Transfer Passengers. Transportation Engineering Journal of ASCE, Vol. 104, No. TE6, Nov. 1978, p. 775.
2. J.P. Braaksma and J.H. Shortreed. Method for Designing Airport Terminal Concepts. Transportation Engineering Journal of ASCE, Vol. 101, No. TE2, May 1975, p. 321.
3. R. Horonjeff. Analyses of Passenger and Baggage Flows in Airport Terminal Buildings. Journal of Aircraft, Vol. 6, No. 5, Sept. 1969, p. 446.
4. J.J. Fruin. Pedestrian Planning and Design. Metropolitan Association of Urban Designers and Environmental Planners, Inc., 1971.
5. R. de Neufville and M. Grillot. Design of Pedestrian Space in Airport Terminals. Transportation Engineering Journal of ASCE, Vol. 108, No. TE1, Jan. 1982, p. 87.
6. G. Zoutendijk. Mathematical Programming Methods. North Holland, Amsterdam, 1976, p. 299.
7. J.C. Yu and R.D. Kerr. Staging Runway Expansion by Dynamic Programming for Washington National and Dulles International Airports. In Transportation Research Record 588, TRB, National Research Council, Washington, D.C., 1976, pp. 11-17.
8. R. Horonjeff. Planning and Design of Airports. McGraw-Hill, New York, 1975, p. 165.
9. N. Ashford, N. Hawkins, M. O'Leary, D. Bennetts, and P. McGinity. Passenger Behavior and Design of Airport Terminals. In Transportation Research Record 588, TRB, National Research Council, Washington, D.C., 1976, pp. 18-26.

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# Aviation Legislation and Infrastructure: Policy Implications for the 1980s

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ABSTRACT

Airport and airway legislation together with technological advances facilitate developments in aviation. Currently aviation is repeating one of its several historical bifurcations as the transition is made from the 1970s to the 1980s. The recently passed airport and airway improvement legislation, for example, authorizes substantially increased expenditures from the Airport and Airway Trust Fund through 1987, the main bulk of which is for modernization of air traffic control facilities and equipment. A collateral legislation, the Airline Deregulation Act of 1978, in addition to rearranging the traffic patterns of the country, may stimulate the growth of the regionals (commuters) and air taxis, thus placing stringent requirements on existing terminal and airway capacity. Exacerbating the terminal capacity problem are certain implications of the Aviation Safety and Noise Abatement Act of 1979, which may result in reducing the time window for flight operations in major hubs, thus further decreasing airport capacity. Fortunately FAA's recent National Airspace System (NAS) plan, together with expanded funding authorized by the Airport and Airway Act of 1982, will address much of the capacity, safety, and productivity issues in the long run--particularly with respect to the enroute environment. In the meantime, however, traffic growth will place serious limitations on terminal capacity--both air and ground operations, with the latter being more intractable. A feasible way to provide both capacity and level of safety in the short run is to redistribute the traffic (particularly connecting traffic) from bottlenecks to the less congested parts of the system; this is clearly allowed by the deregulation act.

In the United States, airport and airway legislation--together with the evolution of the terminal and air traffic control systems--is instrumental in facilitating the development of aviation. The first legislation devoted exclusively to airports, for example, was the Federal Airport Act of 1946, which established a federal-aid program to provide a system of public airports to meet the needs of the rapidly growing civil aeronautics industry. This program was subsidized through the 1950s by the federal government through general revenue appropriations. During this period, the first generation of the Air Traffic Control (ATC) system was put in place.

Traffic growth in the 1960s created a demand for still more airport and airway development, including second generation ATC systems. There was also a requirement for additional financial aid to accommodate growth. By 1968 this, along with the excessive delays at major airports, led to a concerted effort by the federal government and industry that resulted

in the enactment of the Airport and Airway Development Act of 1970. Instead of using the General Fund to finance the airport and airway system, a program was developed whereby users of the system would pay for it. This act created new user taxes to be placed in the Airport and Airway Trust Fund.

Between the end of World War II and the end of the 1960s, federal grants-in-aid for airport development totaled a little more than a billion dollars. The 1970 legislation (PL 91-258) called for a budget twice that amount for the 1970s alone. The act provided for two grant-in-aid programs: the Airport Development Aid Program (ADAP) and the Planning Grant Program (PGP). Both are matching-fund assistance programs in which the federal government pays a predetermined share of approved airport planning and development project costs; and the airport owners at the various state and local levels, who are eligible to participate in the program, pay the rest. The act also provided for acquiring, establishing, and improving air navigation facilities and equipment and provided for research and development and operation and maintenance of the air traffic control and navigation system. This allowed the third generation ATC system to be phased in.

## MAJOR ISSUES

The legislative authority for certain provisions of the Airport and Airway Act of 1970 expired on September 30, 1980. In spite of a generally favorable opinion of the implementation of the Airport and Airway Development Act over the past 10 years, some changes in the 1970 act have been suggested (1).

Federal Aviation Administration (FAA) forecasts (2,3) indicate a need for an increased number of services and for increasing national aviation system and airport capacity. To a lesser degree, other forecasts indicate growth of air traffic over the next decade as well (4,5). This occurs in an era when major portions of the ATC systems are now outdated after 20 or more years of use (6). Replacement of this equipment, particularly computers, must be given consideration.

A major concern for the airport and airway system over the next few years is congestion. Privately owned airports, included in the National Airport System Plan (NASP), often serve transportation needs by relieving congestion at large air-carrier airports or by providing a link to scheduled airline services. Indications are that unless federal funding is forthcoming, a substantial number of these airports may have to be closed in the 1980s, mainly because of financial problems (7).

At the same time, reliever airports are becoming increasingly more important as congestion at major airports grows. Reliever airports are most suitable to handle general aviation traffic, diverting it from the high-density, air-carrier airports. It has been suggested that more reliever airports be designated. These reliever airports, however, must offer services and convenience comparable to major air-carrier airports and constitute a suitable alternative to attract general aviation traffic. Possibilities for the increased funding of reliever airports, or inclusion of these airports under the obligational authority of air-carrier airports, are being considered. It has been suggested, for instance, that regional carrier (commuter), reliever, and general aviation airports should receive a greater percentage of Trust Fund money (instead of 17 percent) in order to provide safer alternatives to the growing use of the already busy air-carrier airports.

Another suggested idea is the renewal of an old practice for some of the larger airports--that of allowing these individual airports to collect their own head taxes. This would be in lieu of the ADAP ticket tax. These airports would drop out of the ADAP under this plan and finance projects with the taxes they collect. As a result of this change, the federal-aid program could be focused more on the needs of smaller airports.

The existing airport and airway system relies heavily on the federal government for both the actual provision of services and the administration of an airport development program. Increased state and local involvement in administering and providing various airport and airway services is considered desirable; this might, however, lead to a lack of standardization of the airport and airway systems.

Air-carrier airports received 86 percent of ADAP funds, but according to the NASP (8) these airports needed only 62.6 percent of the ADAP apportionments. On the other hand, general aviation airports need 37.4 percent but receive only 14 percent. It has been suggested that the current proportions be changed. This priority apportionment is based on the population of a state or region. It is possible that an activity factor could be included in the apportionment formula, and this might result in a restructuring of priorities.

There is an opposite school of thought, namely, that air-carrier activity has generated about 93.5 percent of trust fund revenue and received only about 86 percent of ADAP funds. In contrast, general aviation has generated a mere 6.5 percent of trust fund revenue but received a disproportionately large share of 14 percent of ADAP funds. This line of reasoning argues for an increase of air-carrier share of the expenditures from the trust fund. This equity issue is more controversial and the debate is likely to continue for a long time.

As of September 1980 the Trust Fund had an uncommitted balance of about $2.9 billion, or the equivalent of 2 years' expenditure at the prevailing rate. By 1982 the balance was $3.9 billion. The 1983 and 1984 balances are projected to be $4.6 and $5.1 billion, respectively.

## AIRPORT AND AIRWAY IMPROVEMENT ACT OF 1982

This long-awaited legislation, passed in September 1982 as PL 97-248 (9), extends--with certain modifications--program authorizations contained in the Airport and Airway Development Act of 1970 and continues the funding mechanism. Space limitation prevents a comprehensive coverage of the general reauthorizations, such as the reauthorization of the passenger ticket tax. Instead features of this legislation are cited that indicate how it is different from the previous legislation:

1. A significant increase in the authorized level of funding for the facilities-and-equipment appropriation, which finances the capital costs of modernizing the airway system;
2. An increase in the proposed program level for research, engineering, and development, which paves the way for timely development of advanced airway systems and technology in future years;
3. Increased program levels for airport development and planning grants, which will be consolidated into a single airport grant program;
4. Broadening of the eligible users of airport grants to include certain noise-compatibility items and planning of noise-abatement actions;
5. A 6-year extension of the Airport and Airway Trust Fund;

6. A 6-year extension of existing aviation user taxes in general, with the 7-cent per gallon nongasoline fuel tax replaced by a tax of 14 cents for noncommercial aviation, and the 3-cent gasoline tax by 8 cents or 10.5 cents per gallon (depending on the grade);

7. A large increase in the amount of the ongoing costs of operating and maintaining the airway system that will be coming from the Airport and Airway Trust Fund rather than the General Fund;

8. Emphasis on improved system planning and development of reliever airports in the large metropolitan areas where traffic is congested;

9. Provision for studying the involvement of the states and local authorities in their larger airports' ability for self-financing without federal assistance; and

10. A provision to assure that airport owners and operators make their facilities available for use by air carriers and other users on fair and reasonable terms without unjust discrimination.

The total FAA projected expenditures for the next 5 years, mainly for system modernization, substantially exceed the expenditures for the 1970s. The overall estimated FAA budget of $22.8 billion for the next 5 years (including the $5 billion from the General Fund) calls for major efforts to accommodate the projected growth in air traffic.

The authorized levels for facilities and equipment are comparable substantively with the FAA budget estimate; perhaps this reflects the congressional endorsement of the need for improving air-navigation facilities (see Table 1). Another area of agreement between the authorization and the proposed FAA budget is expenditure for research and development, where both appear to recognize the need for the application of new technology to ATC systems.

In reexamining the figures, however, the funding levels for the authorizations and FAA budget estimate are different in several areas. First, the administration's budget estimate for airport monies is substantially lower for the period during which the larger airports are expected to be defederalized. More precisely, the administration's estimate is $2.54 billion lower than the legislative authorization.

A departure from the 1970 legislation is allowed for the operations and maintenance budget (even though the use of trust funds for the administrative function of FAA is limited) in that the trust fund may be used to cover the operation of air-navigation facilities.

Overall the total authorization from the trust fund shows substantial increases through 1985, mainly because of the increased investment in airway system improvement. From then on the authorizations taper off and even decrease in 1987 (see Table 1).

There are controversial items in the airport and aviation authorizations. Studies to set priorities--such as the congressionally mandated studies on self-financing of large airports and airport access--are needed to clarify these issues. The use of priorities, instead of allocation formulas based on enplanements alone, is an issue pending before the administration and Congress before the reauthorization debate in 1987.

## COLLATERAL LEGISLATION

In addition to the Airport and Airway Improvement Act, several recent acts have direct relationship to the evolution of the airport and ATC system.

### Airline Deregulation Act

The enactment of the Airline Deregulation Act (PL 95-504) has permitted a readjustment of the market served by the majors (trunks), nationals (locals), and regionals (commuters). The majors, which receive no subsidy for low-density service, are abandoning what remains of their short-distance routes, except where these short trips supply enough passengers to their high-density routes to make it economically feasible to maintain them as feeders. Although less rapidly, the nationals, which are still subsidized, are also moving away from short-distance and low-ridership service. At the same time, the regionals are expanding to fill these gaps. This expansion of commuter airline services, which use smaller aircraft, appears to be a dominant factor in the growth of traffic at many airports.

The effects of the deregulation act (as amended) for the remainder of the 1980s include the following:

1. The net result of the termination of domestic route programs in 1981 was a readjustment of the route patterns that had evolved over the decades because of route regulation by the Civil Aeronautics Board (CAB). Such redistribution of traffic among the airports may result from efforts by air carriers to divert through and connecting passengers to hubs that are less busy.

2. Between 1983 and 1985, a subsidized carrier may be replaced on a route by a regional or other carrier if such replacement will result in (a) a reduction in or elimination of a subsidy and (b) improved service. During this replacement process, the number of takeoffs and landings is likely to increase because the same amount of traffic normally carried by larger airplanes will be handled by smaller planes. Therefore, an increase in traffic may occur during the 1983 to 1985 period.

3. Under the deregulation act, service to small communities is encouraged and continued; 555 small communities are designated for essential air ser-

**TABLE 1 Aviation Authorizations ($ millions)** *(9,20)*

| | FY 1982 | FY 1983 | FY 1984 | FY 1985 | FY 1986 | FY 1987 | Total 1982-1987 |
|---|---|---|---|---|---|---|---|
| Grant-in-aid | 450 | 600 | 793.5 | 912 | 1,017 | 1,017.2 | 4,789.7 |
| Facilities and equipment | 261 | 725 | 1,393 | 1,407 | 1,377 | 1,164 | 6,327 |
| Research engineering and development | 72 | 134 | 286 | 269 | 215 | 193 | 169 |
| Operations and maintenance | 800 | 826.7 | 828.6 | 830.6 | 832.7 | 835.0 | 4,953.6 |
| Trust Fund Total | 1,583 | 2,285.7 (3,120) | 3,301.1 (3,920) | 3,418.6 (3,930) | 3,441.7 (3,930) | 3,209.2 (3,740) | 17,239.3 |
| Percentage increase over previous year | – | 44.4 | 44.4 (25.6) | 3.56 (.26) | .68 (-.51) | -6.76 (-4.35) | – |

Note: The figures in parentheses include amounts authorized under the Airport and Airway Improvements Act of 1982 and the Surface Transportation Assistance Act of 1982.

vice. Thus, by law, these 555 communities are guaranteed minimum service at least until 1988. This establishes the lower bound on traffic forecasts for the next 5 years.

### International Air Transportation Competition Act

With several major exceptions, the philosophy of the International Air Transportation Competition Act of 1979 (PL 96-192) is an extension of the Airline Deregulation Act. It amends the Federal Aviation Act of 1958 to place "maximum reliance on competitive market forces" in international air transportation. Under bilateral agreements, there may be a larger number of gateway cities for international air transportation. Also, there would probably be more competition between domestic and foreign carriers in providing low-cost transportation overseas. Depending on the economy and size of aircraft, the total number of flights spread between these gateway cities may be increasing in the decade ahead.

### Aviation Safety and Noise Abatement Act

A number of laws for controlling aviation noise have been enacted. These include the Noise Control Act, the Quiet Communities Act, and, most recently, the Aviation Safety and Noise Abatement Act of 1979 (PL 96-193). These culminate in increasingly stringent noise control measures prescribed for a number of urbanized areas.

In spite of these requirements on aircraft, there appears to be an increased intolerance by the public toward noise, particularly at the airport communities. The Aviation Safety and Noise Abatement Act establishes a single system for measuring noise in coordination with land use planning. Local governments and airport owners play a large part in determining what constitutes acceptable noise exposure.

The act also specifies noise standards for aircraft types at certain airports. The standard is considerably more relaxed for two-engined aircraft that serve most small communities where an exemption is granted for noncomplying aircraft. Because the expected growth of air traffic will come principally from regional carriers, a significant portion of the aircraft may not comply with the latest stringent noise requirements until 1988. If noise exposure is to be defined both as noise from the aircraft engine and the frequency and time of occurrence (exposure), this may imply either fewer aircraft operations or a narrower operating window at most major airports unless breakthroughs occur in the use of noise abatement flight procedures.

Another provision of the act allows the use of funds from the unexpended balance of the Airport and Airway Trust Fund to finance expenditures incurred under this act (as previously alluded to). In addition all foreign carriers engaging in transportation to the United States are expected to meet specified noise standards. Thus it is virtually certain that these noise standards will be implemented.

## TECHNOLOGICAL TRENDS

Technological trends also have a definite bearing on future aviation developments. If timely implementation is no problem, technological solutions can address the capacity, safety, and productivity issues for both the airport and airway components of the aviation system. These technological solutions are reviewed below in two parts: the enroute portion of a flight (airway) and the terminal capacity (airport).

### Airway Systems

Perhaps the most obsolete part of the present ATC system is the computer, which has been frozen to 1960 technologies (such as the IBM 9020s). The present National Airspace System (NAS) plan and other studies (10-12) call for replacement of this computer system by the early 1990s. The key is to make this transition in an evolutionary manner to avoid risks to safety.

When the computers are in place, the second milestone of the airway system will be an Automated Enroute Air Traffic Control System (AERA). Such a computer-based system will undoubtedly relieve the work load of the air traffic controllers at enroute control centers and flight service stations, because much of the work formerly performed manually by controllers will be handled by the computer. Aside from increasing the productivity of controllers, it is conceivable that airlines could save fuel by following a more meticulous and responsive flight path designed by the AERA. The system is scheduled for implementation starting in the early 1990s.

A third component of the airway system is communications. A new data link mode-S (formerly the Discrete Address Beacon) system will allow communication between aircraft, as well as between aircraft and ground. This will replace the existing (less precise) Air Traffic Control Radar Beacon System (ATCRBS). Scheduled implementation date is the late 1980s. User aircraft will have to be equipped with a transponder, which is estimated to cost $10,000. This cost can be absorbed by commercial aircraft, but it may put a strain on general aviation aircraft even though the decision to acquire such equipment is optional.

After Mode-S communications are in place (by the year 2000), the Traffic Alert Collision and Avoidance System (TCAS) can be implemented in aircraft cockpits. The system is designed to alert pilots of intruding aircraft and give optional information on the location of intruders and on possible collision avoidance maneuvers. Obviously the implementation will add to the cost of producing aircraft.

As a summary, the implementation dates of the above technologies are shown in Figure 1.

### Airport Systems

Capacity at terminal areas can be most dramatically increased by new airport or runway construction. Environmental, ease-of-access, and financial constraints, however, will preclude constructing new airports in most large metropolitan areas at least during the 1980s. The addition of runways, particularly short runways for separate, small aircraft operations, is more feasible, although land availability can often become a problem.

The benefit of additional runways can be more fully realized if they are accompanied by the appropriate ATC improvements. Microwave Landing Systems (MLS), for instance, can guide aircraft on more flexible approach paths. Thus, a small aircraft can be brought in on a short runway by a different flight path than a large aircraft and thus avoid wake vortex problems, resulting in a more efficient use of the terminal airspace. This strategy requires aircraft to be equipped with MLS avionics instead of the existing Instrument Landing System (ILS). The required MLS technology exists and a phased implementation is anticipated between 1985 and 2000.

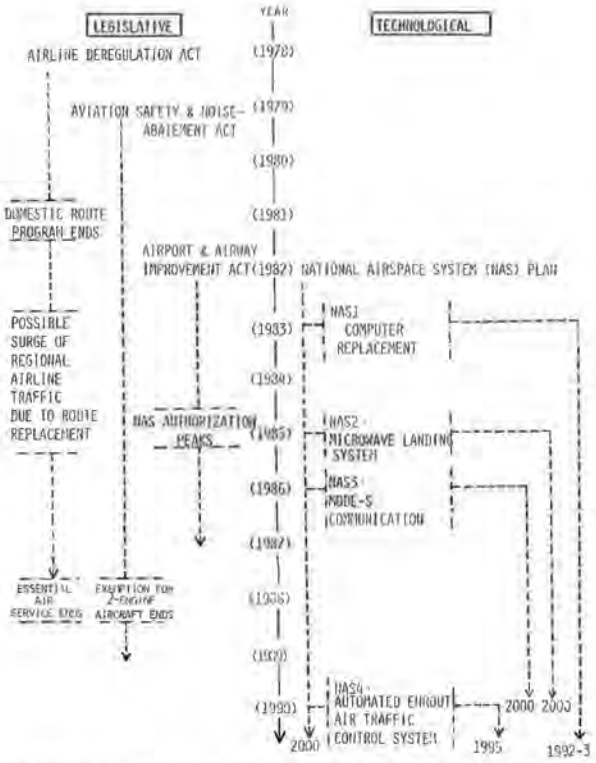


FIGURE 1 Legislative and technological milestones.

Aircraft need to be equipped with the appropriate avionics to use MLS; this represents an added cost to aircraft.

As another example, improved navigation (such as through the use of MLS) can make it possible to reduce minimum-spacing standards between parallel runways. This means that eventually triple parallel runways can be used in all-weather conditions thus reducing the land requirement for new runway construction.

Accurate monitoring of the wake vortex pattern and better understanding of the physics of wake vortex along the approach paths and at the aircraft wings can lead to reduced aircraft separation thus increasing terminal capacity. An allied concept is automated metering and spacing of aircraft after the communication, surveillance, and navigation capabilities of the ATC system are in place. Once the new ATC systems (particularly replacement of the computer system by mid-1990s) are in place, they would significantly reduce the uncertainty of aircraft arrival time at an airport, resulting in more efficient use of its runways.

Depending on the weather, traffic mix, and airspace use at neighboring airports, the capacity achievable in an airport is quite different. Substantial gains in capacity can be realized by a timely and carefully constructed management scheme for a given configuration of airfield and airspace. The computer can play a key role in making strategic decisions about runway use and approach directions under real-time constraints. Such systems offer realistic and practical solutions to the current terminal capacity problems. Regrettably, the implementation schedule for such systems (if any) is uncertain.

All of the above system innovations are geared toward improvement of the safety, capacity, and efficiency of airways. They have little to do with the ground access to airports, which also has a serious set of problems. It is clear that access and linkages between multiple airports in an urban area will significantly increase the traffic-handling capability of the aviation system. Because most of the ground transportation infrastructure has been in place for some time, however, the improvement in airport access is often a political and financial problem that falls largely outside the realm of technological solutions.

## IMPLICATIONS FOR THE 1980s

Under the framework set forth by the legislation and technology discussed previously, what are the most likely configurations and developments for the airport infrastructure in the 1980s? With the concerns for safety, system productivity, cost recovery, and the need to provide additional capacity and minimize delays, what are the most logical system alternatives and what are the logical public policy options for the remainder of the 1980s?

### Noise Abatement

First the possible effects of noise-control requirements on the infrastructure are addressed. There are two parts to the mandate on noise control: one on the aircraft itself and the other on the noise exposure of the community surrounding the airport. The former concerns aircraft engineering, particularly the engine. The latter deals with land use compatibility at the airport, adapting suitable flight paths for noise abatement, and the community's tolerance for airplane noise.

According to the Environmental Protection Agency (13), the application of noise technology certification rules to subsonic aircraft in 1980 and 1985 will show a substantial decrease in noise exposure in future years, but the full effect will not be felt until well beyond 2000. The noise exposure of the basic Concorde supersonic fleet will tend to dominate completely the noise exposure of possible supersonic operations in the United States, which will include existing Concorde-type aircraft and could include any reasonable number of other supersonic aircraft that comply with existing or proposed noise rules.

Before the year 2000, a more immediate achievement in airport noise reduction is possible by using improved takeoff and flight procedures. The optimal procedure will be a function of a particular airport's demographic environment. Maximum power cutback procedures during landing, however, offer additional noise reduction for the nation's airports. With the advent of MLS and other navigational aids, the optimal takeoff and landing procedure will tend to improve.

Noise control around airports is a local issue. The imposition of community noise standards often places a limit on aircraft activity in major hubs. The proposed noise levels in Illinois, for example, would require O'Hare to reduce its traffic to 40 percent of the current level, if the current mix of aircraft types is to be maintained. Another analysis was carried out on the noise abatement procedure for major airports in the United States and around the world. Of the 138 airports studied, 83 or 60 percent have operating restrictions for noise abatement. Of particular interest is the average curfew of 8 hours 21 minutes that is in effect for 28 airports and the corresponding reduction in capacity at these airports. If community concern over noise heightens and substantial relief from noise (due to improved aircraft design) is not forthcoming until the turn of

the century, the total number of operating hours available at all airports will decrease, resulting in more congestion at major hubs.

The noise problem tends to be insidious. As airports attract more surrounding developments the perceived level of airport noise by the neighborhood residents tends to grow. This can only be prevented by judicious land use regulations around airports. Land banking by airport authorities is one way to ameliorate the noise problem and the problem of availability of land for airport expansion.

## Safety Assurance

Safety is intimately related to capacity and productivity because a crowded sky and overloaded controllers invite accidents. Aviation safety can be viewed in two parts: accidents that occur in the vicinity of airports and accidents that occur enroute. Statistics show that the two flight phases--landing and takeoff--account for the majority of all accidents, but the majority of fatal accidents and fatalities occur during the in-flight phase.

Serious concerns are expressed about the safety of commuter operations. More than 50 percent of the 300 or so airports served only by regional carriers do not have a Visual Approach Slope Indicator, ILS, tower, radar, or lights (8). If the expected growth in regional airline operations materializes as a result of deregulation (Figure 1), these safety concerns will become increasingly critical.

At the major hubs and the large airports, the instrumentation for safe takeoffs and landings exists, but the increasing regional airline traffic and general aviation may tax their capacity to the extreme. In an environment where there is a mixed fleet consisting of small commuter or general aviation aircraft and the large major and national aircraft, the wake vortex problem becomes acute. Another allied problem is the definition of positively controlled airspace at a terminal; this becomes critical in congested hubs served by large and small planes.

Microwave Landing Systems (MLS) and short runway construction appear to be an effective means of assuring safety by separating approach paths and expanding terminal capacity, although full implementation will not be completed until the late 1990s (see Figure 1). Automated management schemes--if implemented widely among airports in a timely fashion--are another strategy to assure safety and expand capacity.

In the enroute environment the ATC system, comprised of regional ATC centers and flight service stations, is definitely being improved. For example, increased automation and better communication links (including an upgraded computer network) are underway. Improved data links between the aircraft and controllers pave the way for a better separation advisory service which has the potential to reduce the risk of midair collisions and decrease the burden on air traffic controllers.

## Congestion Relief

The Airport and Airway Development Act of 1970 states clearly that "the airport...will be available for public use on fair and reasonable terms...." This policy has resulted in the historic first-come-first-serve entry into the ATC system around the airports. Growth in traffic, however, has resulted in average delays of 8 minutes in 1978, and this is projected to increase to 25 minutes in 1987, assuming a modest 2 percent annual traffic growth. Most of the airports that experience serious delay problems rank among the top 15 airports in both enplaned passengers and air-carrier operations (2).

One feasible way to overcome the terminal capacity problem is through ATC procedures. In a 1979 User Conference, the following short-term operational solutions were identified: central flow control, flight advisory procedures, profile descents, and manual enroute metering.

In addition to MLSs, short runways, and airfield and airspace management, the wake vortex avoidance system and automated metering and spacing are among the major engineering programs designed to address this problem. Implementation plans for these engineering programs, however, are uncertain and far in the future. Automated metering and spacing, for example, cannot be implemented until most of the ATC improvements are in place in the late 1990s.

## Short-Term Solutions

Of more immediate value (in the 1980s) are solutions that modify the demand for service at terminals. The economic concept of pricing (14), for example, can be implemented by local airport authorities. This will set the landing fee at congested airports (usually large hubs) at the marginal cost imposed on all the delay and inconvenience caused to others who wish to land at the same time. Although such a pricing scheme can be efficient and even cost recoverable, there are problems in implementation. Aside from the technical problem of accurately determining such a fee, the practice tends to discriminate against general aviation aircraft and regional carriers, which cannot pay as much as nationals and majors.

On the other hand at uncongested airports (usually in smaller communities) marginal-cost pricing can result in financial loss to the airport authority. "Ramsey pricing" has been proposed (15) in these airports to maximize net social benefit and recover costs. To implement this, a departure from the current weight-based fee is necessary. In its place, the fee is assessed on the basis of a fixed fee per landing plus a charge per available seat mile, thus taking into account both the aircraft size and distance covered.

Thus, by means of pricing or other incentives, the local authority can achieve a more balanced use of airport facilities in a large metropolitan area. Underutilized airports, including reliever airports, can supplement the terminal capacity--for both air and ground operations--at many large cities. General aviation use of reliever airports, for example, is quite feasible as long as comparable navigational and terminal facilities are available. The use of underutilized airports by commercial aircraft, however, requires that extensive connectivity be provided between the multiple airports in a metropolitan area; this is an issue that defies simple solutions.

The airline route network may be adjusted in a postderegulation era to shift some of the hubbing activities to less busy airports around the country. This applies particularly to connecting traffic--both domestic and international--that can be redistributed among uncongested airports. Aside from using disincentives such as congestion and concern about safety, more positive incentives need to be introduced to expedite the implementation of such a solution.

A simple experiment performed by Chan et al. (16) shows the feasibility of traffic distribution from the point of view of excess capacity that exists in the airport system as a whole. Examining only the

top 24 hub airports, a redistribution of traffic after the complete removal of route authority and addition of more international gateways tends to place loads on some relatively less busy airports such as Cleveland and Kansas City. In other words, cities like Cleveland and Kansas City--under a totally deregulated and institutionally free environment--are logical stops for both domestic and international connecting traffic. They are geographically located to gain the largest share of the possible traffic growth between major cities--ignoring for the time being the precise magnitude of traffic growth projection between major hubs.

All these near-term solutions are quite attractive in their implementation potential, and some of them were put into place at selective terminals during the air traffic controller strike in 1981 through 1983. However, the fundamental policy of equal access to airports appears to be interpreted differently from first-come-first-serve. It is not surprising, therefore, that except for National and John Wayne Airports, allocation mechanisms are supposed to be removed by December 1983. A task force called for by the 1982 legislation to study the problem of allocating the use of airport facilities and airspace among users (17) reached many conclusions that are consonant with the findings in this paper.

It is clear that although highly valuable increases in capacity can be realized from changes in operational philosophy (in the short term) and ATC improvements at the terminal (in the long term), the major gains in terminal capacity are achieved only by adding new runways and building new major airports. Existing public policy, however, does not favor gaining additional airport real estate in the foreseeable future.

The real bottleneck--ground access to airports and connectivity between airports--is still the greatest unresolved problem in the entire aviation system. There are, however, some insights to be gained from past studies of this problem. First, the traffic volume to an airport is only a fraction of total urban travel. It is often too scant to justify an exclusive high-cost access mode. Second, air travelers in general are more sensitive to cost than time in traveling to airports (18), as contrasted with the reverse for the average urban commuter. The air travelers' relative sensitivity to cost means they are unwilling to finance high-cost access modes. Access facilities to airports can be justified, however, if they are part of an integrated urban commuting system.

The proposed use of aviation funds for ground access projects appears to be an innovative departure from the conventional wisdom and would allow an airport to be defined broadly to include ground access and multiple airport linkages in a city. But such a solution is fraught with flaws in equity and political obstacles in spite of its technical merits. Perhaps the proposed amendment to the 1982 act on ground access, the Surface Transportation Act of 1982 (PL9-424), and Emergency Jobs Bill (PL98-8) will help by providing financing for improving the transportation infrastructure in an urban area.

## Future Public Policies

Some projections of the issues in the upcoming 1987 reauthorization legislation are discussed in the following paragraphs.

Projected Trust Fund revenues and FAA expenditures through the year 2000 were estimated based on aviation activity forecasts in the National Transportation Policy Study Commission (NTPSC) 1979 study (19), the NASP distribution of capital expenditures for 1978 to 1987, and the then mandated federal shares for various airport development projects. Accounting for inflation, the gross amount of annual expenditure required, as forecast by NTPSC, is about half the amount of that in the authorization of the 1982 act. It is interesting to note, for instance, that the NTPSC did not foresee the need for substantial improvement in the airway ATC system in the 1980s. This is shown by a comparison of the facility and equipment and research and development budgets. Neither did the NTPSC foresee FAA's use of Trust Funds in operations and maintenance. Traffic forecast by NTPSC, however, was higher than that which materialized. These discrepancies point out the fragility of econometric forecasts, particularly long-term projections.

Accrued revenues to the Trust Fund and funding requirements for 1982-1987 were also forecast and compared by the Office of Management and Budget in April 1982. Using the excise tax proposed by the administration, it was estimated that 85 percent of the FAA expenditures from the trust fund could be recovered by the proposed taxes if coupled with a drawdown of about $2.2 billion from the Trust Fund surplus, which corresponds to the amount that existed in 1978. The 1982 act subsequently allows for a slightly lower general aviation gasoline tax (8 cents or 10.5 cents instead of 12 cents a gallon). In spite of this, subsequent analysis by the Congressional Budget Office (20) still substantiates the findings of the cost-recovery calculations.

Learning from the experience of NTPSC, the thesis of this paper is that projections are only meaningful in a time frame within which there are solid reference points anchored by legislation and technological developments (see Figure 1, for example). Furthermore, a projection should consider all the factors and impacts on all parties--both qualitative and quantitative. The impact of the proposed improvements to airports and airways can be summarized in an impact-incidence matrix such as the one shown in Figure 2. In such a matrix, the objectives of improvements to the aviation system are identified and the effect of implementing the system on the parties concerned is documented.

The chief objectives of airport and airway improvement are

- Increase safety: avoid aircraft conflicts,
- Increase capacity: expand the traffic handling capabilities of airways and terminals,
- Increase productivity: achieve savings in the operations and maintenance budget through automation,
- Reduce noise: enhance the environment near airports and in the community in general through noise abatement, and
- Cost-recovery financing: devise an efficient means to pay for the cost of the system.

The affected parties can be identified also. Among the users of the aviation system are commercial airlines, general aviation, and the military. Where the military shares the same airspace with the civilian sector their domestic flights often have to observe FAA regulations. Included in the user category are passengers and shippers who are concerned with both air and ground operations.

A second group affected by improvements is the operators, which include the FAA for the national airspace and the airport authorities, who typically run the air terminals in the local communities. Private airports that make their facilities available for public use can also be listed, but it is assumed that such operators will be lumped under

| IMPACTED PARTIES | OBJECTIVES: SAFETY | CAPACITY | PRODUCTIVITY | NOISE | FINANCE |
|---|---|---|---|---|---|
| USERS: | | | | | |
| Commercial Aircraft | ++ (enroute) + (terminal) | ++ (enroute) + (terminal) | | | + |
| General Aviation | | + | | | - |
| Military Aircraft | | + | | | - |
| Passengers | +(air) | +(air) | | | + |
| Shippers | +(air) | +(air) | | | + |
| OPERATORS: | | | | | |
| FAA | ++ | ++ | + | + | + |
| Local Authorities | | | | | |
| Airport Authority | +(air) | +(air) | + | + | ? |
| Local Governments | | | | + | ? |
| COMMUNITY: | | | | | |
| Airport Residents | + | | | + | |
| Nonusers | + | | | + | ? |
| CONGRESS: | + | + | + | + | ? |
| ADMINISTRATION: | + | + | + | + | ? |

KEY: + positive impact; - negative impact; ? uncertain impact; empty "not applicable"; +(air) postive on air side only; +(enroute) positive on enroute airways only; +(terminal) positive on terminal airspace

**FIGURE 2 Impact-incidence matrix of airport and airway system improvement.**

local authorities. The inclusion of local governments under local authorities is necessary because the airport authority is primarily concerned with the airport real estate, whereas the local government has a broader concern with such items as ground access and other responsibilities to the community at large.

Under the community group are listed both those who are most critically exposed to aircraft noise around airports and the nonusers of the aviation system who bear part of the cost of the system (through contribution to the General Fund) without a direct benefit of riding as an air passenger or shipping freight directly on an aircraft.

Finally, the Congress and the administration are included in Figure 2 as interested parties. Although one can theoretically think of these agencies as representative of the interest of all the users, operators, and communities, this is not often the case in practice.

An examination of Figure 2 shows that most of the entries are rated as a "+", which stands for positive impacts on the identified parties as far as the specific objective is concerned. Overall, one may say that the general airway and airport improvements discussed in this paper receive support for their long-term potential (21). These are long-awaited improvements in an aging and oversubscribed ATC system. Inasmuch as the improvement thus far is primarily on airways, however, passengers and shippers still have to face the pervasive problem of ground access (and secondarily terminal capacity). In the short run, terminal and ground congestion can be alleviated through redistribution of traffic, and the legislation does begin to address this, although more indirectly than would be desired.

The place where negative impacts appear in general is under the issue of cost-recovery finance. The general aviation community and the military see little benefit from such systems as Mode-S and the Traffic Alert Collision and Avoidance System (TCAS). The cost is deemed too high for both parties when many of them are likely to fly in uncontrolled airspace. The military has a further reservation about the negative aerodynamic effects of such equipment on tactical aircraft.

Among the operators, local matching-fund financing for system improvements is uncertain for some of the smaller airports, particularly regional airline and privately owned airports. The uncertainty is even greater for local governments, which often are responsible for ground access to the airports. On the other hand, the concern shown by nonusers is obvious considering their tax support for a system they do not use and the yet unproven savings from operations and maintenance due to automation.

The stance of the Congress and the administration on the financial arrangement of the 1982 act and the NAS plan can be difficult to understand. The 1984 appropriations for the act, for instance, reduce expenditures from the Trust Fund by $2 billion, or 49 percent below the authorized level. FAA's operating expenditures from the Trust Fund are eliminated entirely--somewhat of a divergence from the intent of the 1982 act. The question could be asked: Why are expenditures cut and a large surplus allowed in the Trust Fund? There appears to be no logical explanation other than perhaps a maneuver to obscure the national deficit. What is really perplexing is the contradiction--which appears to be espoused by both the administration and the majority of Congress--with the intended use of the Trust Fund.

A major controversy also exists in the issue of self-financing of large airports. Studies (20) point to the ability of large airports to support themselves through head tax and tax-exempt bond financing, as they have done in the past. This would save the bulk of the average $800 million yearly expenditure projected for grants-in-aid through 1987 (see Table 1)--although the revenue going into the Trust

Fund would also be less when these large-contributor airports are uncoupled from the federal-aid system.

The self-financing ability of large airports is evident from the discussion on marginal-cost pricing for congested (large) airports and Ramsey pricing for uncongested (smaller) airports, where both the efficiency of such pricing schemes and the cost-recovery potential for large airports have been shown. However, many major airports, including the Port Authority of New York and New Jersey, are opposed to the self-financing proposal (16). The issue of self-financing is not whether the large airport can do it, but rather: Is it desirable?

## SUMMARY AND FINDINGS

Aviation developments in the United States seem to bifurcate every decade or two, perhaps because of the rapid pace of technological change and the American life style. In the last three decades, for example, there have been two major pieces of aviation legislation and three generations of air traffic control systems. It now appears that as the United States emerges from the 1970s to 1980s, another major change is taking place, as characterized by deregulation, the 1982 act, and the FAA's modernization plan.

Partly because of the economy, the national airlines (and the majors) are still struggling to adjust to deregulation, and it appears that the open-sky policy will prevail for the next several years. During the period 1983 to 1985, for example, the expected replacement of national carriers by regionals--due to deregulation--at many communities around the country may result in a significant increase in the number of takeoffs and landings. Forecasters also have suggested traffic growth in the general aviation sector. This places additional requirements on capacity and safety both at terminals and on the airways.

More stringent noise requirements are about to be imposed around many of the airports. In spite of the mandated noise reduction in engines, the most effective noise-abatement procedure before the year 2000 continues to be in the area of land use planning, operational procedures for takeoff and landing, and, most critically, reducing the operating window of the airport. Imposition of curfew hours will definitely reduce the capacity at many of our major airports. Thus, on the one hand, air traffic grows as a result of deregulation; while on the other noise requirements tend to work against accommodating such growth in traffic. One short-term solution is to divert traffic to underutilized, reliever airports. This, together with the poor safety records of the regionals in the past, prompted a need to upgrade the smaller, reliever facilities.

The airport and airway authorizations of the 1982 act begin to address these issues, but much remains to be done. Meanwhile, the Surface Transportation Assistance Act of 1982 also theoretically helped by providing additional funding that potentially can be used to improve connectivity between and access to reliever and multiple airports around urban areas. Perhaps most importantly, airline deregulation allows for a much more flexible route structure for scheduled airlines. This may result in a shifting of through traffic from the existing connecting hubs and gateway cities to others where capacity is less taxed. It may mean, for instance, that much of the capacity problem and, for that matter, the safety problem can be addressed by encouraging a redistribution of traffic from the bottlenecks to the less congested areas. This may mean also the accelerated use of reliever or multiple airports in metropolitan areas.

The National Airspace System plan is generally received well by the users, operators, communities, the Congress, and the administration. There is particularly favorable reaction to its long-run contribution to the enroute part of the aviation system. Much less agreement exists about its short-run (before 1990) benefits, particularly at the terminal portion of the system. Even less agreement exists about an equitable way of paying for the funding authorized by the 1982 act, because a $4.6 billion surplus exists in the Trust Fund. In spite of the healthy tone set by the 1982 act, much room exists for innovation and improvement in future public policies.

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## REFERENCES

1. J. Fischer. The Airport and Airways Development Program. Issue Brief LB81084. Congressional Research Service, Library of Congress, Washington, D.C., 1982.
2. Terminal Area Forecasts, Fiscal Years 1981-1992. FAA, U.S. Department of Transportation, 1981.
3. FAA Aviation Forecasts. FAA, U.S. Department of Transportation, 1983.
4. Review of the FAA 1982 National Airspace System Plan. Report OTA-STI-176. Congressional Office of Technology Assessment, U.S. Congress, Washington, D.C., Aug. 1982.
5. Improving the Air Traffic Control System: An Assessment of the National Airspace System Plan. Congressional Budget Office, Washington, D.C., Aug. 1983.
6. T.M. Ellis. The U.S. Airport and Airway System--Past, Present and Prospects. Paper HE 9901 U.S.E. Economic Division, Congressional Research Service, Library of Congress, 1978.
7. Developing a National Airport System: Additional Congressional Guidance Needed. Comptroller General's Report to the Congress (CED-79-17), General Accounting Office, 1979.
8. National Airport System Plan. FAA, U.S. Department of Transportation, 1980.
9. Title V - Airport and Airway Improvement. Public Law 97-248. Tax Equity and Fiscal Responsibility Act of 1982.
10. National Airspace System Plan. FAA, U.S. Department of Transportation, 1983.
11. J.L. Helms and S.B. Poritzky. The National Airspace System Plan. Aeronautics and Astronautics, 1982, pp. 50-61.
12. Airport and Air Traffic Control System. Report OTA-STI-175. Congressional Office of Technology Assessment, U.S. Congress, Washington, D.C., Jan. 1982.
13. Airport Noise Through the Year 2000: A Parametric Study. Technology and Federal Programs Division, Office of Noise Abatement and Control, Environmental Protection Agency, Washington, D.C., 1979.
14. A. Carlin and R.E. Park. Marginal Cost Pricing of Airport Runway Capacity. American Economic Review, Vol. 60, 1970, pp. 310-319.

15. S.A. Morrison. The Structure of Landing Fees at Uncongested Airports: An Application Ramsey Pricing. Journal of Transport Economics and Policy, May 1982.
16. Y. Chan, B. Gallagher, W.C. Moore, and M. Okin. The Role of the Federal Government in the Planning, Development and Maintenance of a National Airport System. Masters workshop paper. W. Averell Harriman College for Urban and Policy Science, State University of New York at Stony Brook, 1983.
17. Report and Recommendations of the Airport Access Task Force. Pursuant to Public Law 97-248, Civil Aeronautics Board, 1983.
18. R. de Neufville. Airport Systems Planning: A Critical Look at the Methods and Experience. Macmillan, New York, 1976.
19. National Transportation Policies Through the Year 2000. National Transportation Policy Study Commission, 1979.
20. Public Works Infrastructure: Policy Considerations for the 1980s. Congressional Budget Office, Washington, D.C., April 1983.
21. R.J. Bremer. User Response to the FAA National Airspace System Plan. Aeronautics and Astronautics, Oct. 1982.

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