travelers. Inasmuch as the industry depends on attracting a profitable mix of passengers, the displacement of some discretionary travelers would force the airlines to reschedule some of their flights. Based on the nonlinear relationship between the length of average delays and the demand-to-capacity ratio, any rescheduling that results in a decrease in the number of airline operations during peak periods at congested airports would produce a proportionately greater reduction in delays. Properly implemented passenger surcharges could yield desirable reductions in congestion and delays.

Overcoming opposition from travelers and the airlines will be a major hurdle blocking the adoption of passenger surcharges. Nonetheless, many of the same arguments used to support airline deregulation now apply to the market for airport and airway services. Namely, the aviation system is becoming inefficient and inequitable because of congestion and delays. Passenger surcharges could ease some of those problems by reducing the amount of travel at peak periods and diverting some of the remaining demand to less congested airports.

SUMMARY AND CONCLUSIONS

The growing severity of airside, landside, and terminal congestion threatens to clog the aviation network, but political, environmental, operational, and financial considerations limit the number of feasible remedies. Building new airports and expanding existing facilities would provide much-needed additions to capacity, but new-airport development is hampered by high costs, opposition from hubbing airlines, and scarcity of acceptable sites near major metropolitan areas. Various operational enhancements will boost system capacity in the short term but will not increase supply enough to provide lasting relief in the face of rapidly growing demand.

Efforts to reduce congestion and delays by establishing slot quotas are also short-term approaches to the long-term problem. Equitably and efficiently allocating operating rights by means of administrative techniques is difficult if not impossible, and administrative techniques will not resolve the underlying issue of excess demand and insufficient supply. Economic techniques for managing demand do attempt to bring demand in line with existing capacity, and a combination of peak/off-peak landing fees and passenger surcharges might significantly reduce congestion and delays at some airports.

An equitable airport pricing policy would set landing fees equal to marginal costs. Users who demanded access during peak periods would be allowed to do so if they were willing to pay a premium for that privilege. Other users who did not value peak-period access as highly would have the choice of going elsewhere or waiting until a lower off-peak price was in effect. Managing passenger demand also should be part of any plan to reduce congestion and delays. Passenger surcharges could be used to motivate short-haul passengers to consider alternative means of transportation, as an incentive for connecting passengers to use less congested hub airports, and as an inducement for all passengers to travel at less congested times. Moreover, the connecting surcharge would provide an incentive for carriers to introduce competing nonstop service or flights that connect at less congested airports.

Although either technique alone would reduce congestion and delays, it is worth noting how well passenger surcharges and peak/off-peak landing fees complement each other. In the case of peak/off-peak pricing, airside access is allocated according to a user's willingness to pay a peak-period premium. Users who cannot justify the premium will not demand access during peak periods, which allows access by greater numbers of users who place a higher value on airside access. However, in order to recover the higher cost of airside access during peak periods, the airlines might use bigger airplanes carrying larger numbers of passengers, which would increase congestion in other parts of the airport.

On the other hand, passenger surcharges would reduce the number of travelers using the entire airport, which in turn would reduce the airlines' demand for airside access. Consequently, there would be an increase in the number of available takeoff and landing slots that might be taken by users who place a relatively low value on airfield access. An influx of low-value users would increase airfield congestion, which would delay the remaining commercial users. Therefore, in order to obtain efficient use of all airport resources, it appears that a combination of passenger surcharges and peak/off-peak landing fees is desirable.

Many critics argue that economic techniques merely postpone the inevitable need for expansion. They are right. If the national transportation system is to grow, it must have new and better facilities. In the meantime, the combination of peak/off-peak landing fees to control airside access and passenger surcharges to manage travel demand could produce a more equitable and efficient allocation of scarce airport capacity than now exists.

ACKNOWLEDGMENTS

The author wishes to thank several people who have made invaluable contributions to this project. Larry L. Jenney and E. Thomas Burnard of TRB and John Fischer of the Congressional Research Service provided many helpful suggestions at every stage of the research process. Richard Marchi of Massport, Timothy Brosnahan of the Partnership for Improved Air Travel, Michael Tretheway of the University of British Columbia, Gene Mercer and Thomas Henry of the FAA, William Fromme of the International Civil Aviation Organization, and Lloyd McComb of Transport Canada contributed insight and information. Nawal Taneja of Ohio State University supplied continuing guidance and was a valued source of material.

The author also wishes to express gratitude to the FAA for providing financial support for this research project and to TRB for administering the Graduate Research Award Program.

REFERENCES

1. *FAA Aviation Forecasts—Fiscal Years 1988–1999.* Office of Aviation Policy and Plans, FAA, U.S. Department of Transportation, Feb. 1988.
2. McArtor Calls for Blueprint To Increase Airport Capacity. *Aviation Week & Space Technology*, Jan. 18, 1988, p. 61.
3. D. Martindale. Delayed. *OAG Frequent Flyer*, June 1987, p. 50.
4. *Airport Capacity Enhancement Plan.* Transportation Systems Center, Research and Special Programs Administration, Department of Transportation, Cambridge, Mass., 1986.
5. *Massport's Program for Airport Capacity Efficiency.* Massachusetts Port Authority, Boston, Mass., Dec. 1987.
6. *The Report of the Industry Task Force on Airport Capacity Improvement and Delay Reduction.* FAA, U.S. Department of Transportation, Sept. 1982.
7. *The Annual Report of the U.S. Scheduled Airline Industry.* Air Transport Association of America, Washington, D.C., June 1988.
8. *1988 Annual Report of the Regional Airline Association.* Regional Airline Association, Washington, D.C., 1988, p. 8.
9. A. Odoni and J. Vittek. *Airport Quotas and Peak Hour Pricing: Theory and Practice.* Flight Transportation Laboratory, Massachusetts Institute of Technology, Cambridge, Mass., May 1976, p. 8.
10. M. E. Levine. Landing Fees and the Airport Congestion Problem. *The Journal of Law and Economics*, April 1969, p. 92.
11. *Origin-Destination Survey of Airline Passenger Traffic.* Air Transport Association of America, Washington, D.C., Fourth Quarter, 1985.
12. Denver Wrestles With Continental, United Over Need for New Airport. *Aviation Week & Space Technology*, Sept. 12, 1988, pp. 142–144.
13. A. Brummer. Scarce Slots, Big Bucks. *Airline Business*, Nov. 1988, p. 19.
14. N. Taneja. *Introduction to Civil Aviation.* D.C. Heath, Lexington, Mass., 1987.
15. R. W. Coggin. Hub and Spoke Scheduling Versus Direct Flights. *Proc., 13th Annual FAA Aviation Conference*, Office of Aviation Policy and Plans, FAA, U.S. Department of Transportation, Feb. 1988, p. 33.
16. *Policies for the Deregulated Airline Industry.* Congressional Budget Office, Washington, D.C., July 1988.
17. J. Ott. U.S. Reviews Allocation of Slots at Busy Airports. *Aviation Week & Space Technology*, Sept. 26, 1988, pp. 116–117.
18. Task Force Outlines Plan to Increase Airport Capacity. *Aviation Week & Space Technology*, April 4, 1988, p. 70.
19. *Proc., 13th Annual FAA Aviation Conference*, Office of Aviation Policy and Plans, FAA, U.S. Department of Transportation, Feb. 1988, p. 5.
20. FAA Imposes Limit on Airline Traffic at Chicago O'Hare. *Aviation Week & Space Technology*, Oct. 10, 1988, p. 113.
21. *Airport Access: Staff Working Paper.* Civil Aeronautics Board, undated, p. 20.
22. D. Koran and J. D. Ogur. *Airport Access Problems: Lessons Learned from Slot Regulation by the FAA.* Bureau of Economics Staff Report to the Federal Trade Commission, May 1983, p. 33.
23. J. M. Rodgers. FAA Forecast Overview. *Proc., 13th Annual FAA Aviation Conference*, Office of Aviation Policy and Plans, FAA, U.S. Department of Transportation, Feb. 1988, p. 15.
24. *1987 Air Travel Survey.* Air Transport Association of America, Washington, D.C., 1987, p. 14.
25. *The Annual Report of the U.S. Scheduled Airline Industry.* Air Transport Association of America, Washington D.C., 1977 and 1987.
26. M. Mecham. Federal Funding Is Next Hurdle Faced by New Denver Airport. *Aviation Week & Space Technology*, May 30, 1988, p. 125.
27. *Airline Takeoff and Landing Slots.* General Accounting Office, Washington, D.C., Jan. 1986, pp. 1–2.
28. *Comments on Flight Transportation Associates' Description of an Auction Process: A Report to the Port Authority of New York and New Jersey.* Michael E. Levine Associates, Los Angeles, Calif., undated.
29. J. R. G. Brander and B. A. Cook. Air Transport Deregulation and Airport Congestion: The Search for Efficient Solutions. In *Transportation Research Record 1094*, TRB, National Research Council, Washington, D.C., 1986, pp. 18–24.
30. W. R. Fromme and W. M. Swan. *Airport Quotas and Peak Hour Pricing: Analysis of Airport Network Impacts.* Office of Aviation Policy, FAA, U.S. Department of Transportation, June 1976, p. 1.
31. D. W. Gillen, T. H. Oum, and M. W. Tretheway. *Airport Pricing Policies: An Application to Canadian Airports.* Working Paper. Faculty of Commerce and Business Administration, University of British Columbia, Vancouver, British Columbia, Canada, April 1987.
32. W. R. Fromme. *The Airport Passenger Head Tax: Analysis of Its Potential Impact.* Office of Aviation Policy, FAA, U.S. Department of Transportation, July 1974, p. 5.

Any errors appearing in this paper are the sole responsibility of the author.