The NATIONAL AVIATION SYSTEM CHALLENGES Of The DECADE AHEAD

1977 – 1986

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This document is for planning purposes only, and does not represent a commitment by the Executive Branch.

Foreword

In our Nation's bicentennial year, we can be proud that our aviation system has faced and successfully met many challenges. Today, we have a national aviation system second to none in the world in terms of safety, efficiency, and ability to meet the needs of the American public.

During the next 100 years, there undoubtedly will be rapid and astounding changes in transportation technology. It is our responsibility to begin now to ensure that aviation, in whatever form, 100 years from today is as vital and integral to society as is the case in 1976.

To assist in the objective of building a strong aviation system, this year's ten-year plan has been revised substantially to better focus attention on the key issues of safety, capacity, productivity, and environmental compatibility.

All agency planning, programming, and budgeting shall be consistent with the plan. Actual budgetary funding will be subject to the standard executive and congressional budgetary process.

John L. McLucas
Administrator

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Introduction

In this document are summarized the Federal Aviation Administration's plans for the development of the National Aviation System (NAS) over the next ten years. It has been prepared for two purposes:

- —To advise the aviation community of FAA's current activities.
- —To provide a basis for dialogue between the FAA and industry regarding the future of the NAS.

This edition contains the latest version of information presented in previous documents, such as a discussion of fundamental policy factors affecting aviation (Chapter 1) and a review of aviation forecasts (Chapter 2).

In Chapter 3, several challenges to aviation are covered in considerable detail:

- —Meeting Safety Requirements
- —Meeting Capacity Requirements
- —Increasing FAA Productivity
- —Environmental Protection and Energy Conservation

In Chapter 3, also, estimates of future funding for safety, capacity, productivity, and environment are presented. These estimates should not be used as budgeting guides; they are no more than an attempt to assign funds in reasonable proportion to meet needs expressed in broad FAA priorities. Such assignments are frequently a matter of judgment, because a program that one person might consider to be primarily concerned with safety might equally well be considered by another to be principally a contributor to meeting capacity requirements or to increasing productivity. Consequently, the funding breakout is not intended to govern agency use of funds nor to steer future budgets toward greater funding for capacity, productivity, or any other specific area. Such future decisions must and will be based on the priorities that exist when the decisions are made. This new breakout, however, focuses attention on program pay-offs and related trade-offs and is intended to stimulate substantive discussion regarding overall system priorities.

The estimated allocation of funds for safety, capacity, productivity, environment, and energy absorbs all but about two percent of the total FAA budget. This remaining percentage will be used for the National Capital airports and some administrative and training functions that were not assigned under the major headings.

Safety

Most funds are allocated to safety programs, since promoting aviation safety is the primary function of the FAA. The uses to which such funds will be put include establishment of facilities and equipment, aircraft separation functions, medical activities, flight standards activities, and other safety-oriented programs.

Capacity

Capacity funds are generally identified as those funds required to keep the capacity of the NAS ahead of aviation growth. Thus, funds allocated to meeting capacity requirements will be applied to those items that increase airport operating areas and airspace efficiency. Improvements to existing air traffic facilities, procedures, radars, and communications are included in this category.

Productivity

Programs to be funded in this category are concerned with increasing productivity in flight standards and facility maintenance activities. In addition, they will provide increased automation for terminal and enroute traffic control facilities and flight service stations. Initially, a relatively small amount is allocated to traffic control productivity because much of the automation activity is still in the engineering and development phase, and, therefore, does not require large investments. The allocation increases as implementation investments are made for automated facilities.

Environment and Energy

The funds identified as being allocated to the environmental and energy areas include Airport Planning and Development funds plus those needed for salaries of government personnel and for contractual efforts underway or planned in the Office of Environmental Quality. The percentage of the total budget applied to this category could rise significantly if new legislation creates a greater emphasis on meeting environmental or energy conservation needs.

The discussion of the challenges to be met is organized to provide: (1) significant historical background, (2) current activity, and (3) planned programs. Since there is much commonality among program objectives, it was decided to permit some repetition in the text as well as in the figures so that the reader could proceed through the document without being forced to refer frequently to distant chapters or figures.

Following Chapter 3 are appendices containing figures depicting FAA plans along familiar program lines. This section may be used for quick program reference. The figures are the sum total of all program funding discussed in preceding chapters.

Throughout this document, factual material and alternative considerations are presented candidly and clearly. Constructive reaction from all segments of the aviation industry will be welcomed.

This document supersedes Order 1000.27, Appendices 1 and 2, the National Aviation System Policy Summary and the National Aviation System Plan.

Chapter 1

BASIS FOR POLICY

CHAPTER 1.

Basis for Policy

1. INTRODUCTION.

The overall basis for aviation policy is contained in the several statutes pertaining to aviation, of which the Federal Aviation Act of 1958 is of primary importance. Two other important documents provide broad policy guidance for the Federal Aviation Administration:

- "Statement of International Air Transportation Policy of the U.S.," by the President, June 22, 1970.
- "A Progress Report on National Transportation Policy," by the Secretary of Transportation, May 1974.
- "A Statement of National Transportation Policy," by the Secretary of Transportation, September 1975.

Both presentations set forth broad policy considerations that underlie the Federal Government's response to the Nation's transportation needs. Aviation has been, and will continue to be, a rapidly changing industry and form of transportation. Past efforts to respond to these changes in an efficient and timely manner have left much to be desired. A more realistic approach to policy determination can be effected through timely resolution of issues facing aviation today. There are several key policy factors affecting the National Aviation System upon which the aviation community must focus.

2. FACTORS AFFECTING AVIATION POLICY.

a. **The Consultation Process.** Although FAA decisions are ultimately made by the Administrator, it has been and will continue to be FAA's practice to encourage pre-decision comment from those concerned, including user groups, the Congress, Federal, State, and local governments, special interest groups (such as those concerned with energy and with the environment), and the public. It is planned to expand consultation on specific policies in the future to the maximum extent practicable. This may well complicate the determination of policies if those consulted have widely divergent views, but it seems certain that the policies finally established will be better as the result of the policymakers' having examined all sides of the issues involved.

b. **Environmental Considerations.** A factor of growing importance in its effects on aviation policy is the need to assess the environmental impact of proposed changes in the National Aviation System (NAS). The National Environmental Policy Act (NEPA) of 1969, the Airport and Airway Development Act of 1970, and the Noise Control Act of 1972 have made it clear that positive actions must be taken to make sure that NAS "improvements" do not, in fact, have an adverse effect on the environment. This subject is discussed in Section 5 of Chapter 3.

c. **New Federalism.**

(1) The fundamental premise of New Federalism is that the Federal Government should not place itself in the position of telling the people, through the state and local governments, how their needs are best served. Further, decision-making should be conducted at the level of government closest to the problem at hand.

(2) Within the FAA, the principle of New Federalism has manifested itself most recently in 1975 legislative proposals for the airport development aid program. Beyond airport development are policy factors such as environmental issues on noise and airport curfews. State and local authorities are taking active steps to protect their local populace from excessive aircraft noise. These actions by non-Federal entities raise basic questions regarding the proper role of the Federal Government to promote and protect interstate commerce without unduly restricting valid local concerns. Several basic questions must be resolved:

—What is the continued proper Federal role in aviation development?

—What current Federal aviation functions can best be taken over or administered by state and local authorities?

—How does the existing Federal/State relationship in aviation matters compare to what is needed in the future?

(3) At present, the area of concern seems to be related solely to the question of airport development rather than the full range of ramifications of New Federalism. Failure to resolve these issues could have the most serious consequences for aviation and it is clear that all protagonists must become involved, not just the FAA and others in the Federal establishment.

d. **User Charges (Cost Allocation).**

(1) For almost 30 years, the Federal Government has attempted to lighten the burden of aviation system costs borne by the general taxpayers by proposing that users of the NAS be charged equitably for services received. The Airport and Airway Development Act of 1970 provided for financing of improvements through additional tax levies on users of the system. In addition, the 1970 act directed the Secretary of Transportation to:

—Determine the costs of the Federal Airport and Airway System

—Determine how these costs should be allocated among the users.

—Recommend equitable ways of recovering these costs.

(2) The Cost Allocation Study, submitted to Congress in September of 1973, found that:

—The costs should be allocated in about the following relationships: 50 percent to air carriers, 30 percent to general aviation, and 20 percent to the public sector (to support military and Government flying).

—The present tax structure recovers about 55 percent of total Federal costs from the non-public users (compared with 80 percent that should be recovered).

—The largest short-fall in tax recovery is in the general aviation sector. Only about 20 percent of the costs assigned to general aviation are being recovered through user taxes.

(3) FAA policy will continue to be directed toward the equitable collection of costs from users, though there is no present consensus on how this can be achieved.

e. **The Possibility of Constrained Growth.**

(1) It is expected that aviation activity in general will continue to grow over the next 10 years, but not as rapidly as it did over the past 10. It is not believed that technology will create quantum jumps in NAS capacity and airline profitability as it has in the past; gains are expected to be modest. Further, much of the gain in

capacity of major airports that it was once believed could be achieved by banning general aviation from them has already been used up. In a recent study of the 25 largest air carrier airports, it was determined that general aviation accounted for only 24 percent of all operations. On a national basis, however, general aviation accounted for 75 percent of total operations at all FAA-towered airports. It is presently forecast that, by 1985, national general aviation activity will climb to 81 percent of total operations at towered airports, but will drop to 21 percent of total operations at the 25 largest air carrier airports.

(2) In the New York area, for example, La Guardia Airport has displayed the following trend in activity as measured in terms of the percentage of total activity:

Year	G.A. Activity (Percent)
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

Meanwhile, the large, adjacent all-G.A. Teterboro, New Jersey Airport was similarly showing declines in activity from 265,679 operations in 1965, to 209,772 operations in 1973.

(3) Inspection of general aviation activity shows that it is shifting in two ways. First, all general aviation is shifting away from the larger air carrier airports (as was evidenced by the La Guardia Airport statistics); and second, recreation and training activity is being pushed out of major general aviation airports by rising costs of operations and maintenance, which, generally speaking, only the business and corporate interest can absorb. This hypothesis is confirmed by looking at a further breakdown of Teterboro activity. Local activity dropped from 60 percent of all activity in 1965 to 22 percent in 1973. These figures do not represent isolated instances, but instead depict a national trend. In effect, the system, either by virture of operational (safety related) requirements or by basic economics has constrained the nature of market demand by causing a shift of recreation and training interests from the major air carrier and major general aviation airports to the less costly, less operationally restricted rural areas. This trend in turn has influenced the near doubling of U.S. airports from 6,426 in 1960 to 12,700 in 1975. In view of heightening environmental concerns and spiralling costs of new airport construction, this or any other source of relief may not be maintained.

(4) Given these problems, FAA and the aviation community must explore the possibility that in the long term, it may not be feasible to continue increasing system capacity, to accommodate unconstrained growth in demand without degrading safety. At present, for example, airlines are encountering increasing delays because of excessive scheduling into key hub airports even though FAA has utilized improved technology and operational procedures to minimize such delays. Some postulate such concepts as peakload pricing and airport quota and curfew regulations as potentially feasible methods to restrict or shift demand. Some difficult questions need to be answered:

—Should the Federal Government continue an active policy of promotion of aviation, expecially general aviation?

—Should more effective policies be adopted to shift demand of airlines to off-peak hours and general aviation away from major hub airports?

3. THE POLICY DEVELOPMENT SYSTEM.

The FAA has recently started to develop a process to be called the FAA Policy Development System. This proposed system is intended to ensure that future policies will be established in an orderly fashion, with those persons creating any policy fully aware of the available alternatives and of the probable effects of the policy. It will contain the following key elements:

—Base-Case Work, which will include ongoing determinations of future system capability based on projections of current capability guided by major policy factors.

—Alternative Future Scenarios, which will be potential world scenarios within which the NAS might be required to function. Concomitantly, NAS capabilities that would be required within each of these scenarios will be identified.

—Policy Alternatives Development, which will compare future potential needs of projected capability. The intent will be to surface potential future system deficiencies far enough in advance so that system needs can be anticipated and met. Alternative policies can then be developed for further analysis—still far in advance of decision-making time.

—A National Aviation System Model, which will provide an analytical tool to aid the FAA in evaluating alternative policy determinations. This concept, the feasibility stage of which is being investigated, will provide a computer-based model capable of determining the impacts of candidate policy actions on all elements of the NAS.

—Policy/Plan Interface. As policy decisions are made, they will be translated into actions or regulatory plans for the FAA and aviation community.

Statement of FAA General Policies

Based upon legislation, Presidential guidance, and Departmental direction, the FAA has a broad range of general policies governing its major areas of responsibility. These policies are a reflection of Secretarial policy statements which are issued from time to time.

The most recent major issuance was the Statement of National Transportation Policy by the Secretary of Transportation in September 1975. While this document contains a Statement of National Transportation Policy, it should be noted that Secretary Coleman remarked, "Since policy formulation is a continuing process, the positions presented here are preliminary and may be amended and refined as we learn from experience and listen to your views. Also, no transportation policy statement may be fully implemented unless it has the full support of the Congress, Federal and State public officials, shippers, consumers, the industry and other concerned citizens. Thus, we invite and urge your criticisms and comments. In fact, your views are most necessary because a living, national transportation policy must reflect an evolving consensus of what the American people want and expect from their transportation system." Policy Priorities contained in that document which relate to aviation are noted below.

Consistent with general transportation policy principles, the Administration is formulating an aviation policy that will serve as a basis for coordination among Executive Branch agencies, for advocacy before the Civil Aeronautics Board (CAB) and in the submission of Administration legislative proposals to the Congress. Our aviation policy initiatives include both domestic and international issues.

Domestic Air Policy Priorities:

- Maintain aviation's excellent safety record, enhance existing safety regulations, drop unnecessary regulations and continue to upgrade the air traffic control system to reflect the needs of different users;
- Reform the air economic regulatory structure through increased pricing flexibility, some liberalization of entry and exit policy over a transitional period, prevent anticompetitive practices and expedite administrative processes. (We have

proposed permitting air carriers to lower prices without regulatory interference to the direct cost level, permitting some upward price flexibility subject to supervision by the CAB. Our entry proposals will free carriers from cumbersome certificate restrictions, permit some sensible expansion by existing firms into new markets and encourage some new entrants);

- Take measures to foster more efficient use of fuel, consistent with the national objectives of fuel conservation and market allocation of energy resources. (We have recommended to the CAB a temporary fuel-cost pass-through. Over the long term, the increase of load factors from 55 percent to 65 percent will promote more efficient use of fuel. The Federal Aviation Administration will continue to stress conservation measures.);
- Strengthen the financial viability of the carriers thereby enabling them to provide reliable long-haul trunk line service between major cities, assure adequate service to smaller communities and *enable healthy competition between efficient carriers*, permitting them to earn a reasonable rate of return on capital;
- Improve the equity of the airports and airways user charge system;
- Improve airport planning consistent with regional land use planning, projected capacity requirements nationwide, fairness among State and metropolitan areas and environmental protection (such as noise abatement);
- Recognize and support the development of general aviation, consistent with the need for it to pay its own way to the extent appropriate.

International Air Policy Priorities:

- Seek a more rational international route structure to enhance economic viability; maximize fuel efficiency and minimize adverse environmental impact; develop improved domestic-international route system integration and establish the relative roles of scheduled and charter service. (For example, we will assess the relative merits of an air policy for international service in which a few U.S. carriers provide most of our international service in comparison to a system in which U.S. international carriers would be encouraged to have domestic routes and present domestic trunk line carriers to acquire international routes with feeder service behind major gateways, or variants of the foregoing.);
- Promote a strong U.S. flag carrier system through an affirmative action program to represent U.S. foreign and commercial policy interests before international bodies and to protest vigorously anticompetitive and discriminatory practices by subsidized foreign carriers;
- Seek fare structures that permit efficient, unsubsidized U.S. air carriers to earn a reasonable return on investment in order to attract capital from the private sector and to provide job opportunities;
- Facilitate efforts by the U.S. airframe and engine manufacturing industry to maintain its leading role in international aviation.

These policies are more specifically reflected in the following:

Airports

The FAA will concentrate on increasing the capacity of existing airports in accordance with official FAA forecasts of activity. This will include ground passenger handling and the roles of multiple airports which serve a given metropolitan area. Proposals for major new airports will be considered on a case-by-case basis.

Because public ownership provides greater assurance that an airport will remain available for use, it is agency policy to encourage public acquisition of airports which are privately-owned but which are included in the national system of airports. It is also agency policy to promote joint civil/military use of airports whenever feasible. Except for the Federally-owned Metropolitan Washington airports (Washington National and Dulles), it is agency policy that initiation of airport development projects be the responsibility of the appropriate airport authority of the local community. Further, it is FAA's policy to afford maximum flexibility to state and local jurisdictions to determine airport needs and decide financial investments consistent with the need for development of the national airport system.

FAA has major responsibilities for promoting an adequate civil airport system through financial assistance to communities undertaking the planning and development of airports. To this end, FAA administers grant-in-aid programs. It is the policy of FAA to provide leadership at the national level in airport planning and development and to develop advisory information regarding airport location, land use, construction, ground access and other factors. It is FAA policy to develop and implement design standards and criteria for airport development projects consistent with the need for national standardization and for purposes of safety.

The agency will promote a continuous planning process at the state and local levels to insure airport planning is responsive to changing conditions and included as a part of local comprehensive planning.

The airport has a considerable environmental impact on the surrounding area it serves, and FAA takes an active role in reducing the side effects of environmental pollution caused by airport operation. Further, the FAA encourages the involvement of local citizens and their elected officials in airport development projects so that the projects respond positively to local environmental considerations.

FAA policies will be adjusted as required to conform with appropriate airport legislation as it is signed into law.

Regulatory

The Federal Aviation Act of 1958, as amended, provides for the regulation of air commerce in such a manner as to best promote its development and safety, without degrading the environment. Safety must be considered in all decisions regarding use of the navigable airspace, air traffic rules and installation of air navigation facilities. The problem of balancing safety requirements with the need for efficient use of the airspace and with economic impacts is one recognized by the agency. On these matters, it is FAA policy to achieve a level of safety which is a reasonable balance with the cost and efficiency of air commerce. The agency's regulatory functions are broken into five major areas: rule-making, certification, surveillance and inspection, compliance and enforcement, and accident investigation.

On rule making, it is agency policy:

1. To recognize the primary right of an individual to incur personal risk but to limit that right when it creates risk for others.
2. To regulate only to the extent necessary to protect the public interest.
3. To regulate in a manner which recognizes the need for efficient allocation of public resources and the need to minimize economic burden on users.
4. To afford all interested persons the opportunity to participate in rule making.
5. To actively implement necessary rules before actual incidents occur.

To ensure that pertinent rules, regulations and minimum standards are met, the agency has established a certification process. Certificates, approvals, and ratings for personnel, operators, agencies, products, parts, facilities, practices, methods, and procedures are issued by the agency to insure safe system operation.

According to FAA policy, all operations conducted under the terms of any certificate issued by FAA shall be conducted so as to continuously comply with the rules, regulations, and standards under which the certificate was issued. To insure that this is done, FAA maintains an inspection force which monitors system operation in order to insure that compliance is being accomplished; if operators, et al, fail to comply with rules, regulations and standards, the agency will impose civil penalties on the offenders.

While the primary responsibility for accident investigation rests with the National Transportation Safety Board (NTSB), FAA assists the Board through interagency agreement by making investigations of aircraft accidents and reporting conditions and circumstances to the Board. Neither the Administrator nor his representatives, however, shall participate in the NTSB determination of probable cause.

Airspace Control and Utilization

According to the Federal Aviation Act of 1958, FAA has the responsibility for management of the airspace in the United States. The legislative mandate includes responsibility for allocation and efficient utilization of airspace; developing, establishing, operating, and maintaining a common system of navigation; providing air navigation and air traffic control services; and establishing aircraft and airmen requirements for operation within the system. To permit the Administrator of the FAA to accomplish the purposes and objectives of Title III, Airspace Control and Utilization, and Title XII, Security Control of Air Traffic, of the FAA Act, Executive Order No. 10854 extended application of the Act to those areas of land or water outside the United States and the overlying airspace thereof over or in which the Federal government of the United States, under international treaty, agreement or other lawful arrangement, has appropriate jurisdiction or control.

FAA attempts to regulate airspace control only as it is needed to promote safe and efficient movement of aircraft. This in turn, should help to provide freedom of transit through the airspace with minimum restrictions. There are three basic constraints on the airspace available for civil use: safety, national security, and environmental considerations, therefore, the agency tries to keep the amount of unusable airspace to a minimum. In this respect, the agency will take all practical action it can to prevent erection of obstructions which constitute hazards to aircraft or which jeopardize Federal, State, or local investments in aviation facilities. FAA also works with the Department of Defense to keep national airspace restricted to military purposes to a minimum. Environmental considerations include noise abatement routing and airspace use restrictions.

Air traffic control is required principally to ensure the safe and efficient flow of traffic and it is the policy of FAA to utilize a ground based system of air traffic control to provide required services. In providing this service it is agency policy to provide the minimum degree of control required to accomplish that end; however, FAA must require certain airmen skills and specific aircraft equipment in portions of airspace where a high degree of control is required. In determining the degree of control necessary, FAA will consider the mix and sophistication of aircraft involved, the level of airspace usage, number of people served, and similar factors.

The provision of air navigation and air traffic control services will be based upon criteria which incorporate safety considerations and benefit/cost principles. In making such decisions, the agency will consider the needs and payoffs to both the active users and the public in general.

Environmental Factors

As a result of the growing concern about the environment, FAA makes every effort to reduce the adverse aviation side effects of noise and air pollution both in handling existing traffic and in planning for future growth; it is also agency policy to explicitly consider the environmental impact in all major decisions and to actively seek ways to afford environmental protection as the system is expanded or altered.

In order to alleviate noise problems caused by aircraft, FAA is working to develop quieter engines and appropriate flight procedures and to improve land use planning. In addition, the agency will promote the voluntary reduction in aviation-related noise supplemented by regulatory action whenever required.

Other pollution elements include engine emissions, smoke, spilled hydrocarbons, toxic material runoff at airports, and airport construction impact on natural water flow and drainage plus aesthetic degradation. Here also the FAA will take an active role both in regulation to reduce pollutants generated by the aviation community and in conforming with environmental requirements on agency projects.

Research, Engineering and Development

As stated in the amended Federal Aviation Act of 1958, the Secretary shall develop, modify, test, and evaluate systems, procedures, facilities and devices to meet the needs for safe and efficient navigation and control of all civil and military aviation (except air warfare).

A major aspect of the agency's operation is to carry out an aggressive research and development program to meet future aviation needs. However, research and development efforts will be focused on high payoff programs such as the current ATC system improvements. Future system concepts work will be done on a benefit/cost or cost effectiveness basis in close consultation with those who will benefit from and pay for improvements of the future. Implementation of R&D products is, however, dependent upon the evaluation of total system costs to users and government and, as in the case of the Microwave Landing System (MLS), reaching international agreement on standard systems.

Though the agency does have responsibility in aircraft and airframes development, it will limit its involvement and encourage and promote such development by the National Aeronautics and Space Administration and the private sector. Aircraft safety research and development is carried on by FAA in order to provide the basis for regulatory and advisory actions designed to promote increased air safety.

International Affairs

The FAA's international aviation policy is designed to enhance the national interest to maintain the United States world leadership in aviation. The FAA recognizes that the ability of the United States to maintain this leadership role will, in part, be determined by the agency's efforts to assure the safety of flight of our aircraft and citizens abroad, facilitate world-wide movement of United States aircraft and airmen, and promote the export of United States aeronautical equipment.

To insure that these efforts succeed, it is FAA policy to seek development and implementation of international safety standards for aviation which, to the maximum extent possible, are patterned upon and consistent with our domestic standards, and to cooperate in the development of international air traffic control and air navigation systems.

In order to promote the orderly and timely provision of the air navigation facilities and services required by international aviation, it is the policy of FAA to encourage the development of international principles governing cost allocation and recovery for these facilities and to support international programs of aviation statistical and data collection.

An increasing number of foreign countries are recovering all, or at least a major part, of their aviation system costs directly from the airlines. It is FAA's policy to review these charges to insure that they are not discriminatory or unreasonably excessive, and if they are to take their adjustment.

While the FAA's international aviation policy assigns primary importance to insuring air safety and promoting air commerce, the FAA also is aware that international aviation enhances the national security of the United States. Inasmuch as the agency is uniquely qualified to strengthen this role of international aviation, it is FAA policy to support those economic development or security assistance programs of other United States Government agencies and international organizations which require the provision of aviation technical advice and assistance.

Personnel

The FAA strongly supports affirmative action in the development, employment, and advancement of minorities and women. It is the policy of FAA to operate, maintain, and support the National Aviation System with the minimum number of employees consistent with safe and efficient operations and wherever possible to base the required work force on analytically derived staffing standards. Consistent with this, it is agency policy to delegate certain certification, examination, and inspection functions associated with the safety regulatory program to qualified private persons.

GENERAL AVIATION AND AIR CARRIER FORECASTS

CHAPTER 2.

General Aviation and Air Carrier Forecasts

200. INTRODUCTION.

Since its inception, the FAA has had as one of its primary responsibilities the determination of and planning for the short- and long-term future manpower, facility, and equipment requirements of the National Aviation System (NAS). Forecasts of aviation activity have been an important ingredient in this planning process. In the past, forecasts were based on judgment and extrapolation, but in 1975, in an attempt to minimize forecast errors, new sophisticated econometric models and methods were introduced. The following considerations also governed development of this years forecasts:

a. National Economic Trends and Aviation. The likely national economic situation in the early part of the 1975–1980 period will be difficult, but from the middle of the period onward there should be slow but steady improvement which is expected to produce more real discretionary income (i.e., consumers will have more money available for air travel). Oil is expected to remain in adequate, perhaps abundant, supply throughout the period, but prices are expected to remain high. In fact, due to energy conservation and/or user taxation, general aviation fuel costs may rise still more. Governmental resources available for aviation are expected to be constrained because of sizeable Federal budget deficits. Figure 2-1 contains a listing of key economic indicators. The source for these is the Fiscal Year 1976 Presidential Budget Message and FAA's Aviation Forecasts, Fiscal Years 1976–1987.

b. Major Influences on Aviation System Demand.

Air Carrier. Only the general economic situation is expected to constrain demand for long-haul air travel. The growing population in the 25–55 age group, the growing white collar workforce and internal migration are expected to reinforce demand for long-haul travel. Air carriers, however, could face stiff competition from improving rail service for the estimated 45 percent of intercity passengers whose trip lengths are less than 500 miles. The stiffer rail competition could be somewhat offset by softened competition from private automobile travel resulting from mandatory lower speed limits,

Figure 2-1. Trends in Economic, Resource and NAS Indicators

INDICATOR	LIKELY TRENDS UNTIL 1980
#1 Gross National Product (billion $1958)	Fall from $821 in 1974 to $794 in 1975, then rising to $1,061 in 1980.
#2 Inflation Rate (Consumer Price Index)	Rise from 10.2% in 1974 to 10.8% in 1975, then falling to 4.0% in 1980.
#3 Real Disposable Income	Likely to rise through 1980 due to income tax cuts and slackening inflation.
#4 Unemployment Rate	Probably down from 2nd quarter 1975 peak of 9.2% to 5.5% by 1980.
#5 Energy Cost and Supply	Probably continued high prices. Physical shortages unlikely but possible.
#6 Federal Budget Margin	Annual deficits not less than $20 billion until FY 1978. $400 million surplus in FY 1979. $25.0 billion surplus in FY 1980.
#7 State/Local Government Surplus/Deficit in National Income Accounts	$1.4 billion surplus in 1975. $.2 billion in 1976. Improving to $6.7 billion in 1980.
#8 Degree of Federal Economic Control	Decreasing probability of wage/price controls likely throughout. Some economic de-regulation of air carriers likely.

#9 *Aircraft Operations (at airports with FAA towers)	Increase 46% from 56.8 million in FY 1974 to 83.2 million in FY 1980.
#10 *U.S. Civil Aircraft Fleet Size	Increase 23% from 156,000 in FY 1974 to 191,907 by FY 1980; of the 2,193 air carrier and 107,000 GA aircraft produced during this period 60% and 27%, respectively, will be exported.
#11 *Passenger Enplanements	Increase 31% from 208.1 million in FY 1974 to 273.6 million in FY 1980.
#12 Revenue Passenger Miles	Increase 34% from 165 billion in FY 1974 to 220.4 billion by FY 1980.
#13 Aircraft Noise	By the mid-1980's total aircraft fleet noise could be reduced below today's levels by 70–90%.
#14 Safety	Aviation should continue to be the safest intercity passenger mode.
#15 Airport Capacity	Installation of UG3RD and complementary airport capital improvements will increase airport airside capacity an average of 52% for IFR operations and 28% for VFR operations by mid-1980's.
#16 Aircraft Delays	Even with UG3RD ATC improvements, 1980 terminal airspace and airport delays will probably not be better than the 1974 level of 3–4.2 minutes per operation, which cost (DOC) the air carriers approximately $382 to $527 million. Delay costs in 1980 could approach $1,000 million.

*Based on Aviation Forecasts Fiscal Years 1976–1987, September 1975.

higher gasoline prices, and the trend toward less comfortable smaller cars.

General Aviation. An increase in the fuel tax would somewhat reduce general aviation flying hours and operations from current forecasts. If enacted, energy conservation taxes on fuel would hae an additional restraining effect.

Military. The planned reduction in defense strength is expected to cause little or no growth, perhaps even a decline, in military system demand.

c. Current and Future NAS. Although the effects of increased fuel costs are being felt by the National Aviation System, growth in domestic operations is forecast to increase 46 percent over the next six years to a level of 83 million operations per year by 1980. General aviation is expected to account for 89 percent of this growth and military operations are anticipated to remain at approximately 1 million. These projections correspond to a 21 percent increase in the U.S. aircraft fleet.

Passenger air travel is also expected to continue to grow but at a slower rate than in the past decade because of economic conditions. The increase in passenger enplanements will reach 274 million per year by FY 1980, a 31 percent increase over 1974. Revenue passenger miles are forecast to increase 34 percent to a level of 220 billion during this same period.

Resolution of problems relating to system capacity, environment, energy and economic viability will largely determine the extent of increase in the growth of aviation activity in the next five years. For example, congestion-related delays in FY 1974 at most high activity terminal airspace and airports average between 3 and 4.2 minutes per operation. These delays have increased annual direct operating costs for air carriers by more than $382 million and could approach $1,000 million by 1980 if adequate capacity improvements are not made.

201. THE MODELS. The fundamental assumptions underlying the new econometric models are that various measures of aviation activity are related to the level of economic activity and that the various activity measures are dependent on one another in a specific way.

a. General Aviation Model. The data base for the G.A. model includes annual data for the years 1960 through 1974. The driving economic forces of the model are real per capita personal disposable income, civilian employment, capital investment in the aircraft industry, and factory sales of automobiles. Tests of the model show that increases in any but the last of

Figure 2-1 (Continued)

IMPLICATIONS

Greater resources available to governments, firms, and individuals for aviation purposes.

Slower rates of increase in costs of all inputs to aviation (except fuel) and, therefore, in costs of aviation services to consumers.

Consumers should have more resources available to purchase aviation services.

High rates in early periods probably will not cause significant reduction in population of air travellers. Should minimize labor relations problems of air carriers.

Continued high air carrier fares. Increased cost of operating general aviation aircraft. Reduction in expected rate of growth in GA activity.

Increasingly strict criteria for FAA budget justification.

More opportunity for active state and local government role in aviation.

Decreasing expectation of price controls should cause softening of prices of inputs to aviation. De-regulation of air carriers could mean either more or less air carrier activity.

Either we improve ATC and airport capacity or we constrain or shift the growing demand at congested airports.

In addition to what is stated above regarding airport congestion, the projected increase in aircraft exports will enhance the Nation's balance of payments position.

Projected increase will, at many airports, overburden already strained airport landside capacity. However, the growth rate may be affected by planned improvements in short-haul rail service.

If the growth in operating costs does not out-pace this projected increase in RPM's the picture for the airline industry is good over the next 5 years.

Current and proposed FAA noise regulations should bring about this change if economic considerations do not cause an extension of the planned implementation schedule. Such a diminution in fleet noise will greatly facilitate the community acceptance of airport operations and developments.

If safety related E&D, procedural and regulatory activities can improve NAS safety as anticipated, much of the current criticism of FAA, which includes rising costs, can be abated.

In addition to the implications discussed under aircraft delays, below, we must recognize that even if airside capacity were improved sufficiently to meet future demand, landside capacity may still constrain activity at many major metropolitan airports.

The cost of these delays will significantly decrease the economic viability of many airlines. The UG3RD alone may not provide the capacity increases required in the 1980's. Airport construction will also be required. Other actions, such as schedule redistribution should be investigated.

these variables can be expected to increase fleet size and activity levels. For example, as discretionary income increases, it is likely that the number of active G.A. aircraft and activity levels will increase.

An increase in the sales of automobiles, a principal substitute for air travel, is likely to accompany a decrease in the number of aircraft and operations. Although all the predictors are statistically significant, fleet size appears to be more sensitive to change in civilian employment than to any other independent variable in the equation.

b. Air Carrier Model. The data base for the A.C. model includes quarterly data from 1964 through 1973. The driving economic forces behind the A.C. model are total consumption of services, the number of civilians employed, investment expenditure in the aircraft industry, the price of air travel relative to that of other modes of transportation, and purchases of automobiles. Tests of the model show that an increase in automobile purchases or air fares can be expected to result in a decrease in domestic revenue passenger miles and revenue passenger enplanements, whereas increasing the portion of the population that uses air carrier services, improving the level of service, or increasing the consumption of services can be expected to increase revenue passenger miles and enplanements. Revenue passenger miles is most sensitive to changes in the consumption of services.

202. ASSUMPTIONS. The assumptions and the forecast economic variables for both models are those used by the Council of Economic Advisors. The forecasts assume that the economy bottomed out in mid- to late-1975, and then began a gradual recovery. Real personal disposable income was expected to increase as a result of the personal income tax cut and other expansive fiscal policies. Investment spending was expected to increase because of congressional approval of the increase in the investment tax credit from seven to 10 percent. Total industrial production is expected to resume positive full year growth during 1976. The impact of increases in real income will not be felt in the air carrier industry, however, because of the increased consumption of consumer durables. Since people will begin to make durable purchases, which have been postponed during the recession, consumption of air carrier services will remain low through 1980.

a. Stable Employment. As income grows, the employed population will remain fairly stable throughout the forecast period. Two offsetting effects will contribute to this: early retirement will decrease the employed population, the return of the unemployed to the labor force will increase it.

b. Automobile Costs. Continuing restraints on fuel consumption will increase the cost of private automobile transportation. Assuming the airlines maintain a policy of holding down fares to encourage demand, the price of air transportation will fall relative to the cost of alternative modes. Consistent with the increases in real income and the consumption of consumer durables, purchases of automobiles will rise until the late 1970's. Then, as gasoline costs continue to rise and as the prices of new automobiles increase, automobile purchases will begin falling off.

	1975	1986	Average Annual Growth Rate
Air Fare Index (10 = 1967)	14.8	17.0	1.5%
Cost of Auto Travel Index (10 = 1967)	15.2	21.3	3.0%
Per Capita Income (1958 $)	2800	3800	3.0%
Auto Purchases (Thousands)	6800	9200	2.5%
Investment in Air Transportation ($ Billion)	1.5	4.1	9.5%
RPM's (Billions)	128	263	6.7%

Figure 2-2. The Economy and Revenue Passenger Miles

	1975	1986	Average Annual Growth Rate
Number of Employed Persons (Millions)	84	104	2.0%
Auto Purchases (Thousands)	6800	9200	2.5%
Investment in Aircraft Production ($Billions)	0.8	3.7	15.0%
Active GA Aircraft (Thousands)	162	245	4.0%

Figure 2-3. The Economy and the Active General Aviation Fleet

c. Illustration of Models. The average annual growth rates and the values of selected dependent and independent variables used in the forecasting models are indicated for the 1975–1986 period in Figure 2–2 and 2–3.

203. EFFECTS OF CHANGES IN VARIABLES. Figure 2–4 shows how changes in the economic variables used in the models will affect aircraft operations and manpower positions required at FAA towers and centers. These translations are based on current manpower formulas and do not take into account any future improvements in productivity. For example, an increase in the employed population (CMP) of one million suggests an increase in tower operations of 850,000 and a requirement for 17 additional terminal positions. This increase may also be expected to cause instrument operations to increase by 2,720,000, requiring 544 new tower personnel.

204. OTHER FORECASTS. Forecasts of various important elements of NAS activity are shown in Figure 2–5 through 2–12.

	Economic Variables					
	SUB (100K)	PPDPI ($10)	CMP (M)	PAC (B$)	SRVC (B$)	PAT (B$)
IFR Aircraft Handled (100K)	-1.8		3.2	2.5	3.2	5.6
Center Positions (Controllers)	-72.0		128.0	100.0	128.0	224.0
Aircraft Tower Operation (100K)	-1.2	1.5	8.5	88.4	3.2	5.6
Terminal Positions (Controllers)	-2.4	3.0	17.0	176.8	6.4	11.2
Instrument Operations (100K)	-1.6		27.2		3.2	5.6
Terminal Positions (Controllers)	-32.0		544.0		64.0	112.0

SUB represents factory sales of automobiles in hundreds of thousands of automobiles.
PPDPI represents real personal disposable income in tens if 1958 dollars.
CMP represents number of civilians employed in millions.
PAC represents investment in the aircraft industry in billions of current dollars.
SRVC represents real income spent in services in billions of 1958 dollars.
PAT represents investment in air transportation in billions of current dollars.

Figure 2–4. Effect of Changes in Economic Assumption on Operations and Center Positions

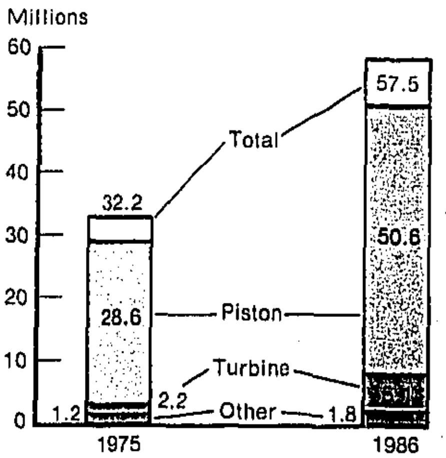


Figure 2–5. General Aviation Hours Flown by Aircraft Type

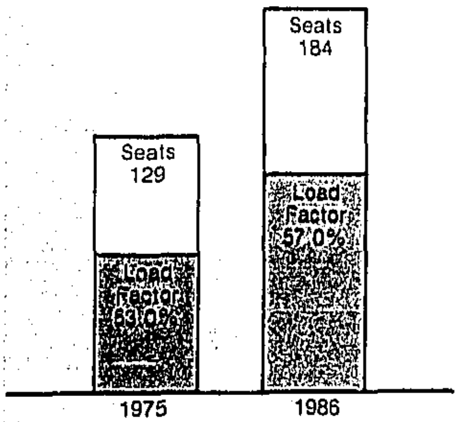


Figure 2-6. Air Carrier Load Factor and Average Seats Assumptions

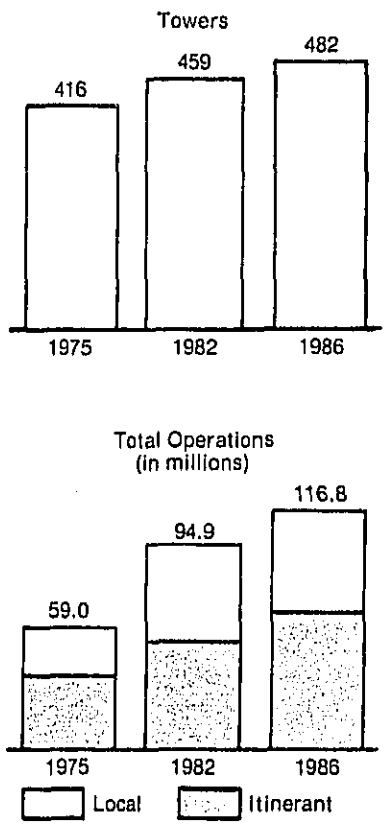


Figure 2-7. FAA Towers and Total Operations

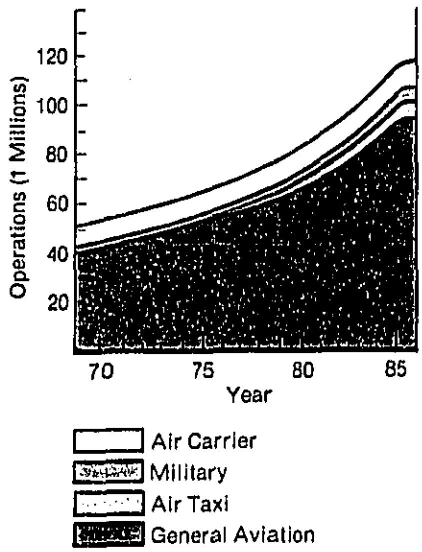


Figure 2-8. Aircraft Operations

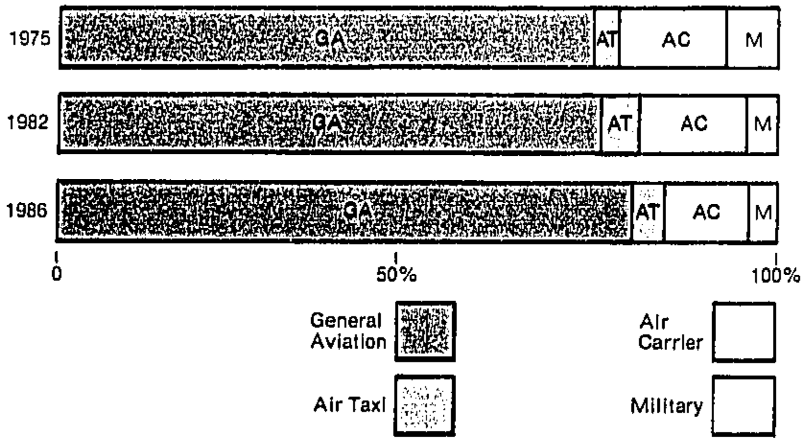


Figure 2-9. Percentage Contribution to Total Operations by User Category

	1975 (Millions)	1982 (Millions)	1986 (Millions)
IFR Departures	9.3	13.0	15.2
IFR Overs	5.1	6.3	7.5
Aircraft Handled	23.6	32.3	37.9

Figure 2-11. Total Activity at FAA Centers

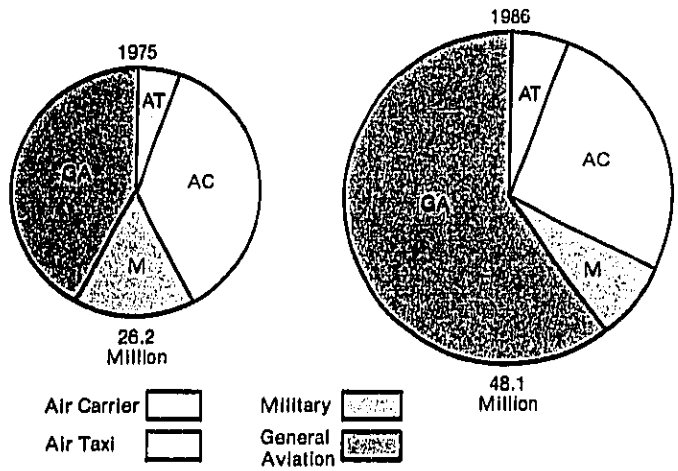


Figure 2-10. Instrument Operations by User Category

	1975 (Millions)	1986 (Millions)
Total Flight Services	58.3	132.9
Pilot Briefs	16.2	39.7
Flight Plans Filed	8.0	15.6
Aircraft Contacted	10.0	22.3

Figure 2-12. Total Flight Services

Chapter 3

NAS PROGRAMS AND PLANS

CHAPTER 3.

NAS Programs and Plans

SECTION 1. PLANNING OVERVIEW

300. PLANNING FOR SYSTEM IMPROVEMENT. Basic fundamentals underlying the development of system improvements are the identification of needs (including system imposed constraints), the identification of alternative solutions, the evaluation of alternatives (including environmental/energy considerations), and the implementation of the most effective solution. Efficient system development can be greatly assisted by a plan which lays out appropriate time-phased and coordinated activities. The following paragraphs describe activities that can be used to accomplish these fundamentals.

a. Requirements/Needs Definition. In the National Aviation System, the basic factor in determining future requirements is aviation demand. This, combined with desired operational capabilities, helps establish regulatory and operational parameters. Technical analysis is required to establish the technical and quantitative dimensions for proposed system elements, e.g., landing systems. Having determined the technical capability required to meet the operational needs, it is necessary to determine the ability of the existing system elements to meet those requirements at a given time. Any differences in existing system capabilities and operational parameters, either current or forecast, become a requirement or need.

b. Alternative Analysis. Having identified requirements or needs, it is necessary to seek a cost-effective solution. This is accomplished by identifying, analyzing, and if necessary, performing development work on possible solutions. For example, these might include improving existing systems (such as improved ILS equipment), replacement of existing systems with new systems utilizing current concepts and new technology (such as a solid state ILS) or utilizing new systems based on new technology (such as MLS). Alternative analysis should include factors such as technical and operating capability and characteristics and benefit/cost of the proposed solutions. Comprehensive alternative analyses must not only deal with capital investment approaches, such as hardware/software investments, but must also consider options such as regulatory or procedural approaches.

c. Implementation. Once a particular system alternative has been adopted, criteria must be developed (utilizing measures of activity and need) to serve as a basis for formulating a proposed system implementation program. Locations meeting investment criteria become candidates for system installation, i.e., an implementation requirement. Funding of implementation requirements must necessarily be governed by availability of total agency resources and funding as well as priorities. Progress on specific implementation programs is, therefore, subject to the year-to-year budget variations and priority needs in other capital investment areas.

d. Transition Planning. Accomplishment of system improvement requires considerable effort by many organizations and individuals, both inside and outside government. To be effective, responsibilities of all parties must be identified and overall schedules developed in concert. For effective implementation, a major planning effort is required to transition from the existing system to a new system structure. Such planning must include justification for undertaking major implementation investments and should also establish a basic framework to guide initial implementation activities of both FAA and users of new system elements.

e. Joint Participation in Planning. The National Airspace System is composed of several parties including pilots; aircraft owners; general aviation, business and air carrier operators; aircraft and avionics manufacturers, airport owners; and other industrial and government organizations. While responsibility for regulation and operation of the National Airspace System rests with FAA, success in accomplishing safety improvements, more effective airspace utilization, and other major objectives must be a cooperative process.

(1) Just as use of the National Airspace System is a cooperative activity between controllers and pilots, planning for, and accomplishment of, system improvements must be a cooperative process since so many FAA decisions directly impact system users and the public. These impacts range from techniques and procedures for operating in the system to a requirement for substantial financial investment by users for various types of avionics. For these reasons, it is imperative that there be user participation early in the process of planning for system improvements.

(2) While input has been obtained through listening sessions, consultative planning conferences, the aviation review conferences, various technical and advisory committees and review of the National Aviation System planning documents, a new technique first utilized during 1975, was the active participation by users in the development of transition plans. Transition plans document the agency's developmental and analytical work regarding major system improvements and provide guides for initial implementation of, and the transition to, new system elements. The purpose of the plan is to optimize, insofar as practical for both FAA and the user, the accomplishment of desired system changes. Coming to grips with a multi-billion dollar capital investment program over the next decade will require intensive cooperative effort on the part of users and the agency to ensure such expenditures are planned well and wisely made.

301. PLANNING ASSUMPTIONS. The following assumptions were utilized in the planning process leading to preparation of this plan:

—Air traffic and demand forecasts, prepared as described in Chapter 2, will be fulfilled. There will not be a revolutionary change in defense requirements or common ground system needs.

—Annual funding levels for system improvements during the plan period are expected to be $250 million for F&E, an average of about $80 million for R&D, and $350 million for ADAP. Cost allocation, trust fund tax, and user charge issues will not significantly change the funding available to FAA.

—The dollar's buying power will not erode excessively. System improvement funding levels indicated are in 1975 dollars. (If large inflation rates are experienced, increased funding levels will be required to provide equivalent system improvements.)

—NAS improvements will not be unduly constrained by environmental factors; solutions will be found for environmental problems that arise.

—Development and analytic work accomplished during the plan period will confirm the need for, and satisfactory worth of, improvements to the Third Generation air traffic control and navigation systems, and will provide an increasingly better definition of when improvements will be required.

302. RESOURCES AVAILABLE TO FAA. Significant resources will be available to the FAA for accomplishing its mission. In FY 76, these will include 57,000 employees, a budget of $2.2 billion, 160,000 acres of owned and leased land, $1.1 billion in real and personal property, and $340 million in operating and project materiel. Personnel, financial resource, and facility plans are summarized in the following paragraphs.

a. *Manpower.* Figure 3-1 indicates the manpower requirements forecast through 1986. The largest requirements are those for Air Traffic and Airways Facilities operation of the air traffic, flight service, and air navigation systems, and Flight Standards safety activities. Other major manpower usages are:

—System improvement activities in Research, Engineering and Development, Facilities and Equipment, and Operations—Development Direction.

—System material and leased service support in Operations—Installation and Materiel.

—FAA management, administrative, and training activities in Operations—Direction, Staff and Supporting Services and Centralized Training.

b. Fiscal Resources. Estimated fiscal resources available during the plan period are indicated in Figure 3-2. Facilities and Equipment funding is indicated by major facility type in Figure 3-3. FAA activities are financed from the Aviation Trust Fund and the General Fund. The Trust Fund provides for the expansion and improvement of the Nation's airport and airway system. All revenues from aviation user taxes are appropriated to the Trust Fund. Appropriations from the General Fund and the Trust Fund may be used to finance costs of operating and maintaining the airway system. Trust Fund revenue history is indicated in Figure 3-4. Projected Trust Fund revenue during the Fiscal Years 1977–1980 is indicated in Figure 3-5.

c. Funding Resources Related to Critical Functions. Planned funding has been distributed to the agency mission areas of Meeting Safety Requirements, Meeting Capacity Requirements, Increasing FAA Productivity, and Environmental Protection and Energy Conservation. Funds supporting these critical functions and activities are summarized in Figure 3-8. Programs have been distributed to the subject areas upon the basis of analysis, when available, or judgment. The subject areas are interrelated; for example, an item contributing to capacity may also increase safety. The distribution of programs within the subject areas requires more substantive analysis in the future and could form the basis for extended discussion among FAA, the aviation community, and the public.

Figure 3-1. Manpower Requirements

POSITIONS	PLAN 1977	1978	1979	1980	1981	1986
A. OPERATIONS						
1. Air Traffic (1)	29,083	31,900	33,300	34,200	35,200	37,800
2. Airways Facilities	12,766	13,225	13,430	13,650	13,900	15,090
3. Installation and Material	1,440	1,500	1,545	1,590	1,625	1,875
4. Flight Standards	4,675	5,100	5,230	5,375	5,500	6,145
5. Medical	288	320	325	330	335	350
6. Development Direction	197	200	200	200	200	200
7. Airport (2)	629	629	629	629	629	629
8. Centralized Training	990	1,075	1,100	1,125	1,150	1,250
9. Direction Staff and Support	3,587	4,100	4,160	4,225	4,285	4,550
Operations Total	**53,916**	**58,049**	**59,919**	**61,324**	**62,824**	**67,889**
B. FACILITIES, ENGINEERING AND DEVELOPMENT	187	193	193	193	193	193
C. NATIONAL CAPITAL AIRPORTS	844	867	871	875	880	900
D. AVIATION WAR RISK	2	2	2	2	2	2
E. FACILITIES AND EQUIPMENT	1,492	1,500	1,520	1,540	1,560	1,650
F. RESEARCH, ENGINEERING AND DEVELOPMENT	945	945	945	945	945	945
Total Positions	**57,386**	**61,556**	**63,450**	**64,879**	**66,404**	**71,579**

(1) Projected levels based on existing engineered staffing standards. Appropriate adjustments will be made when new ARTCC standards are available.

(2) Work load and associated staffing needs may change, depending upon the new Airport and Airway Development legislation content.

Figure 3–2. Estimated Resource Availability Summary
(In millions of dollars)

	PLAN						
APPROPRIATION	**1977**	**1978**	**1979**	**1980**	**1981**	**1982–86**	**1977–86**
TRUST FUNDS:							
Research, Engineering, and Development (1)	76.7	75.0	75.0	75.0	75.0	430.5	807.2
Facilities and Equipment	226.6	250.0	250.0	250.0	250.0	1,250.0	2,476.6
Grants-in-aid for Airports	350.0	350.0	350.0	350.0	350.0	1,750.0	3,500.0
GENERAL FUND:							
Operations	1,677.5	1,855.8	1,936.7	2,010.5	2,086.9	10,650.0	20,417.4
Facilities, Engineering, and Development	14.6	18.3	18.3	17.5	16.8	84.2	169.7
Operation and Maintenance, National Capital Airports	20.7	21.1	21.5	21.5	21.7	110.0	216.5
Construction, National Capital Airports (2)	8.1	6.3	22.4	25.0	22.0	90.0	173.8
Total	**2,374.2**	**2,576.5**	**2,673.9**	**2,749.5**	**2,822.4**	**14,564.7**	**27,761.2**

(1) Current planning estimates for the Aerosat program are as follows:

Fiscal Year	78	79	80	81	82–86	78–86
Dollars in Millions	25.4	26.6	22.2	25.2	39.7	141.1

These amounts are not projected in the activity totals at this time as the precise requirements for the Aerosat program are subject to certain lease and contract negotiations. However, such amounts as are required to meet commitments relating to the program will be sought as part of FAA's E&D funding requirements in the regular budget process.

(2) Dollar figures past FY-78 reflect proposed projects for construction at Washington Dulles and National Airports. These are subject to revision pending development and approval of master plans for both airports.

Figure 3–3. Facilities and Equipment Program Funding Summary *

Program	PLAN (Amount in millions of dollars) 1977 Amount	1978 Amount	1979 Amount	1980 Amount	1981 Amount	1982–86	Total 1977–86 Amount
EN ROUTE CONTROL FACILITIES							
Radar	12.3	21.0	8.5	15.0	15.0	100.0	172.8
Automation	12.7	18.0	8.0	6.0	6.0	75.0	122.7
Center Facilities	22.2	16.0	17.0	16.0	15.0	70.0	158.2
Total	47.2	55.0	33.5	37.0	36.0	245.0	453.7
TERMINAL CONTROL FACILITIES							
Radar	23.5	16.0	15.0	20.0	28.0	154.0	256.5
Automation	0.6	16.0	23.0	24.0	2.0	16.0	81.6
Control Tower Facilities	25.2	44.0	36.0	46.0	37.0	232.0	404.2
Total	49.3	76.0	74.0	90.0	67.0	402.0	742.3
FLIGHT SERVICE FACILITIES							
Automation	27.9	22.0	20.7	41.2	43.5	93.0	248.3
Communications	12.2	10.0	9.5	6.0	6.0	18.0	61.7
Weather	3.2	6.0	11.5	8.5	7.5	25.0	61.7
Station Facilities	4.9	4.5	3.5	3.8	3.7	25.0	45.4
Total	48.2	42.5	45.2	59.5	60.7	161.0	417.1
NAVAIDS							
VOR/TVOR/VORTAC/VOR–DME	12.3	14.5	26.5	15.0	22.5	100.0	190.8
L/MF	2.2	1.5	—	1.0	—	—	4.7
Total	14.5	16.0	26.5	16.0	22.5	100.0	195.5
LANDING AIDS							
ILS/MLS	23.9	12.0	27.8	37.2	25.2	155.0	281.1
Visual	11.9	16.0	15.6	7.7	15.4	39.0	105.6
VAS/WVAS	—	6.0	5.0	2.0	3.5	18.0	34.5
Total	35.8	34.0	48.4	46.9	44.1	212.0	421.2
SYSTEM SUPPORT							
Housing, Utilities & Misc	27.9	12.5	10.0	10.0	12.0	70.0	142.4
Aircraft	0.7	9.0	7.4	1.6	2.7	35.0	56.4
Development, Test & Evaluation	3.0	5.0	5.0	5.0	5.0	25.0	48.0
Total	31.6	26.5	22.4	16.6	19.7	130.0	246.8
Total F&E Funding	**222.6**	**250.0**	**250.0**	**250.0**	**250.0**	**1,250.0**	**2,476.6**

* For planning purposes some new/improved facilities are included for which implementation decisions have not been made.

Figure 3–4. Trust Fund Revenue History
($ in thousands)

	1971	1972	1973	1974	1975*
Unexpended Balance of Fund Start of Year	$—	896,509	1,058,346	1,187,098	1,534,181
CASH INCOME	$1,183,999	1,550,989	827,958	868,217	1,045,000
Excise Taxes	(562,823)	(648,652)	(758,159)	(840,110)	(951,000)
Interest on Investments	—	—	—	(28,107)	(94,000)
General Fund	—	(646,882)	(73,397)	—	—
Transfer of G.F. Balances	(621,176)	(255,455)	(−3,598)	—	—
CASH OUTGO	$ 287,489	1,389,152	699,206	521,134	676,139
Federal Aviation Admin.	(287,331)	(1,388,466)	(698,105)	(521,075)	(676,139)
Aviation Advisory Comm.	(158)	(686)	(1,075)	(20)	—
Interest on Refund of Taxes	—	—	(26)	(39)	—
Unexpended Balance of Fund End of Year	$ 896,509	1,058,346	1,187,098	1,534,181	1,903,042
COMMITMENT	$ 728,470	1,237,939	1,200,784	1,250,545	1,169,584
Appropriated/Not Expended	(508,470)	(829,939)	(612,784)	(602,545)	(491,584)
Contract Obligations	(110,000)	(298,000)	(404,601)	(454,333)	(484,333)
Public Law 92–174	(110,000)	(110,000)	(183,399)	(193,667)	(193,667)
Uncommitted Balance End of Year	$ 168,039	$−179,593	$ −13,686	$ 283,636	$ 733,458

*Estimate.

Figure 3–5. Projected Trust Fund Activity: FY 1977–1980 *

Fiscal Year	1977	1978	1979	1980
Beginning Uncommitted Balance	$1,188	$1,275	$1,434	$1,671
Trust Fund Revenues	1,054	1,121	1,154	1,217
Subtotal	2,242	2,396	2,588	2,888
Less: Development Expenditures	350	350	350	350
F&E Expenditures	250	250	250	250
O&M Expenditures	476	470	489	509
Other Expenditures	77	100	98	94
Subtotal	1,153	1,170	1,187	1,203
Difference	1,089	1,226	1,401	1,685
Interest on previous years balance	186	208	220	236
Ending Uncommitted Balance	1,275	1,434	1,621	1,921

* Based on Administration Proposal: 7 percent airline ticket tax; 5 percent freight waybill; 15 cents/gallon fuel tax for FY 76–78; 10 cents for FY 79–80; $5 international enplanement fee.

Figure 3–6. Planned Funding Distribution *
(In millions of dollars)

	1977	1978	1979	1980	1981	1982–86	1977–86
By Subject							
SAFETY							
R, E&D	17.7	15.6	14.4	12.7	11.5	50.7	122.6
F&E	80.4	85.9	74.5	73.6	84.2	364.5	763.1
ADAP	169.0	169.0	169.0	169.0	169.0	845.0	1,690.0
Operations	1,315.1	1,447.7	1,511.9	1,570.9	1,631.7	8,491.4	15,968.7
F, E&D	6.4	9.9	9.9	9.1	8.4	42.2	85.9
TOTAL	1,588.6	1,728.1	1,779.7	1,835.3	1,904.8	9,793.8	18,630.3
CAPACITY							
R, E&D	20.6	13.0	16.1	16.3	14.5	69.0	149.5
F&E	33.9	40.6	45.1	56.8	52.1	350.6	579.1
ADAP	143.0	143.0	143.0	143.0	143.0	715.0	1,430.0
Operations	223.9	246.7	258.5	269.5	280.3	1,460.5	2,739.4
TOTAL	421.4	443.3	462.7	485.6	489.9	2,595.1	4,898.0
PRODUCTIVITY							
R, E&D	38.4	46.4	44.5	46.0	49.0	310.8	535.1
F&E	112.3	123.5	130.4	119.6	113.7	534.9	1,134.4
Operations	129.3	150.3	154.5	158.1	162.2	833.5	1,587.9
TOTAL	280.0	320.2	329.4	323.7	324.9	1,679.2	3,257.4
ENVIRONMENTAL ENERGY							
ADAP	38.0	38.0	38.0	38.0	38.0	190.0	380.0
Operations	9.2	10.4	11.0	11.4	11.8	60.4	114.2
F, E&D	7.0	8.4	8.4	8.4	8.4	42.0	82.6
TOTAL	54.2	56.8	57.4	57.8	58.2	292.4	576.8
By Appropriation							
R, E&D	76.7	75.0	75.0	75.0	75.0	430.5	807.2
F&E	226.6	250.0	250.0	250.0	250.0	1,250.0	2,476.6
ADAP	350.0	350.0	350.0	350.0	350.0	1,750.0	3,500.0
Operations	1,677.5	1,855.1	1,935.9	2,009.9	2,086.0	10,845.8	20,410.2
F, E&D	13.4	18.3	18.3	17.5	16.8	84.2	168.5
Total Appropriations	**2,344.2**	**2,548.4**	**2,629.2**	**2,702.4**	**2,777.8**	**14,360.5**	**27,362.5**

* For planning purposes some new/improved facilities are included for which implementation decisions have not been made.

SECTION 2. MEETING SAFETY REQUIREMENTS

303. AVIATION SAFETY IN PERSPECTIVE. The Federal Aviation Act of 1958 and the Department of Transportation Act of 1966 charge the FAA with responsibility for the regulation of air commerce to promote its development and safety. How well these obligations have been discharged is indicated by the fact that the U.S. safety record in aviation serves as a benchmark for the world. For example:

—United States standards for aircraft, airmen, traffic control, and maintenance inspection are accepted worldwide and have served as the foundation for many international standards.

—United States airlines have achieved international leadership and have demonstrated levels of safety performance that are still only future goals for the rest of the world.

—The U.S. system for civil aviation security has been recognized by the world for its significant contribution to the safety of the air traveler.

—U.S. air carrier hijackings have been virtually eliminated in the past three years. During this same period, 17 foreign aircraft were hijacked.

—Aircraft developed and manufactured by U.S. companies have dominated the airways of the world for decades and continue to set the pace for standards of safety, reliability, and economical performance.

—The system of air traffic control created and operated by the FAA is the international standard for safe and efficient control of aviation traffic.

304. INTERMODAL SAFETY COMPARISON. Despite a steady increase in activity, the record for aviation safety continues to compare favorably with other modes of travel. Safety programs and facilities are designed to make this record even better. As shown in Figure 3-7, aviation activities of all types contributed only a small fraction of the total transportation fatalities in 1975. It is interesting to note, in light of the close attention paid to air carrier fatalities by the press and general public, that in the last 10 years, there has been no year in which air carrier fatalities were even half the 1,035 lives lost in bicycle mishaps in 1975.

305. FUTURE TRENDS. Current projections are that aviation activity will continue to rise over the next decade. For example, the number of passengers carried by scheduled U.S. air carriers is expected to increase from the 201.9 million carried in 1975 to 360.8 million in 1986. General aviation activity is projected to show an even more vigorous growth, with general aviation intercity carriage growing from 85 million in 1975 to 141.0 million by 1986. This continued

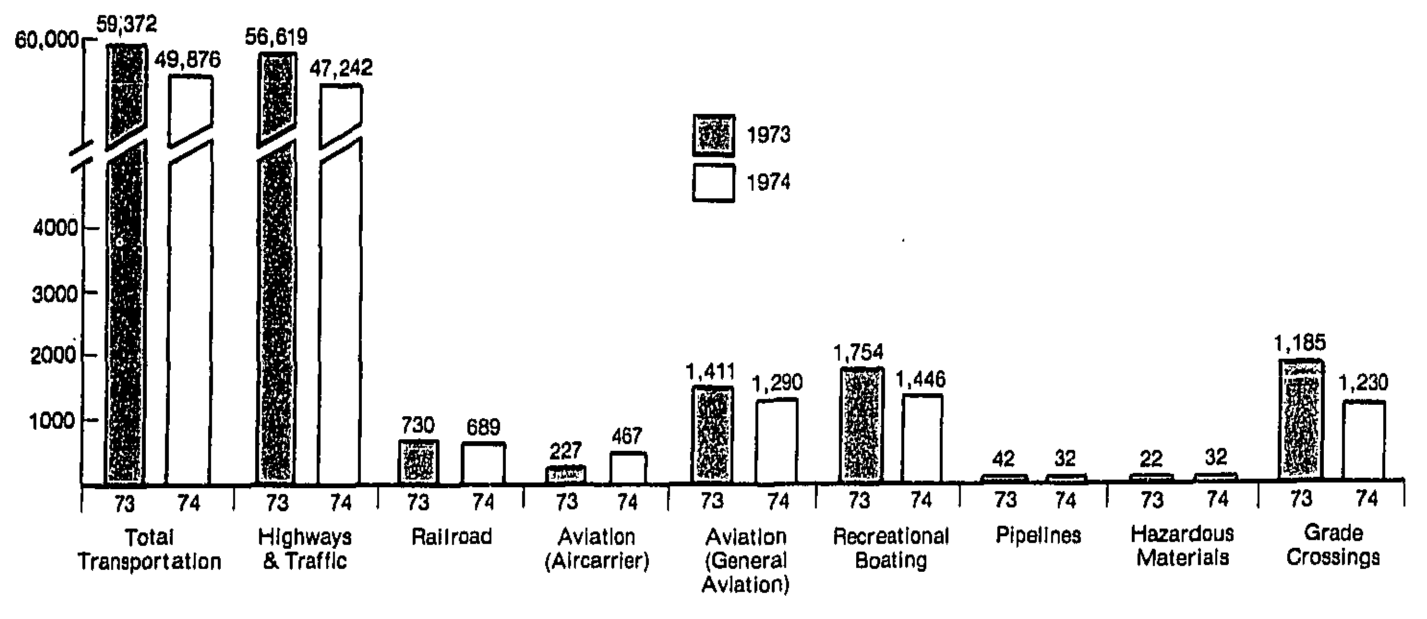


Figure 3-7. Total Transportation Fatalities, 1973–74

rise in activity will impact on a number of FAA's safety programs.

a. **Airmen.** The latest statistics indicate that there are now 750,000 pilots, with 1,568 certificated pilot schools graduating an ever increasing number of new pilots. If the rate of increase over the past decade continues, there will be in excess of 1,000,000 pilots to be certificated by the FAA in 1986, and the number of schools will very likely have a proportionate rise in number.

b. **Mechanics.** Aviation now employs 300,000 mechanics and has 2,983 certificated repair stations to maintain and operate the U.S. fleet of over 156,000 aircraft. To train these skilled specialists, there are now 139 certificated aviation mechanic schools. All of these personnel, students, instructors, and mechanics, must be certified by the FAA on a continuing basis. It is projected that the numbers of individuals comprising this aviation community will increase by 75 percent over the next decade.

c. **Aircraft.** The FAA mission includes responsibility for the certification of aircraft airworthiness and safety from initial design through flight. The magnitude of this task is apparent when one realizes that 90 percent of the world's aviation fleet is U.S. manufactured. Present projections are that the world aviation fleet will increase by 70 percent over the next decade. The domestic air carrier fleet will increase from 2,600 to 3,400; and the general aviation fleet will increase from 160,000 to 245,000.

d. **System Operations.** The effect of these growth trends on the air traffic control system will be substantial. Operations at airport control towers will increase from 54.0 million in 1975 to 116.8 million in 1986. The traffic count at air route traffic control centers will increase from 23.6 million in 1975 to 37.5 million in 1986. At flight service stations, the number of operations will more than double by 1986. Overall projections of NAS activity indicate that the FAA must be prepared to provide safe control of aviation activity at two times the present level by 1986.

e. **Ground Facilities.** To regulate the safe movement of air traffic, the FAA has established a network of over 15,500 air traffic control and air navigation facilities. The FAA plans to expand this network to accommodate the projected traffic growth over the next decade. This increase in facility numbers will be accompanied by an increased sophistication and complexity of these air traffic control and navigation facilities. The changes planned for specific systems and facilities are addressed beginning with paragraph 309.

306. AVIATION SAFETY MEASUREMENT. One measure of the level of safety in aviation activity is the number of accidents that occur in a given period of time and traffic density. Examples are the number of accidents and fatalities per 100,000 aircraft hours flown or fatalities per million aircraft miles flown. These measurements may be subdivided into specific areas, such as air carrier and general aviation data. Analyses of such data will be covered in following paragraphs. Material compiled for the safety measurement and safety assessment discussions is derived primarily from the FAA Flight Standards Service Accident Investigation Staff, the National Transportation Safety Board, and the FAA Office of System Engineering. Data categories include accident causes or related factors, types of accidents, and phases of operations in which they occurred.

307. AIR CARRIER SAFETY RECORD ASSESSMENT. Fatal accident and fatality rates of U.S. air carriers decreased in 1975. Three fatal accidents resulted in 124 fatalities. The decrease in passenger fatalities and passenger miles flown caused the passenger fatalities rate per million passenger miles flown to decrease from 0.019 in 1974 to 0.016.

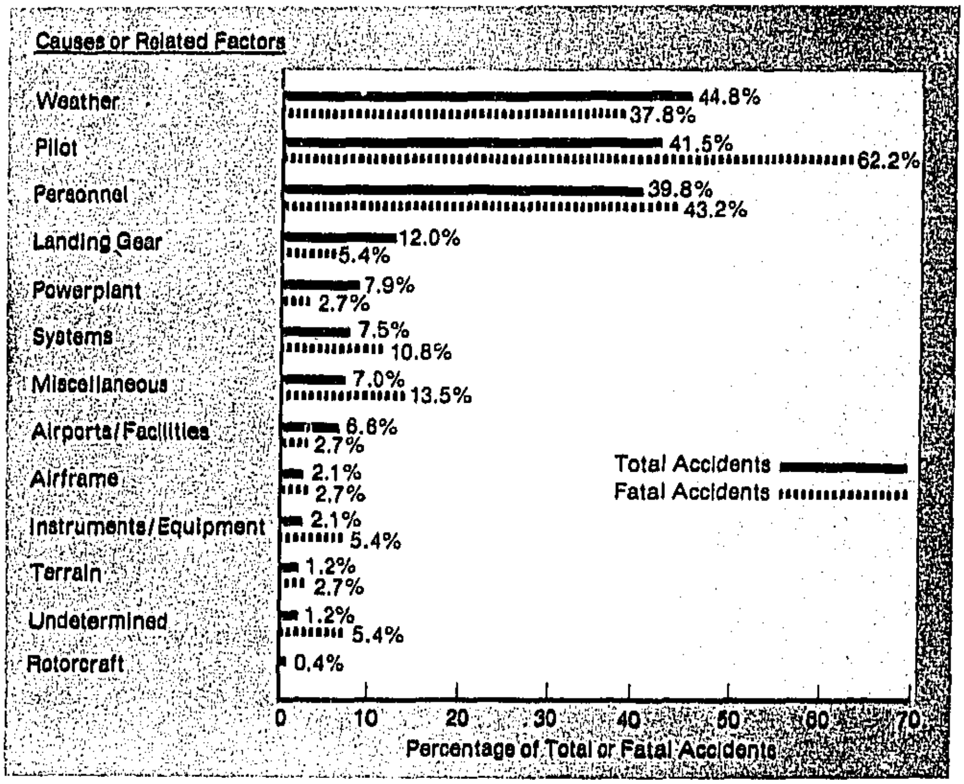


Figure 3–8. Causes or Related Factors Percentage Distribution U.S. Air Carriers, 1969–1973

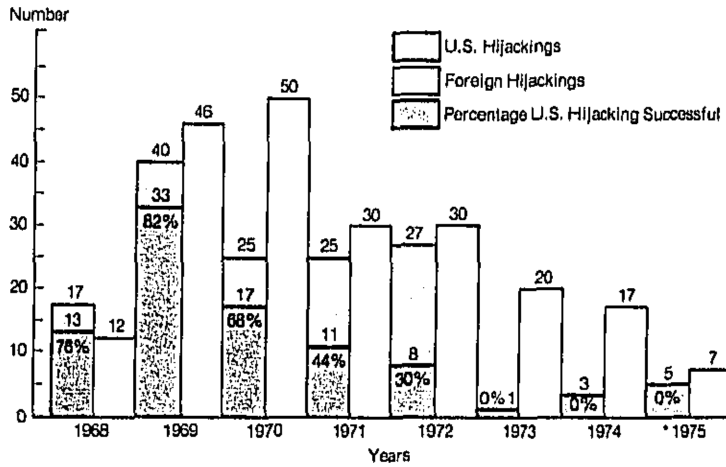
a. **Human Factor.** For the five-year base period, there were 259 accidents and 43 fatal accidents involving air carriers in which causal determinations were made. As illustrated in Figure 3–8, 81.3 percent of the total accidents were attributed to error or deliberate action.

b. **Criminal Attacks.** In 1971 and 1972, fatalities associated with crimes against aviation (e.g. hijackings, bombings, sabotage) were relatively low—less than three percent of U.S. air carrier fatalities. In 1973, a substantial increase began, with 13 percent of the fatalities attributed to criminal attacks. In 1974, almost 20 percent of U.S. air carrier fatalities were the direct result of criminal acts against aviation. The record of hijacking attempts on U.S. scheduled air carrier aircraft indicates 36 were made from January 1, 1972, through June 30, 1975; only eight were successful, and none since November 1972. It has been estimated that about 45 potential hijackings have been averted by the passenger screening system during 1974 and the first six months of 1975 (Figure 3–9). Only three were successful, and then only during the first half of FY 73. Despite these accomplishments in diminishing successful U.S. air carrier hijackings, it is clear that the threat of hijacking still persists worldwide.

c. **Phase of Operation.** Air carrier accidents that occurred during the inflight phase of operation made up 40.7 percent, landing 29.3 percent and takeoff 11.8 percent of the total (Figure 3–10 and 3–11). Weather phenomena were the probable cause of 71 percent of inflight accidents. In the landing phase, the leading probable factors for fatal accidents were improper IFR operations, low ceiling and fog.

d. **Vortex Turbulence Avoidance.** Vortex turbulence is a factor in 30.9 percent of air carrier accidents. It is believed that use of up-to-the-minute forecasting techniques and rapid dissemination of the information to pilots can greatly reduce the number of turbulence accidents. Air carrier operations have procedures for keeping their pilots advised of frontal systems and thunderstorms at departure and destination airports. New ways to predict and assess vortex turbulence, such as FAA's Wake Vortex Avoidance System, are being developed in the effort to reduce the number of turbulence-induced accidents.

e. **Aircraft Crash Survivability.** An NTSB study has revealed that a significant number of passengers and crew are being killed by smoke and fire following "survivable" accidents. An analysis of ten certificated air carrier crashes between 1969–73 showed that disorientation and choking from inhalation of gases



*as of June 30, 1975

Figure 3–9. Civil Aviation Security U.S./Foreign Air Carrier Hijackings

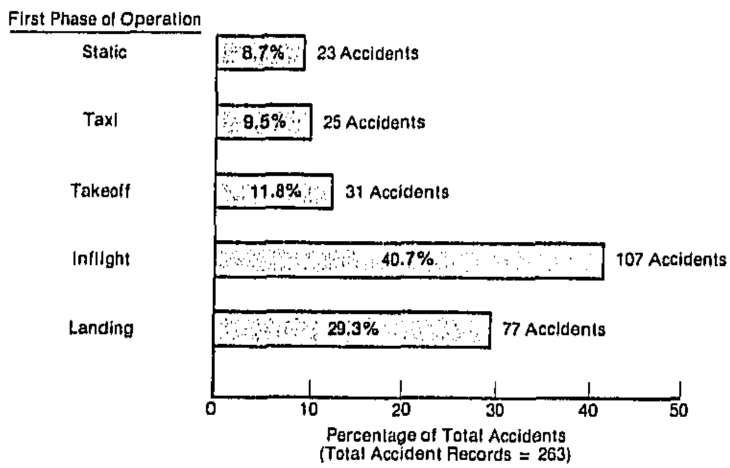


Figure 3–10. Phase of Operation Total Accidents U.S. Air Carriers, 1969–1973

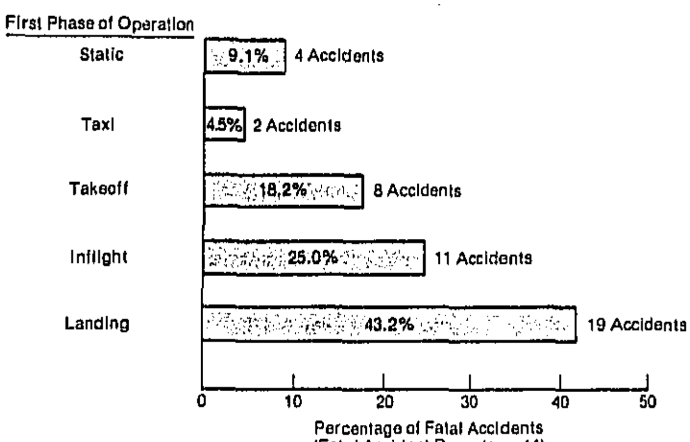


Figure 3–11. Phase of Operation Fatal Accidents U.S. Air Carriers, 1969–1973

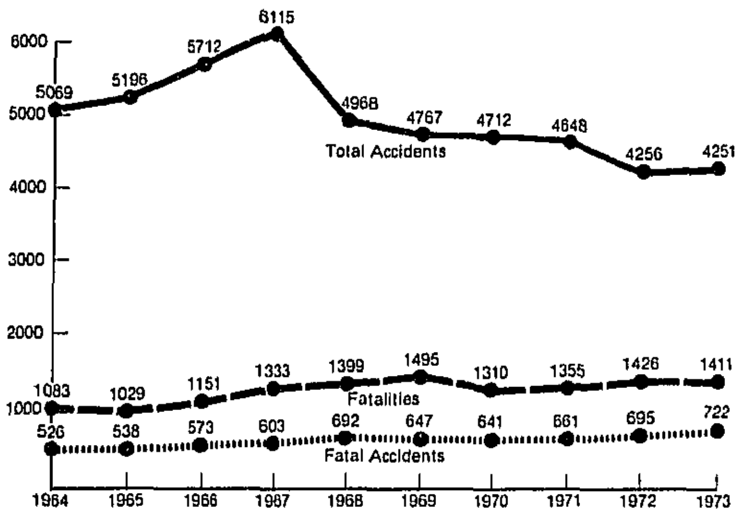


Figure 3–12. Accidents, Fatalities U.S. General Aviation, 1964–1973

greatly hampered escape attempts by the crash survivors. Autopsies made for the study show that high concentrations of carbon monoxide and hydrogen cyanide in the victims' blood were derived from burning of man-made fibers and plastics used in the aircraft cabins. The use of different materials for cabin interiors can reduce this hazard. Research and development, and rule making, now in progress, are intended to lead to a reduction of the hazards posed by smoke and toxic gases. Other findings of the study are:

(1) "The rapidity with which passengers can leave a crashed aircraft is an important safety factor. Several programs are in being to promote more rapid evacuations, including development of a computer simulation model of the emergency evacuation process and improved emergency lighting."

(2) "Flight attendants are an important part of the emergency evacuation system and their well-being must be assured so that they can provide assistance to the passengers. Proposed rulemaking would provide safer flight attendant seats, and the development of flammability standards for flight attendants' uniforms is being considered."

(3) "FAA is evaluating new flight checking and training procedures of flight attendants. More realistic training and checking atmosphere is the planned goal. The use of the coordinated crew concept in training and flight checks appears to hold promise. Flight attendant training that emphasizes 'hands on' training in the specific areas of emergency equipment, evacuation, and first aid will be promoted."

308. GENERAL AVIATION SAFETY RECORD. The general aviation safety record shows a trend of improvement over the past decade. Figures 3–12 and 3–13 show that there was a reduction of approximately one-eighth in total accidents although the number of hours flown increased by one-fifth. In the same period, the rate of fatal accidents has been reduced by over one-fourth. This encouraging trend is reinforced by examination of the accident rates per 100,000 aircraft hours flown, using the 1969–1973 base period for a comparison with 1974 statistics. (Figure 3–14)

a. Human Factor. The commonly used term "pilot error" continues to be the leading factor in general aviation accidents. This factor consists of an interaction of faulty judgment, inadequate skills, and physical/mental impairment. Faulty judgment and inadequate skills are so closely related that they will be considered as one. NTSB accident investigation figures for 1972 indicate that the pilot was either the principal cause or a significant factor in 84 percent of all accidents and in 85 percent of fatal accidents. In

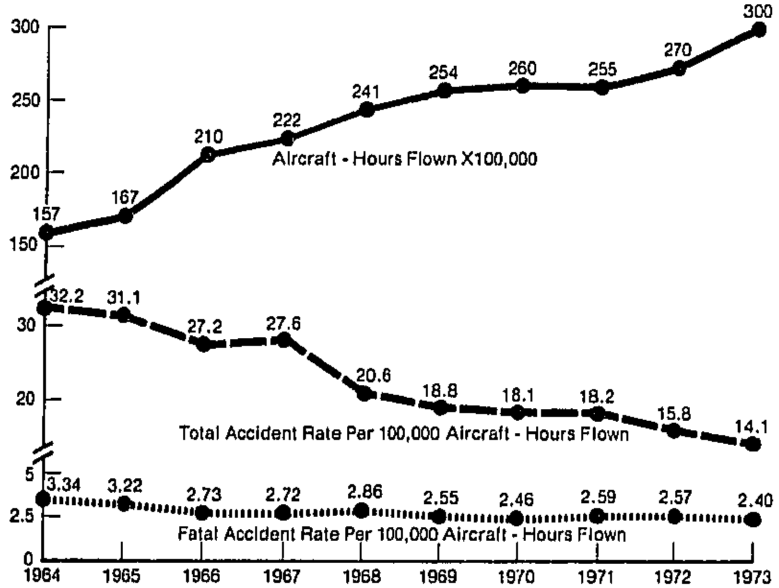


Figure 3–13. Aircraft-Hours Flown, Accident Rates U.S. General Aviation, 1964–1973

Figure 3–14. Ten Most Frequently Cited Causes/Factors of Fatal Accidents All Operations

10 Most Frequently Cited Causes/Factors	1972 Fatal Accidents—681 Frequency	Percentage of Fatal Accident
Weather—low ceiling	183	26.87
Pilot—failed to obtain/maintain flying speed	156	22.91
Pilot—continued VFR flight into adverse weather conditions	148	21.73
Weather—fog	124	18.21
Terrain—high obstructions	110	16.15
Pilot—spatial disorientation	105	15.42
Pilot—inadequate preflight preparation or planning	98	14.39
Weather—rain	83	12.19
Pilot—exercised poor judgment	57	8.37
Miscellaneous—undetermined	54	7.93

spite of the improving trend in general aviation safety, weather-related accidents that involve pilot judgment continue at a high rate as evidenced in the list of the 10 most frequently cited accident causes (Figure 3–14). Approximately 13 percent of the general aviation accidents that were attributed to pilot impairment involved ingestion of alcohol (Figure 3–15).

b. **Aircraft.** Analysis of 4,256 general aviation accidents revealed that 24 percent of the aircraft involved in accidents were destroyed and 76 percent suffered substantial damage.

Additionally, about seven percent of aircraft involved in accidents experienced fire after the crash. These statistics support the concept that continued efforts are needed to improve crash worthiness and reduce fire damage in general aviation aircraft.

c. **System Operations.** Although a number of general aviation aircraft are equipped for ATC controlled flight (IFR, TCA's, above 12,500 feet), the impact of the ATC system on general aviation accidents is much less than with air carriers. Most mid-air collisions occur at uncontrolled airports. The NTSB analysis of weather-related general aviation accidents revealed that in at least 28 percent of the fatal weather-related accidents, the pilot involved received no preflight weather briefing. This causal factor is magnified by the fact that available weather forecasts were substantially correct in almost 75 percent of the cases. No doubt, greater availability, capability to access, and utilization of higher quality weather services should aid in reducing these general aviation accidents. The Flight Service Station Modernization Program is designed to increase the accessibility and quality of flight planning and weather information services.

309. FAA SAFETY PROGRAMS AND PLANS. The quest for safety in aviation permeates virtually all of FAA's activities and colors every decision. Many agency activities are designed primarily to further goals other than safety—e.g., to increase capacity or to reduce aircraft noise—but the safety impact is always the first measure applied to any program. Often programs and projects undertaken, for instance, to increase capacity also have benefits to safety. These programs, although in part safety programs, are discussed elsewhere as appropriate. Similarly, safety programs often contribute toward the attainment of other goals as well. The FAA's primary programs for safety fall into four major areas—Facilities and Equipment Programs, Research and Development Programs, Operations Programs, and Airport Grant Programs.

310. FACILITY AND EQUIPMENT SAFETY PROGRAMS.

a. **Enroute Communications.** The purpose of enroute traffic control and service is to promote the safe, expeditious, and orderly flow of aircraft operating on Instrument Flight Rules (IFR) flight plans, within controlled airspace, primarily between departure and destination terminal areas. These enroute services are provided in the airspace over the Continental United States from 21 FAA facilities known as Air Route Traffic Control Centers (ARTCC's or Centers). Six other ARTCC's, including the combined Center/Radar Approach Control (CERAP) facilities on Guam and in the Canal Zone, provide enroute ATC services in the airspace overlying Alaska, Hawaii, U. S. territories, and other areas under the sovereignty of the U.S. The number of ARTCC's in the Continental U.S. will be reduced to 20 upon the completion of the phase-out of the Great Falls, Montana facility during late FY 1976.

(1) Communication between pilot and controller, as well as between air traffic control facilities (ARTCC/ARTCC or ARTCC/ATCT for example) is the essential link in providing enroute safety. It is planned to expand the remote center air-ground (RCAG) communications network to assure adequate communications for the traffic and sector growth projected through the plan period. In addition, many RCAG facilities will be improved or relocated to correct the air/ground communication problems or coverage deficiencies that have developed at existing sites.

(2) Implementation plans are to install new, solid-state VHF equipment, capable of being modified to 25 kHz channels, at all RCAG facilities serving high altitude enroute sectors. It appears that the use of 25 kHz channelization for high altitude purposes will permit the use of 50 kHz spaced channels in the lower altitudes for a number of years. However, the future need for 25 kHz spaced communications channels remains a subject for continuing study. The backup emergency communications (BUEC) program provides a certain amount of redundancy to the RCAG system by installing tuneable VHF and UHF transceiver equipment in the ARTCC buildings, long range radar (LRR) sites, Flight Service Stations (FSS's), etc.

b. **Establish Air Traffic Control Towers.** Airport traffic control towers (ATCT's) are established at qualified airports to provide airport traffic control services to visual flight rules (VFR) aircraft operating on or in the vicinity of an airport. At certain low activity airports, the flight service station functions are combined with those of the tower and the facility becomes known as a combined station tower (CS/T). Some towers also provide for the separation—approach control service—of instrument flight rules (IFR) aircraft operating in terminal areas and, on occasion, when those aircraft are operating between terminal areas (tower enroute control).

(1) The level of terminal services provided and the configuration of the control facilities are dependent upon selected indicators of air traffic activity—aircraft operations, instrument operations, user categories, and so forth. All ATCT's provide airport traffic control (visual) services, but all towers do not provide approach control (instrument) services. When the IFR separation function is performed in a tower, it becomes known as an IFR or approach control tower. Approach control facilities are further subdivided according to the type of services they provide, based on whether or not they are equipped with radar.

(2) Nonradar approach control towers provide separation procedurally, from the control cab. Radar approach control facilities provide radar separation and services from the control cab (TRACAB), or from a control room located elsewhere in the tower building or in a separate building (TRACON-FAA, RAPCON-USAF, RATCC-USN). Additionally, terminal radar facilities are being equipped with computers and automation equipment to provide automated radar terminal services (ARTS).

(3) Current ATCT establishment criteria are published in Airway Planning Standard Number One, as revised by Change 3 on October 16, 1975. The revised criteria, based on benefit/cost analysis identify candidates satisfying a weighted combination of air carrier, air taxi, general aviation and military aircraft operations. Furthermore, all candidates will be validated via a detailed benefit/cost study based upon specific costs and operations data obtained from each airport.

(4) To assure that commissioned facilities retain the efficiency and service levels for which they were designed, certain improvement efforts will be necessary. These efforts will involve relocation of ATCT's and TRACON's. This plan assumes that changes in physical layouts at airports and advances in technology will necessitate an average of six relocations a year through the year 1986 and beyond.

c. **Radar Tracking for ARTS III.** Under the present system, the identification and tracking of non-transponder equipped aircraft is initiated and maintained manually by the controllers.

A planned radar tracking "add-on" feature to the basic ARTS III system will tag non-beacon equipped aircraft, accomplish automatic radar tracking, and provide a backup to beacon tracking that will improve the accuracy of the reported target position. Radar tracking is planned for high activity locations. Along with the "add-on" hardware, software related safety improvements include Minimum Safe Altitude Warning (MSAW) which will provide terrain avoidance warnings alerting the controller of a "low-altitude" condition. In addition, it is planned to augment the ARTS III with future functions resulting from present development efforts—metering and spacing, improved flight data processing, conflict prediction and alert, and final approach course monitoring.

d. **FSS Air/Ground Communications.** Flight assistance and weather information services are provided by specialists from manned flight service stations operating on a full-time or part-time basis and unmanned stations located in the coterminous United States and in the Alaska, Pacific, and Caribbean areas. In addition to these facilities, there are international flight service stations (IFSS's) which provide flight assistance services on an international basis and aeronautical telecommunications switching centers, which automatically transmit messages throughout the United States and the world. The current demands on the system and future flight service requirements have brought forth a program of major reconfiguration and facility modernization leading to the eventual automation of the flight service station system. The new system is expected to reduce the estimated labor cost gradually to about 50 percent of the total system cost. A full discussion of the automated FSS programs can be found in Section 4 of this chapter.

e. **FSS Preflight Briefing and Flight Plan Filing Services.** FSS preflight briefing service is an important accident/incident prevention service that enables most flights to be planned and conducted without getting into weather related troubles. Additionally, properly completed preflight briefings encourage the pilot to complete all other recommended planning actions prior to flight. IFR and VFR flight plan filing assists in entry into enroute airspace as well as acting as an automatic alerting process in the event of misadventure.

f. **Establish/Improve/Relocate Direction Finder (DF) Equipment.** To fulfill the requirement to provide emergency guidance assistance to lost or disoriented pilots, a Direction Finding (DF) system is desirable. Establishment of a network of DF facilities located 80 to 160 nautical miles from each other along major air traffic routes will meet this requirement. It is planned to put into service a new type of DF, far superior to the existing one in terms of operational capability and total coverage. It is expected that programs will be

Figure 3–15. Pilot Impairment

	1972	1973	1974
Fatal Accidents	684	717	672
Number of Fatalities	1438	1896	1345
Pilot Toxicology Obtained	399	420	405
Percent Accidents Associated with Alcohol	15	13	13

established to improve existing DF facilities and to relocate them when required. A study intended to develop emergency service criteria for the automated FSS system will be completed next year; it is expected to recommend a number of DF relocations.

g. **Provide Weather Radar Displays.** Up-to-the-minute weather information is one of the most important items of safety information for the general aviation pilot. The National Weather Service has acquired remoting equipment for many of their WSR-57 radars. This equipment transmits digitized video over long-distance telephone lines. The data received can be displayed in graphic form. As an additional feature, the remoting transmitter is equipped with a multiple-access device for dial-up capability. It is planned to install these displays at those FSS's already providing or scheduled to provide enroute flight advisory services.

h. **Establish/Relocate and Improve VORTAC Systems.** Very high frequency omni-directional radio ranges (VOR) are used for air navigation and as approach aids by aircraft pilots to assist them in conducting safe and efficient flights and landings. A network of these facilities makes up the airway system throughout the country. However, because of the increasing volume of air traffic, it is occasionally necessary to provide new airways structures to cope with air traffic control needs.

(1) VOR is collocated with TACAN (Tactical Air Navigation Equipment) to form a VORTAC, the basic enroute navigation aid. The TACAN provides azimuth to military pilots and distance from the station to pilots of both civil and military aircraft. More than 80 percent of the FAA's VOR's are collocated with TACAN.

(2) Civil distance measuring equipment (DME) is installed with VOR to provide positive distance information where there is no military requirement for TACAN azimuth information. It is planned to equip all non-TACAN VOR's with civil DME—the standard DME at enroute VOR's and a low-power version at terminal VOR's.

(3) Present plans for expansion of the enroute VORTAC system are limited to the installation of new or relocated facilities to serve new airports, to facilitate the flow of air traffic in the vicinity of high density terminal areas, and to support an occasional new airway. Terminal VOR's (TVOR) provide approach guidance for instrument operations, and are planned for installation at locations that are not expected to qualify for an ILS and are not near an enroute VOR or VORTAC.

i. **Establish Localizer/Marker/Approach Lights.** Localizer/marker facilities are partial Instrument Landing Systems that provide directional guidance for aircraft and reduce landing minimums. These partial ILS's are installed at airports having insufficient traffic to qualify for a complete ILS and at secondary runways of major airports having obstructions or terrain features that preclude a glide slope. DME may be installed in lieu of an outer marker where the marker is not practical. An airport that records 200 or more annual instrument approaches or has 1,825 or more scheduled annual passenger originations is a candidate for a localizer marker.

j. **Add DME to ILS.** The DME system enables pilots to determine positive distance information. The DME improvement should be considered for locations where: (1) terrain makes front course approaches difficult or hazardous; (2) mountains or expanses of water make the siting of navigation aids difficult or uneconomical; (3) there is nonradar approach control and DME at ILS may be used as an additional aid in separating and expediting air traffic; or (4) there is high density radar approach control and the DME would expedite departures and arrivals. An ILS airport recording 1,400 or more annual instrument approaches also is a candidate for DME when lower landing minimums will be authorized or the DME will expedite the flow of IFR air traffic arriving and departing the airport. These DME needs will be met with a new low-power, solid-state DME now being procured. Improvements in airborne and ground DME accuracies are expected to permit DME to be substituted for middle markers and also to provide cockpit landing rollout distance-to-go information. The DME located at the localizer site should eventually have an accuracy on the order of one percent (combined ground and airborne error). Use of DME for outer and middle markers will eventually reduce costs for marker equipment and eliminate marker site costs.

k. **Establish Runway End Identification Lights (REIL).** Runway End Identification Lights are installed on busy runways with a history of approach difficulties caused by the inability of pilots to identify the runway rapidly and positively. A REIL may be installed for VFR use with 3,000 or more annual runway landings.

l. **Establish Visual Approach Slope Indicators (VASI).** Visual Approach Slope Indicators are installed on qualifying runways with a need for visual glide slope guidance because of jet aircraft operations, hazardous or deceptive terrain, overwater approaches, back course ILS approaches, obstructions, or noise problems. The four-box VASI typically is installed on runways used for turbojet aircraft operations.

m. **Establish Lead-in Lighting Systems (LDIN).** Lead-in lighting systems are installed for use at locations with particular terrain, visibility, or noise abatement problems that cannot be overcome with one of the standard approach lighting systems. These systems usually guide the pilot safely along a curved approach to the runway.

n. **Frangible Approach Light Mounting Retrofit Program.** Existing FAA approach light systems associated with instrument approach procedures (precision and nonprecision) use structural steel towers to achieve the required lighting plane. Because these structures can severely damage aircraft in the event of an accident, FAA has initiated a planned, multi-year program to replace existing structural steel towers with lightweight frangible structures that, upon impact, will collapse or break apart, thus reducing damage to aircraft.

o. **Program for Improved Safety of Nonprecision Approaches.** As a result of numerous accidents (164 between 1966 and 1972) of civil aircraft while executing nonprecision approaches, Flight Standards Service initiated studies for the purpose of improving safety of non-precision approach procedures. Following approval of these studies in October 1974, action was taken to establish additional approach and landing aid facilities to support operational safety requirements. The facilities consist of Distance Measuring Equipment (DME) or 75 MHz Marker Beacons to identify the visual descent point on the final approach course. VASI's are also installed to provide visual vertical guidance to the runway threshhold. Priority for the required facilities has been given to locations served by jet air carriers and were programmed during FY–1976. Locations served by nonjet air carriers will be provided with necessary facilities in FY–1977, and planning for general aviation airports will follow in subsequent years.

p. **Establish Omni-Directional RAIL/REIL Approach Lights Systems.** To improve safety of instrument approaches, this system will be installed at locations where the final approach course is offset from runway alignment and where another approach light system is impractical or undesirable. Additionally, circling approaches are enhanced by this system as they are omni-directional and provide excellent runway identification.

311. SAFETY RESEARCH AND DEVELOPMENT PROGRAMS.

a. **Airborne Separation Assurance Program** With no airborne Collision Avoidance System (CAS) or Proximity Warning System (PWI) presently in operational use, the main thrust of this program is to consider feasible alternatives to reduce and/or eliminate the threat of mid-air collisions. This FAA program has been closely planned and coordinated with DOD and NASA efforts in CAS/PWI. Even though there are a number of hard technical, practical, and economic problems to be resolved, these joint FAA/DOD/NASA efforts are moving ahead rapidly, on a broad front, in testing and evaluating competing CAS systems; in further refining airborne lighting to make the aircraft more easily seen; and in insuring the compatibility of evolving airborne CAS systems with the ground-based air traffic control (ATC) system. The primary objective of this program is to foster the development and implementation of cost-effective and ATC compatible airborne hardware and software to serve as a backup to the ATC system, in the event of its failure, and to provide protection (to aircraft) in geographical areas not covered and/or serviced by the ground-based ATC system. The secondary objective is to increase the aircraft's visibility to the naked eye.

b. **Intermittent Positive Control (IPC).** The objective of this program is to provide a ground-based collision prevention system focused on three principal functions:

—Provide VFR/VFR collision protection.

—Provide VFR/IFR collision protection.

—Serve as a backup to the ATC system.

(1) To satisfy the objectives stated above, the development of a new collision avoidance service called Intermittent Positive Control is underway. IPC is a totally automatic ground-based service that provides pilots with proximity information on other aircraft and provides collision avoidance service to avert an impending collision. Although IPC is a prime candidate for selection as the solution to the problem of providing collision avoidance services, other alternatives including airborne systems are still under evaluation.

(2) The IPC service operates through the DABS system. To receive IPC advisories and collision avoidance commands, the aircraft must be equipped with a DABS transponder, an encoding altimeter, and an IPC display. Once so equipped, IPC will provide that aircraft with collision avoidance protection against all other DABS and ATCRBS transponder-equipped aircraft. IPC envisions the use of interconnected ground-based computers located at the DABS surveillance sites or designed as an integral part of the DABS computer for the generation of IPC commands. Using the improved surveillance of the DABS system and the DABS ground-air data link, these IPC computers will track aircraft (DABS and ATCRBS), provide traffic advisories on proximate traffic on non-collision courses, identify collision threats, and generate collision warnings and subsequent maneuver commands for automatic transmission to the aircraft over the DABS data link. The interconnected network of IPC site computers will provide the basic IPC service, which will also serve as an independent safety backup capability to the ATC system in the event of the failure of an ATC facility. IPC will require no data processing to be performed in the aircraft; all processing will be done on the ground.

(3) **Conflict Alert.** As a part of the separation assurance and collision avoidance program, safety software features are being developed and implemented through increased use of the ground based automation capability already established in the en route and terminal environments. In the en route system, through conflict prediction software, there is a forced automatic displaying of an alert on the controller's display two minutes prior to a predicted encounter. No additional avionics equipment is needed to implement conflict alert, only tracked data from beacon equipped aircraft with mode C is required to provide this enroute safety feature. In the terminal environment there is equal emphasis on conflict alert and increased safety in the terminal airspace. Development is underway to incorporate in the current ARTS software a first level conflict alert feature which will project on a controller's display an extension leader indicating the predicted path of the aircraft for 1 minute prior to encounter. Initially the conflict alert capability will be provided for only controlled and beacon equipped aircraft with an ultimate goal to include all aircraft in terminal airspace when planned enhanced packages are available.

c. **Airports/Airside Programs.** Work in this program includes development, testing, and evaluation of fog prevention and dispersal techniques and improvement of techniques and equipment for fire and crash work, and for snow/ice/slush removal. A major effort is the development of an Airport Surface Traffic Control (ASTC) system. This program is discussed in the Capacity section of this chapter.

d. **Aviation Weather Programs.** As shown earlier, weather is a primary cause of accidents, particularly in the general aviation sector. The aviation weather program efforts are directed toward improving and modernizing (through automation and improved techniques and sensors) data acquisition, processing, and dissemination of aviation weather information. Increased emphasis and effort have been placed on the detection, sensing, tracking, and display of hazardous weather (severe storms).

e. **Aviation Safety Program.** This program covers engineering and development to increase civil aircraft safety. It demonstrates technical, operational, and economic feasibility of safety improvements and provides the data base for new or improved criteria for aircraft design, operations, maintenance, and pilot performance and for weapon and bomb detection specifications. Effort is divided into fire safety, transport safety, general aviation flight safety, and aviation security program elements. Larger aircraft, new low and high speed aerodynamic concepts and designs, higher thrust engines, new operating techniques, increased cockpit and control automation and new weapon and bomb detection equipment dictate the development of additional (or upgraded) standards and certification criteria.

f. **Aviation Medicine Program.** This program consists of program elements aimed at: (1) improving the efficiency, performance, and work environment of airmen and air traffic control personnel and, (2) improving the safety, performance, and health of pilots, ground personnel, and passengers. The medical research program provides information and answers to problems caused by the operation and characteristics of the NAS. Specifically, it concerns the following areas: identifying and eliminating aeromedical factors that contribute to accidental injuries and death; establishing medical standards for airmen; maintaining health fitness and performance of aviation personnel; and improving work conditions in all parts of the system.

312. OPERATIONS SAFETY PROGRAM. The promotion of aviation safety by the FAA through the operation of its many programs—noted in other sections of this chapter—requires that the agency workforce represent a broad spectrum of occupational skills. These essential talents, which must be available if agency plans and programs for improved aviation safety are to be a reality, range from the highly technical through the general administrative and managerial skills needed to upgrade the overall safety efforts of the agency. The level of staffing for the several programs is primarily determined by the application of staffing standards to aviation activity indicators, but the prime criterion is staffing quality and capability consistent with the agency's high standards for aviation safety. The FAA's operation programs, which can be identified as existing primarily to improve air safety, are: (1) operation of the air traffic control system; (2) maintenance of airway facilities; (3) installation and materiel management; (4) the flight standards program; (5) aviation medical program management; and (6) direction, staff, and support of the overall safety mission of the FAA.

a. Air Traffic Control. Enroute air traffic control personnel are employed in Air Route Traffic Control Centers (ARTCC) and are responsible for the safe separation of aircraft flying under IFR conditions by use of radar and air/ground communications. Other air traffic control specialists are employed in Air Traffic Control Towers (ATCT) and Terminal Radar Control Facilities (TRACON and TRACAB). Their primary responsibility is to ensure aviation safety in the terminal area by controlling the separation of arriving and departing aircraft. Specialists employed at Flight Service Stations (FSS) contribute to air safety by providing such services as in- and pre-flight weather briefings, and emergency guidance.

b. Airway Facilities Maintenance. The network of air navigation, communications, and air traffic control facilities is maintained by FAA electronics technicians. The airway facilities electronics technicians contribute to the total aviation safety effort through their inspection, monitoring and maintenance of these facilities. Their efforts ensure maximum reliability and integrity of the navigational intelligence carried by the facility signals.

c. Installation and Materiel Management. FAA logistics personnel are responsible for the procurement, distribution, inventory control, and contract management aspects of the agency's safety programs. Included are electronic aids to navigation, leased telecommunication services, agency aircraft and avionics and air traffic control, and other logistical elements needed to support the continued safe and reliable performance of the NAS.

d. Flight Standards Programs. FAA flight standards personnel help assure flight safety through the establishment and enforcement of rules and standards governing the airworthiness and operations of aircraft and the competence of airmen, the inflight inspection of air navigation facilities, the development of flight procedures, and the management of the FAA aircraft fleet. Flight standards responsibilities begin at the drawing boards where aircraft are conceived, continue at the factories where they take shape, and end with the men who fly them, the aviation technicians who maintain them, and the flight inspectors who monitor the air navigation facilities. Specific flight standards programs include:

(1) Safety Regulations Program. To keep pace with the ever increasing technical complexities of the aeronautical state-of-the-art, the FAA has embarked on a comprehensive biennial review of its airworthiness and operations regulations. The airworthiness review, begun in 1974, has resulted in extensive rule-making activity. The operations review, now well underway, will update the regulations governing airmen, air traffic, operators, air agencies, training, maintenance and other related sections.

(2) Engineering and Manufacturing Program This program concerns the design and production of civil aircraft through the development and maintenance of regulations for type and production certification of aircraft, engines, propellers and appliances. It includes a system of inspections and surveillance to assure compliance with these regulations and also a system of delegation of FAA responsibilities to individuals and manufacturers to perform specific tasks for the Administrator of FAA. There are over 1,500 product, parts, and appliance manufacturers and suppliers subject to FAA regulations. These organizations produce more than 15,000 aircraft, 23,000 engines, and 26,000 propellers per year. Planning has been initiated to increase the effectiveness of the Delegation Option Authorization held by some manufacturers of aircraft and to strengthen the effectiveness of designee activities.

(3) Air Carrier Program. One of four major programs in the flight standards area is the air carrier program, which covers the operational and maintenance aspects of the certification and surveillance of air carriers (including air taxi operators of large aircraft and commuter air taxis), air carrier airmen, air agencies, and commerical operators of large aircraft. This program also covers the recurring certification and continued airworthiness of air carrier aircraft and avionic systems; the operational aspects of enroute and instrument approach procedures; and the proper handling, storage, and carriage of hazardous materials. Increased emphasis is being placed on this last area: during FY 1975, over 13,000 hazardous materials inspections were conducted by the FAA. The FAA currently has 22 full-time hazardous materials coordinators and an additional 399 inspectors trained to conduct hazardous materials inspections in conjunction with their other duties. The increased responsibilities placed upon the FAA by Public Law 93-633, the Hazardous Materials Transportation Act, along with the continuing growth rate of the air transportation of hazardous materials, will increase the future total effort by flight standards in this area.

(4) General Aviation Program. This major program covers the operational aspects of the certification and surveillance of general aviation airmen, air agencies, air taxis, and other commercial operators of small aircraft, and the recurrent certification and continued airworthiness of general aviation aircraft and avionic systems. Accident prevention is a major project in this program. Accident prevention specialists in FAA Flight Standards and General Aviation District Offices organize and participate in clinics, meetings, and group discussions aimed at improving flight safety by increasing the knowledge, improving the skills, and updating the techniques of pilots and other airmen. From the program's nationwide implementation in 1971, through June 1975, accident prevention specialists conducted 18,818 meetings or clinics with a total attendance of 1,171,700 people. A major subgoal of the accident prevention program is to involve aviation associations in safety promotional activities. These efforts are expected to increase as aviation activity grows.

(5) Other General Aviation Projects. Random sampling of selected segments of general aviation has been implemented on an experimental basis. The results will be evaluated when sufficient data are available, and a decision will be made at that time whether or not to broaden this management tool to other functions of general aviation inspection. Forecast of increases in airplanes and pilots, without proportional increases in the FAA general aviation inspector workforce, have generated a need to find alternative means to fulfill FAA responsibilities provided by the Act.

e. Aircraft Program. This program is concerned with operation, maintenance, development and use of the FAA aircraft fleet; inflight monitoring of the performance of air navigation facilities; establishment of terminal and enroute procedures; and the use of air navigation facilities, appliances, and systems by civil aircraft. Some of the more important events that have occurred, or are scheduled to occur, include:

(1) Flight Inspection. Prior to the establishment of the Flight Inspection National Field Office (FINFO), flight inspection of terminal and en route air navigation facilities and communications equipment in the contiguous 48 states had been carried out by 17 flight inspection district offices under the jurisdiction of five FAA regions. With the centralization of the flight inspection organization under FINFO and the acquisition of modern turbojet aircraft, seven field offices geographically located within a maximum of one hour flying time to most NAVAIDS now accomplish flight inspection in the contiguous 48 states. Flight inspection activities for the Alaskan, Pacific and European Regions are administered separately from FINFO by these regions in their respective geographical areas.

(2) Flight Procedures Automation. The flight procedures program involves the application of criteria and standards for the development and processing of instrument flight procedures to ensure flight safety. Present planning calls for the automation of the instrument flight procedures program. This would involve installation of computer terminals at the National Flight Inspection Field Office and each flight inspection field office to achieve maximum accuracy. Automation will also decrease the time required for development, review and printing of instrument approach procedures.

f. Medical Program Management. Aviation safety demands that airmen be in excellent physical condition when involved in the operation of an aircraft. FAA medical personnel develop, disseminate, and enforce physical examination procedures and certification requirements for all airmen. Ancillary responsibilities required for the operation of the program include the development of medical standards, aircraft accident medical evaluation, preventive medical education programs for airmen, and the operation of the aviation medical examiner system and data processing file.

g. Civil Aviation Security Program. Aerial piracy and acts of terrorism continue as a threat to aviation safety. FAA security specialists continually review the anti-hijacking and passenger screening programs to ensure the safety and security of the air traveler.

h. Direction, Staff and Support. Approximately seven percent of the total agency staffing is devoted to the administrative support of the FAA safety mission. These individuals provide executive direction and administrative support including personnel, budget, accounting, air transportation security, planning, training, and program supervision.

313. AIRPORT GRANT PROGRAM. FAA administers an airport grant program for which legislation is pending—the Airport Development Aid Program (ADAP). The ADAP program helps airport sponsors to fund for planning, new runways and taxiways, land acquisition for airport expansion or protection, safety equipment and associated buildings, and other major projects necessary to maintain and improve levels of safety on airports. These include airport runway and taxiway lighting, repaving of operational surfaces, obstruction removal, pavement marking, and ground traffic direction signs and signals.

a. Standards. In 1972, the FAA promulgated Federal Aviation Regulation Part 139, which provided for the issue of airport operating certificates to airports serving scheduled air carriers that hold certificates of public convenience and necessity from the CAB. This regulation laid down minimum standards for airport operations and facilities that affect air safety. These standards must be met in order for the airports to continue serving the scheduled air carriers. In general, ADAP includes as eligible items (i.e., Federal funding available on a proportionate basis) all projects directed toward meeting the established standards. Standards are set for the following:

—Pavement Areas (runways, taxiways, aprons).

—Safety Areas (abutting paved areas).

—Marking and Lighting Runways, Taxiways, and Threshholds.

—Airport Fire Fighting and Rescue Equipment.

—Hazardous Materials Handling and Storage.

—Traffic and Wind Direction Indicators.

—Emergency Planning.

—Obstructions.

—Protection of NAVAIDS.

—Airport Fencing.

—Bird Hazard Control.

—Obstruction Marking.

314. SAFETY PROGRAM FUNDING. Figures 3–16 through 3–20 show planned programs with funding over the plan period. There is a figure for each appropriation and all funds attributable to safety activities in FAA are shown. All programs in FAA have been assessed for applicability to the four areas covered in the Plan—Safety, Capacity, Productivity, and Energy/Environment.

Figure 3–16. E&D Program Costs Attributable to Safety

Program	Plan (Dollars in Millions)						Total
	1977	1978	1979	1980	1981	1982–86	1977–86
02 Radar	—	0.3	0.3	0.1	—	—	0.7
03 Beacon	2.2	2.8	1.6	1.0	0.8	2.6	11.0
04 Navigation	0.3	1.1	1.1	0.9	0.9	3.0	7.3
05 Airborne Separation Assr.	2.5	2.3	0.7	0.5	0.5	2.0	8.5
06 Communications	0.2	0.5	0.6	1.5	1.5	4.4	8.7
07 Approach & Landing Sys.	5.1	2.1	3.8	2.1	0.9	3.7	17.7
08 Airport/Airside	1.4	1.2	1.2	1.5	1.5	5.8	12.6
15 Weather	3.2	4.0	4.0	4.0	4.0	17.0	36.2
17 Satellites	1.2	—	—	—	—	4.5	5.7
19 Aviation Medicine	1.5	1.3	1.1	1.0	1.1	5.2	11.2
21 Support	0.1	—	—	0.1	0.3	2.5	3.0
Total	**17.7**	**15.6**	**14.4**	**12.7**	**11.5**	**50.7**	**122.6**

Table 3–17. F, E & D Program Costs Attributable to Safety

Program	Plan (in millions of dollars) 1977	1978	1979	1980	1981	1982-86	Total 1977-86
16 Aircraft Safety	4.3	7.0	7.0	6.2	5.5	27.5	57.5
18 Aviation Medicine	2.1	2.9	2.9	2.9	2.9	14.7	28.4
Total	6.4	9.9	9.9	9.1	8.4	42.2	85.9

Figure 3–18. F&E Program Costs Attributable to Safety *

Program	Plan (millions of dollars) 1977	1978	1979	1980	1981	1982-86	1977-86
EN ROUTE CONTROL FACILITIES**							
Long Range Radar	1.3	2.3	.9	7.4	7.4	31.0	50.3
Secondary Radar							
• Establish ATCRBS							
• Discrete Address Beacon Sys.							
Automation	.9	1.2	.8	.6	.6	6.0	10.1
Center Facilities	7.6	6.9	10.7	10.6	9.6	43.0	88.4
Total	9.8	10.4	12.4	18.6	17.6	80.0	148.8
TERMINAL CONTROL FACILITIES*							
Terminal Area Radar	1.1	1.8	3.7	4.7	9.6	43.1	64.0
Establish ASR/ATCRBS/ARTS II							
Establish/Replace ASDE							
Airport Surface Traffic Control							
Discrete Address Beacon System							
Automation			1.0	1.6	1.6	9.8	14.0
ARTS II/ARTS III Enhancements							
Conflict Prediction/Resolution							
Control Tower Facilities	10.2	17.2	8.6	12.0	10.9	89.5	148.4
Total	11.3	19.0	13.3	103.	22.1	142.4	226.4
FLIGHT SERVICE FACILITIES							
Modernization/Automation	5.6	4.4	4.1	8.2	8.7	18.5	49.5
Communications	11.5	8.5	8.0	6.0	6.0	16.0	56.0
Direction Finder							
Weather	0.8	3.0	3.0	1.0	.8	4.5	13.1
Station Facilities	0.9	.8	.6	.7	.6	3.6	7.2
Total	18.8	16.7	15.7	15.9	16.1	42.6	125.8
EN ROUTE NAVAIDS							
VORTAC System	8.1	9.5	6.5	5.0	5.5	20.0	54.6
Establish/Relocate/Replace							
Add DME to VOR/TVOR							
Off-Shore Navigation System							
Total	8.1	9.5	6.5	5.0	5.5	20.0	54.6
LANDING AIDS							
ILS/MLS	10.4	5.7	2.7	2.1	1.5	7.2	29.6
• Establish ILS/MLS							
• Improve ILS/MALS							
• Add DME to ILS							
Visual Aids	11.3	14.6	15.1	6.7	14.9	31.0	93.6
Establish REIL							
Establish/Improve VASI							
Establish Lead-In Lights (LDIN)							
Establish MALS							
Retrofit light structures with frangible towers							
Wake Vortex and Wind Shear		1.0	2.0	2.0		5.0	10.0
Total	21.7	21.3	19.8	10.8	16.4	43.2	133.2
SYSTEM SUPPORT							
Housing, Utilities and Misc.	9.5	4.3	3.0	3.0	4.0	19.6	43.4
Aircraft and Related Equip.	0.2	3.0	2.2	0.5	1.0	9.7	16.6
Development, Test and Evaluation (NAFEC)	1.0	1.7	1.6	1.5	1.5	7.0	14.3
Total	10.7	9.0	6.8	5.0	6.6	36.3	74.3
Safety Grand Total	80.4	85.9	74.5	73.6	84.2	304.5	703.1

* For planning purposes some new/improved facilities are included for which implementation decisions have not been made.

** Only major programs are indicated.

Figure 3–19. Operations Costs Attributable to Safety

Activity	Plan (Dollars in Millions)						Total
	1977	1978	1979	1980	1981	1982–86	1977–86
Air Traffic	596.5	653.2	689.0	721.5	751.9	3,935.4	7,347.5
Airways Facilities	305.6	326.0	332.3	339.6	350.0	1,820.5	3,474.0
Installation and Material	118.6	131.1	138.3	145.3	152.2	791.3	1,476.8
Flight Standards	148.9	160.0	167.0	172.5	178.6	928.8	1,755.8
Medical	9.2	9.9	10.1	10.3	10.6	54.1	104.2
Development Direction	0.8	1.0	1.0	1.0	1.0	5.2	10.0
Airports	11.1	12.3	12.5	12.8	12.9	66.1	127.7
Centralized Training	21.6	26.1	26.5	26.7	26.9	137.4	265.2
Direction, Staff and Support	102.8	128.1	135.2	141.2	147.6	752.6	1,407.5
Total	1,315.1	1,447.7	1,511.9	1,570.9	1,631.7	8,491.4	15,968.7

Figure 3–20. Airport Grant Program Costs Attributable to Safety

Program	Plan (Dollars in Millions)						
	1977	1978	1979	1980	1981	1982–86	1977–86
*Airport Development Aid Program (ADAP)	169.0	169.0	169.0	169.0	169.0	845.0	1,690.0

NOTES: * ADAP costs attributable to safety will be revised as soon as legislation is approved.

SECTION 3. MEETING CAPACITY REQUIREMENTS

315. THE CAPACITY PROBLEM IN PERSPECTIVE.

a. Delays in the 1960's. Throughout the 1960's, the aviation industry experienced major changes. During the early part of the decade, there was accelerated changeover to pure jet aircraft for air carrier and general aviation (business) use. Wide-bodied aircraft were introduced by carriers toward the end of the period. At the same time, demand for services by all classes of users (air carrier, military, and general aviation) continued to increase to the point where, by 1968, the NAS was severely congested and very large delays became common. Figure 3-21 shows delay data compiled by several airlines over the period 1964–1974. Figure 3-22 shows the total annual numbers or aircraft of all classes delayed over 30 minutes from 1968 through 1974, as reported by the FAA's National Airspace Communications System.

b. Improvement in the 1970's. The delays reduced sharply early in the 1970's, principally because of an economic downturn and the introduction of hourly quotas in force during certain hours at Chicago O'Hare, J. F. Kennedy, La Guardia, Newark, and Washington National, and partly as a result of the growing fleet of wide-bodied aircraft. After a significant drop in the first quarter of 1971, the frequency of landings began a renewed ascent toward a peak in the third quarter of 1973, and then, as a result of the fuel crisis, fell sharply again. Figure 3-23 shows the activity level by quarter from the second quarter in 1968, to the second quarter in 1974, for twelve air carriers.

c. Congressional Concern. During 1973, the House Appropriations Committee reported its concern "... that air traffic control delays are again on the upswing and that there is no clear indication of what immediate and near term results may be expected from the Research, Engineering and Development (RE&D) and Facilities and Equipment (F&E) programs to produce the needed increased airport and air traffic control capacity and productivity at major terminals." The FAA was directed "... to report to the Committee regarding the impact it expects its current RE&D and F&E programs to have in producing the needed capacity and productivity increases."

d. FAA Report. In response to this request, eight busy airports (Atlanta, Chicago O'Hare, Denver, Los Angeles, Miami, New York Kennedy, Philadelphia, and San Francisco) were selected for detailed exami-

Figure 3-21. Operations and Operations Delayed as Reported by Four Airlines CY 1964–1974

Year		Airline	Operations Reported [1]	Operations Delayed	Percent of Operations Delayed
1964		UA*	997,724	277,567	22.8
1965		UA	1,081,194	269,331	24.9
1966		AA	640,705	137,096	21.4
		NW	257,848	43,701	16.9
		UA	1,022,186	290,363	28.4
	Total		1,920,739	471,160	24.5
1967		AA	757,768	184,971	24.4
		NW	358,267	86,458	24.1
		UA	1,229,676	397,470	32.3
	Total		2,345,711	668,899	28.5
1968		AA	837,127	246,347	29.4
		NW	399,990	104,563	26.1
		UA	1,310,406	505,069	38.5
	Total		2,547,523	855,979	33.6
1969		AA	821,844	264,142	32.1
		NW	418,683	174,903	41.8
		UA	998,617	446,330	44.7
	Total		2,239,144	885,375	39.5
1970		AA	832,649	238,090	28.6
		UA	1,288,198	—	—
	Total		2,120,847	238,090	
1971		AA	772,725	170,712	22.1
		UA	1,069,314	—	—
	Total		1,842,039	170,712	
1972		AA	724,610	163,024	22.5
		UA	1,104,432	—	—
	Total		1,829,042	163,024	
1973		AA	755,463	200,953	26.6
		TW[2]	452,206	—	—
		UA	1,117,830	—	—
	Total		2,325,499	200,953	
1974[3]		AA	307,588	61,081	19.9
		TW	252,622	—	—
		UA	490,830	—	—
	Total		1,051,040	61,081	—

*UA=United; AA=American; NW=Northwest; TW=Trans World

Source: FAA, Terminal Area Airline Delay Data, 1964–1969, September 1970
FAA, Airline Delay Data, 1970–1974, February 1975

[1] Includes Departure/Arrival.

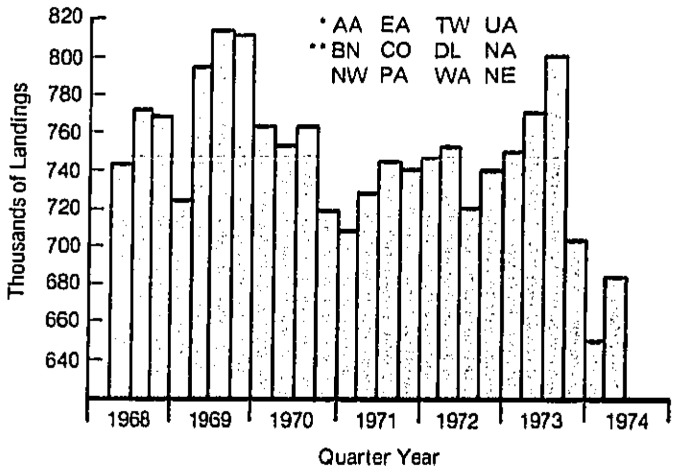
[2] Strike (Full strike from Nov. 5, 1973 to Dec. 18, 1973, partial operations on Dec. 19 and 20, 1973 with resumption of full service on Dec. 21, 1973.)

[3] Six months of 1974 (January/June).

Year	Total Delays
1968 (Last 8 Months)	97,894
1969	106,348
1970	71,959
1971	34,335
1972	36,828
1973	45,907
1974	47,427

Under the FAA NASCOM (National Airspace System Communications) procedure initiated in February 1968, towers and centers report the daily number of aircraft delayed over thirty minutes.

Figure 3-22. NASCOM Delay Summary



AA - American	NE - North East
BN - Braniff	NW - North West
Co - Continental	PA - Pan American
DL - Delta	TW - Trans World
EA - Eastern	UA - United
NA - National	WA - Western

Figure 3-23. 12 Air Carrier
***Four Trunk and **Eight Small Airlines [CAB Form 41 Data]**

nation. The results were published in a two volume "FAA Report on Airport Capacity," in January 1974. The significant findings:

—Nearly two-thirds of all reported delays in the total NAS occur at the eight airports.[1]

—Currently, six of the eight airports experience peak hour IFR airside saturation. (Airside and landside are terms used to denote the operating areas of an airport. Airside includes all aircraft maneuvering areas and landside refers to the ground access and terminal building area.) By 1982, without the provision of planned ATC improvements, all of the airports could experience IFR saturation, and six of the eight could experience VFR saturation.

—The airside lapacity of these airports can be extended, within the present E&D and F&E framework, to meet projected demand for the mid- to late-1980's.

—Under current and proposed plans, most of the surveyed airports will have exceeded their landside capacity limitations before airside saturation is reached. The problems are primarily physical access/egress/parking limitations. The airports surveyed account for a significant percentage of all aircraft delays and experience a wide spectrum of problems that typify large airport operations. It is, therefore, felt that similar problems exist at virtually all of the major U.S. airports.

e. Delay Rankings, 25 Airports. Figures 3-24 thru 3-26 show 25 airports ranked by estimated air carrier delay for 1968, 1969 and 1973. They show that three quarters of all air carrier delays occur at the top 25 airports in any one year and the delay time and cost have risen for each of the years shown. The figures are an extrapolation of data reported by four airlines (Figure 3-23) to the total airports with FAA towers. The top 25 airports include only those airports reported by the airlines.

f. Other Problems Under Review. Beside aircraft delays, other airport problems are under review. Figure 3-27 shows sponsor identified capacity problems at four airports. For the other airports at which no sponsor capacity estimates were provided, a range based on airport size was used. Airport access was frequently identified as a problem.

g. Access. Most airports are provided ground vehicle access through a single major entrance way connected to complex systems of streets, freeways, expressways, and interstate highways. Several have plans for additional access ways and Kennedy, Philadelphia, Atlanta, San Francisco, and O'Hare have active or potential plans for direct rail mass transit facilities.

[1] This study finding is not in agreement with airline reported delay data that indicates these airports account for 46% of delay.

Figure 3-24. Estimated Ranking of High Delay Airports for CY 1968 Air Carrier Delays of 240 Airports with FAA Towers and Receiving Scheduled Air Carrier Service

		Estimated Total Air Carrier Delay							
		Minutes (000)				Cost (000 dollars)			
		Airport		Cumulative		Airport		Cumulative	
Rank by Delay	Arpt Ident.	Number	% of all	Number	% of all	Number	% of all	Number	% of all
1	JFK	3,139.9	16.4	3,139.9	16.4	22,042.1	18.6	22,042.1	18.6
2	ORD	2,476.8	12.9	5,616.7	29.3	15,430.5	13.0	37,472.6	31.6
3	LGA	1,350.5	7.1	6,967.2	36.4	6,239.3	5.3	43,711.9	36.9
4	ATL	913.7	4.8	7,880.9	41.2	5,427.4	4.6	49,139.3	41.5
5	LAX	881.2	4.6	8,762.1	45.8	5,278.4	4.5	54,417.7	46.0
6	EWR	763.2	4.0	9,525.3	49.8	4,281.6	3.6	58,699.3	49.6
7	DCA	693.4	3.6	10,218.7	53.4	3,959.3	3.4	62,658.6	53.0
8	PHL	623.6	3.3	10,842.3	56.7	4,053.4	3.4	66,712.0	56.4
9	MIA	464.1	2.4	11,306.4	59.1	3,620.0	3.1	70,332.0	59.5
10	SFO	449.4	2.3	11,755.8	61.4	2,440.2	2.1	72,772.2	61.6
11	BOS	403.1	2.1	12,158.9	63.5	2,305.7	2.0	75,077.9	63.6
12	DAL	344.6	1.8	12,503.5	65.3	2,208.9	1.9	77,286.8	65.5
13	DTW	297.1	1.6	12,800.6	66.9	2,023.3	1.7	79,310.1	67.2
14	STL	270.2	1.4	13,070.8	68.3	1,640.1	1.4	80,950.2	68.6
15	HOU	229.0	1.2	13,299.8	69.5	1,655.7	1.4	82,605.9	70.0
16	CLE	220.8	1.2	13,520.6	70.7	1,433.0	1.2	84,038.9	71.2
17	PIT	218.9	1.1	13,739.5	71.8	1,282.8	1.1	85,321.7	72.3
18	HNL	178.8	0.9	13,918.3	72.7	1,099.6	.09	86,421.3	73.2
19	BAL	175.9	0.9	14,094.2	73.6	941.1	0.8	87,362.4	74.0
20	MKC	160.1	0.8	14,254.3	74.4	810.1	0.7	88,172.5	74.7
21	MSP	146.1	0.8	14,400.4	75.2	1,306.1	1.1	89,478.6	75.8
22	TPA	137.6	0.7	14,538.0	75.9	932.9	0.8	90,411.5	76.6
23	DEN	132.1	0.7	14,670.1	76.6	675.0	0.6	91,086.5	77.2
24	SEA	112.6	0.6	14,782.7	77.2	846.8	0.7	91,933.3	77.9
25	MSY	107.4	0.6	14,890.1	77.8	547.7	0.4	92,481.0	78.3
Sub Total (25 Airports)		14,890.1	77.8			92,481.0	78.3		
Other (215 Airports)		4,244.6	22.2			25,558.7	21.7		
Grand Total (240 Airports)		19,134.7	100.0			118,039.7	100.0		

Source: FAA, Terminal Area Airline Delay Data 1964–1968, Sept 1969.

Figure 3-25. Estimated Ranking of High Delay Airports for CY 1969 Air Carrier Delays of 251 Airports with FAA Towers and Receiving Scheduled Air Carrier Service

		Estimated Total Air Carrier Delay							
		Minutes (000)				Cost (000 dollars)			
		Airport		Cumulative		Airport		Cumulative	
Rank by Delay	Arpt Ident.	Number	% of all	Number	% of all	Number	% of all	Number	% of all
1	ORD	3,286.6	13.7	3,286.6	13.7	21,691.6	13.7	21,691.6	13.7
2	JFK	2,537.0	10.6	5,823.6	24.3	18,012.7	11.4	39,704.3	25.1
3	LGA	1,660.2	6.9	7,483.8	31.2	8,101.8	5.1	47,806.1	30.2
4	ATL	1,315.1	5.5	8,798.9	36.7	9,363.5	5.9	57,169.6	36.1
5	LAX	1,006.1	4.2	9,805.0	40.9	5,885.7	3.7	63,055.3	39.8
6	EWR	987.9	4.1	10,792.9	45.0	5,858.2	3.7	68,913.5	43.5
7	MIA	774.0	3.2	11,566.9	48.2	6,416.5	4.1	75,330.0	47.6
8	SFO	773.5	3.2	12,340.4	51.4	4,424.4	2.8	79,754.4	50.4
9	PHL	706.9	3.0	13,047.3	54.4	4,842.3	3.1	84,596.7	53.5
10	DCA	669.9	2.8	13,717.2	57.2	4,562.0	2.9	89,158.7	56.4
11	BOS	513.9	2.1	14,231.1	59.3	3,037.1	1.9	92,195.8	58.3
12	DAL	470.8	2.0	14,701.9	61.3	2,744.8	1.7	94,940.6	60.0
13	STL	427.5	1.8	15,129.4	63.1	2,603.5	1.7	97,544.1	61.7
14	DTW	426.3	1.8	15,555.7	64.9	3,282.5	2.1	100,826.6	63.8
15	PIT	372.7	1.5	15,928.4	66.4	2,590.3	1.7	103,416.9	65.5
16	MSP	257.5	1.1	16,185.9	67.5	2,487.5	1.6	105,904.4	67.1
17	CLE	256.5	1.1	16,442.4	68.6	1,810.9	1.2	107,715.3	68.3
18	DEN	236.5	1.0	16,678.9	69.6	1,291.3	0.8	109,006.6	69.1
19	HNL	221.1	0.9	16,900.0	70.5	1,087.8	0.7	110,940.4	69.8
20	TPA	196.9	0.8	17,096.9	71.3	1,630.3	1.0	111,724.7	70.8
21	SEA	187.0	0.8	17,283.9	72.1	1,447.4	0.9	113,172.1	71.7
22	MSY	183.5	0.8	17,467.4	72.9	961.5	0.6	114,133.6	72.3
23	BAL	182.7	0.8	17,650.1	73.7	1,088.9	0.7	115,222.5	73.0
24	HOU	170.2	0.7	17,820.3	74.4	1,121.6	0.7	116,344.1	73.7
25	MKC	165.2	0.7	17,985.5	75.1	887.1	0.6	117,231.2	74.3
Sub Total (25 Airports)		17,985.5	75.1			117,231.2	74.3		
Other (226 Airports)		5,957.2	24.3			40,602.9	25.7		
Grand Total (251 Airports)		23,942.7	100.1			157,834.1	100.0		

Source: FAA, Terminal Area Airline Delay Data 1964–1969, Sept 1970.

Note: Airport Identifiers Decoded for figures 3-24, 25, & 26.

JFK	Kennedy Int'l.
ORD	O'Hare Int'l.
LGA	Laguardia
ATL	Atlanta Hartsfield Int'l.
LAX	Los Angeles Int'l.
EWR	Newark Int'l.
DCA	Washington National
PHL	Philadelphia Int'l.
MIA	Miami Int'l.
SFO	San Francisco Int'l.
BOS	Boston Logan Int'l.
DAL	Dallas (Love)
DTW	Detroit Metropolitan
STL	St. Louis Int'l.
HOU	Houston William P. Hobby
CLE	Cleveland Int'l.
PIT	Greater Pittsburgh Int'l.
HNL	Honolulu Int'l.
BAL	Baltimore-Washington Int'l.
MKC	Kansas City
MSP	Minneapolis-St. Paul Int'l.
TPA	Tampa Int'l.
DEN	Denver Stapleton Int'l.
SEA	Seattle-Tacoma Int'l.
MSY	New Orleans Int'l.
FLL	Fort Lauderdale-Hollywood Int'l.
LAS	Las Vegas McCarran Int'l.

Figure 3-26. Estimated Ranking of 25 High Delay Airports for CY 1973

		Estimated Total Air Carrier Delay							
		Minutes (000)				Cost (000 dollars)			
		Airport		Cumulative		Airport		Cumulative	
Rank by Delay	Arpt. Ident.	Number	% of all	Number	% of all	Number	% of all	Number	% of all
1	ORD	4,159.5	14.2	4,159.5	14.2	26,912.0	13.8	26,912.0	13.8
2	ATL	3,148.7	10.8	7,308.2	25.0	29,597.8	15.2	56,509.8	29.0
3	JFK	1,998.4	6.8	9,306.6	31.8	16,346.9	8.4	72,856.7	37.3
4	LGA	1,581.4	5.4	10,888.0	37.2	8,903.3	4.6	81,760.0	41.9
5	SFO	939.4	3.2	11,827.4	40.4	5,833.7	3.0	87,593.7	44.9
6	LAX	898.4	3.1	12,725.8	43.5	6,207.9	3.1	93,801.6	48.1
7	DEN	814.4	2.8	13,540.2	46.2	4,943.4	2.5	98,745.0	50.6
8	PHL	811.4	2.8	14,351.6	49.0	5,168.6	2.7	103,913.6	53.2
9	EWR	768.9	2.6	15,120.5	51.6	5,167.0	2.6	109,080.6	55.9
10	MIA	757.2	2.6	15,877.7	54.2	4,694.6	2.4	113,775.2	58.3
11	DAL	711.2	2.4	16,588.9	56.6	4,722.4	2.4	118,497.6	60.7
12	DCA	697.1	2.4	17,286.0	59.0	3,757.4	1.9	122,255.0	62.6
13	PIT	604.6	2.1	17,890.6	61.1	3,676.0	1.9	125,931.0	64.5
14	BOS	479.2	1.6	18,369.8	62.7	3,440.7	1.8	129,371.7	66.3
15	CLE	463.9	1.6	18,833.7	64.3	2,741.6	1.4	132,113.3	67.7
16	DTW	394.0	1.4	19,227.7	65.7	2,675.3	1.4	134,788.6	69.0
17	MSY	381.4	1.2	19,609.1	66.9	1,919.0	1.0	136,707.6	70.0
18	LAS	345.5	1.2	19,934.6	68.1	2,135.2	1.1	138,842.8	71.1
19	HNL	340.3	1.2	20,274.9	69.2	3,311.1	1.7	142,153.9	72.8
20	STL	282.5	1.0	20,557.4	70.2	1,949.3	1.0	144,103.2	73.8
21	FLL	269.4	0.9	20,826.8	71.1	1,435.9	0.7	145,539.1	74.6
22	TPA	246.3	0.8	21,073.1	72.0	1,416.2	0.7	146,955.3	75.3
23	MSP	241.7	0.8	21,314.8	72.8	1,288.3	0.7	148,243.6	75.9
24	SEA	217.0	0.7	21,531.8	73.5	1,538.5	0.8	149,782.1	76.7
25	BAL	198.7	0.6	21,730.5	74.2	1,277.6	0.6	151,059.7	77.4
Sub Total (25 Airports)		21,730.5	74.2			151,059.7	77.4		
Other (252 Airports)		7,561.4	25.8			44,179.0	22.6		
Grand Total (277 Airports)		29,291.9	100.0			195,238.7	100.0		

Source: FAA, Airline Delay Data 1970-1974, Feb 1975.

Figure 3-27. Access/Egress/Landside Limitations

	AIRPORT	ESTIMATED MAX ENPLANEMENTS	SATURATION* (FAA DEMAND)	SPONSOR IDENTIFIED LIMIT
SPONSOR ESTIMATES	NEW YORK (JFK/LGA/EWR)	50 M	1984 (20M/14M/14M)	ACCESS
	O'HARE	27 M	1985	TERMINAL BLDGS, ACCESS MAY LIMIT SOONER
	LOS ANGELES	15 M (W/O FREEWAYS) 19 M (W/ FREEWAYS+)	1978 1982	ACCESS, ENVIRONMENT
	SAN FRANCISCO	12 M (W/O TRANSIT) 15.5 M (W/TRANSIT)	1977 1981	ACCESS, MASS TRANSIT
SIZE ESTIMATES	DENVER	12 M—15 M	1981—1984	CONTINUING AIRSIDE
	PHILADELPHIA	12 M—15 M	1990—1995	POSSIBLE AIRSIDE
	MIAMI	12 M—15 M	1982—1986	ACCESS
	ATLANTA	25 M—30 M	1984—1988	POSSIBLE AIRSIDE

Source: FAA Report on Airport Capacity—January 1974.
*FAA Forecasts have been revised downward since the report so the saturation time table will slip by a year or two in several instances. It may still be used for comparative purposes.

h. Landside Capacity. Landside (terminal) capacity represents a potential ultimate limitation to growth at airports. Many sites have plans for major expansion of the terminal complex (Newark recently completed building a new complex); others have lesser plans. Although cursory observation seems to indicate that airports such as Kennedy and La Guardia may have reached the limits of terminal building expansion, a recent study at La Guardia indicates there are alternatives available to increase access and landside capacity at highly developed locations.

i. Airside Problems. Airside problems are directly related to airfield configuration. One of the major limiting factors is the runway/taxiway acceptance rate, but problems are also related to apron parking space, gate availability, or inefficient use of existing facilities.

j. Airspace Problems. Airspace delays, terminal and enroute, are primarily caused by weather that limits airport acceptance to the state of the art of navigational aids. Another cause of terminal airspace delay is the increased separation required because of the presence of potentially dangerous, high-energy wake vortices generated by large aircraft—particularly wide-bodied aircraft. Still other contributing factors include noise restrictions that require use of inefficient flight patterns; improper design, location, and use of high-speed taxiways; temporary runway closures or other major construction; and airline scheduling to satisfy demand for service during prime morning or evening hours.

k. New Sites. Despite planned improvements, new airports will be needed eventually to sustain further system growth. Sites are under consideration at various places including Atlanta, St. Louis, New York, Los Angeles (Palmdale) and Miami. In some cases new sites have already been acquired while elsewhere redevelopment of existing military sites is a possibility. Federal funding will not be provided for new airports until environmental, social, and economic impacts of development are fully explored.

l. Follow-On Surveys. As various capacity problems discussed above were made apparent by the eight-airport study, follow-on detailed surveys of major airports began. To date, surveys of Chicago Midway (July 1974) and New York La Guardia (March 1975) have been published, and work or planning is underway to cover as many as 25 major hub areas that may include up to 100 airports. Perhaps the most significant effect of the completed and ongoing studies is that the FAA, heretofore primarily concerned with developing systems to handle forecasted airspace and airside demand, is now viewing all elements including access/egress and landside to determine what must be accomplished to assure balanced system growth.

m. Recapitulation. All data indicate the problems exist primarily at major hub areas, with four airports—O'Hare, Atlanta, Kennedy and La Guardia—accounting for approximately 40 percent of all delays. Beyond the major hubs, delays are related to a few site-specific problems rather than to the general system-wide capacity constraints that exist at the busiest airports. The main aviation system problems are:

—Access/Egress. Access to airports is limited by inadequate roadway capacity and lack of convenient mass transit facilities.

—Landside. Congested and poorly designed passenger and baggage processing facilities (including curb and parking space) result in inconvenience and delay.

—Airside. Runway, taxiway, apron and gate acceptance rates are incapable of handling current or forecast peak-hour demand.

—Airspace. Terminal area delays are directly related to airport acceptance rates but also to navigational aid limitation, arrival/departure procedures and separation standards required to avoid wake vortices. Enroute capacity is also affected by terminal acceptance rates, but other problems are the result of separation required by navigational aid limitations (especially on the busy city-pair or oceanic routes).

316. CURRENT LEVELS AND TRENDS.

a. Current Levels. The actual operations recorded by Air Route Traffic Control Centers and Air Traffic Control Towers from 1965 to 1975 (Figures 3–28 through 3–30) show an 84 percent increase in aircraft handled by Centers and a 58 percent increase for tower operations. Significant growth was experienced for the first five years; then there was a leveling trend. Instrument (IFR) flight by general aviation recorded by centers and towers increased by 286 percent (since 1965) and 258 percent (since 1968), respectively. This illustrates the impact that increasing use of business jets and other well-equipped privately-owned aircraft are having on the NAS.

b. Forecasts. Because of the fuel crisis and the economic slowdown, the latest FAA forecasts (Figures 3–31 through 3–33) show reduced growth compared to projections published in the past few years. Even so, it is estimated that operations at airports with towers will double the present level by FY 1987, principally because of growth in general aviation.

Figure 3–28. Major Measures of Air Traffic Activity at FAA Facilities, by Aviation Category—Calendar Years 1965–1975

Workload measure	Year	Total: Number	Total: Percent Annual change	Air carrier: Number	Air carrier: Percent Of total	Air carrier: Percent Annual change	Air taxi: Number	Air taxi: Percent Of total	Air taxi: Percent Annual change	General aviation: Number	General aviation: Percent Of total	General aviation: Percent Annual change	Military: Number	Military: Percent Of total	Military: Percent Annual change
IFR Aircraft Handled at Enroute Centers	1975	23,017,503	+2	12,050,822	52	—	1,403,921	6	+17	5,708,531	24	+7	4,254,229	18	−2
	1974	23,146,079	−1	12,261,071	53	−4	1,197,894	5	+23	5,321,901	23	+8	4,364,213	19	−6
	1973	23,346,832	+6	12,823,227	55	+4	976,334	4	+19	4,920,964	21	+16	4,628,307	20	−1
Aircraft	1972	22,062,529	+2	12,316,169	56	−3	819,702	4	—	4,241,374	19	—	4,685,284	21	−2
Handled	1971	21,683,038	+1	12,657,587	53	−4	—	—	—	4,246,494	20	+15	4,778,957	22	+7
(=2X	1970	21,404,869	−1	13,215,456	62	−1	—	—	—	3,705,664	17	+7	4,483,747	21	−5
Departures	1969	21,571,306	+11	13,351,862	62	+13	—	—	—	3,473,213	16	+17	4,746,231	22	+3
plus Overs)	1968	19,383,097	+17	11,807,148	61	+21	—	—	—	2,963,091	15	+20	4,612,858	24	+5
	1967	16,719,762	+18	9,876,049	59	+26	—	—	—	2,469,034	15	+22	4,374,669	26	+1
	1966	14,096,947	+10	7,757,339	55	+14	—	—	—	2,021,217	14	+37	4,317,391	31	−5
	1965	12,859,018	+10	6,826,942	53	+14	—	—	—	1,470,695	11	+34	4,552,381	35	−1

Source: FAA Air Traffic Activity CY 1975, March 1976.

Figure 3-29. Major Measures of Air Traffic Activity at FAA Facilities, by Aviation Category—Calendar Years 1965-1975

		Total		Air carrier			Air taxi			General aviation			Military		
			Percent		Percent			Percent			Percent			Percent	
Workload measure	Year	Number	Annual change	Number	Of total	Annual change	Number	Of total	Annual change	Number	Of total	Annual change	Number	Of total	Annual change
Aircraft Operations at Control Towers															
Total	1975	59,962,468	+4	9,223,556	15	—	2,752,346	5	+7	45,297,055	76	+5	2,689,511	4	−3
	1974	57,687,516	+2	9,202,726	16	−7	2,582,218	4	+16	43,123,407	75	+4	2,779,165	5	−9
	1973	56,553,953	+6	9,922,044	18	+2	2,227,945	4	+9	41,363,042	73	+8	3,040,922	5	−9
	1972	53,255,919	−1	9,698,397	18	−1	2,042,068	4	—	38,171,922	72	−5	3,343,532	6	−5
	1971	53,702,396	−3	9,791,525	18	−6	—	—	—	50,000,593	75	−2	3,510,278	7	—
	1970	55,280,498	−2	10,393,294	19	−5	—	—	—	41,384,006	75	−1	3,503,198	6	+5
	1969	56,231,821	+2	10,929,013	19	+5	—	—	—	41,956,677	75	+1	3,346,131	6	—
	1968	55,292,005	+11	10,377,089	19	+11	—	—	—	41,564,024	75	+12	3,350,892	6	+1
	1967	49,886,840	+11	9,350,960	19	+14	—	—	—	37,222,622	74	+11	3,304,258	7	—
	1966	44,952,816	+19	8,206,322	18	+5	—	—	—	33,445,126	75	+28	3,301,368	7	−5
	1965	37,870,535	+11	7,819,111	21	+5	—	—	—	26,572,650	70	+15	3,478,771	9	−7

Source: FAA Air Traffic Activity CY 1975, March 1976.

Instrument operations at these airports will rise by 92 percent by 1987, and IFR traffic at centers is expected to increase by 67 percent by the same year. Indeed, except for military traffic, it is expected that operations by all classes of users will increase significantly by FY 1987—air carriers by 52 percent, general aviation by 140 percent.

317. AIRCRAFT DELAY LEVELS—PRESENT AND FORECAST.

a. Delay Times Increase. Congestion-related delays at most high activity airports during 1974 averaged three to 4.2 minutes per operation. The upper level represents a slight increase over the estimated 3.26 minutes average delay per operation in 1973.

b. Causes of Delays. As Figure 3-34 shows, a summary of system-wide delays for 1972 to 1974 indicates that 63.5 percent to 89.4 percent of delays are caused by weather problems such as ice and snow (9.5 percent to 20.9 percent), thunderstorms (14.8 percent to 21.2 percent), wind (7.4 percent to 20.9 percent), and conditions below current landing minimums (14.7 percent to 17.4 percent). Traffic volume contributed to 2.7 percent to 14.7 percent of system-wide delay time, but its impact is generally limited to a few busy hubs. It is currently estimated that approximately 40 percent of delays (weather and others) can be reduced by airport and ATC system improvements, use of secondary airports and upgrading existing or building new airports.

c. Delay a Continuing Problem. Delay at major hubs is expected to remain a problem because of forecasted growth, even though many new FAA programs are designed to reduce delay. Capacity at the top 10 or so airports is already a problem, and even modest growth will worsen the situation.

318. AIRCRAFT DELAY COSTS—PRESENT AND FUTURE.

Delays are estimated to have cost air carriers between $382 and $529 million in 1974 and could exceed $1.0 billion by 1980 and $1.5 billion by 1985. These costs will significantly decrease the economic viability of commercial service unless sizeable capacity increases are made.

Figure 3-30. Major Measures of Air Traffic Activity at FAA Facilities, by Aviation Category—Calendar Years 1965–1975

Workload measure	Year	Total		Air carrier			Air taxi			General aviation			Military		
			Percent		Percent			Percent			Percent			Percent	
		Number	Annual change	Number	Of total	Annual change	Number	Of total	Annual change	Number	Of total	Annual change	Number	Of total	Annual change
Instrument Operations at towers RAPCONS and RATCCS [1]															
Total	1975	26,784,405	+7	9,352,645	35	—	1,993,817	7	+19	11,642,927	44	+17	3,795,016	14	−3
	1974	25,016,487	+4	9,373,988	37	−5	1,674,261	7	+30	9,928,979	40	+15	4,039,259	16	−4
	1973	24,001,342	+17	9,896,752	41	+4	1,289,311	5	+31	8,624,596	36	+44	4,190,683	18	+3
	1972	20,586,111	+13	9,561,559	46	+1	986,687	5	—	5,986,107	29	+16	4,051,758	20	+11
	1971	18,260,913	+6	9,426,213	52	−2	—	—	—	5,174,088	28	+20	3,660,612	20	+11
	1970	17,214,460	+1	9,619,331	56	−4	—	—	—	4,297,776	25	+10	3,297,353	19	+3
	1969	17,079,335	+8	9,968,981	58	+8	—	—	—	3,899,840	23	+20	3,210,514	19	−2
	1968	15,770,142	+17	9,236,132	—	—	—	—	—	3,250,178	21	—	3,283,832	21	—
	1967	13,453,940	+20	—	—	—	—	—	—	—	—	—	—	—	—
	1966	11,199,452	+9	—	—	—	—	—	—	—	—	—	—	—	—
	1965	10,291,464	+13	—	—	—	—	—	—	—	—	—	—	—	—
Instrument Approaches	1975	1,858,522	+2	772,817	42	−1	194,832	10	+9	765,868	41	+2	125,187	7	+2
	1974	1,828,431	−1	780,881	43	−9	178,480	10	+9	747,131	41	+6	121,939	7	−5
	1973	1,854,847	+2	855,952	46	−5	163,821	9	+13	706,845	38	+11	128,229	7	−6
	1972	1,815,486	+14	897,608	49	+9	145,000	8	—	636,484	35	+2	136,394	8	−10
	1971	1,596,282	−5	822,157	51	−9	—	—	—	622,354	39	+2	151,771	10	−11
	1970	1,683,579	−5	902,081	54	−8	—	—	—	610,156	36	+4	171,342	19	+3
ARTC Centers (includes Approach Control Facilities)	1969	1,763,228	+15	980,429	56	+17	—	—	—	587,953	33	+20	194,846	11	−11
	1968	1,527,272	+7	837,497	55	+4	—	—	—	471,223	31	+20	218,552	14	−7
	1967	1,432,533	+18	805,747	56	+21	—	—	—	392,912	28	+20	233,874	16	+3
	1966	1,218,069	+7	664,423	54	+7	—	—	—	326,578	27	+23	227,068	19	−9
	1965	1,134,463	+13	620,645	55	+10	—	—	—	265,177	23	+28	248,641	22	+6
Approach Control Facilities	1975	1,676,825	+1	729,165	44	−1	166,414	9	+9	665,450	40	+2	115,796	7	+3
	1974	1,654,287	−3	734,165	44	−10	152,650	9	+7	655,060	40	+4	112,412	7	−6
	1973	1,705,423	+2	812,068	48	−5	142,245	8	+12	631,410	37	+11	119,700	7	−5
	1972	1,673,814	+12	852,012	51	+9	126,875	8	—	669,442	34	—	125,485	7	−13
	1971	1,490,482	−6	778,770	52	−9	—	—	—	668,071	38	+1	143,641	10	−14
	1970	1,585,873	−4	857,127	54	−7	—	—	—	562,611	36	+4	166,135	10	−10
	1969	1,653,796	+16	925,484	56	+17	—	—	—	538,860	33	+26	189,452	11	−11
	1968	1,427,383	+6	787,731	55	+4	—	—	—	426,917	30	+19	212,735	15	−7
	1967	1,343,181	+18	757,785	56	+22	—	—	—	357,464	27	+20	227,932	17	+3
	1966	1,142,440	+8	622,426	55	+8	—	—	—	298,395	26	+23	221,819	19	−8
	1965	1,059,143	+13	577,072	54	+10	—	—	—	241,725	23	+29	240,346	23	+9

[1] RAPCON = Radar Approach Control (USAF).
RATCC = Radar Air Traffic Control Center (USN) recently changed to RATCF (Facility).

Source: FAA Air Traffic Activity CY 1975, March 1976.

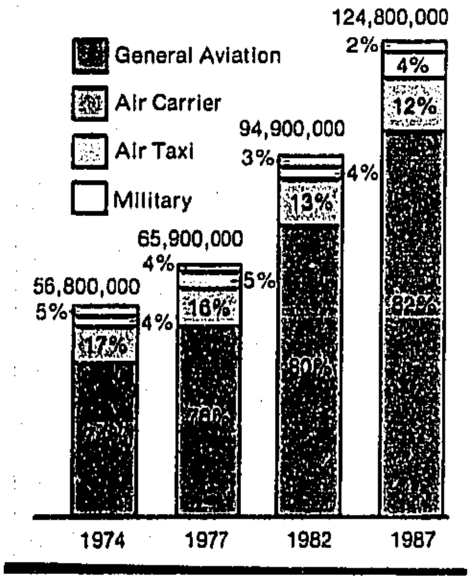


Figure 3-31. Total Aircraft Operations at Airports with FAA Traffic Control Service
Note: Percentages May Not Total 100 Due to Rounding.

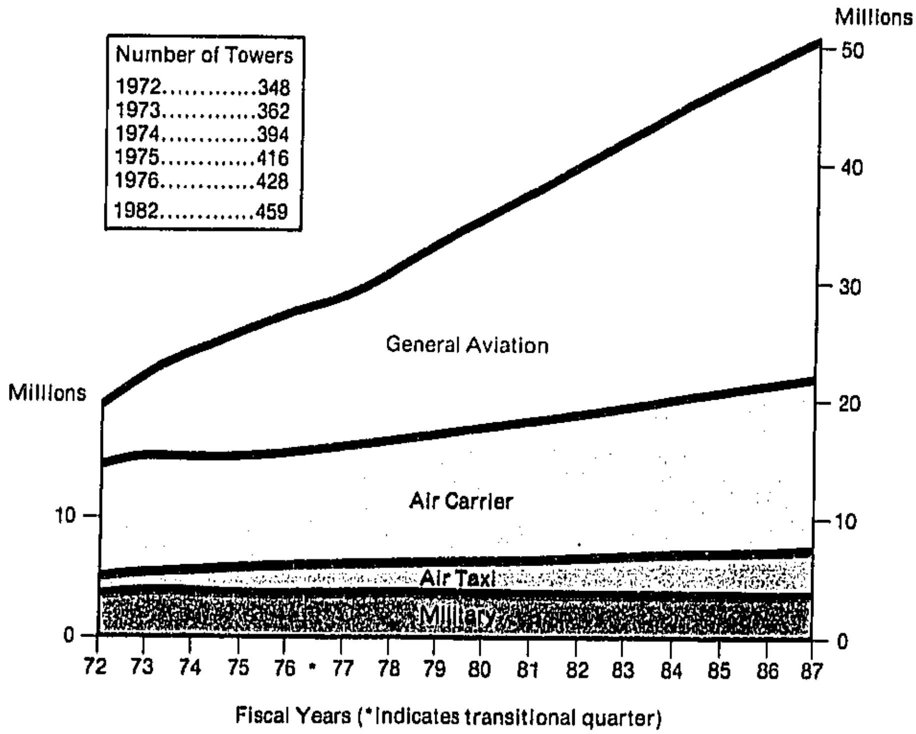


Figure 3-32. Instrument Operations at Airports with FAA Traffic Control Service

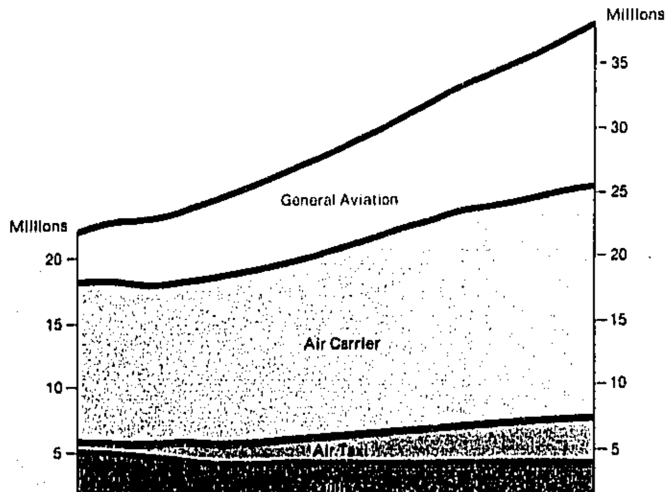


Figure 3–33. IFR Aircraft Handled by FAA Air Route Traffic Control Centers

	1972	1973	1974
Weather			
— Non-Specific	7.7%	5.8%	2.0%
— Below Minimums	17.4%	16.9%	14.7%
— Low Ceiling/Visibility	12.6%	14.6%	8.5%
— Thunderstorms	17.3%	14.8%	21.2%
— Snow and Ice	20.9%	9.5%	9.7%
— Wind	13.5%	12.3%	7.4%
Weather Total	89.4%	73.9%	63.5%
Airport and Runway Closure	3.2%	14.1% 1/	14.6% 2/
FAA Equipment	2.9%	5.5%	5.6%
Power	—	0.2%	0.3%
Traffic Volume	2.7%	4.6%	14.3% 3/
Various	1.8%	1.7%	1.7%
Total	100.0%	100.0%	100.0%

1/ Increase in delays due largely to repairs at Atlanta and O'Hare.

2/ Mostly runway repairs at O'Hare.

3/ Primary increase caused by the introduction of a more refined method of cause identification, which caused a shift in percent delays from weather to traffic volume related cause factors.

Figure 3–34. NASCOM Causal Summary of Delays (System-Wide)

319. DEMAND PROFILES—PRESENT AND FORECAST.

a. Possible Profile Changes. The hourly passenger and aircraft demand profiles have tended to remain the same from year to year, with highest demand during early morning and early evening hours at many airports within commuting time of other cities. These profiles are expected to change as a result of increasing congestion or imposed hourly quotas at busier points. For example, the May 1975 demand profiles at O'Hare and Washington National in Figure 3-35 and 3-36 show flights spread fairly evenly throughout the daylight hours. This effect may be experienced at other airports in the future.

b. General Aviation Demand. General aviation system demand may be altered because of general economic conditions and enactment of proposals to increase user charges. However, fairly substantial growth is expected under most circumstances.

c. Use of Larger Aircraft. Another factor, specifically affecting demand on landside and access facilities, is the increased use of larger aircraft with greater seating capacity. Each carrier is expected to obtain progressively larger aircraft, reduce first class sections to increase seating capacity in coach sections, and increase the number of flights.

d. Socio-Economic Changes. Still other potential major influences on future systems demands are the expected changes in the socio-economic characteristics of the population (Figures 3–37 and 3–38). These changes include a larger percentage of people in the travelling age group, 25-55, after 1980, and an increasing white collar workforce with higher discretionary income.

320. ENVIRONMENTAL CONSTRAINTS.

The 1975–1976 edition of the FAA Environmental Plan, published separately, describes the FAA environmental policy and delineates a five-year program designed to implement that policy. The following is a brief discussion of the problems as they impact on system capacity. A more detailed discussion of the environmental program is contained in the environmental section of this chapter.

a. Negative Effects on Capacity. Concern for existing and potential noise problems has resulted in delay or stoppage in expansion of existing airports or development of new airports. Decisions regarding such projects have, at times, rested almost entirely on environmental considerations. Even at existing airports, noise complaints and legal suits are having negative effects on capacity. In some cases, any development that would increase traffic or allow operations of larger aircraft is opposed; in other areas, special flight patterns are imposed for arriving and departing aircraft specifically to reduce noise impact on populated areas. Such restrictions may negate any

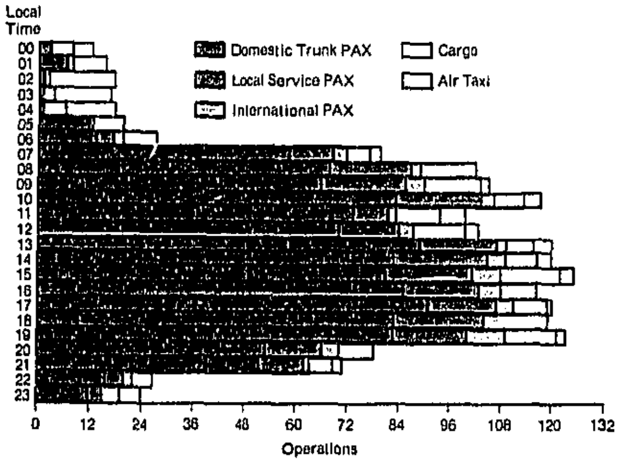


Figure 3-35. Chicago, Ill. ORD Scheduled Operations by Hour Friday—May 2, 1975

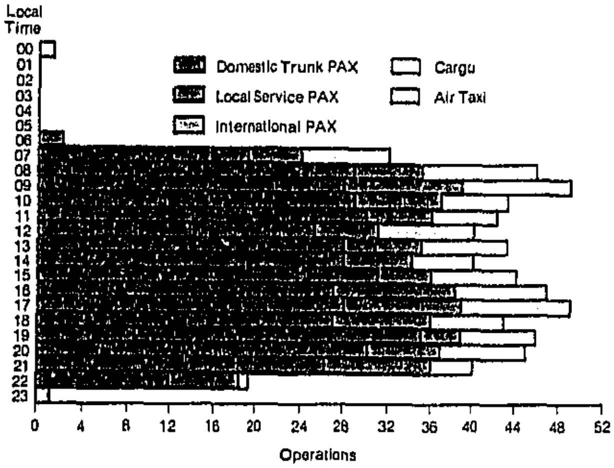


Figure 3-36. Washington/Baltimore, D.C., Md., Va. DCA Scheduled Operations by Hour Friday—May 2, 1975

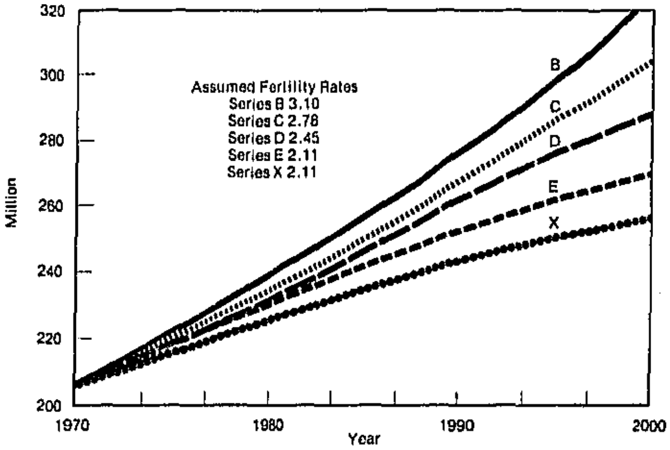


Figure 3-37. U.S. Census Population Projections, 1970–2000

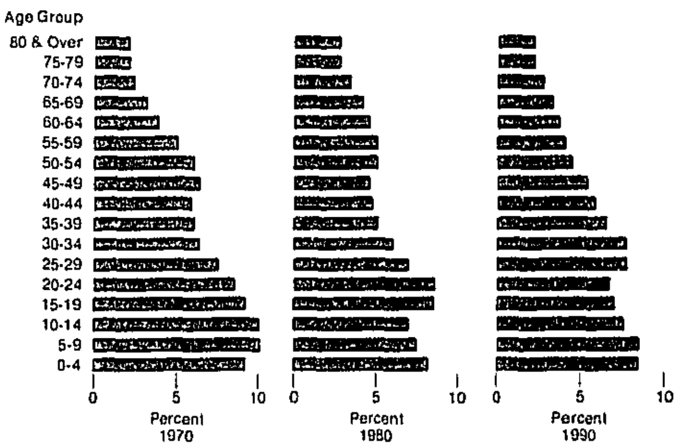


Figure 3-38. Population Age Distribution Nationwide, 1970, 1980, 1990 (Series D)

Figure 3–39. Capacity Measures of National Aviation System

System Element	Responsible Authority	Capacity Measure	Overload Result
ACCESS/EGRESS			
Private Vehicles	Local government, transportation industry, Federal Highway Admin.[1]	Vehicles/passengers handled.	Passenger delay and inconvenience.
Mass Transit Facilities	Airport owner, transportation industry, Urban Mass Trans. Admin., Local government.	Space and seats available.	Congestion and passenger delay.
LANDSIDE			
On-airport Access/Egress	Airport owner, Fed. Aviation Admin., transportation industry, Local government.	Vehicles/passengers handled, curb space.	Passenger delay.
Auto Parking	Airport owner, concessionaire.	Space available.	Congestion and passenger delay.
Passenger Processing			
Ticketing	Airport owner, airlines.	Curb and counter space.	Passenger delay.
Baggage	Airport owner, airlines.	Curb and counter space, baggage transport facility.	Passenger delay.
Security Check	Airport owner, airlines, FAA.	Availability and efficiency of facilities.	Passenger delay.
Gate (Apron at General Aviation fields)	Airport owner, airlines.	Availability and efficiency of facilities.	Passenger delay.
Passenger Services (Pilot Services at General Aviation Airports)			
Car Rental	Airport owner, concessionaire.	Facilities and vehicles available.	Loss of service.
Restaurants	Airport owner, concessionaire.	Space, seats, employees available.	Passenger delay or loss of service.
Rest Rooms	Airport owner.	Space and facilities available.	Congestion and passenger delay.
Shops	Airport owner, concessionaire.	Space and facilities.	Congestion and passenger delay or loss of service.
Waiting Room	Airport owner, airlines/general aviation fixed base operation (FBO).	Space and seats available.	Congestion.
Cargo Facilities			
Cargo Terminal	Airport owner, airlines/general aviation FBO.	Space available.	Degradation or loss of service.
AIRSIDE FACILITIES			
Aircraft	Airlines/general aviation.	Seats available.	Loss of service.
Apron Areas	Airport owner, FAA/general aviation FBO.	Size and efficiency of facilities.	Congestion and delay.
Taxiways	Airport owner, FAA.	Acceptance rate.	Operational delay.
Runways	Airport owner, FAA.	Acceptance rate.	Operational delay.
AIRSPACE			
Terminal Arrival/Departure	FAA, local zoning authorities, airlines, general aviation (pilots).	Traffic control routes and procedures and navigation aid capability.	Operational delay, rerouting.
Enroute	FAA, airlines, general aviation (pilots).	Traffic control routes and procedures and navigation aid capability.	Operational delay, rerouting.

[1] Federal Involvement, excluding ATC and NAVAIDS, is limited by eligibility requirements of grant and certification programs.

capacity gains expected from an improved air traffic control system.

b. Other Restrictions. Other restrictions placed on operations and reducing total airport capacity are the imposition of a curfew, bans on jet aircraft, and limitations on numbers of operations. Some of these restrictions may be in the form of a mutual agreement between airport operators and airlines for curtailment of flights during late night hours or restricting operations to certain runways at night under certain meteorological conditions. Alternatively, these restrictions may be unilaterally imposed by the airport operator. The need for continued growth of an environmentally compatible air transportation system indicates the urgent need to consider alternative methods for increasing capacity of existing sites, wider use of noise abatement flight procedures, plus land purchases and zoning to ensure compatible development around airports.

321. CAPACITY MEASUREMENT.

a. Complexity. The capacity of the National Aviation System, broadly defined, is its ability to process people, cargo, and equipment efficiently. Accommodation of demand requires the identification of the many interrelated elements comprising the system and development of specific methods for determining and increasing their capacity. Figure 3–39 shows the complexity of the system and the many organizations that must function together to achieve necessary improvements.

b. Effects of Changes. Obviously, a change in any area can have serious consequences on other system elements. This was illustrated by the effect of the introduction of wide-bodied aircraft that reduced total operations for several years, but contributed to severe capacity problems in practically all areas:

—Runway acceptance rates were reduced due to generation of wake turbulence.

—Taxiways and aprons had to be reconfigured and strengthened.

—Gate facilities and mobile lounges required remodeling to serve higher cabin entrances.

—Increased passenger volume of several closely spaced flights placed heavy strain on all access/egress, processing, and service facilities.

c. Service Improvements Needed. Any improvements in capacity in any area must also be concerned with improving service to individuals. The identification and measurement of such service is difficult since it relates to quality and quality by its nature is subjective. However, a minimum level of service at carrier or general aviation airports must be maintained or acceptance of the facility will be limited. There are service measurements in use by highway departments and others responsible for planning transportation facilities, but these are not applicable to all facilities comprising the airport system. Recent FAA sponsored landside capacity studies have discussed level of service measurements; this work is expected to lead eventually to publication of relevant guidelines.

d. Improvement Means Available to FAA. The latest legislative proposals to extend the airport grant-in-aid program have included provisions for improving public use portions of terminal areas, but until the proposals are enacted into law, the FAA is limited to other means of fostering landside improvements. These may include withholding grant funds for airside development that is not matched by landside capacity improvements; adding level of service requirements in the airport certification program; dissemination of studies and planning guides emanating from the newly instituted landside program; increasing involvement in Department-wide intermodal planning groups; and coordination with other government agencies involved in passenger processing, such as customs and immigration. Regardless of method applied, direct or indirect, all capacity improvements must ultimately consider user time, comfort, cost, and convenience in some measureable form.

322. CAPACITY ASSESSMENT. Agency efforts have been directed primarily toward developing capacity criteria for airside facilities. However, the need for system-wide improvement requires assessment of all major system components: access/egress, landside, airside and airspace (terminal and enroute).

323. ACCESS/EGRESS AT MAJOR AIRPORTS

a. No Single Solution. No one mode of transportation will solve the airport access/egress problems. Presently, the roadway is the major means of access, but space limitations require consideration of rail, subway, and other alternatives, including helicopter and short takeoff and landing craft operating away from major airports. Several cities, such as Brussels, Tokyo, and Cleveland, have rapid rail transit systems and others have studied, proposed, or plan to inaugurate train service between the city center and the airport. In the meantime, highway traffic to many metropolitan airports continues to be congested. The problem continues to be studied, with responsibility for solutions being passed from one authority to another without affirmative action. Figure 3–40 shows passenger modes of transportation at airports served by highways.

b. Ground Travel Time a Problem. The airport access/egress problem is highlighted by two surveys conducted by the Federal Highway Administration in 1968 and 1972. The findings were published in a December 1972 DOT Report, Air Passenger Trip Travel Times, Ground and Air, 1968 and 1972. It reported that ground travel time to many airports is the same today as it was in the 1940's, and, for major airports, predicted travel will worsen unless improvements are made to access facilities. The ground travel coupled with other time-consuming actions, such as parking, ticketing, security, boarding, and holding for takeoff, may account for a significant portion of the total trip time. Another finding showed that travel during peak periods at some locations was 60 to 70 percent greater than off-peak travel.

c. Some Improvements. At large hubs, travel during peak periods was reduced by eight percent between 1968 and 1972, and ranged in 1972 from a low of 11 minutes at Miami to 50 minutes at Kennedy. The Miami figure was cut from 24 to 11 minutes (54 percent) by the opening of the eight-lane East-West Expressway after the 1968 study. For medium hubs, half showed improvement for an overall reduction of eight percent. Travel for the 31 medium hubs in the study ranged from a low of 8.8 minutes at Omaha to 30 minutes at Hartford. Tulsa registered the greatest improvement (40 percent) with driving time down from 26.2 to 15.6 minutes after the opening of Interstate 244 and the Gilcrease Freeway.

Figure 3–40. Passenger Modes of Ground Transportation

Category	Description of Category	Number of Passengers/ Vehicle	Number of Visitors/ Vehicle	Percent Departing Passengers	Percent Arriving Passengers
1	Cabs, buses, and limousines.	1.3	0.0	60	60
2	Private auto drops departing passenger at curb.	1.3	0.0	15	—
3	Private auto parked with visitor and departing passenger.	1.3	2.6	10	—
4	Private auto parked and picked up by passenger.	1.3	0.0	15	15
5	Private auto parked by visitors meeting arriving passenger.	1.3	2.6	—	25
				100	100

Sources: DOT, Office of High Speed Ground Transportation (1968), Massachusetts Department of Transportation (1972), Los Angeles Department of Airports (1968).

d. Possible Effect on Commuter Travel. When total air/ground trip time (Figures 3–41 through 3–48) for short-haul flights (under 500 miles) was considered, several city-pairs showed greater trip time in 1972, compared with 1968. Among them were New York-Boston, Los Angeles-San Diego, Baltimore-New York, Boston-Philadelphia and Cleveland-New York. *In the short-haul markets, ground travel time frequently accounted for one-half to two-thirds of the total trip time.* For medium-haul trips (500–1,000 miles), ground time accounted for one-forth to one-third of air/ground time; for long-haul trips (more than 1,000 miles), it was one-fifth to one-fourth of the total. Since all forecasts point to increased demands on access facilities, improvements are necessary for acceptable levels of service. The total travel time statistics for the short-haul market indicate that other transportation modes, if designed to provide reasonable levels of service between city centers at low cost, could replace commuter flights from several major airports.

324. AIRPORT LANDSIDE.

a. Landside Criteria Under Development. Although there has been extensive work over many years toward developing and improving airside criteria, development of detailed FAA landside capacity criteria is in initial stages. In April, 1975, FAA cosponsored landside capacity workshops attended by transportation experts from government, industry, and universities as a first step toward attaining useful information on landside capacity problems, capacity definitions, and identifying means for instituting necessary improvements. Although the landside problems are complicated by the existence of many more varied components than on the airside, eventual achievement of capacity measurement and modeling is expected.

b. Factors Affecting Capacity. The capacity of each of the on-airport landside components, access/egress, parking, terminal building, and gates is affected by several factors:

—Arrival/departure method, rate, reason, and time.

—Total occupancy time of parking facilities, terminal building, apron, and gate facilities.

—Space available for facilities.

—Compatibility and accessibility of facilities (locations, driving and walking distances, gate/aircraft compatibility).

—Maximum acceptable delay at particular facilities (level of service).

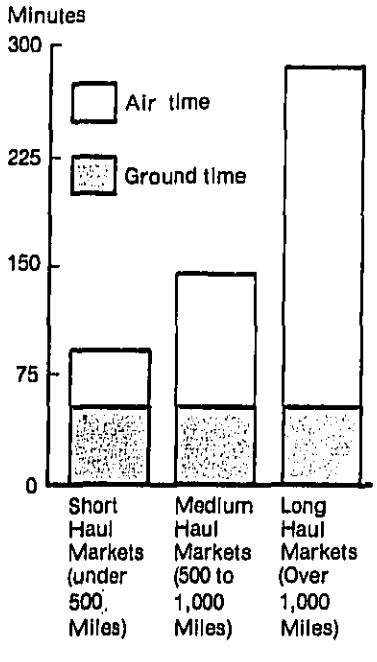


Figure 3–41. Average Ground and Air Travel Times for Short, Medium and Long-Haul Trips, Summer 1972

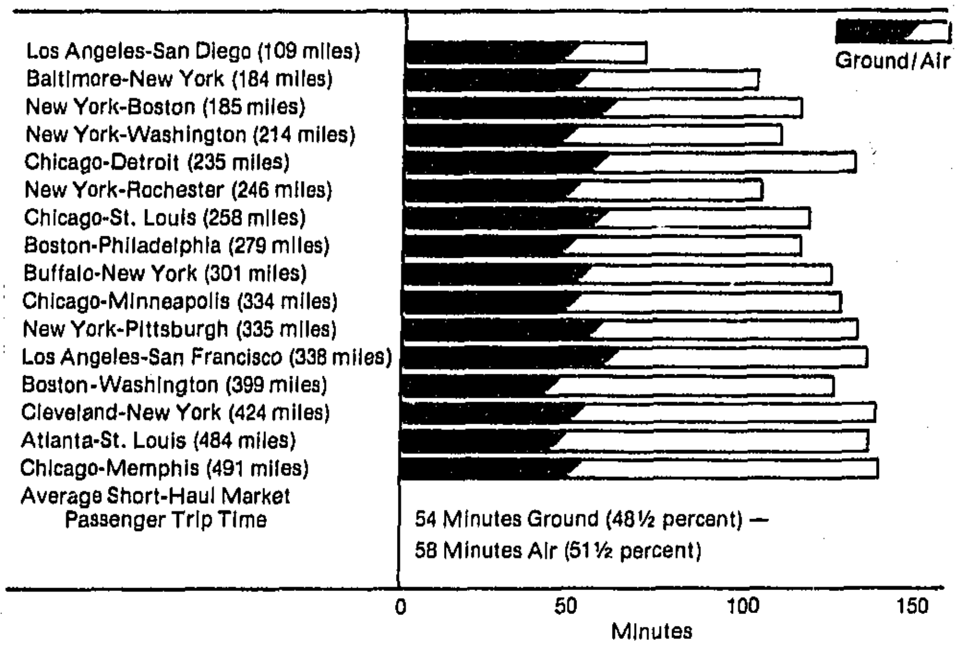


Figure 3–42. 1972 Vehicle Travel Time in Minutes, Short-Haul Markets under 500 Miles

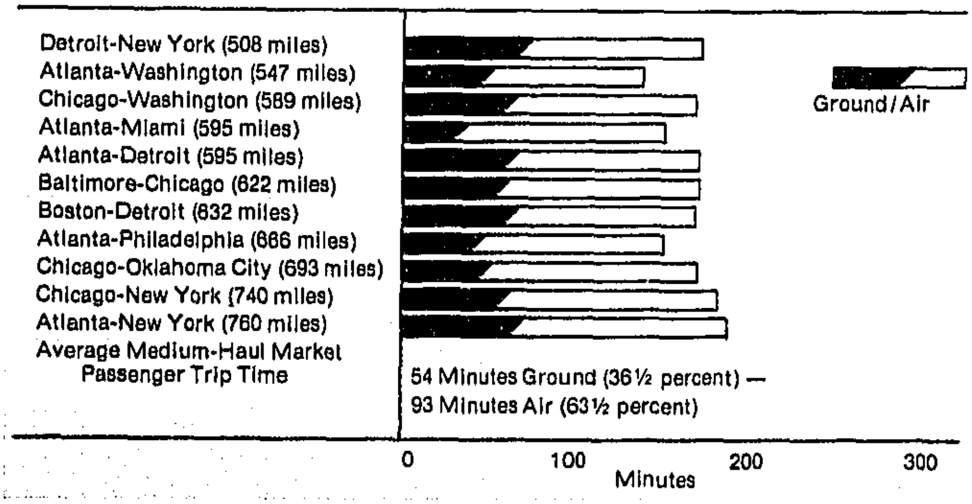


Figure 3-43. 1972 Vehicle Travel Time in Minutes. Medium-Haul Markets 500 to 1,000 Miles

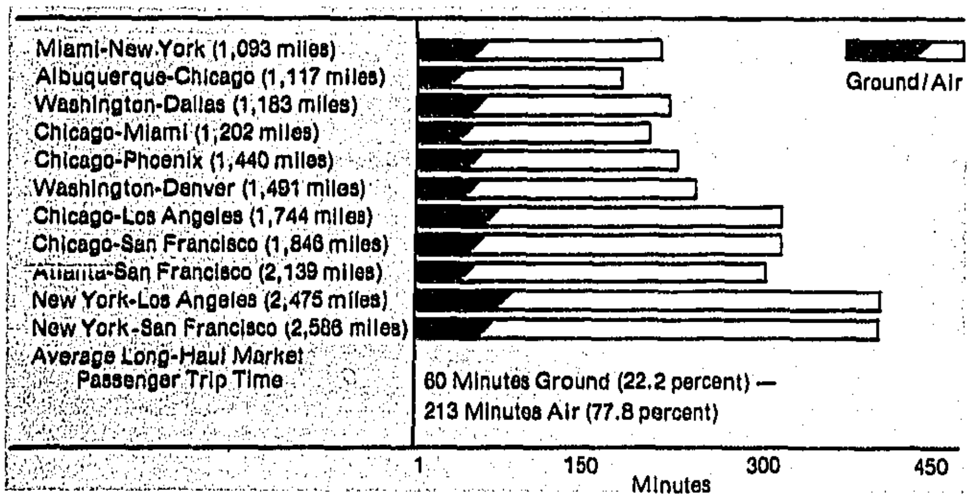


Figure 3-44. 1972 Vehicle Travel Time in Minutes. Long-Haul Markets over 1,000 Miles

c. Non-Passenger Effects. Although the passenger is the primary concern on the airport landside, the facilities are also used by well wishers, visitors, employees, and concessionaires. All of these have an impact on access/egress modes and various service facilities. Figures 3-45 through 3-48 show passenger/visitor departure times and flows through terminals and the passenger/visitor times and percentages at various airport service functions. Similar flow diagrams for arriving passengers must be added to show the complex capacity considerations necessary during planning for new or remodeled landside facilities.

325. AIRPORT AIRSIDE.

a. Grants-in-Aid for Airside Development. Through FY 1975, the airport grant-in-aid programs were provided primarily for airside development with landside funding limited to major access roadways within airport boundaries. Access improvements outside the boundaries had to be funded locally or, wherever possible, with an assist from the Federal Highway Administration or the Urban Mass Transportation Administration.

b. Airside Criteria. The emphasis on airside development led to detailed analysis of airside capacity criteria. These criteria, first published in 1966 as "Airport Capacity Criteria Used in Preparing the National Airport Plan," (AC150/5060) are now being updated. The updating includes the development of models for determining capacity and delay, the validation of these models, and development of a capacity and delay handbook to make the outputs available to airport planners.

c. PANCAP Limitations. The original handbook included the concept of "practical" capacity. This is defined in terms of operations that can be handled within specified acceptable delay limits. This methodology has been in use for more than 10 years following work by Airborne Instrument Laboratories in the early 1960's that preceded publication of the FAA handbook. Problems arise for some users because runway configurations can accommodate levels that exceed the practical capacity levels derived from the existing methodology. Figure 3-49 shows 11 airports that operated at levels exceeding their practical annual capacity (PANCAP).

d. Maximum Throughput Rate. To avoid the problems that arise through use of PANCAP, current model work is based on "maximum throughput rate" that is independent of demand or delay. The maximum throughput rate is defined as the maximum number of aircraft that can be handled by a facility during a specified time period under conditions of continuous

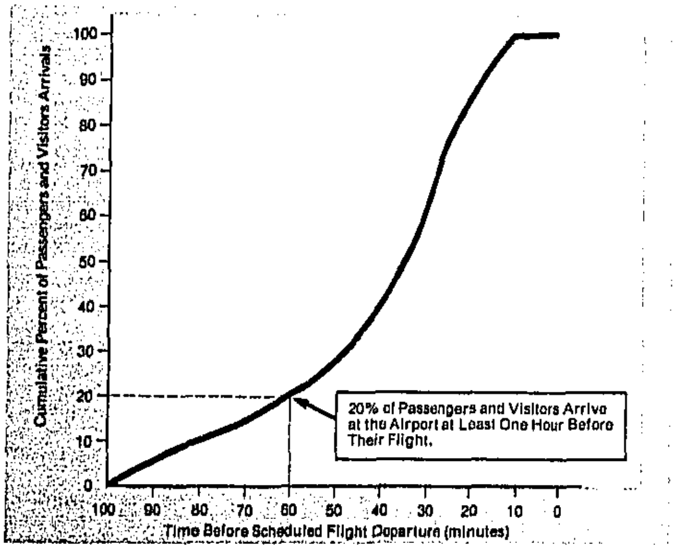
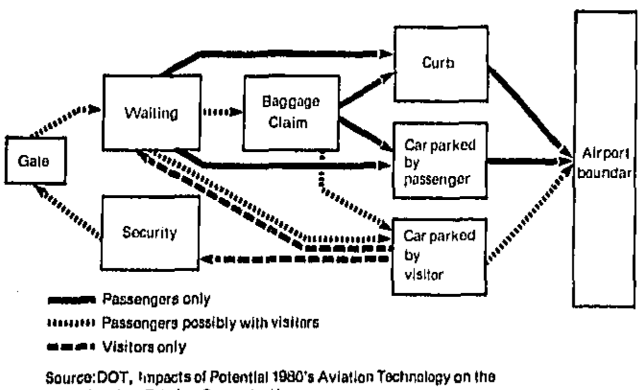


Figure 3-45. Cumulative Distribution of the Departing Percent of Passengers and Visitors Arriving at the Airport Before Flight Time

Source: Transportation Engineering Journal, pp 143-156 (1969)



Source: DOT, Impacts of Potential 1980's Aviation Technology on the Capacity of an Existing Car parked by passenger

Figure 3-46. Flow of Departing Passengers and Their Visitors Flow through the Terminal

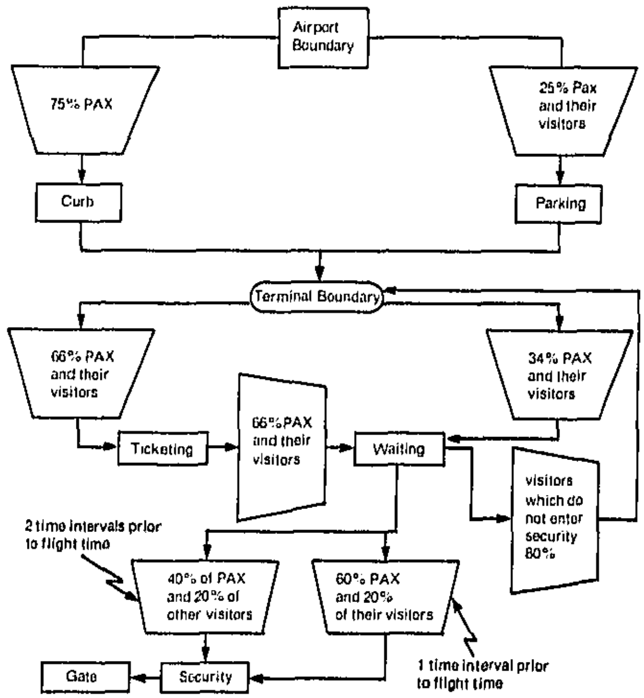


Figure 3-47. Percentage of Departing Passengers and Visitors which Enter Each Airport Service Function

demand. Further, the models cover the capacity of the entire airside, including the apron gate areas and the taxiway network.

e. Delay Model. A separate delay model allows predictions of delay times under varying operating configurations and conditions. Delay, rather than being linked to capacity as under the PANCAP concept, is simply defined as the difference in time for aircraft movement under two different conditions. Condition one is the actual time required for movement; condition two is the time it would take if there were no interference from other aircraft (zero delay).

f. Expected Results. Eventually, this effort is expected to provide planners with reliable means for measurement of runway/taxiway/gate acceptance rates. The models will allow computer analysis for improvements at existing facilities or configuration for new facilities to achieve higher site capacity.

g. Performance Measurement System. Another measure, Performance Measurement System (PMS), developed by Air Traffic Service for high-activity airports, was introduced in 1974. Since then, it has been accepted by certain key industry groups. The PMS develops airport acceptance rates based on airport configuration, aircraft mix, and runways in use under various weather conditions. The actual traffic is measured against the developed standard to measure Air Traffic Control Performance. PMS standards are developed and refined for each airport as required by changes in types of aircraft and runway/taxiway configurations.

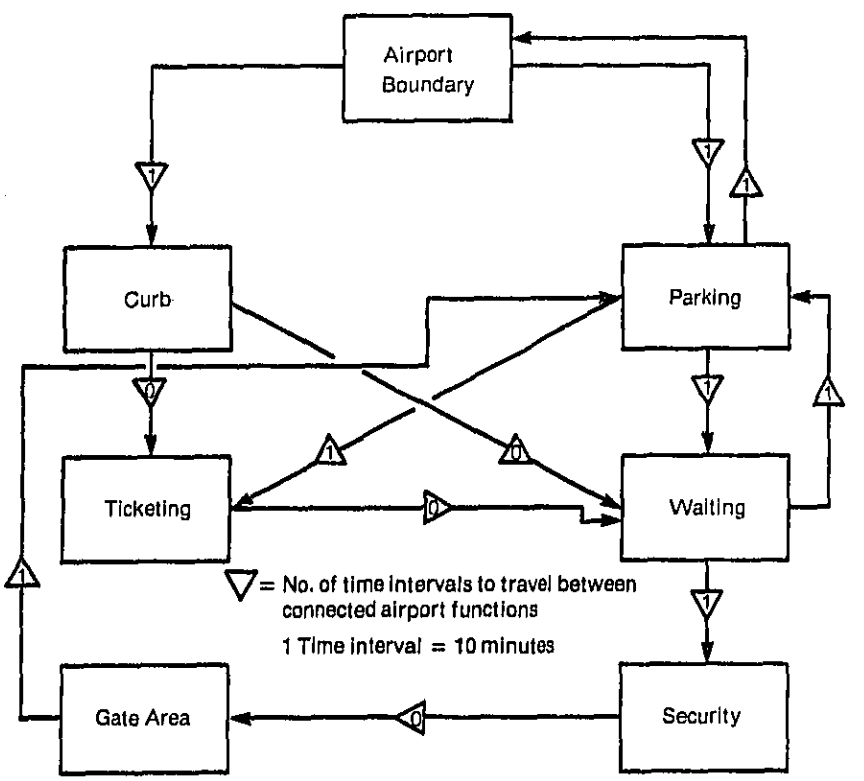


Figure 3–48. Number of Time Intervals Required to Proceed through Airport Service Functions for Departing Passengers and Visitors

326. AIRSPACE—TERMINAL/ENROUTE.

a. Problem at Major Hubs. The airspace capacity problem exists primarily in the busy hub areas. The eight-airport study previously cited reported "that ATC/airport capacity at several major U. S. airports is not capable of accommodating today's IFR traffic without causing substantial delays and that a modest growth in air traffic would result in saturation of several more major airports under both IFR and VFR conditions by 1982."

b. Capacity Limiting Factors. Terminal airspace capacity is limited by the physical layout of the airport and by the ability of the ATC system to meter and space aircraft for safe operations. The required spacing is a function of several factors, including the margin needed to assure avoidance of wake turbulence, inaccuracies in the surveillance and NAVAID systems, communications and controller/pilot response times, and the efficiency of ATC procedures and routing structures. Other factors that cause airspace congestion are proximity of other airports, restricted use areas, and unusual weather phenomena.

c. Traffic Models. Terminal and Enroute Airspace capacity is not easily quantifiable. A September 1968 report, Air Traffic Control System Capacity and Demand, provided numerical capacity values, but their validity was questionable. More recently, FAA developed traffic models for the Los Angeles Terminal and Enroute Areas to evaluate impacts of traffic increases and system improvements. The models consist of: (1) all IFR and VFR activity within 60 miles of the Los Angeles long-range radar; (2) all IFR traffic within the Los Angeles ARTCC; and, (3) all traffic at Long Beach Airport. These models have already found wide usage by FAA and industry analysts concerned with expected performance in a future traffic environment.

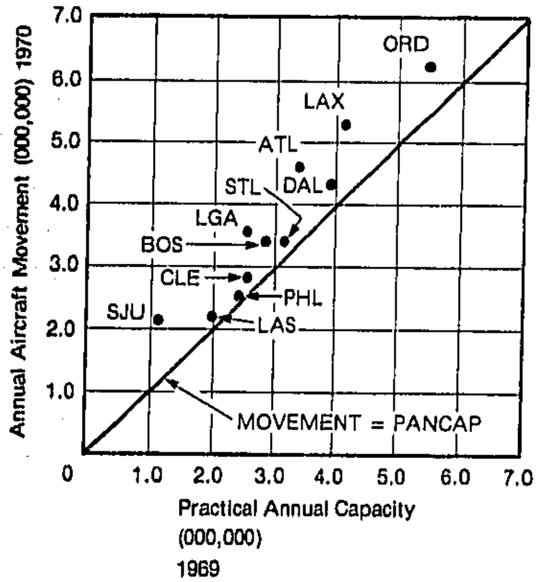
d. Other Studies. Other work in this area includes a study of the enroute system capacity conducted by the Federal Systems Division of IBM in 1973. It concluded that present ARTCC automation is adequate up to 1985, but that additional capability will be required for eight centers beyond that time. More recent studies conducted with the additional automation planned for enroute control under the Upgraded Third ATC System (UG3rd) showed that the improvements will adequately handle increased traffic loads in the en route system through the 1990's.

327. ALTERNATIVE APPROACHES TO CAPACITY PROBLEMS.

a. **Available Options.** There are several options for increasing aviation system capacity:

- —Access/Egress: add more lanes for highway access, add or improve access roads on airports, add or improve mass transit facilities.
- —Landside: fully use existing capacity, improve existing facilities, or build additional facilities.
- —Airside: fully use capacity at existing sites, add runways, taxiways, aprons, and gates configured for greatest capacity achievable within airport boundaries, add all-weather capability to reliever airports in major hub areas, or build new airports.
- —Airspace: add navigational aids and institute ATC improvements to streamline routing and reduce separation standards.
- —Develop alternate travel modes.
- —Constrain demand.

b. **Additional Road Access.** As noted earlier, most airports are served only by roadways with a single access way to the airport. Where possible, additional roadways or lanes may be added off-airport and additional on-airport access ways to various terminal buildings or building areas may be built away from or over existing roadways. Ideally, off-airport expressways that offer movement without interference from parked vehicles should replace city roads. The improved access times registered at Miami and Tulsa show the benefits realizable by roadway improvements. Further, airport freeways should be tied to other major expressways, since, as Figure 3-50 shows, many passengers originate at points outside the central city.



ORD = Chicago O'Hare
LAX = Los Angeles Int'L.
ATL = Atlanta Hartsfield Int'l
DAL = Dallas Love Field
STL = St. Louis, Lambert
LGA = N.Y. LaGuardia
BOS = Boston Logan Int'l.
CLE = Cleveland Hopkins Int'l.
PHL = Philadelphia Int'l.
LAS = Las Vegas, McCarron Int'l.
SJU = San Juan Int'l.

Source: Madison, Adarkar and Linn "New Methods of Determining Airport Capacity and Delay" Paper Presented at ASCE International Air Transportation Conference, March 1975.

Figure 3-49. Runway Capacity—Eleven Airports

Figure 3-50. Local Origins of Air Passengers in Selected Cities

CITY / AIRPORT	Passengers Originating in Central Business District (%)
Chicago / O'Hare	33
Cleveland / Hopkins	10
Denver / Stapleton	30
Kansas City / Municipal	40
Los Angeles / International	15
New York / JFK International	33
La Guardia	56
Newark	29
Phoenix / Sky Harbor	24
San Diego	10
Seattle-Tacoma / International	17
Washington, D.C. /National	23

Source: de Neufville, Richard et al., Airport and Air Service Access, DOT Report, March 1973.

c. **Mass Transport.** Continuing improvements to mass transit, whether bus, limousine, or rail, are needed. Washington National, which is congested by vehicular traffic at peak hours, may benefit from a new rapid rail system linking the airport with downtown and several suburban areas. It is anticipated that many people who have experienced access and parking problems at the airport will switch to the rail system if the stations are conveniently located. Convenience is essential. Figure 3-51 shows the results of a Port of New York Authority (PONYA) study of Cleveland Airport's rapid transit. It clearly shows preference for other travel modes if stations are too far or if there are more than three pieces of luggage to be carried.

d. **Landside Improvements Needed.** Terminal building and other landside improvements are essential at many airports. At points where existing facilities are overcrowded, new buildings may be the best solution. Newark is an excellent example of what could be accomplished within limited space. The old north terminal was abandoned and replaced by three new units along the west side of the airport.

Figure 3–51. Most Frequent Reasons Given for not Riding the Rapid to the Airport, Cleveland, (PONYA survey, October, 1971)

Area	Order	Reasons	Percent	Percent Who Had Used Transit Before	Remarks
Two-mile East	1	Other Mode More Convenient	45	39	Of these, 67% used Private Car, 20% Limousine.
	2	Luggage	18	54	0 bags: 4%; 1 bag: 12%; 2: 33%; 3+: 51%.
	3	No Knowledge	11	0	
	4	Other	5	50	
	5	Too Far to Station	3	56	
	6	Transfer	3	38	Few from Shaker Heights. 0 bags: 19%; 1 bag: 38%; 2: 24%; 3+: 19%.
Over two miles East, but in Rapid Market Area	1	Other Mode More Convenient	31	37	Of these, 78% used Private Car, 16% Limousine.
	2	Not in Rapid Market Area	24	27	
	3	Luggage	11	65	0 bags: 3%; 1: 9%; 2: 30%; 3+: 58%.
	4	Other	6	58	
	5	Too Far to Station	5	65	
	6	Was Driven	5	64	
Two-mile West	1	Other Mode More Convenient	38	40	Of these, 79% used Private Car, 2% Taxi, 5% Limousine.
	2	Used Courtesy Bus	17	21	All non-residents; 84% businessmen
	3	Luggage	8	24	2 bags: 53%; 3+:47%.
	4	Was Driven	6	50	
	5	Not in Rapid Area	6	29	
	6	Too Far to Station	5	42	

Source: de Neufville, Richard et al., Airport and Air Service Access, DOT Report, March 1973.

e. Sharing. Another solution is to use existing capacity by sharing counters and gates. This is currently done by smaller airlines with infrequent schedules.

f. Full Use of Existing Capacity The option of fully using the airside capacity at existing airports is undergoing agency review. The Chicago Midway study focused on this approach as a means to increase hub capacity. Among the findings are:

—Midway has a market potential for up to 50 percent of Chicago's short-haul origin-destination passengers.

—This potential could lead to an annual passenger volume at Midway of 10 million by the 1980's, without degrading connecting service at O'Hare.

—The majority of this traffic could be realized by shifting 42 percent of the forecast traffic on 16 high density, short-haul city pair links from O'Hare.

—Accelerated growth of Midway to 10 million annual passengers could increase Chicago hub capacity by almost 20 percent in the mid-1980's, while relieving potential airside and groundside congestion at O'Hare.

—By the mid-1980's, with growth of Midway to 10 million annual passengers and O'Hare at 55 million, access/egress requirements at O'Hare remain relatively constant, resulting in significant potential alleviation of a serious problem.

g. Objections to Midway Approach. Although these findings are promising, there are several costly actions necessary to realize Midway's potential. These include upgrading the existing facilities, constructing additional access ways to Midway, constructing 2,600 additional parking spaces, and constructing a more efficient terminal, which would cost about $60 million. Further, the airlines are reluctant to move from O'Hare and Midway until economic analysis proves such action is favorable and airspace conflicts with O'Hare are solved. The city, on the other hand, views the FAA findings in a favorable light. In a May 21, 1974, letter incorporated in the report, they say they have "strong feelings about the need to provide early and effective relief from rising levels of congestion and delay at O'Hare."

h. Improving Relievers. Alternatively, Midway could be developed as a major reliever. Opening or improving reliever airports in busy areas to provide adequate all-weather service to general aviation aircraft can reduce congestion of the major carrier airport. Convenient access to the reliever from the metropolitan area is necessary to make it fully acceptable. It should be noted that, although the use of available underused sites would seem to be of great value, many of these airports are located in, or convenient to, the central city and improvements may, therefore, create complex traffic control problems in hub areas where airspace is already at a premium.

i. Additional Improvements. Improvements impacting on both airside and airspace include: dual-lane runway operations, reducing separation between operations on parallel runways, reducing longitudinal separation standards, and constructing or improving outlying airports to satisfy all-weather air carrier and general aviation training requirements. The dual-lane runway is defined as two parallel runways at least 700 feet apart, but less than 2,500 feet apart centerline to centerline in an FAA Dual-Lane Runway Study, dated May, 1974. Among the findings of this study are:

—Dual lane runways can support basic VFR flow rates of 100 operations/hour and IFR flow rates from 70 to 80 operations/hour.

—Segregation of arrivals and departures with arrivals using the outer runway is the preferred mode of operation.

—Staggered runways can reduce departure delays.

—For heavy jet operations, a minimum of 1,000 feet centerline/centerline separation is desirable.

(1) Reducing separation of parallel runways is undergoing continuing evaluation in the agency with a goal of upgrading surveillance accuracy to a point where simultaneous approaches separated by 2,500 feet is possible.

(2) Reductions in ATC longitudinal separation standards depend on improved surveillance, increased automation, and other UG3rd features such as wake vortex detection and metering and spacing of arrivals and departures. Figure 3-52 illustrates the possible application of these and other UG3rd components at 10 of the major air carrier airports.

(3) Providing navigational facilities at presently non-qualifying sites to remove flight training activity from busy hubs would help reduce congestion. Consideration is being given to making such installations. Criteria for establishment of ILS at training sites exists, but installation of other training aids, such as ASR, is still under discussion; it is too early to predict the outcome. There is agreement that training aids are necessary, but the costs of installation can be justified only if it is certain that training at a facility will continue for a long time.

Figure 3-52. Possible Applications of UG3rd Improvements

E&D APPLICATIONS	ATL	ORD	OEN	LAX	MIA	JFK	LGA	EWR	PHL	SFO
DUAL-LANE RUNWAY OPERATIONS	X	X	X	X				X	X	X
4300 FT. PARALLEL APPROACHES	X			X						
ASDE-2 IMPROVEMENT PACKAGES [1]	X	X				X				X
WAKE VORTEX ALARM SYSTEMS [2]	X	X	X	X	X	X	X	X	X	X
WAKE VORTEX AVOIDANCE SYSTEMS	X	X	X	X	O	X	X	X	X	X
ASDE-3	X	X	X	X		X	X	O	X	X
BASIC METERING & SPACING	X	X	X	X	X	X	X	X	X	X
3500 FT. PARALLEL APPROACHES										
REDUCE IFR MINIMUM LONGITUDINAL SPACING	X	X	X	X		X	X	X	X	O
ATC APPLICATIONS OF MLS		O	O	O	O	X	X	X	O	X
ADVANCED M&S (ARR/DEP)	X	X	X	X	O	X	X	X	O	X
2500 FT. PARALLEL APPROACHES						X				

X= DEFINITE APPLICATION
O= POSSIBLE APPLICATION
Source: FAA Report on Airport Capacity—January 1974.
[1] ASDE—Airport Surface Detection Equipment. A surveillance system to assist surface movement of aircraft during adverse weather conditions.
[2] Sensors to detect wake turbulence generated by large aircraft.

j. New Airports. The option to build new airports, as noted earlier, is no longer viable in some areas for environmental reasons; other methods for achieving capacity increases must be exploited to the fullest extent at such locations. In many cases, though, new airports can and must be built to meet increasing demand. The new airports may range from large new land-based facilities, such as planned for the Los Angeles area, or small allweather reliever fields, and short takeoff and landing (STOL) fields on land or water. Both STOL ports and off-shore airports have been under study for several years by the FAA and local authorities and remain as potential solutions to the aviation system capacity problem.

k. Canadian Project. A Canadian Government-sponsored project to explore the benefits of using short takeoff and landing craft between Montreal and Toronto shows this type of service is acceptable for business trips (a large percentage of the traffic consists of "briefcase" trips, since baggage weight limitations on the small Twin Otters being used are strict). Part of the popularity of this service is due to the downtown location of the fields. Victoria parking lot, five minutes from downtown Montreal, unused since EXPO '67, is the Montreal STOLPORT. In Ottowa, Rockliffe Airport, unused since the mid-1960's, except by a flying club, is 12 minutes from downtown. Transportation to and from downtown locations is included in the cost of the service. The Canadian experiment begun in July 1974, and is scheduled to run for two years. It is designed to develop technical and operational components, assess community and passenger reaction, evaluate the economics of STOL service, and demonstrate its value to an international clientele. The STOL service operates on direct RNAV (Area Navigation) routes that reduce total downtown to downtown travel time by 30 minutes despite use of non-jet aircraft. The distance of 110 miles is covered in an average of one hour and forty-five minutes air and ground time by conventional (non-STOL) aircraft.

l. Emergence of Non-Air Alternatives. The findings by the Federal Highway Administration that show a major amount of total trip time for shorthaul flights is devoted to airport access and processing point to the need for alternate short-haul travel modes. Increasing inconvenience experienced by many air travellers could drastically affect the traditional growth patterns in high density corridors served by good rail links. Figure 3-53 shows a shifting pattern of travel over the last several years between Washington—New York and New York—Boston as the Metroliners, turbotrains, and conventional trains became increasingly popular.

A similar shift in travel preference occurred in Japan after inauguration of the high-speed Tokyo-Osaka train, "Shinkansen." Within one year after service was instituted, 30 percent of the air travelers, mostly to points short of Osaka, switched over to "Shinkansen," and several short-haul flights were cancelled.

m. Other Alternatives. Other more exotic travel modes—for example, hydrofoil service on over-water routes, such as Boston and Provincetown—are all potential alternatives to air travel. In cities experiencing severe airport congestion and environmental opposition to new sites, these alternate modes must be considered as a means of coping with increased demand.

n. Constraints. Constraints on traffic may be necessary to reduce or contain the serious capacity problems. This may be unpopular but must be considered. From 1960–1970, revenue passenger miles increased 13 percent. To meet this growth, industry and the FAA undertook expensive modernization programs. Now, although the growth rate has slowed, aviation activity may double within 10 years. It is doubtful if new systems and technology will allow the great capacity increases built into the system during the past.

(1) As a result, the FAA along with industry, must study alternatives to fulfilling unconstrained demand. There are capacity problems at several large hubs at present and few near-term solutions. One cause of the problem is excessive scheduling into these key hubs. Solutions include restricting or shifting demand through such concepts as peak-load pricing, airport quota regulations, FAA/CAB cooperation to ensure that route awards do not add to capacity problems, Federal involvement in scheduling, and restricting general aviation use of major hub airports.

(2) Many of these issues have been addressed but require additional study and public-wide consideration to determine their full impacts and their feasibility.

Figure 3-53. Washington-New York/Newark City Pair Passenger Trips (in 000's)

Year	Trips By Air	% of Total	Trips by Rail	% of Total	Total Trips
1969	2,467.0	75.2	812.4	24.8	3,279.4
1970	2,239.6	75.5	726.5	24.5	2,966.1
1971	2,215.6	75.5	720.0	24.5	2,935.6
1972	2,283.1	72.8	854.0	27.2	3,137.2
1973	*2,095.5*	*68.1*	*980.5*	*31.9*	*3,076.0*
1974	1,843.9	61.3	1,165.5	38.7	3,009.4
Total	**13,144.7**	**71.4**	**5,258.9**	**28.5**	**18,403.7**

Boston-New York City Pair Passenger Trips (in 000's)

Year	Trips by Air	% of Total	Trips by Rail	% of Total	Total Trips
1967	2,667.2	87.8	371.5	12.2	3,038.7
1968	2,865.8	89.4	339.4	10.6	3,205.2
1969	2,608.8	89.5	307.5	10.5	2,916.2
1970	2,618.5	91.1	256.3	8.9	2,874.8
1971	2,309.5	91.4	218.5	8.6	2,528.1
1972	2,409.4	87.4	346.1	12.6	2,755.5
1973	*2,270.2*	*83.3*	*455.7*	*16.7*	*2,726.0*
1974	1,794.8	73.8	735.6	26.2	2,430.4
Total	**19,544.2**	**87.0**	**2,930.6**	**13.0**	**22,474.9**

Source: Winestone, Robert L., Federal Railroad Administration Staff Papers, March 1975 (Washington), and April 1975 (Boston).

328. FAA PROGRAMS.

Many of the programs discussed below have been mentioned earlier. More detail is provided here, and additional programs are discussed, to show the full *extent of FAA's commitment toward increasing the* capacity of the NAS.

329. ACCESS/EGRESS.

a. Funding. Planning grants are the only means by which FAA is directly involved in off-airport facilities. Although no funding is provided or anticipated for development of off-airport access ways, the system and master plans partially funded by the FAA ensure coordinated planning of all on/off-airport components required for an effective system. An estimated 10 percent of the funds granted were used for access/egress planning (Figure 3-54).

Figure 3-54. Grants Issued for Planning Purposes, FY 1971–1975 (Dollars in thousands)

Fiscal Year	Master Plans No.	Master Plans Amount	System Plans[1] No.	System Plans[1] Amount	Total Grants No.	Total Grants Amount
1971	29	$1,227.4	14	$2,408.6	43	$3,636.0
1972	149	5,127.0	30	3,919.7	179	9,046.7
1973	229	6,582.9	23	2,968.6	252	9,551.5
1974	266	5,618.6	23	2,575.4	289	8,194.0
1975	276	7,998.8	19	1,571.9	295	9,570.7

[1] Includes metropolitan, regional and state plans.

b. Planning Grants to Continue. Proposed legislation seeks continuation of planning grants as part of the Airport Development Aid Program (ADAP). Specifically, Federal involvement will be limited to system planning while master planning will be accomplished by airport sponsors under development funding grants. These changes are not expected to have significant impacts on capacity-related planning. The funding level proposed for system planning is an amount not to exceed $10 million annually and is to be made available from a discretionary fund.

c. Current Involvement. Currently, the FAA has influence over airport access planning through participation in intermodal planning groups established in the Department of Transportation. These groups ensure that Department programs, such as Highway, Mass Transport and Airport Aid, are fully coordinated to achieve balanced transportation system growth.

330. AIRPORT LANDSIDE.

a. FAA Study. The increasing concern over landside constraints has led to greater activity in this area. FAA's Office of Systems Engineering Management is studying landside problem areas to identify where Federal involvement is justified. This program effort is directed toward developing a better understanding of the major factors in landside restrictions, developing practical measures of landside capacity and levels of service, and analysis of possible corrective measures.

b. Terminal Improvements. Proposed airport grant legislation will provide direct Federal funding for all public use areas of the terminal area. These will include on-airport access along with passenger processing and baggage handling facilities. Early in the program, participation is expected to be minimal, but the dollar amount should increase as eligiblity criteria become known to sponsors. Eventually, this program may involve substantial sums, perhaps as much as $10 million anually, for terminal building area capacity increases at major hubs (in addition to funds for roadway access).

c. Past Funding. Current airport aid legislation prohibits participation in landside development aside from major on-airport access ways. An estimated $10 million per year is spent for this purpose. Federal airport grant funding for access at major hubs for Fiscal Years 1971 through 1974 was in excess of $30 million and included $3.0 million at San Francisco, $10.3 million at Dallas/Fort Worth, $3.2 million at O'Hare, $3.5 million at La Guardia, $8.1 million at Philadelphia, and $1.2 million at Newark. the estimated $10 million annual level is expected to be maintained under new legislation as other busy hub areas require improved on-airport access to handle expected traffic increases.

331. AIRPORT AIRSIDE.

a. Funding History. Through the Airport Grant Program, the FAA has been directly involved in funding for capacity improvements on the airport airside. The Airport and Airway Development Act of 1970 provided approximately four times the annual assistance available for development under previous airport grant programs.

b. Accomplishments. Data on development items directly related to capacity indicate the following accomplishments after five years of the Airport Development Air Program (ADAP).

—Construction of 85 new airports (includes three air carrier and three reliever airports).

—Construction of 178 new runways.

—Extensions to 201 runways.

—Construction of 520 new taxiways.

c. Changes in Application of Funds. For the first two decades of Airport Grant Program life, a high percentage of funds was spent for capacity increases. As the existing airport system came into being, more funds were used to rehabilitate and strengthen existing pavements than were used for construction of new facilities. As a result, percentages of Federal grant funds directly applicable to capacity increases have fallen; it is currently estimated at 40 percent of total funds. This percentage may rise again in the future for several reasons:

—At a few major locations, airport sponsors are currently planning new access ways, and more are expected to construct improvements as demand makes existing facilities obsolete.

—Research is underway to reduce lateral separation to allow closely spaced parallel runways. This may allow construction of more runways at existing sites.

—Eligibility of landside facilities under a new program will impact on funding.

—Additional airports, either conventional or short takeoff and landing, are needed to relieve airports where the demand is forcast to exceed the ultimate capabilities of existing sites.

d. Expected Funding. Under the proposed program level of $350 million through FY 1978, and $300 million thereafter, an average of $135 million annually is anticipated for capacity related work over the five-year life of the program. Future program extensions are expected to contribute at least this amount for necessary system-wide capacity increases.

e. E&D Capacity Improvement Projects. In addition to the grant program administered by the Airports Service, there are several items in the FAA's Engineering and Development (E&D) Program directed at airside capacity improvements. The capacity criteria discussed earlier fall in this category. There is also on-going research to improve pavement design and construction standards that can eventually be promulgated by the Airport Service through the Grant Program. Other programs that may improve capacity of airports in adverse weather provide for development of improved equipments and techniques for fog dispersal and snow, ice, and slush removal.

(1) A major E&D program involves the design and development of improvements to the present ground surveillance system (Airport Surface Detection Equipment—ASDE-2) and eventual replacement of this system with a more sophisticated Airport Surface Traffic Control (ASTC) system. Currently, for operation of surface traffic, there are ASDE radars at nine airports and television systems at a few airports where obstructions block the view from the control tower. The TV is of little use in bad visibility conditions, and the ASDE-2 is of limited value because of reliability/maintenance problems and inadeuqate presentation of targets on the display.

(2) Since restricted movement of airport surface traffic during poor visibility conditions is a limiting factor in airport capacity at a few airports today, modifications to improve the ASDE-2 are underway and various other surface detection systems are being evaluated. The new systems include digitized airport-wide surveillance to provide an all-weather display showing aircraft positions and identity and an automatic intersection control with discrete sensors at intersections to communicate stop/go commands visible to pilots and controllers. A more complex phase of ASTC system development, still undergoing preliminary analysis, would combine the above features into a fully automated system that would minimize the need for human intervention.

(3) Current plans, in addition to ASDE improvements (ASDE-3's), call for installation of ASTC systems at the busiest airports in the early 1980's. The ASTC systems will replace ASDE-3's that will be relocated to other airports that will qualify for such equipment in the 1980-85 time frame.

332. TERMINAL AIRSPACE.

a. ATC Improvements. The FAA's Facilities and Equipment (F&E) program involves the acquisition, establishment, and improvement of air traffic control and navigational facilities that are beyond the R&D stage. In this role, it is concerned with solving relatively short-term capacity problems with equipment designed and approved for the current ATC generation. F&E will become increasingly involved in the installation of UG3rd and other improvements as the

R&D for future systems is completed and they are approved for use.

b. **F&E Programs.** The F&E programs directly related to improving terminal airspace capacity include installation of:

—additional Airport Traffic Control Towers (ATCT) with Remote Transmitter/Receiver Facilities and Terminal Weather Facilities.

—additional Airport Surveillance Radars (ASR).

—Airport Surface Detection Equipment (ASDE-3).

—additional Instrument Landing Systems (ILS and MLS) with associated approach light system (MALSR, ALS, ALSF) (MALSR—Medium intensity ALS with Runway Alignment Indicator lights, ALS—Approach Light System, ALSF—Approach Light System with Sequence Flasher).

c. **Improved Efficiency.** In F&E criteria development, the essential benefits are safety and efficiency. Efficiency (probable benefit of saving time) is related to capacity improvement. In the case of a control tower, an example of added efficiency resulting from existence of the facility is apparent when an aircraft can be cleared for a straight-in approach because a controller knows there is no conflicting traffic. At a non-tower airport, the pilot would have to circle to check wind conditions and traffic before landing. At airports with low amounts of traffic, capacity benefits are low, but at higher volumes of traffic, tower control is necessary to reduce delays.

d. **Quantifiable Benefits.** Capacity benefits attributable to other facilities, such as the ASR and ILS, are generally easier to quantify then benefits resulting from control tower establishment because the impact of a tower's presence has a more subtle impact on total system performance than does a specific navigational aid. For an ASR, the fundamental reason for establishment is to reduce delays due to manual separation standards. On any given route, this means a reduction from approximately 60 miles (manual) to five or three miles (ASR). Translated into numbers of aircraft at a single altitude, with ideal weather, aircraft mix, and traffic conditions (no crossing or converging traffic), this means an increase from two aircraft in trail to 12 or 20. Multiply this by all routes and usable altitudes in any block of airspace and it is evident that an ASR greatly improves airspace capacity. The capacity benefits of an ILS (or MLS) are also quantifiable. A reduction in minimums from a 400-foot decision height above touchdown (HAT) and one mile visibility (nonprecision approach) and 1/2 miles (ILS approach) provides an average increase of 15 percent in runway utilization. The capacity increase at different sites will vary, of course, depending on demand, current nonprecision approach minimums (which may be as high as 700–1), and weather conditions.

e. **Regulatory Programs.** Ongoing regulatory programs related to terminal airspace capacity include revisions to existing Federal Aviation Regulations (FAR's) as necessary to ensure efficient use of airspace. In some cases, the regulations may have a negative effect on capacity—for example, restrictions to certain operations in designated Terminal Control Areas (TCA).

f. **Wake Vortex Avoidance System.** Of the several FAA E&D programs that will contribute to increasing terminal airspace capacity, significant benefit is expected from development of a Wake Vortex Avoidance System (WVAS). A system to detect the presence of dangerous vortices in the wake of large jets is essential before any reduction in arrival separation standards is possible. The introduction of the new aircraft required FAA to increase IFR separation standards for light aircraft following heavy aircraft. This increase reduces arrival and departure capacity and poses serious obstacles with respect to increasing capacity at congested airports. It has been estimated that the imposition of the new standards has caused a 10 percent loss in runway acceptance rates under IFR conditions and a 10 percent—20 percent loss under VFR. The problem will worsen as more large jets enter service.

(1) The purpose of the WVAS program is to gather data on the characteristics of wake turbulence and its relationships to wind conditions and to develop means to detect or predict the existence of vortices. Data indicate vortices have a very short life, their intensity and movement can be predicted, and they can be detected and tracked by means of sensors along the approach and departure path.

(2) There are presently five sensors in the advanced development state:

—Ground wind sensors

—Bi-static pulsed acoustic radar

—Doppler acoustic radar

—Monostatic doppler acoustic radar

—Laser doppler sensor

Any or several of these sensors may be coupled with the ATC computer to advise controllers when reduced separations can safely be used. As the computers are upgraded, automated metering and spacing will further refine system capability. The sensors have provided sufficient information to allow testing of a relatively inexpensive, basic, predictive Vortex Advisory System (VAS) consisting of meteorological towers, mini-computers and an uncomplicated GO/NO GO tower display.

(3) A combination VAS plus lowest cost vortex sensors (WVAS) will be installed at busy airports with significant amounts of large aircraft operations. The implementation schedule is expected to begin in 1978 and end in 1981, with no additional units planned immediately beyond that time.

g. **Approach and Landing Aids.** Another program that will result in more efficient use of terminal airspace is directed at improving approach and landing aids to ensure system performance under all siting and weather environments through development of better antennas, monitors, and lighting systems and possible eventual development and implementation of microwave landing systems (MLS).

h. **Other Programs.** Other E&D programs (see Figure 3–55 for cost estimates) that will improve terminal airspace capacity include:

—Improvements to terminal radars.

—Improving the accuracy and reliability of navigational aids.

—Improving communications systems including data transfer links.

—Advancing automation capabilities of terminal air traffic control towers—includes advanced metering and spacing (feeding several runways simultaneously), conflict prediction and resolution, and Airport Surface Traffic Control (ASTC).

—Identification and minimization of undesirable environmental effects attributable to the air transportation system, such as noise and emissions. Work in this area may improve capacity at sites where traffic flow is hampered by noise abatement procedures.

333. ENROUTE AIRSPACE.

a. **F&E Programs.** F&E Programs directed at improving the capacity of the enroute airspace include installation of the following:

—Additional Air Route Surveillance Radars (ARSR).

—Automated Oceanic Sector Displays. (Six of nine oceanic centers are presently candidates for modified ARTS III systems called Oceanic ARTS (OARTS). This plan may be affected by current studies to reduce the number of Oceanic Centers.

Figure 3-55. Engineering & Development (E&D) Program Costs Attributable to Capacity

PROGRAM	PLAN (In millions of dollars)						
	1977	1978	1979	1980	1981	1982-86	1977-86
02 RADAR	—	0.2	0.2	0.1	—	—	0.5
03 DABS/IPC	2.2	2.8	1.6	1.0	0.8	2.6	11.0
04 NAVIGATION (Incl RNAV)	0.3	1.3	1.3	1.2	1.2	4.0	9.3
06 COMMUNICATIONS	0.4	1.0	1.2	2.9	3.0	8.8	17.3
07 APPROACH AND LANDING SYSTEMS (Incl MLS)	10.2	4.2	7.8	4.2	1.9	7.4	35.7
08 AIRPORT/AIRSIDE (Incl ASTC)	3.4	2.7	3.0	3.5	3.5	13.4	29.5
09 AIRPORT/LANDSIDE	—	0.3	0.5	1.0	1.0	3.0	5.8
10 OCEANIC (Incl. oceanic sector automation)	—	—	—	1.0	1.3	6.5	8.8
11 ATC SYSTEMS COMMAND CENTER AUTOMATION	0.8	0.5	0.5	1.0	1.0	5.0	8.8
17 SATELLITES (Incl AEROSAT)	2.9	—	—	—	—	11.3	14.2
21 SUPPORT (Incl VAS/WVAS)	0.4	—	—	0.4	0.8	7.0	8.6
Capacity Grand Total	20.6	13.0	16.1	16.3	14.5	69.0	149.5

—New Direct Access Radar Channels (DARC), which provide direct path backup radar and beacon capability needed in the event of the failure or scheduled shutdown of NAS data processing systems.

—Very High Frequency Omni-Directional Radio ranges with Distance Measuring Equipment (VOR/DME).

—VOR's collocated with military Tactical Air Navigation Equipment (VORTAC).

—Air/Ground communications channels in the 118–136 MHz band allowing 25 kHz spacing in lieu of present 50 kHz spacing.

—VOR/ILS/TACAN/DME Aids with 50 kHz spacing. Although the 50kHz capability will be available, frequency assignments will not be made unless congestion demands reduced frequency separation (from present 100 kHz spacing) and proposed changes are coordinated with users.

—Automation improvements to increase the capability of the existing headquarters based Air Traffic Control Systems Command Center (ATSCC). Eventual automation with interfaces to all centers and major terminals is intended to monitor flight plan information and flight conditions to predict overloads and delays and calculate alternative flow control strategies for optimum use of airspace.

—Continuing work on the RNAV (Area Navigation) System. RNAV permits direct routes in the present NAVAID environment without having to fly along radials generated by the existing installations. RNAV routes have already been established; their use is increasing as controllers and pilots realize they help to reduce workload and communications required by radar vector methods. As noted in the discussion of the Canadian STOL experiment, RNAV may be applied for direct routing with minimum conflict with existing route structures. Routes paralleling existing busy airways can also be easily developed.

—Use of Aeronautical Satellites (AEROSAT) for continental and oceanic control. Communications and surveillance by way of several satellites in synchronous orbit over oceanic areas will allow greatly reduced oceanic separation standards. The present standards are keyed to unreliable HF communications.

—Concurrently with the AEROSAT program, there will be development of advanced data processing and display systems to provide controllers with improved oceanic communications, surveillance, and automated displays. Included in the automated system will be the functions of oceanic flight data processing and display, traffic display, flight plan conflict probes, and on-line interfaces with the continental U. S. center computer system (NAS Stage A). These improvements will be made to the planned OARTS; eventual tie-in with AEROSAT will occur as the satellite ground and space systems become operational.

—The capacity of the continental system will also be improved through use of satellites in the 4th Generation system, but work in this area in FAA is still in the preliminary study stage. USAF work on a satellite-based Global Positioning System (GPS) planned for full implementation in the 1980's is creating considerable interest and may change the FAA timetable for use of satellites.

—Figure 3-57 includes dollar estimates for RNAV, AEROSAT programs, and oceanic sector displays.

c. **Other Programs.** Other E&D programs described earlier as benefitting terminal airspace utilization are also applicable to the enroute system. These include automated metering and spacing along busy routes and improved communciations.

334. COSTS OF CAPACITY PROGRAMS. The costs of FAA programs attributable to system-wide capacity increases are shown in Figures 3-55 through 3-58. The figures list planned programs with funding levels over the plan period. There is a figure for each appropriation, and all funds attributable to capacity activities in FAA are shown. All programs have been assessed for applicability to the four areas covered in the plan—Safety, Capacity, Productivity, and Energy/Environment.

Figure 3–56. F&E Program Costs Attributable to Capacity *

PROGRAM	PLAN (in millions of dollars)						
	1977	1978	1979	1980	1981	1982–86	1977–86
EN ROUTE CONTROL FACILITIES							
Long Range Radar**	5.4	9.2	3.6	3.6	3.6	27.0	52.4
• Establish ATCRBS							
• Discrete Address Beacon system							
Automation						15.0	15.0
Total	5.4	9.2	3.6	3.6	3.6	42.0	67.4
TERMINAL CONTROL FACILITIES							
Terminal Area Radar	4.4	7.2	4.3	8.3	11.4	63.5	99.1
• Establish ASR/ATCRBS/ARTS II							
• Establish/Replace ASDE							
• Airport Surface Traffic Control							
• Discrete Address Beacon System							
Control Tower Facilities	4.9	7.3	4.6	4.8	5.3	38.5	65.4
Total	9.3	14.5	8.9	13.1	16.7	102.0	164.5
LANDING AIDS							
ILS/MLS	13.5	6.3	5.1	5.1	3.7	17.8	51.5
• Establish ILS/MLS							
• Improve ILS/MALS							
• Provide Slant Visibility Range							
Microwave Landing System (MLS)	—	—	20.0	30.0	20.0	130.0	200.0
Visual Aids	0.6	1.4	0.5	1.0	0.5	8.0	12.0
• Establish/Improve/MALSR Wake							
Vortex and Wind Shear	—	5.0	3.0	—	3.5	13.0	24.5
• Provide Aircraft Vortex Avoidance							
System							
Total	14.1	12.7	28.6	36.1	27.7	168.8	288.0
SYSTEM SUPPORT							
Housing, Utilities and Misc.	4.5	2.0	1.8	2.4	2.5	20.3	33.5
Aircraft and Related Equip.	.1	1.4	1.3	0.4	0.6	10.2	14.0
Development, Test and Evaluation (NAFEC) Support	.5	0.8	0.9	1.2	1.0	7.3	11.7
Total	5.1	4.2	4.0	4.0	4.1	37.8	59.2
Capacity F&E Total	33.9	40.6	45.1	56.8	52.1	350.0	579.1

* For planning purposes some new/improved facilities are included for which implementation decisions have not been made.
** Only major programs are indicated.

Figure 3–57. Operations Costs Attributable to Capacity

ACTIVITY	PLAN (in millions of dollars)						
	1977	1978	1979	1980	1981	1982–86	1977–86
AIR TRAFFIC	149.1	163.3	172.3	180.4	188.0	983.0	1,837.0
AIRWAYS FACILITIES	38.2	40.8	41.5	42.5	43.0	227.6	434.4
INSTALLATION AND MATERIEL	14.8	16.4	17.3	18.2	19.0	98.9	184.0
DEVELOPMENT DIRECTION	1.5	1.8	1.8	1.8	1.8	9.6	18.3
AIRPORTS	5.6	6.1	6.3	6.4	6.6	33.1	64.0
DIRECTION, STAFF AND SUPPORT	14.7	18.3	19.3	20.2	21.1	107.6	201.1
TOTAL	223.9	246.7	258.5	269.5	280.3	1,460.8	2,739.4

Figure 3–58. Airport Grant Program Costs Attributable to Capacity

PROGRAM	PLAN (in millions of dollars)							
	1977	1978	1979	1980	1981	1977–80	1982–86	1977–86
*AIRPORT DEVELOPMENT AID PROGRAM (ADAP)	143.0	143.0	143.0	143.0	143.0		715.0	1,430.0

*ADAP costs attributable to capacity will be revised as soon as legislation is approved.

SECTION 4. PRODUCTIVITY

335. THE PRODUCTIVITY PROBLEM IN PERSPECTIVE.

a. **Productivity Studies.** Historically, productivity studies have been confined to the relationship between the number of people employed (input) and the physical volume of goods or services produced (output) by those employees. The emphasis has been placed on measuring the output per man-year or some other unit of staffing input. By defining and evaluating measures of output in quantitative terms, productivity indices can be derived that will reveal emerging trends; management may then be able to take steps to influence those trends.

b. **FAA Participation Studies.** The FAA first explored the feasibility and usefulness of productivity measurements as a participant in a project initiated by OMB in 1962. In 1970, the FAA again participated in a similar study. The second study resulted in the establishment of a system to be used in a continuing program for measuring and improving Federal productivity. That program includes 46 agencies and 200 separate organizational elements.

c. **Overall Trends.** Overall productivity trends of the Federal sector are shown in Figure 3-59. (FY 1967 is utilized as a base year with a Productivity Index of 100). Since FY 1967, the Productivity Index has increased to 111.1, an average annual gain of 1.9 percent.

d. **Civilian Agencies.** Outputs of Civilian Agencies, one of three major groups of employees in the total Federal Sector productivity program (others are Defense and Postal Service), have grown steadily from an index of 100 in FY 1967, to an index of 130.6 in FY 1973. During the same period, there has been an input (staffing) increase, but at a somewhat lower rate, resulting in an FY 1973 index of 112.9. The differences between output and input indices resulted in an FY 1973 Productivity Index of 115.7, an average gain of 2.6 percent a year since FY 1967 for Civilian Agencies (see Figure 3-60).

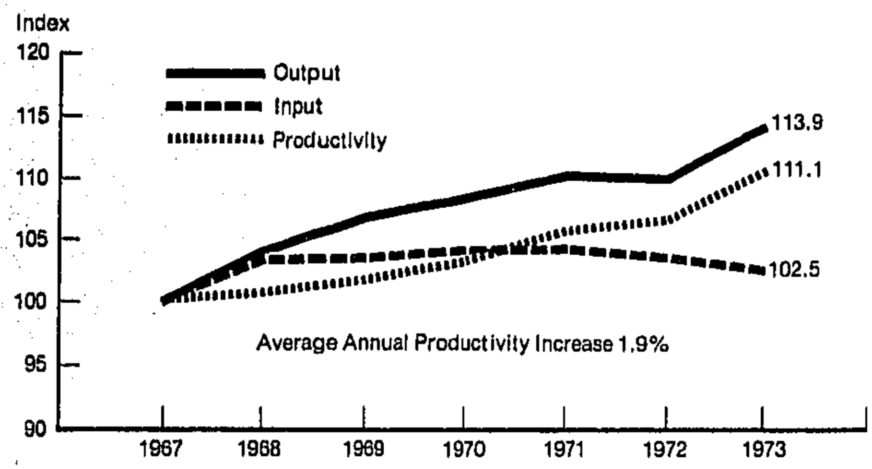


Figure 3-59. Productivity Trends—Federal Sector

e. **Transportation Agencies.** Within the above Civilian Agency group of employees is a category relating to Transportation. The participating agencies are listed in Figure 3-61. Figure 3-62 indicates that while the output index has increased to 136.0 for Transportation Agencies, the input index has increased to 110.5. The resulting productivity index is 123.1, an average annual increase of 3.9 percent over the six year period.

f. **FAA Indices.** The FAA is the largest employer shown under the Transportation Participating Organizations. Figure 3-63 shows the FAA's Productivity Trend since FY 1967. In FY 1975, the outputs index had increased to 163.9 over the FY 1967 base, while the input index had increased to 124.6. The resulting Productivity Index was 131.5, or an average annual productivity increase of 3.9 percent since 1967.

336. PRODUCTIVITY ASSESSMENT.

a. **Factors Affecting Productivity.** A joint CSC, GAO, and OMB study published in June 1974—a "Report on Federal Productivity"—classifies the factors that contribute to increases or decreases in productivity as: (1) product factors, (2) human factors, and (3) process factors. Each of these three categories has been subdivided into two subcategories as shown in Figure 3-64.

b. **Product Factors.** The output of employees must be described in terms of both quality and quantity of the product they produce. If the product is a service—say, air traffic services—quality refers to how well those services were performed and quantity indicates how many were provided.

(1) While quality is difficult to quantify, it must be taken into account when productivity measures are developed; otherwise, the measures may be misleading. For example, when FAA controllers issue low altitude alerts to pilots, the quality of their service has been increased. If the output measures for controllers do not reflect this activity, it might appear that controller productivity has been reduced if the transmission of warnings reduces the number of aircraft a controller can handle. Quality of product must also be considered when changes to increase productivity are proposed; here, the concern must be not to decrease quality without realizing what is being done.

(2) Quantity, or volume of workload, is a significant productivity factor that is easily measured. Gains in productivity are usually easier to achieve when workload is increasing than when it is stable or decreasing, because it is usually possible to get at least a little more output per employee when necessary, but often very difficult to reduce the labor force rapidly when the

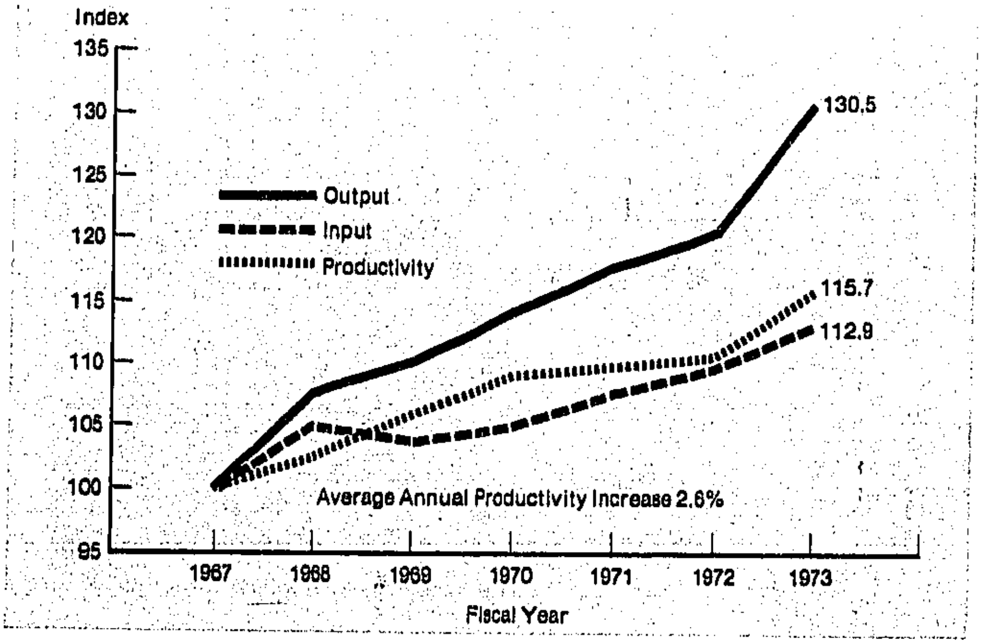


Figure 3-60. Productivity Trends—Civilian Agencies

Figure 3-61. Participating Organizations and Output Measures

Agency and Elements	FY 1973 Man-Years	Number of Outputs	Output Example
Canal Zone Government:			
Panama Canal Company	15,535	1	Net tons transited
Justice:			
Marshals Service—Prisoner Movement	69	1	Prisoners moved
Department of Transportation:			
St. Lawrence Seaway	180	1	Net tons transited
U. S. Coast Guard	45,380	12	Aids to navigation administered
Federal Aviation Administration	52,373	1	Weighted composite
Total	113,537	16	

workload levels off or declines. This may not be true when the workload increases beyond the capacity of the labor force to handle, because then such remedial actions as the addition of extra work shifts, authorization of overtime, implementation of new procedures, construction of new facilities, and development of new systems may reduce overall productivity for a while.

c. Human Factors. Human factors in productivity fall into two subcategories—motivational influences and skill levels.

(1) Positive motivational influences that contribute to increased productivity are job enrichment programs, employee opinion surveys, incentive awards, equal employment opportunity programs, personnel interchange opportunities, and the use of a team concept. Effective grievance procedures can also add to employee satisfaction, thereby helping to create a productive environment. In fact, one of the objectives in a productivity improvement program is to identify and eliminate the factors that have adverse impacts on employee morale and performance.

(2) The skill level of employees is a major contribution to productivity improvement, especially where programs or work methods are changing. Lack of proper training is often one of the causes of decreased productivity. The important consideration here is that training must be geared specifically to the requirements of the work and the organizational element concerned. Upward mobility programs and emphasis on employee development provide opportunities for employees to apply their skills and encourages them to develop new skills. Conversely, the loss of skills through retirement is a deterrent to increased productivity.

d. Process Factors. Process factors are probably the most frequent causes of productivity changes. This category contains a host of elements, which can be broadly separated into technology or physical resources on the one hand and systems, controls, methods, and procedures on the other. Technology considerations involve capital investment in new or modernized facilities, equipment, and materials. It also includes the research and development activities that precipitate capital investments. Economists have reported that, over the long run in the private sector of the economy, 40 to 60 percent of the productivity improvements have been the result of technological change.

e. Application of Productivity Measures. Since productivity measurement compares the output/input ratio of a base year with the ratios of successive years, overall trends from year to year can be re-

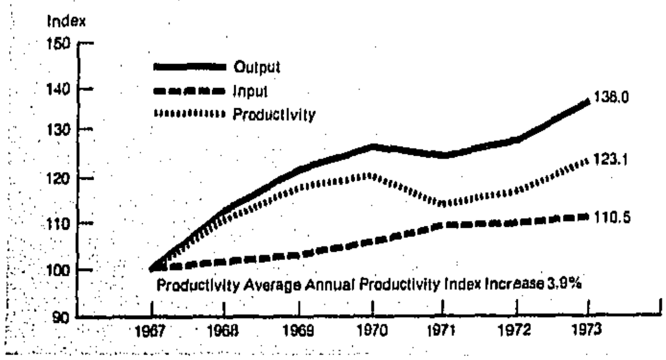


Figure 3-62. Productivity Trends—Transportation Agencies

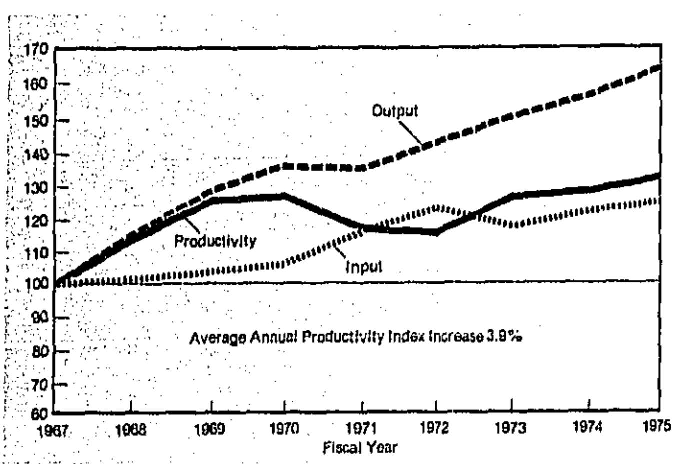


Figure 3-63. Productivity Trends—FAA

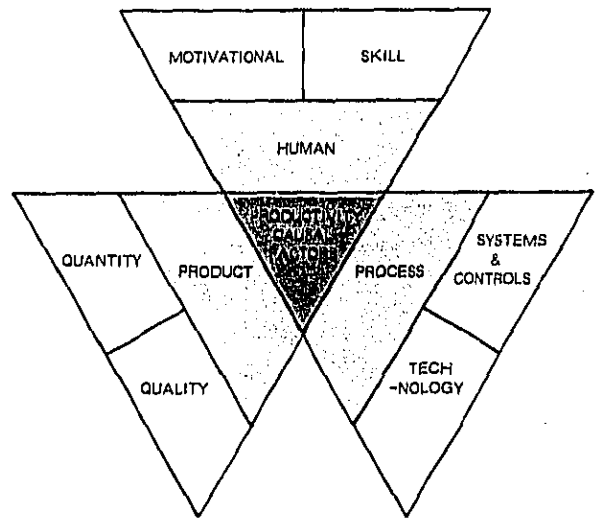


Figure 3-64. Causal Factors Affecting Productivity Change

viewed on a consistent basis. The trends indicate gross results of past actions to improve productivity, but they neither reveal the causal factors nor evaluate the interrleationships among the factors. Therefore, productivity measures should be used primarily as trend indicators. Productivity data are also useful in projecting staffing requirements based on forecast output trends.

337. PRODUCTIVITY MEASUREMENT.

a. Method of Measurement. The first step in a measurement program is to define specific and meaningful work products that are the final outputs of a significant group of employees whose time and costs can be directly identified with the output. Then productivity indices can be constructed by dividing the annual number of physical units produced by the manpower required to produce them. A base year that will provide a broad and consistent time period is selected and assigned an index of 100. Indices for subsequent years are a ratio to that base year.

b. Output Measures. The output measures used in this chapter generally meet tests presented in a report, jointly prepared by the Civil Service Commission, General Accounting Office, Office of Management and Budget, and 17 participating agencies, titled: "Measuring and Enhancing Productivity in the Federal Sector." Those tests require the output products to be to an acceptable degree:

—easily and consistently counted, year after year,

—mutually exclusive of any other output product, so that double counting will be avoided,

—the final product (or an intermediate product contributing to a final product) of a significant group of workers whose time and costs can be directly identified with the output, and

—defined in terms of its quality requirements.

c. Computation of FAA Productivity Indices. The total Air Traffic Services provided to both civil and military aircraft for the safe and efficient use of the airspace meet the tests for output products. These services have been quantified by using the following formula:

Air Traffic Service = Aircraft Services + 6.56X IFR Aircraft Handled + 1.84X Flight Services

Where:

Aircraft Services = Aircraft Operations + 4X Instrument Operations; IFR Aircraft Handled = 2X Departures + Overs, Flight Services = 2X Flight Plans + 2X Pilot Briefs + Aircraft Contacted

Using as inputs the total authorized full-time permanent positions expressed in man-years, the productivity index for any particular year has been determined using the following method:

$$\text{Current Year Output Index} = \frac{\text{Current Year Output}}{\text{Base Year Output}} \times 100$$

$$\text{Current Year Input Index} = \frac{\text{Current Year Input}}{\text{Base Year Input}} \times 100$$

$$\text{Current Year Productivity Index} = \frac{\text{Current Year Output Index}}{\text{Current Year Input Index}}$$

338. EFFECT OF PRODUCTIVITY ON STAFFING.

a. Output Trends. One reason for measuring productivity is to assist in planning future staffing needs. The forecasted air traffic activity outputs related to productivity measurement are: (1) Aircraft

Figure 3-65. Output Measures

Fiscal Year	Aircraft Handled	Instrument Operations	Aircraft Operations (In Millions)	Flight Services	Weighted Composite
1967	15.1	12.1	47.6	34.0	259.0
1968	18.1	14.6	53.0	37.1	300.1
1969	20.6	16.7	55.9	42.2	336.9
1970	21.6	17.5	56.2	46.7	354.7
1971	21.3	17.5	54.2	47.7	351.5
1972	22.0	19.4	53.6	50.4	368.4
1973	22.8	22.0	53.9	53.7	382.9
1974	22.9	24.1	56.8	56.2	406.7
1975	23.8	26.2	59.0	60.3	425.2
1976	24.7	27.2	63.0	67.0	457.1
1977	25.6	28.6	65.9	72.9	482.3
1978	26.7	31.1	71.6	80.2	518.8
1979	28.0	33.6	77.8	86.8	559.8
1980	29.0	35.5	83.2	89.9	580.0
1981	30.6	37.4	88.4	96.3	615.9
1982	32.3	39.7	94.9	104.4	657.7
1986 Baseline	37.5	48.1	116.9	132.9	799.7
Quick Recovery	39.8	50.9	123.5	139.6	845.4
Slower Recovery	37.1	46.8	109.5	123.4	767.1

Operations, (2) Instrument Operations, (3) IFR Aircraft Handled, and (4) Flight Services. Figure 3-65 depicts those four categories, and shows the composite weighted Total Air Traffic Services from FY 1967 out to FY 1986. The Total Services are expected to grow from 425 million in FY 1975 to about 800 million by FY 1986, roughly doubling over the period.

b. Staffing Standards. Extensive quantitative measurement has been used by the FAA in planning future manpower requirements. It is agency policy to use staffing standards—engineered standards, staffing guidelines, and other objective criteria—as the basic method for the development and justification of staffing needs. In addition, it has been a long standing FAA policy not to achieve economies at the expense of either safety or efficiency in the use of the national airspace.

c. Engineered Staffing Standards. An engineered staffing standard is based on the relationship between man-hours expended, as measured by a statistically valid method, and the work units produced. An engineered standard is derived from data that have been collected in an on-site measurement with respect to workload, activity rates, peak load requirements, safety standards, etc. They are characterized by objectivity and statistical validity. Engineered standards are currently used to determine the staff required for operating ATC facilities—air route traffic control centers, air traffic control terminals, and flight service stations. Also, an engineered staffing standard is being developed for application to the manpower requirements for the maintenance of the aids to air navigation and ATC facilities.

d. **Staffing Trends.** As shown in Figure 3-63, FAA staffing increased during the 1967–1975 period, but at a slower rate than the increases in aircraft services, i.e., the average annual increase in staffing was three percent while the outputs increased, on the average, at a rate of about eight percent a year. The cumulative savings to the Government in salary costs alone, represented by the increased productivity over this period, amounts to 1.6 billion 1975 dollars.

e. **Analysis of Trends.** As mentioned earlier, productivity measures provide a means of comparing the relationships between trends. Perhaps the most important conclusion to be derived from an analysis on the trends shown in Figure 3–63 is that the staffing changes show a two-year lag behind the output changes: for example, a decreased output in 1971 is reflected in a staffing reduction in 1973. Such occur because of the time required to go through the budget cycle: the staffing request for 1973 was prepared in 1972, and was based on the 1971 workload indicators (the latest data available). A similar situation occurred in 1971, when staffing increased by some nine percent over the previous year while output was decreasing. This was because the output had been increasing at an annual rate of 12 percent a year during the prior three years, and better than 14 percent in 1969—the base year used to project the 1971 staffing requirements.

f. **Future Staffing Trends.** Since productivity measures express the ratio of outputs to inputs, future staffing trends may be constructed by using forecast demands and certain productivity assumptions. The trends shown in Figure 3–66 are based on the output measures found in Figure 3–65 and the following assumptions:

Case I —No change in productivity, i.e., productivity remains at the Fiscal Year 1975 level.

Case II—A three percent a year increase in productivity beginning in Fiscal Year 1976.

Under Case I, full-time permanent employment would increase from 54.5 thousand in 1975 to roughly 103 thousand by 1986, depending on the demand growth factor. In Case II, staffing would increase to about 78 thousand by 1986, a net increase of 23 thousand employees. The cumulative difference between the two assumptions amounts to approximately 140 thousand man-years over the period FY 1976-FY 1986. This equates to an additional 2.4 billion 1975 dollars in salary costs alone.

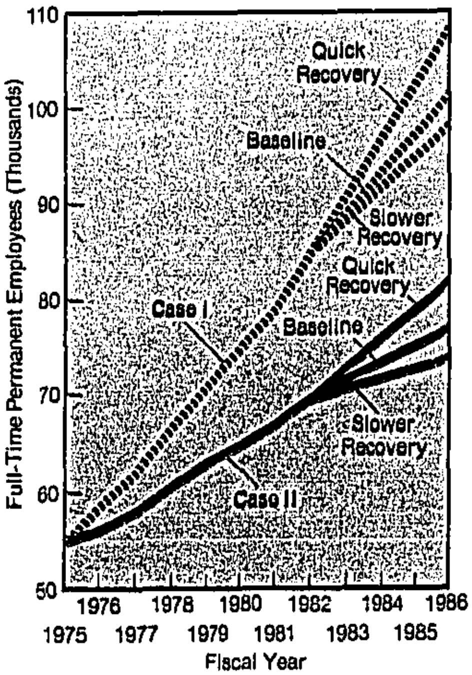


Figure 3–66. Productivity Impacts on FAA Staffing

339. POSSIBILITIES FOR PRODUCTIVITY IMPROVEMENT.

a. **Productivity Factors.** As discussed earlier, there are three primary categories within which actions affecting productivity can be classified—product factors, human factors, and process factors. Of these, only the process factors, specifically, technological change, appear to promise substantial increases in productivity. The product factors, because of the continuing requirement to improve the quality of services at the same time the quantity is increasing, can be expected to affect productivity very little (and even that little might conceivably be negative). The human factors will continue to receive a good deal of attention, especially in the labor relations area, however, further productivity increases do not appear probable.

b. **The Work Force.** The deployment of the agency's work force by major occupational groups is shown in Figure 3–67. The bulk of the agency's 57,000 employees consists of air traffic controllers and airway facilities technicians. Together, they represent 74 percent of the total agency staffing. The next largest group consists of flight standards personnel, who constitute nine percent of the workforce. The All Other grouping includes such areas as accounting,

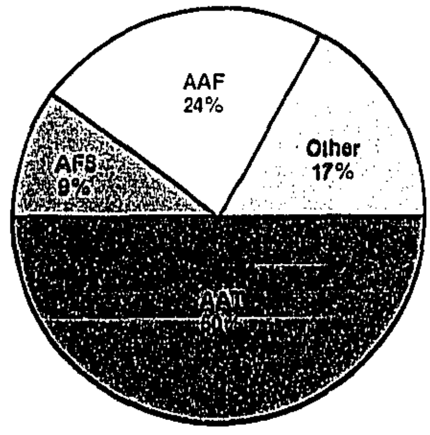


Figure 3–67. Work Force by Major Occupational Groups.

finance, legal, medical, personnel, procurement, research, training, etc. Since 83 percent of the agency's workforce is in three general groupings, it appears that these groups are prime candidates for technological efforts to improve productivity.

c. **Validity of Projections.** There is neither operational nor experimental evidence to indicate how much improvement in productivity can be achieved; projections of increased productivity are only educated guesses. However, since it has been shown that very significant effects on staffing levels can be produced by relatively small increases in productivity (Figure 3–66), the benefits derived from productivity improvements are very substantial. Moreover, there appears to be little choice: productivity must be increased if the NAS is to continue its overall growth, and technological advances seem to offer the best alternative for providing those increases.

d. Air Traffic. The productivity of the air traffic control system can be stated as the demand serviced by the system. Productivity can be increased either by servicing an increased demand with the same number of controllers, or by servicing the same demand with fewer controllers. Since the enroute and terminal control facilities have divided the airspace into sectors in which one or more controllers provide the services, increasing productivity means either reducing sector staffing or increasing sector capacity. In the flight service station area, productivity increases can be achieved by holding staffing levels constant while the output increases.

e. Facilities Maintenance. The maintenance, operations and support services performed by this group include the inspection, monitoring, and technical control, on a 24-hour-a-day basis, of the air navigation, communications, and ATC facilities that comprise the NAS. Since the total number of these facilities is expected to increase as demand increases, productivity improvements can be achieved by improving the reliability of these facilities so that their increased number will not require a proportionate increase in manpower.

f. Flight Standards. The two main activities covered by this portion of the agency's workforce are flight inspection and regulatory actions. Flight Standards personnel establish and enforce the majority of the Federal Aviation Regulations. They also conduct related activities to assure that the highest standards of aeronautical safety are maintained. These personnel are responsible for certifying that airmen, aircraft, aircraft operators, and aviation agencies meet safety and competency requirements. Productivity improvements in this area can be achieved only in the methods and procedures used to provide both the flight inspection and regulatory functions.

340. AIR TRAFFIC CONTROL.

a. Current Situation. At present, an integrated, computer-based network of ATC facilities is deployed across the United States. All the CONUS ARTCC's are operational using the NAS Stage A Model 3d en route automation program. This system provides for the semi-automated processing of flight plans and the fully automatic store-and-forward capability within and between the ARTCC's as well as between the ARTCC's and those terminal facilities equipped with the automated radar terminal systems (ARTS). Sixty-three high and medium density terminal facilities have been equipped with ARTS III, and selected lower activity locations are being equipped with a reduced level of terminal automation, ARTS II. For convenience, the presently deployed system has been commonly referred to as the Third Generation ATC System. This system is characterized by the use of state-of-the-art surveillance, data processing and display techniques to provide the air traffic controller with a display of the air situation, including the identity and altitude of suitably equipped aircraft.

b. Upgraded Third Generation ATC System. In 1969, the Department of Transportation's Air Traffic Control Advisory Committee (ATCAC) concluded that the capabilities of the Third Generation ATC System would not be adequate to meet the predicted demand. Furthermore, the ATCAC concluded that a substantial upgrading of the system was the only practical way to solve, in a timely and orderly manner, the problems of the 1980's and beyond. The Committee's report recommended the development of capabilities that would permit substantial increases in the ability of controllers to handle greater traffic loads through the use of additional automation.

c. Options. As previously stated, productivity can be increased by either reducing sector staffing or increasing sector capacity.

d. Reduced Sector Staffing. In a report released by the FAA in 1973 (Report No. FAA-EM-73-3), various approaches for increased productivity in both enroute and terminal control areas were discussed. It was pointed out that achieving enroute productivity gains by reducing the average number of controllers per sector would entail:

—Reducing support workload,

—Revising control team organization, and

—Redesigning control positions.

It was also stated that productivity could be improved in the terminal control areas by reducing the following support positions:

Tower: Clearance Delivery, Flight Data, and Coordinators.

TRACON: Radar Assistant, Flight Data, and Coordinators.

The reduced sector staffing concept is based on an analysis that shows that manual support tasks, rather than direct control tasks, tend to create the need for additional controllers. Consequently, a reduction in manual support tasks will result in increased productivity. With the aid of appropriate techniques—hardware, software, and procedures—it should be possible either to reduce the actual amount of support tasks or transfer them to the computer. For example, reducing the complexity and frequency of data entry should make it easier for a controller to update his own flight progress strips. If fewer strips are printed per flight and if sources of flight-plans-in-error are held responsible for correction, the support workload could be reduced. The introduction of data link and command generation logic for clearances would relieve the control sector of much of the routine workload in voice communications. However, reductions or transfer of the support tasks are likely to change the data entry and display requirements for the direct control tasks. Therefore, an expansion of interactive display techniques may be required to assure an uncluttered display and to simplify the mechanics of message entry.

e. Increased Sector Capacity. Another means of achieving productivity gains is to increase the control capacity of a sector. The previously mentioned report on Controller Productivity stated that productivity increases could be achieved by increasing the average number of aircraft that can be concurrently separated and expedited within the sector by a control team. Such increases in direct control capacity are likely to result from a reduction in voice communications per controlled aircraft, reduced mental calculation effort, and, ultimately a reduction in the frequency of direct intervention by the controller.

f. Flight Services. Since the flight service stations do not employ the sector concept, neither the reduced sector staffing nor the increased sector capacity option is applicable in this area. However, an OST/FAA study, "A Proposal for the Future of Flight Service Stations," published in August, 1973, pointed out that automation of flight services would satisfy the need for increasing quantity and quality of services, and would provide sufficient system capacity for projected growth while operating at a significantly reduced cost per service. Productivity increases in the flight service station area are expected to be achieved through a proposed new system that will embody centralization, automation techniques, and improved mass weather dissemination.

341. FACILITIES MAINTENANCE.

a. Objective. Increases in maintenance personnel reflect the requirement for maintaining an expanding system of communications, navigation, radar and air traffic control facilities. The FAA is continuously striving to minimize these staffing increases. The main objective is to improve the facilities within the NAS to the point where the increased number of facilities, operating at or above current performance levels, will not require proportionate increases in manpower.

b. Technology Factors. The two primary elements affecting equipment maintenance are the mean time between failure (MTBF) and mean time to repair (MTTR). Essentially, MTBF refers to the reliability of the equipment, and the agency intends to assure that specifications for equipment procured for new facilities embody the highest reliability obtainable consistent with cost-benefit evaluations. In addition, the agency is initiating programs to replace older, more expensive to maintain, equipment with state-of-the-art systems that are highly reliable, easy to maintain, and equivalent or superior to the older systems in terms of performance.

c. Review and Update. Maintenance standards are a result of engineering determinations. Based on equipment design concepts and characteristics these standards specify scheduled periodic maintenance and are promulgated in maintenance handbooks. The handbooks are reviewed and changed continuously based on actual experience and new technology to limit any over-maintenance of equipment.

342. FLIGHT STANDARDS.

a. Regulatory. Productivity increases in the regulatory area have been accomplished primarily by delegating certain examiner activities to segments of the aviation industry and by improving operating and management procedures. Future improvements in management techniques (such as random sampling and statistical inferrences) will enable Flight Standards to conduct its programs with staffing increases that will be moderate in comparison with the large increases expected in aviation industry activities.

b. Flight Inspection. Flight inspection productivity has increased significantly over the years. The modernization of the flight inspection aircraft fleet is expected to permit a continuation of that trend. The key areas in which changes have resulted in productivity gains are:

—Better management techniques by the establishment of the Flight Inspection National Field Office.

—Major changes in flight inspection procedures.

—The establishment of better communications and coordination with system users.

—The reduction of Semi-Automatic Flight Inspection (SAFI) cycles from four to two per year.

—The modernization of the flight inspection aircraft fleet, replacing piston with turbine-powered aircraft equipped with more sophisticated electronics.

343. PROGRAMS FOR AIR TRAFFIC CONTROL.

a. En route Control. In the en route area, two methods were analyzed as means for achieving productivity gains (e.g., reduce staffing and/or increase instantaneous aircraft handled). The primary emphasis is to be placed on automation. The near-term programs are aimed at improving the existing system until the upgraded automation programs can be implemented. The near-term programs are:

(1) Long Range Radar. The present operational long-range radar (LRR) network consists of search radars collocated with radar beacons. It is planned to increase the domestic radars and to expand the coverage outside the conterminous U.S. It is now planned to install ATCRBS (beacon-only) at a few locations. The potential future use of the beacon-only technique in Alaska may be warranted.

In addition, the near-term plan includes providing an ARSR to the FAA Academy for the training of radar technicians, and purchasing Mobile En route Radar Facilities (MERFs) to provide the continuity in radar coverage during necessary shutdowns of operational systems or in the event of critical component failures. The costs for these systems include the LRR/ATCRBS equipment (hardware), interface modifications for NAS Stage A, site selection and preparation, buildings, etc. All of the radar systems, including a number of military radars, in the en route environment were designed before or during the early 1950's. Although various modifications have been applied to the systems, they were corrective in nature and did not bring the systems into the state of the art. For example, the radars use vacuum tubes almost exclusively. As a result, the existing inventory of en route radars is difficult to maintain. Under the near-term plan the gradual replacement of some of these radar systems will be accomplished.

Since the replacement of the existing radar systems will be gradual over a period of years, certain improvements will be required during the interim period. These improvements are required to alleviate known deficiencies and to upgrade the network to meet NAS Stage A specifications. This program covers a wide variety of projects to assure that each radar system meets minimum requirements at all times. Accordingly, existing antennas will be replaced with new antennas, both primary and secondary. This effort also includes various projects to improve the reliability and data handling capacities of the Government owned radar microwave links. Furthermore, since the performance of the search radars and the ATCRBS can deteriorate between periodic checks without being visually detected on the radar scopes by the air traffic controllers, the plan is to equip all FAA long range radars with both radar and beacon performance monitors. Additional units will be provided to Atlantic City (NAFEC) and Oklahoma City (Academy).

(2) En route Automation. The plan for en route automation provides for flight data processing, radar data processing, and NAS improvements.

Flight Data Processing (FDP) provides a computerized flight data processing capability for the centers. This capability eliminates delays caused by manual handling and significantly increases the accuracy of flight plan distribution and updating. More timely and accurate flight plan handling throughout the system is the result.

Radar Data Processing (RDP) was commissioned in the last of the centers during 1975. The RDP function, which completes the basic en route Stage A program, provides automatic aircraft tracking and computer generated alphanumeric (A/N) displays using digitized radar data. The A/N displays provide the air traffic controller with aircraft identification and altitude for all aircraft which have the appropriate transponders. The result is a much needed "third dimension" (altitude information) which has relieved frequency congestion and decreased the workload for both pilots and controllers. The RDP function also includes a weather subsystem display which provides the controller with the location of severe weather areas.

To meet the demands for en route control services during the late 1970s and the 1980s, a substantial upgrading of the NAS Stage A system is envisioned. The first improvements will be those which can be implemented in the near term, without waiting for major new subsystems or other long lead-time developments. These improvements will make more efficient use of system resources, simplify the man-machine interfaces, and enhance operational performance. Also, it is planned to manage the national flow of air traffic from a centralized, semiautomated air traffic control system command center. Its mission will be the coordination of national traffic based on current demand, routes, major equipment outages, airport flow rates, prevailing weather, etc.

(3) Center Facilities. A reduction in the number of centers from the present total of 26 to 25 is planned, and one of these, San Juan, will be converted to a combined Center/Radar Approach Control (CERAP) facility. The Great Falls, Montana ARTCC is being phased-out and its functions are being absorbed by expanding the boundaries of adjacent centers. Of the remaining 25 centers, 20 are within the conterminous United States. The other five are located in Alaska, the Canal Zone, Guam, Hawaii, and Puerto Rico. An en route automated radar tracking system (EARTS) is planned for implementation at Anchorage, Alaska ARTCC; Honolulu, Hawaii ARTCC, and the San Juan combined Center/Radar Approach Control Facility (CERAP). The planned 20-center CONUS configuration was approved in 1967 and forms the basis for the National Airspace System (NAS) En route Stage A automated system.

Other improvements should provide increased reliability, efficiency and capacity in the en route system. These include new sectors, radar displays, communications equipment, refurbishment of buildings, and so forth.

New, solid-state VHF transmitters and receivers, capable of 25 kHz channels, are being installed at all RCAG facilities serving high altitude en route sectors. It appears that the use of 25 kHz channelization for high altitude purposes will permit the use of 50kHz spaced channels in the lower altitudes for a number of years. However, the future need for 25 kHz spaced communications channels remains a subject for continuing study. The back-up emergency communications (BUEC) program provides a certain amount of redundancy to the RCAG system by installing tuneable VHF and UHF transceiver equipment in the ARTCC buildings, LRR sites, Flight Service Stations (FSSs), etc. High capacity voice recorders provide additional numbers of voice and time channels with spare channels for future use, yet markedly reduce space consumption and maintenance problems.

(4) Long Term Programs. Many of the program features of the "Upgraded Third Generation Air Traffic Control System" offer the greatest potential for productivity gains. These programs will introduce further automation of some elements (e.g. upgraded automation in ARTCC's, TRACON's) and initial automation at others such as FSS's. It must be understood that the UG3RD programs are still under review and that program decisions are still to be made.

—Upgraded ATC Automation. The upgraded ATC automation program is in the developmental stage. Upgraded ATC automation functions will primarily be afforded through additions or modifications to the computer programs of the data processing systems installed at the en route control centers, at terminal area control facilities, and at the ATC System Command Center.

Under this program the air traffic controller team productivity and capacity are expected to increase. The following activities are aimed at improving the efficiency and effectiveness of the control teams.

—Flight Plan Conflict Probe. This is an advanced development activity currently in progress which would provide the air traffic control teams in the en route control centers with the capability to check each flight plan in advance for potential conflicts throughout the center's area of control. This would assist in planning flight clearances that avoid future conflicts.

The present schedule calls for the completion of the development stage in FY 1976. NAFEC and field evaluation are scheduled for completion during FY 1977. The implementation decisions (NAS software) could be made following the completion of the evaluations.

—Control Message Automation (using data link). This activity sees the gradual deployment of DABS to cover all terminal hub areas and the busier en route airspace between those hubs. DABS would provide a high capacity, ground/air/ground data link between ATC facilities and properly equipped aircraft with coverage over much of the nation. Within this environment, the data link delivery of ATC clearances, information, and advisories for most IFR operations could be anticipated. Non-routine clearances and exceptions taken by the pilot would be handled via either voice radio or manual data entry devices. Advanced development activites are in progress in the en route and terminal programs to automate the various types of control messages and to investigate operational procedures for their use. The current E&D schedule for this program activity indicates that the design and development phase will be completed in FY 1978. Prototype development will depend on the DABS decision.

—Control Sector Design. In addition, there are advanced and exploratory automation development activities to improve both design of the control sector positions and the methods of handling and displaying flight and control data to en route and oceanic ATC control teams. These activities are investigating the use of electronic tabular displays and quick entry devices to replace the existing flight strip printing equipment for en route and terminal control positions. The objectives are to improve the efficiency of data handling by controllers whose primary air situation displays show position data for all controlled traffic and to reduce the need for assistant controllers now required for manual flight strip handling tasks.

The experimentation phase of this activity is underway and decisions concerning advanced development will be made following completion of the experimentation phase.

—Area Navigation (RNAV). This program, which is expected to improve the efficiency of ATC operations and possibly reduce controller workload and costs by relieving them of the need to provide radar vector commands, has been underway for several years. Some RNAV routes (primarily in the high altitude sturctures) have already been implemented. The current E&D program is basically a series of studies and simulations which have been structured to:

—Develop terminal area route designs.

—Develop high and low altitude route designs.

—Develop a universally acceptable method of way-point identification.

—Develop RNAV avionics standards.

—Implement RNAV routes.

The terminal area RNAV applications included in these studies are to change the orientation of the current terminal ATC system from one which is highly dependent on naviation directions issued from the ground to one where navigation is performed primarily in the cockpit. For example, in the current high density terminal areas the air traffic controller often guides aircraft by issuing heading and speed instructions (called radar vectors) as part of the process of separating, sequencing, spacing, and getting aircraft to follow the desired tracks within the terminal area. RNAV will enable aircraft to fly from one designated way point to another within the terminal area without being told when and where to turn by the controller by using (1) delay fan, (2) direct to next way point, (3) parallel offsets on base leg, and (4) multiple discrete parallel departure paths.

—Discrete Address Beacon System (DABS). Should a thorough analysis of the proposed DABS program support its implementation, this program could be the key to improving the surveillance of airspace and will be providing a high-capacity, low-cost, ground-air-ground data link which could contribute to the successful implementation of the other features of the UG3RD system. The data link would reduce the communications workload and provide productivity gains. The development of DABS is proposed to be accomplished in three phases as outlined below:

Phase I—System Validation and Definition. The objective of Phase I is to validate the concept and feasibility of DABS and make the design decisions necessary to define the system operation. Phase I was initiated in January 1972 when the M.I.T. Lincoln Laboratory began work for the FAA as its DABS System Engineering Contractor. Concept validation and system design are being carried out at Lincoln Laboratory with support from industrail subcontractors, the National Aviation Facilities Experimental Center (NAFEC), the Transportation Systems Center (TSC), and the DOD's Electromagnetic Compatibility Analysis Center (ECAC). The principal outputs of Phase I include:

—A DABS system description.

—Specifications for procurement of developmental (engineering) model DABS ground and airborne hardware for Phase II.

—Functional specifications for integration of DABS into the ARTS and NAS Stage A automation system in Phase II.

—An experimental DABS test bed.

—An update of a previous DABS/ATCRBS alternatives study to reflect cost estimates based on more detailed design information and to examine the sensitivity of conclusions to various assumptions.

Phase II—System Engineering and Evaluation. Phase II covers DABS performance evaluation and system level engineering and evaluation activities. It is comparable to the DOT Advanced Development phase. It will consist of three parallel and interrelated efforts. One is to evaluate the total system operation when interfaced with terminal and en route (ARTS and NAS Stage A) automated control systems. A second effort is concerned with conducting tests of functions that uniquely rely upon DABS and to verify the suitability of DABS to support them. The third effort will be continued system engineering including design refinement, investigation of equipment variations, and planning for the implementation of an operational DABS network.

The principal results of the Phase II activity will be:

—A National Standard for DABS.

—Production specifications for DABS sensors.

—Specifications for integration of DABS into the ARTS and NAS automation systems.

Phase III—Production and Development. Following completion in Phase II of the specifications for production units, competitive soliciation will be conducted by the FAA for fabrication and installation at field sites of operational DABS units.

The following benefits could be expected from DABS:

—The digital data link would provide a quick and highly reliable transfer of information already contained in the NAS or ARTS computer to the aircraft. Such information may include heading, speed, and altitude messages, radio frequency settings, and radar advisories (alerts as to nearby traffic). The automatic transfer of such information could be expected to result in a decreased workload on the controller and an increase in controller productivity. The degree to which such benefits would be achieved will be determined later on in the program.

—DABS would provide improved surveillance accuracy and eliminate the risk of synchronous garble for DABS equipped aircraft.

Phase I has been underway for several years. Experimental tests have begun and are scheduled to be completed by mid CY 78. The second phase is expected to begin in mid CY 76 with the procurement of the DABS development (engineering) sensor model and associated avionics. The operational trials could start in FY 1978. Phase III (system implementation) could begin following operational trials and a favorable implementation decision.

b. **Terminal Control.** As stated under "enroute control" automation is the principal tool for improving productivity. In the short-term however, improvement to the existing systems will be stressed until automation which is under development has been tested and implemented. The short-term programs are:

(1) **Terminal Radar.** A new generation of solid-state, van mounted ASRs is being procured to meet expanding needs. This equipment offers the distinct advantages of (1) improved primary radar detectability, (2) superior MTI (Moving Target Indicator), (3) reduced ground and weather clutter, and (4) increased reliability and maintainability because of solid-state circuitry. These newest generation ASRs are planned for installation at high density locations. The plan then calls for refurbishing the existing ASRs and relocating them to newly qualified locations. By this arrangement, the most critical locations in the system will be assured of the latest advances in radar technology while newly qualified locations will be provided radar services compatible with their needs at a commensurate cost.

New locations normally receive equipment which enables controllers to provide approach control services from the tower cab. This type of facility is referred to as terminal radar approach control cab or a TRACAB. Equipment provided by the ASR establishment program for TRACABs include ASR, ATCRBS, ARTS II, video mapper, communications for two positions, and three BRITE displays (DBS) for the tower cab.

Within many metropolitan areas, several ATCTs are served by a common radar approach control facility. Also, some of these satellite airports are within the radar coverage area of the ASR. The remoting of the ASR data to the tower cab at a satellite airport enables those tower controllers to more adequately sequence arriving aircraft, release departures with minimum safe separation, and provide traffic information to other aircraft operating in the displayed area.

Where operationally adequate low-altitude radar coverage can be assured and other criteria are met, it is planned to remote the ASR data from the approach control facility to satellite tower cabs via a low-cost television microwave link. The radar bright tube display system (BRITE) includes a plan position indicator (PPI), a television camera with a special vidicon tube, and a high-bright TV display which can be used under high ambient light conditions.

Many terminal radar facilities have become obsolete due to equipment deterioration, technological improvements in the state of the art, inadequate operating or equipment space, and changes in airport location or configuration. These factors require periodic improvements or relocations of commissioned radar facilities. In addition, studies of the increasing interference environment, resulting from the increasing numbers of radar and beacon facilities, are leading toward improved equipment compatibility and system availability. The efforts in this area include relocating ASR's; providing mobile ASRs, and improving terminal radar beacon antenna systems. Video mappers, beacon performance monitors and BRITE displays are also included in the planned program of major improvements to terminal radar.

Airport Surface Detection Equipment (ASDE) is a data acquisition system presently in use for airport ground control purposes. Because ASDE can be adversely affected by weather conditions, new airport construction, and equipment obsolescence, major improvements are planned for these facilities to increase their availability and provide better contrast of display information in the tower environment.

(2) **Automation.** The ARTS II systems are expected to fulfill the current and future requirements at low and medium density radar terminal facilities. In addition to presenting primary and secondary radar returns, the basic ARTS II system provides for the decoding and numeric display of beacon code of altitude data re-

ceived from aircraft transponders. For aircraft responding with unique codes, the system also provides the capability to display alphanumeric flight identification data in lieu of beacon codes. The basic package does not perform tracking functions and, therefore, does not provide a source of speed/direction data for display or to support other functions. ARTS II consists of two options: a system utilizing Plan Position Indicator (PPI) display in the radar control room or a system which utilizes BRITE displays in the tower cab. Each option has the capability to interface with the en route automation system.

The installation of 61 ARTS III systems at selected large and medium density locations is essentially completed. Two additional systems are installed at NAFEC for use in the system enhancement effort and support function. A third system is located at the Aeronautical Center and is used for training purposes. Action is underway to replace the ARTS I at Atlanta and the ARTS IA at New York with improved versions of the ARTS III.

The identity of all aircraft controlled by terminal facilities is not automatically achieved by the ARTS III systems. Under the present system, the identification and tracking of nonbeacon equipped aircraft is initiated and maintained manually by the controllers.

The radar tracking "add-on" feature to the basic ARTS III system will tag nonbeacon equipped aircraft, accomplish automatic radar tracking, and provide a backup to beacon tracking which will improve the accuracy of the reported target position. Radar tracking is planned for high activity locations. In addition, future functions resulting from present development efforts—metering and spacing, improved flight data processing, conflict prediction and alert, and final approach course monitoring—are planned to augment the ARTS III.

Provisions of disc subsystems, levels of redundancy, and modified computer processors will improve the reliability of the fully enhanced ARTS IIIA systems. These additions will afford a fail-soft capability and enable continuous, 24 hour a day operation. The provision of ancillary subprograms and electronic subsystems will foster an improved training capability, i.e., enhanced target generators, as well as facilitate software support and maintenance functions.

(3) Tower Facilities. There is always a need to develop a more efficient means for collecting, processing, and exchanging radar, meteorological and other data among controllers and pilots. Also, there exists a need to resolve current operational problems—squeezing an ever increasing number of radio channels into a fixed amount of radio frequency spectrum, equipment deficiencies (including obsolescence), and inadequate telephone service. These needs result in a continuing program to modernize and improve the terminal system.

To assure that commissioned facilities retain the efficiency and service levels for which they were designed, certain tower modernization and improvement efforts are necessary. These efforts involve the relocation and/or modernization of ATCTs and TRACONs, the installation of additional air/ground communications channels and equipment (including the establishment or relocation of remote transmitter/receivers), the separation of combined station/towers, and the establishment of automatic terminal information service (ATIS).

A long-term program in the terminal area is:

—Airport Surface Traffic Control (ASTC). This program will provide the means for the safe and efficient movement of air traffic on the surface of the airport in the face of increasing traffic, more complex mazes of runways/taxiways, and trends toward operations in lower visibility conditions. Initially, improved radar surveillance and simple stop-go and visual signals to pilot are planned for early development. Automation of some of the control functions, and improved displays and facilities in the tower cab for the local controller and ground controller are planned for the long-term. It will be during this long-term program that productivity increases are expected to be achieved.

In reviewing the need for improving airport surface traffic control it became obvious that the needs of individual airports differed to the extent that no one system configuration would be applicable to all airports. It was also recognized that some developments could be undertaken to provide near term improvements but that a longer range program would be needed for a more complete solution of the problems. As a result, a three phase program has been structured to provide increasing levels of capability through modular expansion. Basically, Phase I provides for an upgrading of existing ASTC system and capabilities. This Phase includes:

—Upgrading the ASDE-2 radars to improve their performance and to reduce their maintenance costs at those airports where they are currently installed.

—Developing a new ASDE-3 radar to replace the ASDE-2 as well as for use at newly qualifying airports.

—Developing an improved BRITE display which incorporates a higher resolution CRT and provides scan conversion circuitry having a ASDE compatible bandwidth.

—Improving visual guidance—lights, signs and markings—for pilots on the airports surface. Items under consideration include the improvement of runway and taxiway lights/signs, lights for identifying runway exits to taxiways, and stop/go clearance bar lights.

Phase II would represent the first major change in ASTC operations and might be viewed as the initial step toward a new ASTC system. This phase would be characterized by the introduction of a new, advanced surveillance system (using either radar or multilateration techniques), the possible introduction of a limited amount of autonomous, automatic control at critical interesections, improved communications, and some associated procedural changes.

Phase III is planned as a further expansion of the Phase II system and would be characterized by the introduction of automatic control and cooperative guidance systems. Automatic control envisions the automation of the Local and Ground Control functions. Based on data inputs, a central computer would generate commands which then would be transmitted to the aircraft by data link or visual signals. Since visual guidance is expected to be virtually impossible as operating weather minimums are reduced, the cooperative guidance equipment will provide the pilot a cockpit display of his position on the airport.

With the exception of the ASDE-3 radar, all the Phase I development work will be completed during CY 1976. Installation of the first ASDE-3 is not expected before the end of CY 1980. The Phase II trilateration and automatic intersection control systems are under development. The Phase III system design is underway and this development activity is scheduled to be completed in FY 1981.

In addition to the above long-term program, there are the DABS, Upgraded Automation and Area Navigation programs which are expected to provide improved productivity in the terminal area. These programs have been discussed under En Route Control above.

c. Flight Service Stations. The agency has proposed a Flight Service System Modernization Program, the objective of which is to implement a system that supports the basic concepts described in an OST/FAA study, "A Proposal for the Future of Flight Service Stations." The technical details of the program have evolved since that report was published (8/73) and the forthcoming FAA document—FSS-01, "Master Plan for the Flight Service System Modernization

Program"—should be referred to for a complete description of the proposed program. The most cost effective system would consist of a relatively small number of sites, called Hubs. All the services provided by the system would emanate from the Hubs through the use of telephones and automation equipment. The users, through the use of telephones and other appropriate devices, would have direct access to all the information they would need. In addition, automation support to the FSS specialists will enhance both their efficiency and effectiveness. Final implementation decisions for this proposed FSS program have not been made. If, however, test, evaluation, and other factors indicate implementation is beneficial the program is expected to take place in three phases. The three phase program has been developed to provide a realistic transition from the present, manual FSS operation to the planned, highly automated system. The three phases are near-term (1976-1980), intermediate-term (1980-1985), and long-term (1983-1986).

(1) Near Term. This phase focuses on those areas that can provide immediate improvements in service but are not dependent upon automation equipment. These areas are mass weather dissemination and FSS productivity improvements. Mass dissemination of aviation weather is accomplished through two services—Pilot Automatic Telephone Weather Answering Service (PATWAS) and Transcribed Weather Broadcast (TWEB). The content and accessibility of these weather messages is being improved by providing specific route-oriented recordings, weather product improvements, more frequent updates, and the addition of more telephone lines. En route Flight Advisory Service (EFAS) has been implemented, is operating at four locations, and has proven to be very successful. Activation of EFAS at the remaining 40 locations will be completed during the Near-Term.

Station productivity will be improved through the use of modern display techniques, similar in function to the Meteorological and Aeronautical Presentation System (MAPS) originally developed for the Air Route Traffic Control Centers. This minicomputer system will store, retrieve, edit and display weather data for the specialist, thus relieving the station personnel of much of the unproductive present day paper handling procedures.

(2) Intermediate Phase. Current plans call for deployment of automation equipment that will provide automation aids to the FSS specialist and will permit direct access to the system by the user. This automation base is called the Baseline System and the equipment will be installed in the 1980-1985 time frame. An automated system, known as the Aviation Weather and NOTAM System (AWANS) is already operational in Atlanta and is providing a foundation for this effort. This operational test facility utilizes minicomputers to rapidly collect, store, retrieve, reformat and display weather and flight plan information required by the Flight Service Specialist. This system offers the specialist significantly more capability than the MAPS. This AWANS experiment is providing the data required to procure the national Baseline System.

The Baseline System will support the specialist by providing automation aids for many of his functions. In addition, the system will allow the user direct access to the Hub weather data base. This will be achieved by allowing a user who has a privately owned computer terminal, to call the computer and obtain a briefing by retrieving the appropriate weather. This initial service will be the forerunner to the more widely available direct access services which would be offered during the Long Term Phase of the program. Near term improvements to PATWAS, TWEB, and EFAS will be continued in the Baseline System.

As the initial Baseline Systems are installed, consolidation of all present FSS activities and functions into the Hubs will begin. This consolidation will not interrupt services to the user and possible reductions in manpower will be achieved through normal attrition.

(3) Long Term. Additional capabilities will be added to the Baseline System. These enhancements are centered around two subsystems—a computer-generated voice response system and a family of direct user access devices. The voice response system will provide automatic generation of the PATWAS recordings, telephone/interactive weather briefings, and specialist support. The pilot with a touch-tone telephone may call the FSS Hub and by pressing buttons on his telephone obtain a very specific, tailored briefing from the computer. The voice response system will also be used to support the specialist and thus improve his productivity.

The automatic system will provide a number of possible means for pilots to satisfy all or most of their flight service information and filing requirements by self-service actions. System capabilities will range from pilot self-service by a telephone call from home, interactive techniques which may use "Touch-Tone" (TM) telephones or pilot owned special devices, through fully interactive data terminals. During the enhancement phase, pilot use and/or ownership of any one of the family of user direct access devices will be encouraged by FAA. The agency has not made a decision to purchase or deploy data terminals at airports, other than for test and demonstration purposes. Potential deployment of such terminals will be based on cost-benefit analyses.

Both of these areas—Voice Responses Systems and Direct User Access Devices—offer the potential for great payoff to the government and the taxpayer, in that, as demand for FSS services increases, staffing levels may be held constant or gradually decreased. Implementation of these enhancements could begin in 1983.

d. Reassessment of UG3rd. It is important to note that the output of the ATCAC effort was a well thought-out and reasoned concept for evolutionary and significant ATC improvement. The ATCAC concept for upgrading the Third Generation ATC System (UG3rd) was the result of an extensive analysis of possible alternatives and provided the point of departure for further study. Detailed systems analyses, engineering, and design efforts were required to validate or modify the ATCAC concept in order to translate it into actual improvements to the operational ATC system. Since recent traffic growth and forecasts have been well below the projections used by the ATCAC, reassessment of the ATCAC recommendations has been made. It was concluded that because of the projected costs for operating and maintaining the ATC system as well as the need for continued improvement in air safety, the development of the UG3rd should be continued.

e. UG3rd Goals. The main goals of the UG3rd ATC system are to improve safety, reduce operating costs, and increase performance. These goals are closely interrelated, and it does not appear possible to satisfy one without impacting another. Furthermore, the interrelationships and differences in priorities make it exceedingly difficult to qualitatively define the impacts from each feature of the UG3rd, either separately or jointly, on those goals.

f. UG3rd Features Impacting Productivity. Of the nine principal features that characterize the UG3rd, six are expected to contribute to increased controller productivity.

(1) The Discrete Address Beacon System (DABS) would be the key to improving surveillance of airspace and would provide a high capacity, low cost, ground-air-ground data link.

(2) The Intermittent Positive Control (IPC) feature would generate pilot warning advisories and collision avoidance commands on the ground, and transmit these messages via the data link feature of DABS to appropriately equipped aircraft.

(3) The Flight Service System would be restructured and automated. Through the utilization of modern data handling and processing techniques, the capacity of the FSS system would be expanded to a level that

meets user needs and allows further growth with a reduced staffing level. The projected use of pilot self-service techniques would result in a more efficient FSS staff, greater use of the FSS, and significant reduction in cost per unit of service.

(4) Upgraded Automation functions would, for the most part, be provided by additions or modifications to the computer programs of the data processing and displays installed in the enroute centers, terminal control facilities, and the national level traffic management and flow control center at FAA Headquarters. Substantial reductions in the unit cost of controller services are expected.

(5) Area Navigation (RNAV) permits pilots to fly a direct course between preselected fixed points rather than along radials of VOR stations or in compliance with radar vectors issued by the controllers. The RNAV feature is expected to improve the efficiency of ATC operations in terminal areas and possibly reduce controller workload costs by relieving them of the need to provide radar vector instructions.

(6) The Aeronautical Satellite (AEROSAT) program, being pursued jointly with ESRO and Canada, is aimed at exploring the use of satellite technology for improving the management of oceanic air traffic. Over the long term, it is expected that the consolidation of oceanic air traffic control centers and the greater efficiency of oceanic air services, i.e., reduced separation standards, would result in greater productivity.

g. Implementation. Engineering design and development has been initiated on those UG3rd features enumerated above. Commitments have not been made for the actual implementation of any one of those features however, for planning purposes, estimated implementation dates and probable funding requirements have been developed. Such estimates are always subject to major change as developmental effort proceeds to the point where decisions can be made as to the quantities needed and the costs involved. Finally, implementation decisions concerning those features will be based on the benefits and costs to both the Government and the users. Such an approach recognizes that the UG3rd is a cooperative system that will require the users to buy avionics equipment in order to participate.

h. Productivity Lag. In all probability, at least four years will be required to experience productivity increases after a decision is made to implement any one of the UG3rd features. This lag comprises two years between submission and final approval in the budget cycle, at least one year in the contract, production, and installation phase, and another year to develop proficiency with the new feature.

344. PROGRAMS FOR FACILITIES MAINTENANCE.

a. Factors Affecting Productivity. Some of the factors that influence manpower requirements in facilities maintenance are:

(1) Availability. Most navigational aids, communications systems, and ATC facilities are required to be available for use 24 hours a day, seven days a week. Availability figures of over 99 percent are common for the majority of the equipment in the system.

(2) Reliability. The mean time between the failure of individual components of equipment determines both the availability of a system and the amount of manpower required to maintain the system.

(3) Sector Configuration. FAA facilities are maintained by personnel who are assigned to operate within a given geographical area or sector. The location and size of the sector combined with the type, number and distance to the facilities help to determine the man-years needed to perform maintenance activities in that sector.

b. Productivity Feature. As discussed earlier, productivity gains in this area will require either improving the reliability of the equipment or decreasing the amount of time required to repair the equipment when it does malfunction. In turn, those activities require continued quality control of production items, review of design specifications, improved monitoring and diagnostic equipment, higher skill levels, and continual update of maintenance handbooks. In addition, vigilance is required to see and take advantage of technological advances that would permit increased productivity. For example, the FAA has a very substantial program underway to replace older, hard to maintain enroute and terminal radars with state-of-the-art equipment. These new radars should have a considerable effect on maintenance productivity, even though they cannot be expected to produce much in the way of controller productivity.

345. PROGRAMS FOR FLIGHT STANDARDS.

a. Factors Affecting Productivity. Flight Standards personnel are required to establish and enforce the Federal Aviation Regulations. They also conduct related activities to assure that the highest standards of aeronautical safety are maintained. These personnel are responsible for certifying that airmen, aircraft, aircraft operators, and aviation agencies meet safety and competency standards. Their responsibilities also include the original, production, and continued airworthiness certification of aircraft. In addition, they maintain and operate the agency's fleet of flight inspection aircraft, which are used to assure that the facilities and equipment of the FAA are operating safely and effectively. Flight standards personnel also develop and implement special obstacle clearance standards that are incorporated into charts for all navigable airspace, including all airways and instrument approach procedures.

Figure 3–68. E&D Program Costs Attributable to Productivity

	Plan (Dollars in Millions)						Total
Program	**1977**	**1978**	**1979**	**1980**	**1981**	**1982–86**	**1977–86**
01 System	4.7	8.7	9.1	10.0	13.4	124.8	170.7
02 Radar	----	0.6	0.5	0.3	----	----	1.4
03 Beacon	6.6	8.8	4.8	3.0	2.4	7.6	33.2
04 Navigation	0.3	1.1	1.1	0.9	0.9	3.0	7.3
06 Communications	0.4	1.0	1.2	2.9	3.0	8.8	17.3
07 Approach & Landing Sys.	1.7	0.8	1.3	0.8	0.3	1.2	6.1
12 EnRoute Control	8.5	11.1	11.0	11.0	11.0	47.5	100.1
13 Flight Service Station	4.9	4.6	5.0	5.0	5.0	9.5	34.0
14 Terminal/Tower Control	8.5	9.5	10.0	10.0	10.0	46.5	94.5
16 Technology	1.0	0.2	0.5	2.1	3.0	55.0	61.8
17 Satellites	1.8	----	----	----	----	6.9	8.7
TOTAL	**38.4**	**46.4**	**44.5**	**46.0**	**49.0**	**310.8**	**535.1**

Figure 3-69. F&E Program Costs Attributable to Productivity *

PROGRAM	1977	1978	1979	1980	1981	1982-86	1977-86
	PLAN (dollars in millions)						
EN ROUTE CONTROL FACILITIES							
Long Range Radar (1)	5.6	10.5	4.0	4.0	4.0	42.0	70.1
Discrete Address Beacon System						(30.0)	
Automation	11.6	13.5	7.2	5.4	5.4	54.0	97.6
Center Facilities	14.0	11.1	6.3	5.4	5.4	27.0	69.6
TOTAL	32.0	35.4	17.5	14.8	14.8	123.0	237.5
TERMINAL CONTROL FACILITIES							
Terminal Area Radar	15.0	7.0	7.0	7.0	7.0	47.4	93.4
Discrete Address Beacon System						(22.4)	
Automation	[illegible]	15.0	22.0	22.4	0.4	6.2	67.6
a. ARTS II/ARTS III Enhancements							
b. ARTS III Metering and Spacing							
c. Terminal Information Processing and System (TIPS)							
Control Tower Facilities	10.1	10.5	22.0	13.2	20.6	104.0	190.4
TOTAL	28.7	42.5	51.0	42.6	28.2	157.6	351.4
FLIGHT SERVICE FACILITIES							
Modernization/Automation	22.3	17.6	15.5	33.0	34.0	74.5	196.9
Communications	0.7	1.6	1.6			2.0	5.7
Weather	2.4	3.0	6.5	7.5	0.7	20.5	40.6
Station Facilities	4.0	3.7	2.0	3.1	3.1	21.4	35.2
TOTAL	29.4	25.8	29.5	43.6	44.8	118.4	291.3
EN ROUTE NAVAIDS							
VORTAC System	4.2	5.0	20.0	10.0	17.0	80.0	136.2
Low/Medium Frequency Facilities	2.2	1.6	—	1.0	—	—	4.7
TOTAL	6.4	6.6	20.0	11.0	17.0	80.0	140.9
SYSTEM SUPPORT							
Housing, Utilities and Misc.	13.0	6.3	6.2	4.0	5.5	30.1	65.6
Aircraft and Related Equip.	0.4	4.6	3.0	0.7	1.2	15.1	25.7
Development, Test, and Evaluation (NAFEC)	1.6	2.5	2.0	2.3	2.4	10.7	22.0
TOTAL	15.0	13.3	11.6	7.0	9.1	55.9	113.3
Productivity Grand Total	112.5	123.6	130.4	119.0	112.7	534.9	1,134.4

* For planning purposes some new/improved facilities are included for which implementation decisions have not been made.
(1) Only major programs are indicated.

Figure 3-70. Operations Costs Attributable to Productivity

ACTIVITY	1977	1978	1979	1980	1981	1982-86	1977-86
	PLAN (in millions of dollars)						
Airways Facilities	30.2	40.8	41.5	42.5	43.8	227.6	434.4
Installation & Materiel	14.6	16.4	17.3	18.1	19.0	90.9	184.5
Development Direction	3.9	4.6	4.8	4.9	4.9	25.1	48.2
Centralized Training	60.4	61.0	61.9	62.3	62.9	320.1	619.1
Direction, Staff, and Support	22.0	27.5	29.0	30.3	31.6	161.3	301.7
Total	129.3	150.3	154.6	158.1	162.2	833.6	1,587.9

b. Productivity Features. Since the factors that affect productivity are related primarily to regulatory activities and flight inspection functions, productivity gains should be created by improving management practices. For example, random sampling techniques should permit greater regulatory surveillance. The recently acquired fleet of turbine-powered aircraft should permit a continued increase in flight inspection activities coupled with reduced amounts of flight time.

346. PRODUCTIVITY PROGRAM FUNDING. Programs. All the programs planned by the FAA have been assessed for their relevance to the four areas covered in this plan—Safety, Capacity, Productivity, and Energy/Environment. Figures 3-68, 3-69, and 3-70 list the programs and the percentages of their costs attributable to productivity activities. A separate figure has been prepared for each appropriation—engineering and development (Figure 3-68), facilities and equipment (Figure 3-69), and operations and maintenance (Figure 3-70).

SECTION 5. MEETING ENVIRONMENTAL PROTECTION AND ENERGY CONSERVATION REQUIREMENTS

347. BASIS FOR THE FAA PROGRAM. Beginning in 1968, Congress enacted a series of laws that added environmental considerations to the civil aviation safety, control, and promotional functions of the FAA. As is evident from the list below, this legislation laid out many specific directions for FAA action.

Legislation:	Scope:
Amendment to the Federal Aviation Act (1968)	Control and abatement of aircraft noise and sonic boom added to FAA's responsibility.
National Environmental Policy Act (1969)	Declaration of environmental policy requiring all Federal agencies to give full consideration to environmental effects of carrying out their programs.
Airport and Airway Development Act (1970)	Provided for development of airport and airway facilities adequate to meet future requirements of the air transportation system; and assured that airport development projects provided for the protection and enhancement of natural resources and quality of the environment.
Clean Air Amendments (1970)	Provided for promulgation of aircraft emission standards by the Environmental Protection Agency (EPA) with subsequent implementation and enforcement by FAA.
Noise Control Act (1972)	Defined responsibilities of FAA and EPA in the control of aircraft noise and amended the Federal Aviation Act.
Energy Policy and Conservation Act (1975)	Sets energy conservation targets for industry and government; provides policy guidance.

348. NOISE REDUCTION AND CONTROL.

a. The Problem. The noise problem around an airport is a function of the number and type of aircraft that use the facility, the manner in which those aircraft are operated, the operation of the airport, and the use made of surrounding lands. Alleviation of the airport noise problem involves changes to all of these elements:

—Aircraft Design

—Aircraft Operations

—Airport Operations

—Airport Environ Land Use

b. Goals. The goal of the program is to provide for the control and abatement of aircraft noise in order to afford present and future relief from excessive aircraft noise and sonic boom.

c. Objectives. The short- and long-range objectives of the program:

(1) Short-range—Elimination of Severe Aircraft Noise Exposure. The intent for the immediate future is to confine severe aircraft noise exposure levels (i.e., Noise Exposure Forecast 40+) around U.S. airports to those areas controlled by the airport proprietor. (The Noise Exposure Forecast (NEF) is one of many means of expressing cumulative noise exposure around an airport. The NEF procedure adds the noise energy from each aircraft operation during an average 24-hour period. Its use in this document is for descriptive purposes only and does not represent an FAA standard.) The program is also intended to reduce, by 1980, to the extent consistent with economic reasonableness and technological practicability the NEF 40+ (or equivalent) areas outside existing airport boundaries or areas controlled by the airport proprietors, and assist neighboring communities in achieving compatible land use for the remaining areas.

(2) Long-range—Reduction of Excessive Aircraft Noise Exposure. The intent is to continue to reduce the noise exposure levels, minimizing interference with human activities as much as possible consistent with technological and economic considerations. Accomplishment of the short-range objectives will constitute the first step toward achievement of the long-range objectives.

d. Milestones. There follow the titles of the FAA publications that have resulted to date from the noise reduction program.

11/3/69	Rule—FAR Part 36: "Noise Standards Aircraft Type Certification"
2/28/72	FAA Order (7110.22A): "Arrival and Departure Handling of High Performance Aircraft"
2/28/72	FAA Advisory Circular (AC 90-59): "Arrival and Departure Handling of High Performance Aircraft"
8/2/72	FAA Advisory Circular (AC 91-36): "VFR Flight Near Noise-Sensitive Areas"
3/23/73	Rule—Amending FAR 91: "General Operating and Flight Rules Covering Civil Aircraft Sonic Boom"
6/19/73	FAA Order (1050.1A): "Procedures for Considering Environmental Impacts of Proposed FAA Activities"
10/19/73	Rule—FAR's Parts 21 and 36 (Amendment): "Noise Standards for Newly Produced Airplanes of Older Type Designs"
1/18/74	FAA Advisory Circular (AC 91-39): "Recommended Noise Abatement Takeoff and Departure Procedures for Civil Turbo-jet Powered Airplanes"
7/9/74	FAA Advisory Circular (AC 91-36A): "VFR Flight Near Noise-Sensitive Areas"
11/7/74	FAA Notice (1050.4): "Procedures for Considering Environmental Impacts" (Guidance and implementation of DOT Order 5610.1B)
12/12/74	Rule—FAR Part 36 Amendment: "Noise Type Certification and Acoustical Change Approvals"
12/23/74	Rule—FAR Part 36 Amendment: "Noise Standards for Propeller-Driven Small Airplanes"
7/9/75	Federal Register Notice: "Airport Noise Policy"
7/21/75	FAA Advisory Circular (AC 36-1A): "Airplane Noise Levels"

349. NOISE REDUCTION PROGRAM.

a. Program Definition. The noise abatement program reduces aircraft-airport noise levels through noise reduction at the source, by modifying aircraft and airport operational procedures, and by attaining compatible land use in areas adjacent to airports. (The entire process is illustrated in Figure 3-71) To carry out the program, it is necessary to:

—Perform systems analyses to determine environmental effectiveness and potential social, economic, financial, and technological effects on the overall transportation system of each initiative.

—Develop noise reduction at the source by regulating noise levels for types of aircraft, consistent with technological feasibility and economic reasonableness. This includes newly certificated aircraft, previously certificated ongoing aircraft production, previously produced aircraft, and lowering of noise levels for future designs.

—Develop noise reduction through aircraft and ATC operational procedures. Means include separation of aircraft and communities overflown during takeoff and departure, approach and landing, and air traffic routing phases of flight.

—Develop noise reduction through airport usage and operational procedures by techniques such as preferential runways, installation of landing and other guidance aids, airport layout, curfews.

—Reduce noise impact through airport environ land use and construction measures.

b. Development of Civil Aircraft Noise Certification Goals.

(1) As previously indicated, the noise reduction program is directed to developing, evaluating, and implementing feasible programs in the areas of aircraft design and operation, airport operation, and airport environ land use.

(2) Each noise abatement initiative must be examined as to environmental effectiveness. The potential social, economic, financial, and technological effects on the overall transportation system must be analyzed to assure that progress in one area is not detrimental to other areas. A systems approach is being used wherein noise abatement alternatives are identified, relevant costs and benefits are estimated, and appropriate tradeoffs are determined. Resources are then allocated to maximize benefits derived per dollar spent. As new facets of the problem surface, requirements for further developments are identified. Some alternatives will not be used, because they are too expensive relative to the benefit generated, or their introduction would produce an untimely solution. In other areas, solutions will not exist until major technological breakthroughs occur (such as that which came about with the high bypass ratio engine).

(3) The cost and associated noise relief varies with each of the program areas. The emphasis for each area must be consistent with its relative contribution to the total noise solution. Before evaluations of relative effectiveness of complementary programs with widely different characteristics can be made, it is necessary that each program area be fully explored. This is particularly important as each program is composed of a complex set of alternatives varying widely in range, depth, and potential contribution to the noise solution impact.

(4) For certification purposes, source noise control requires the following: adoption of a strict and unambiguous classification system, forecast of aircraft types in use through the year 2000, and development and/or adoption of alternative reference conditions (e.g., number and locations of noise measurement points, noise measurement units, etc.), a noise abatement technology, and cost assessment for each of the aircraft classes in relation to appropriate class certification references. For flight path control procedures, the analysis requires an identification of all piloting (takeoff and landing) and navigation (e.g., use of microwave landing system and area navigation equipment) options that have a beneficial potential for noise reduction. For land use, the analysis requires an identification of all feasible programs to control the use of land around airports impacted by noise.

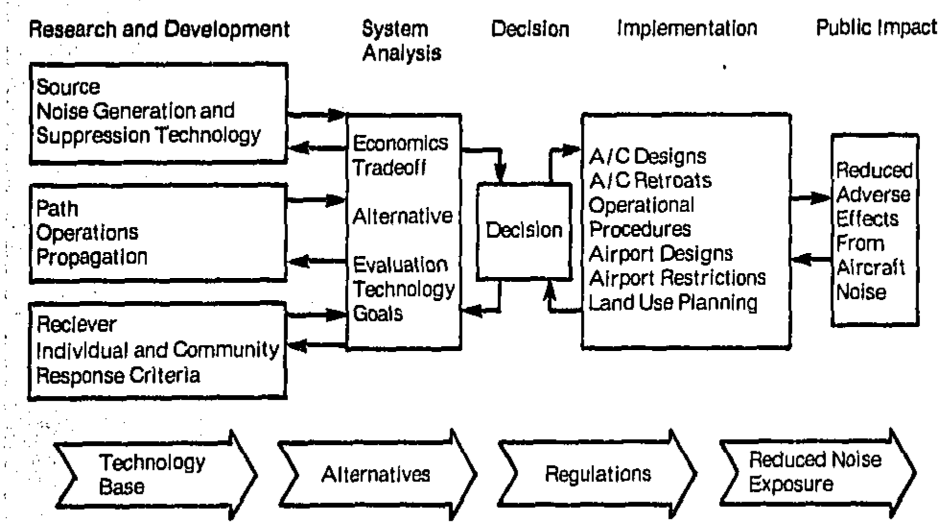


Figure 3–71. Aircraft Noise Abatement Program Elements

350. NOISE REDUCTION AT THE SOURCE.

a. **Noise Ceilings.** The FAA noise abatement actions taken heretofore have put a lid on aircraft noise escalation. The Federal Aviation Regulation (FAR) Part 36 and subsequent amendments established a noise ceiling for subsonic jet transport aircraft. As a result, the escalation of noise at the source, i.e., the vehicle, has been stopped; and the trend is now downward. Outstanding among the results are the Boeing 747, Douglas DC-10, and the Lockheed L-1011, which, although much larger and more powerful than the earlier DC-8 and B-707, are significantly quieter. Further reduction appears technologically feasible, and work leading to lower levels is proceeding.

b. **Future Noise Regulations.** A similar pattern of noise regulation may evolve for all types of aircraft (propeller-driven airplanes, helicopters, supersonic transports, and powered lift aircraft). A noise level is set for newly certificated aircraft consistent with tech-

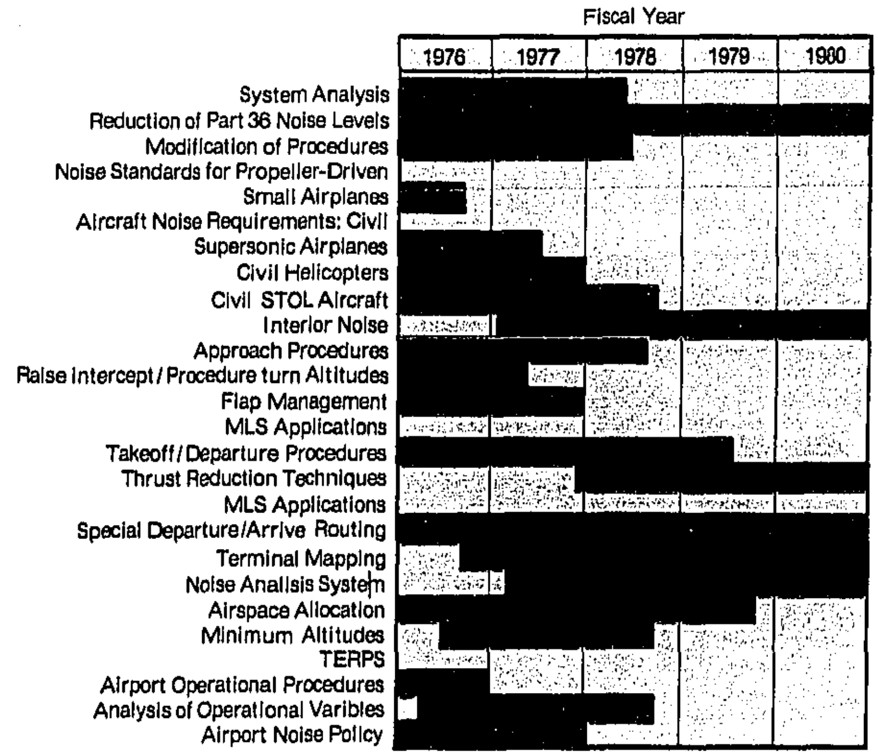


Figure 3–72. Noise Reduction and Control

nological feasibility, economic reasonableness, safety and appropriateness to type. These noise levels may be applied to previously certificated ongoing production aircraft and to previously produced aircraft. These levels will be lowered for future designs using the previously noted technical and economic criteria.

c. **Timing of Activities.** The time frame for the specific activities described below and in later paragraphs is shown in Figure 3–74.

—Periodically modify FAR Part 36 to reflect more stringent noise standards commensurate with technical and economic feasibility.

—Evaluate effectiveness of the noise rule for propeller-driven small aircraft and explore need for further noise level reduction.

—Develop civil supersonic noise certification standards.

—Develop civil helicopter noise certification standards. Investigate alternative regulatory concepts necessary for unique operational and acoustical characteristics.

—Develop civil STOL aircraft noise certification standards.

—Investigate the need for interior noise standards in cockpit and cabins of general aviation, helicopter and transport category aircraft.

351. **AIRCRAFT AND ATC OPERATIONAL PROCEDURES.** Noise abatement operational procedures designed to provide lower noise levels and increased separation between aircraft and the communities overflown are being developed for: approach and landing flight, takeoff and departure flight, and air traffic routing. Noise reduction of varying amounts has been achieved in a number of areas. In many cases, the degree of relief obtained from modified operational procedures is uniquely determined by the relative location of the airport, the flight tracks, and the population centers around the airport. A given procedure will not have the same level of effectiveness at all airports and must be evaluated on an airport-by-airport basis. Future work in this area (Figure 3–72) includes:

a. **Develop Approach Procedures** including:

—Raising of intercept/procedure turn altitudes.

—Flap management.

—Use of MLS and area navigation path definition flexibility.

b. **Develop takeoff/departure procedures,** including:

—Use of thrust reduction techniques.

—Use of MLS and area navigational path definition flexibility.

c. **Continue development of departure/arrival routing** to maximize the advantages of local geography. Relocate noise over such relatively less sensitive areas as water or uninhabited areas. This includes:

—Terminal routing.

—Terminal mapping of noise abatement routes.

—Computer based noise analysis systems.

d. **Continue investigation of airspace allocation** for noise abatement purposes. This includes investigation of:

—Increased minimum operational altitudes for turbojets in terminal areas.

—Environmental considerations in TERPS (Terminal Instrument Procedures).

352. **AIRPORT OPERATIONAL PROCEDURES.** Airport operational procedures are adopted on an individual basis to minimize impacts to noise sensitive areas adjacent to the airport. Although the techniques

vary from one airport to the next, each of the techniques is developed to reduce noise pollution in a particular part of the community. New techniques are being developed.

a. **Preferential Runways.** Preferential runway systems are in use at a number of airports. These vary in complexity, characteristics, and objectives. One system provides a computer program identifying listings of runway combinations in order of preference. This information provides guidance to the controller in making runway assignments. Other preferential runway systems are designed so that approaches and departures are made over water, weather conditions permitting.

b. **Restrictions on Ground.** Aircraft taxiing, holding and parking positions, and procedures are designed to protect particular nearby communities from noise and fumes. In some instances, if aircraft must taxi beyond a certain point, they are required to be towed. Siting of facilities such as hangers, maintenance areas, and parking spaces are specifically directed toward keeping noisy activities as far as possible from residential and other noise sensitive areas.

c. **State and Local Actions.** Over the next year, the FAA will be developing a policy, with respect to state and local actions, to reduce noise through restrictions on airport operations. A multiphased program has been initiated to develop quantitative tools and a data base for assessing the impact of proposed restrictions and encourage public participation in the policymaking process. The program is designed to permit eventual determination of the costs and benefits of airport use restrictions to the airport on airport businesses, the airline industry, users of air transportation and the communities adjacent to the airport.

353. AIRPORT ENVIRON LAND USE AND CONSTRUCTION MEASURES. Airport sponsors, with assistance from the Federal Government, seek compatibility of airport/aircraft operations with local land use through coordination of airport planning with local government land use management, providing guidance as to the impact of the airport, and land acquisition.

354. AIR POLLUTION AND CONTROL.

a. **The Problem.** The FAA has the role of (1) ensuring that facility emissions are in compliance with Environmental Protection Agency (EPA) standards and that (2) all civil aircraft are certificated and operated in compliance with EPA aircraft emission standards. The FAA also recognizes the potential of high altitude pollution as identified under the DOT Climatic Impact Assessment Program (CIAP). As a result, FAA has established the High Altitude Pollution Program (HAPP), which will develop the quantitative information necessary to formulate appropriate Federal emission control policy.

b. Goals. The goals of the FAA are:

—To fulfill responsibilities under the Clean Air Amendments.

—To comply with standards applicable to stationary sources at FAA facilities.

—To ensure that federally assisted projects meet the amendments.

—To issue regulations to enforce aircraft emission standards.

c. Objectives. To meet these goals, the FAA has its objectives:

—To reduce volume of air pollution generated from FAA stationary sources to the lowest level possible, consistent with design constraints and operational requirements.

—To reduce low level air pollution generated by the aircraft/airport system consistent with safety, economic reasonableness, and technical feasibility.

—To quantitatively determine the requirements for reduced cruise/altitude exhaust emissions and, in conjunction with the EPA and the International Civil Aviation Organization (ICAO), to ensure that, if necessary, appropriate action is taken to avoid environmental degradation.

d. Milestones. These publications have resulted to date from the air pollution reduction program.

3/12/74	FAA Advisory Circular (AC 91-41): "Ground Operational Procedures for Aircraft Engine Emission Reductions and Fuel Conservation"
12/23/74	Rule SFAR Part 27 and Amendement 1: EPA Fuel Venting Emission Standards; and JT8D Smoke Standards effective February 1, 1974. EPA Fuel Venting Standards effective January 1, 1975
6/16/75	Initial Planning Documentation: High Altitude Pollution Program
6/30/75	FAA Order 6900.4: Implementation of Executive Order 11507 and Office of Mangement and Budget circular A-78 and A-81, covering the Prevention, Control, Abatement, and Reporting of Air and Water Pollution at Federal Facilities

355. FUTURE PROGRAMS.

a. Revision of Procedures. Agency procedures will be revised as necessary to reflect current Executive Orders and Office of Management and Budget circulars concerning the prevention, control, abatement and reporting of air and water pollution at federal facilities.

b. Emission Standards. FAA is implementing the emission standards established by EPA. These are for the aircraft turbine engine classes—under 8,000 pounds thrust, 8,000 pounds thrust and over, the JT3D and the JT8D—and for auxiliary power units, turboprops and piston engines. In the future, the FAA will:

—Conduct engineering and development programs to determine whether EPA standards are technically feasible and economically reasonable, and ascertain their effect on aircraft safety.

—Encourage the development of international aircraft engine emission standards through the International Civil Aviation Organization.

—Complete engineering and development to provide emission measurement and analysis techniques, to ensure accurate and reproducible results and also, to determine the increase, if any, in emissions from aircraft turbine engines as time in service accumulates.

—Determine what adjustments are required for existing general aviation aircraft to meet EPA's standards without compromising safety, and ascertain major design changes to minimize piston engine emissions.

—Issue regulations to ensure that wide-body aircraft engines meet smoke standards by January 1, 1976, Pratt and Whitney JT3D engines by 1978, and the remaining engine classes by 1979.

c. High Altitude Pollution. The FAA has established a High Altitude Pollution Program to resolve a number of questions in regard to aircraft pollution at high altitudes. (The program is structured as illustrated in Figure 3-73. Its time frame is shown in Figure 3-74.) The stratospheric models will be the means for determining, on a fast-time basis, the effects of engine emissions (and changes in fuels) on stratospheric chemical processes. Since the models are in the development stage, some field and laboratory measurements will be conducted in order to improve the models. (Though FAA will not be the principal source of support for work in these fields, it expects to supplement ongoing efforts where appropriate, to provide answers to specific aviation-related questions.) Information developed from models will be

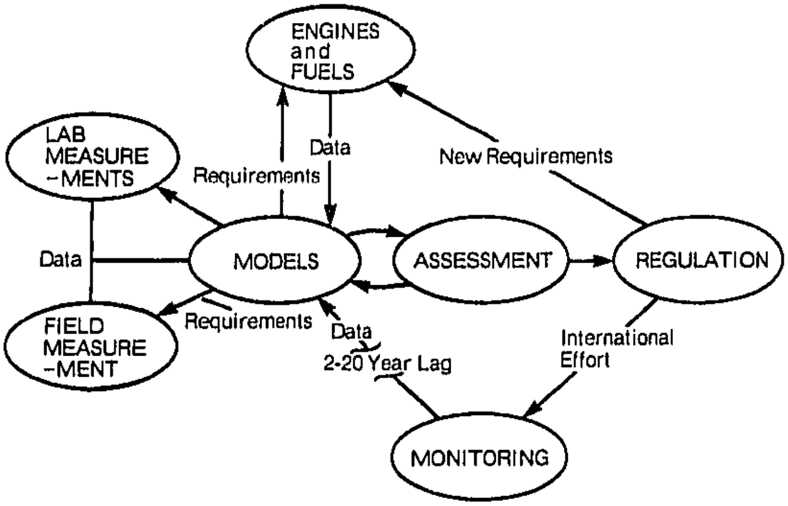


Figure 3–73. Program Elements—HAPP

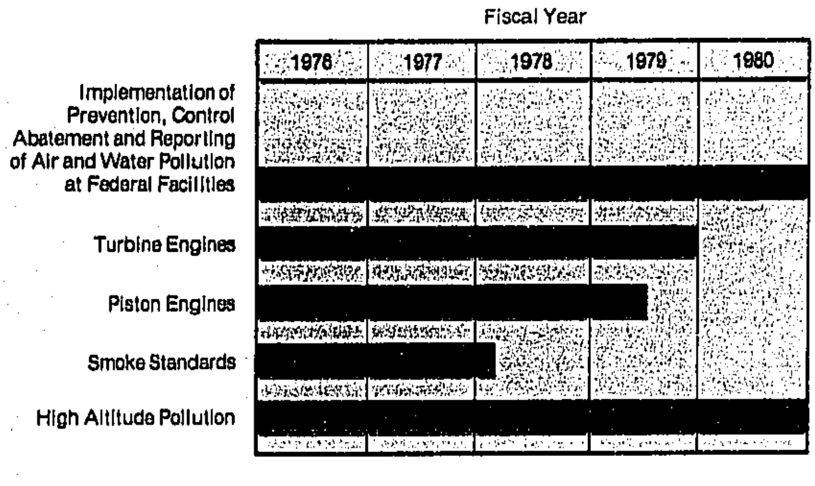


Figure 3–74. Air Pollution Reduction and Control.

combined with a realistic appraisal of air-traffic growth to provide the basis for policy decisions in regard to the need for, timing of, and type of regulations for engine emissions and fuels.

356. LAND USE COMPATIBILITY.

a. **Introduction**. Even after all feasible noise reduction at the source is accomplished, there may be areas where airport/aircraft operations are incompatible with certain land uses. A land use compatibility program will be directed toward achieving compatible new development and construction in noise impacted areas around airports and toward removing or modifying existing incompatible uses whenever possible.

b. **Goal**. The goal of the FAA is to develop land use and construction management measures that will make areas impacted by airport and aircraft operations more compatible.

c. **Objectives**. To attain this goal, the FAA has as its objectives:

—To develop measures that further reduce noise impacts through land use and construction methods after aircraft noise abatement measures and operational methods have been employed.

—To advise responsible officials concerning these measures, to prevent future incompatibility and to reduce present impacts.

—To integrate these measures into local land use controls.

d. **Milestone**. So far, only one publication has resulted from the program:

7/22/75 Outline of approach agency will use in development of land use compatibility program.

357. LAND USE PROGRAMS. The state-of-the-art is being examined to determine to what extent existing methodologies, techniques, and criteria can be used in an FAA program to incorporate airport considerations into local land use planning and regulation. Deficiencies will be supplemented by development of additional material, where necessary. A comprehensive program will be developed in cooperation with the public, including airport sponsors and local officials responsible for land use management. The time frame of the following elements of the program is shown in Figure 3–75.

—Identify role of FAA in achieving compatible land use and prepare appropriate agency guidelines.

—Inventory existing and potential measures to reduce and prevent the impact of aircraft noise.

—Develop criteria for land uses and building construction to achieve exterior and interior compatibility with aircraft/airport environmental impacts.

—Develop guidance material for use by local government.

—Develop FAA state and local government interface to implement guidance material.

—Create awareness and cooperation of the general public in achieving compatibility between aircraft/airport operations and the adjacent community. Develop a public communication program to assist FAA personnel in incorporating airport considerations into local land use controls.

The use of grant agreements and planning funds to further land use planning and space usage has proven to be helpful and will be continued. Program costs attributable to environment are shown in Figure 3–78.

358. ENERGY PERSPECTIVE. Because of the potential shortage and higher costs of available energy in the form of petroleum, the aviation community in the United States, and indeed throughout the world, today faces perhaps a greater threat to its continued growth and economic health than has been posed by any single factor in the past. The total dependence of the airplane on jet fuel and gasoline has tied the well-being of aviation directly to the vicissitudes of world petroleum supply and demand. With mounting impact, early symptoms of a worldwide energy shortage are being felt and public realization that the petroleum supply is not limitless is beginning to take hold. In moderate shoratage conditions, most fuel allocation is taken care of by the user himself in the marketplace—higher prices dictate fuel use only for important travel. Severe shortages call for stronger measures—allocation by regulation to assure equitable fuel availability without imposing an intolerable economic burden on a particular user group. Such measures are not, however, the only answer to the problem. Vigorous efforts to discover new oil deposits may increase the supply, and fuel conservation practices can decrease the demand. Application of new technology and conservation practices are the principal contributions the aviation community can make toward solution of the energy problem.

a. Energy Consumption of the Aviation Industry. Total consumption of petroleum in the United States for all uses has averaged about 17 million barrels a day over the last three years. During this period, the transporation sector has been consuming about 52 percent of total petroleum consumption.

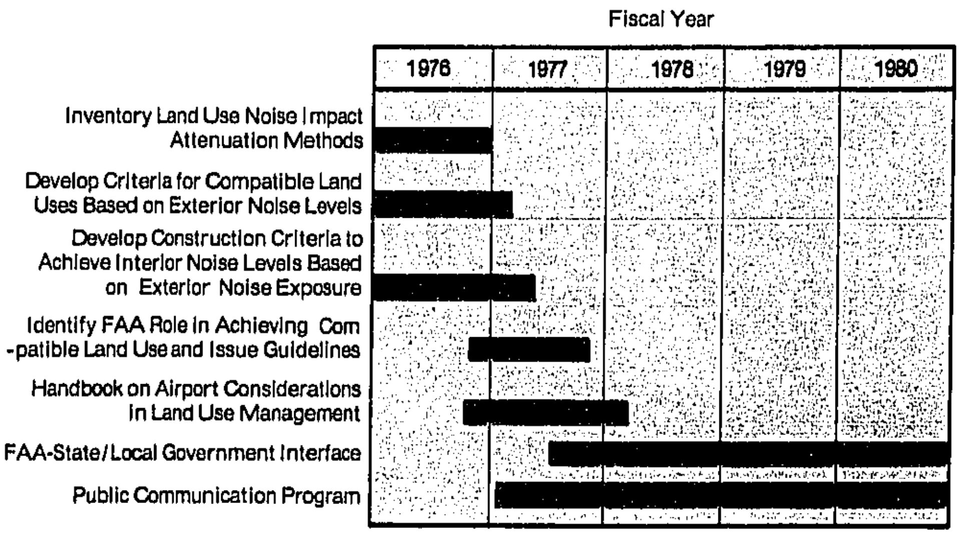


Figure 3–75. Airport Environs—Land Uses and Construction Measures

Domestic civil aviation jet fuel consumption was approximately 535 thousand barrels per day in FY 1975 or about 6 percent of the total transporation share. Aviation gasoline accounts for only 5 percent of civil aviation fuel use. Details on aviation fuel usage are given in Table 3–76. These figures exclude military and international air carrier fuel consumption because those activities are not directly regulated by the FAA in terms relevant to energy conservation purposes.

b. Trends. Costs of jet fuel have more than doubled since mid-1973. Although there has been a recent leveling off, an upward trend is expected to continue. A similar trend is indicated in the cost of aviation gasoline. Despite the resultant rise in airline ticket cost to the revenue passenger, the total amount of commercial air travel has remained fairly stable over the past three years. The normal two to four percent increase per year did not occur in 1975, probably because of higher travel costs. A resumption of the annual increase can be expected in 1976 or 1977 if fuel costs stabilize.

c. Focus. The active role of the aviation community in meeting national energy goals lies primarily in the conservation of fuel—jet fuel and aviation gasoline. Energy conservation should not, however, become an end in itself. Carried too far, energy conservation could be counter-productive by causing economic dislocation in aviation and related industries. A grounded aircraft may represent a significant contribution to an energy conservation program, but it would also represent a loss in investment, functional utility—and, in many cases—of jobs. The desirability of attaining one objective may be nullified by disadvantageous results in related economic areas. The focus of possible solutions must be on aviation doing its job more efficiently, not on aviation doing a lesser job. Air travel is by far the most used mode for intercity trips over 200 mile by common carriers, and the time saving advantages ensure its dominance in medium and long distance travel well into the future.

Figure 3–76. U. S. Domestic Civil Aviation Fuel Consumption FY 1973 and FY 1975 (Millions of Barrels)

	Air Carrier		General Aviation		Total Civil Aviation	
	FY 73	FY 75	FY 73	FY 75	FY 73	FY 75
Jet Fuel	197.6	185.7	7.2	9.6	204.8	195.3
Aviation Gas	0.5	0.5	9.8	10.8	10.3	11.3
Total Aviation Fuel	**198.1**	**186.2**	**17.0**	**20.4**	**215.1**	**206.6**

359. FUEL CONSERVATION PROGRAMS IN FAA. The FAA recognized that prompt action in energy conservation was required before the onset of the energy crisis in late 1973. The agency stressed the importance of the fuel problem as a major issue in its National Aviation System (NAS) Policy Summary, published in March 1972. It warned at that time that more energy-efficient propulsion systems needed to be developed if air transportation was not to be seriously constrained. The FAA Administrator acted promptly to meet impending energy problems and convened a major and unique Consultative Planning Conference in October 1973. The theme of that conference was: "The Energy Outlook for Aviation," and focused on the following issues:

—A review of the energy outlook for the United States to indicate clearly the seriousness of the current and projected situation.

—The impact of anticipated mandatory fuel allocations and their effect on the aviation community.

—Actions to deal with fuel shortages.

The most important result of the conference was to develop a series of steps that could be taken immediately by the FAA and all segments of aviation users to conserve fuel.

a. FAA Seven-Point Conservation Program. In response to the President's fuel allocation program to deal with the oil embargo, the FAA created a high-priority program in coordination with industry to develop energy conservation measures in three phases: Short-Term actions to be implemented 90 days from the President's fuel allocation announcement; Intermediate-term actions to be implemented during a 3-year period (1974–1976); and Long-Term FAA actions to increase aviation fuel efficiency to be implemented during the period 1977–1982. In addition, the Administrator called for programs to conserve direct energy use by the FAA itself. The FAA's energy program goal is to reduce aviation-related energy consumption to the maximum possible extent. The first phase of the FAA program produced a seven-point jet fuel conservation plan designed to save up to 20,000 barrels of fuel per day. This is almost 4 percent the jet fuel consumed daily by civil aviation. The FAA implemented the plan on November 20, 1973, after an intense four-day effort to set up the program. The seven-point plan, which has since been refined and improved, is still in active use producing energy savings. The plan, summarized in Figure 3–77, includes the following actions:

(1) Revised gate-hold procedures. The objective of the revised gate-hold procedures is to eliminate nonproductive fuel use by holding aircraft at the airport loading gate with engines off when departure delays exceed 5 minutes. Rather than burning up fuel in a queue waiting at the end of the runway, air traffic control clears these aircraft to taxi for departure with minimal delay for actual take-off when their place in the queue would have reached the top of the list. The prior criterion for use of gate-hold procedures was 15 minute delays. This was reduced to 5 minutes specifically to conserve fuel. This change in FAA procedure produces an estimated energy savings totaling 2,500 barrels of fuel per day.

Figure 3–77. FAA 7-Point Jet Fuel Conservation Program (Barrels per day)

	Fuel Saved
1. Revised Gate-hold Procedures	2,500
2. Revised Flow Control Procedures	2,800
3. Optimum Cruise Speeds	400
4. Revised ATC Procedures	700 to 3,800
5. Taxi With Fewer Engines	6,000
6. Use of Simulators	3,300
7. Airport Development	1,200
Total	**20,000**

(2) Revised flow control procedures. The purpose of flow control is to avoid airborne congestion and resulting fuel inefficiency by matching airborne traffic demand as closely as possible to airport capacity. Prior to this energy conservation change in procedures, aircraft were held circling over the destination airport or delayed enroute when the number of aircraft exceeded the capacity of the airport to receive them. With the necessity for energy conservation, this fuel-inefficient procedure has been changed. During such congested conditions, aircraft are now held on the ground at the departure airport. This change in procedures reduces airborne delay by 25 percent or more and produces a fuel savings of 2,800 barrels per day.

(3) Optimum Cruise. A moderate reduction in airspeed while cruising produces a reduction in overall fuel burned for the same distance. In order to take advantage of every possible method to increase fuel efficiency, the FAA promoted greater use of this conservation procedure by the airlines. The airlines readily cooperated and the immediate fuel saved through this procedure is estimated at 400 barrels per day.

(4) Revised air traffic control procedures. With the requirement to identify all possible FAA actions to conserve energy, all air traffic control procedures were reexamined for any avenues to save fuel. Three broad opportunity areas were found and immediate changes in policy were made by FAA management to emphasize fuel conservation. Instructions were given to all air traffic controllers to effect these fuel savings by allowing aircraft to operate at higher altitudes where they burn less fuel during periods of airport congestion, by assigning cruise altitudes best suited to fuel efficiency, and by minimizing circuitous routings. Wherever possible and consistent with safety these procedural measures are used. This combination of measures contributes substantially to increased fuel efficiency and produces energy savings estimated to total up to 3,800 barrels per day.

(5) Taxiing aircraft with fewer engines. This procedure was introduced with the dual purpose of conserving fuel and reducing engine emission pollution in the terminal area. After extensive FAA testing of procedures at Atlanta, Georgia, in cooperation with the Environmental Protection Agency, the Air Transport Association, and the Air Line pilots Association, the FAA Administrator strongly urged that airlines practice the following fuel conservation measures when taxiing after landing: Four-engine jet aircraft should shut down one or two engines and three-engine jet aircraft should shut down one engine. This conservation action is estimated to produce continuing fuel savings totaling 6,000 barrels per day.

(6) Use of aircraft simulators. Another area of opportunity for FAA to increase fuel savings was the use of aircraft simulators for pilot training and evaluation. After determining that safety would in fact be enhanced, the agency amended Federal Aviation Regulations 61 and 121 authorizing increased use of simulation rather than actual aircraft flights for training and evaluation purposes. These substantial savings in jet fuel are estimated at 3,300 barrels per day.

(7) Airport development. The FAA investigated improvement in runways and taxiways to reduce delay and taxi distance and thus produce tangible fuel savings. Certain projects were identified with the potential for completion within 90 days and were encouraged during the initial phase of the seven-point program. The agency has continually encouraged airport owners to accelerate construction of such improvements. The immediate actions taken during the 90-day period continue to produce significant fuel savings amounting to 1,200 barrels daily.

Following up on these actions, the FAA Administrator reemphasized the agency's commitment to full and continuing energy conservation efforts when he urged all air traffic control specialists to individually support the President's campaign to conserve fuel. This policy direction was further emphasized in detailed guidance by all levels of FAA management on specific procedures to be used to maximize fuel conservation, consistent with the need for continuing high levels of safety.

b. Follow-on Alternatives. The FAA is committed to a strong continuing effort to search out all possible techniques for conserving fuel. The Short-Term program was not a one-time, limited effort. The seven-point plan was intended to be a continuing effort and is continually refined for increased fuel efficiency. In addition, Intermediate-term alternatives are being developed and investigated. All new alternatives that show an economic potential for fuel savings are implemented as soon as practicable. The fuel conservation alternatives investigated to date include the following:

(1) Aircraft towing. The use of tugs to tow aircraft to and from the airport runways was investigated. An extensive analysis was conducted for the top 20 air carrier airports. The analysis considered the options of towing arriving and departing aircraft, and towing departing aircraft only. The analysis indicated a maximum fuel savings of over 6,000 barrels a day might be realized, but it was not economically feasible unless the price of fuel increased by at least 150–200 percent over 1974 prices. In addition, a number of operational problems would have to be overcome before any towing procedure could be implemented.

(2) Improvement of major airport landing systems. In its efforts to conserve energy, the FAA early identified the possible fuel savings from installing additional or improved landing systems. These systems would permit aircraft to land during the periods of weather considerably more adverse than allowed at many airports with the present systems. A comprehensive analysis determined that this additional instrumentation would conserve only about 1,400 barrels of fuel per day. The cost of providing the additional capability at 36 major airports, however, was estimated at $27 million for the Federal Government and $425 million for air carriers to equip the 1,700 aircraft needed to achieve that level of fuel savings. In light of this high cost, this project has not been implemented.

(3) Additional/improved runway exits. Another opportunity area is in additional or improved runway exits. By providing more direct routing between the terminal building and the runway considerable fuel savings could be produced. FAA analyzed the potential for such fuel savings at three locations in FY 1974. At San Francisco, Chicago O'Hare and Newark airports the analysis showed potential for saving about 5,000 minutes of aircraft delay and over 1,000 barrels of fuel per day. By continuing to stress these fuel conservation measures at other airports since that time, a much higher level of conservation has been promoted by the agency.

(4) Optimum jet aircraft descent profile. Premature descent and level-off at lower altitudes where fuel consumption is high wastes fuel. The difference in fuel consumption between a continuous descent and one taken in three stages is about 2 barrels of fuel for a Boeing 727 aircraft during each landing. Based on average traffic activity this revised procedure produces fuel savings estimated at 6,000 to 8,000 barrels per day. The procedure was authorized by FAA in 1973 and has since been refined for even greater fuel efficiency through joint efforts with the airline industry.

(5) Reduced runway spacing. Until it became a necessity to pursue every possible technique for conserving energy, 5,000 feet had been the minimum spacing authorized by FAA between runways where simultaneous approaches to airports were made by aircraft using instrument guidance. Several airports had closer parallel runways which could not therefore be used in this way. This restriction inhibited maximum fuel efficiency. FAA immediately conducted a comprehensive analysis of those situations with the objective of reducing the minimum spacing to permit increased operations and conserve fuel. The analysis concluded that the minimum spacing could be reduced safely to 4,300 feet. FAA promptly revised the standard and provided simultaneous approach capability to six additional airports. The potential for even more fuel savings is high if additional runways are constructed at those high traffic airports that can accommodate them.

c. Continuing FAA Efforts. In its continuing effort to identify and develop new opportunities to conserve fuel, the FAA has examined the following areas and taken the actions indicated. These are new efforts identified since the Short and Intermediate Term programs were implemented in late 1973:

(1) Revised climb and descent procedures. In the interest of improving fuel efficiency the FAA authorized new climb and descent procedures on July 31, 1975. To enhance fuel efficiency, aircraft operators desire to use optimal climb and descent profiles for their particular aircraft to the maximum extent possible. Pursuing this objective beyond the original seven-point plan adjustments, the FAA promoted pilot/controller forums in coordination with the Air Transport Association to fine-tune the earlier optimum descent profile procedure. In addition, air traffic control procedures were formally changed to authorize pilots to climb or descent with maximum flexibility for purposes of fuel conservation.

(2) Fuel Advisory Departure(FAD) procedures. The FAA also has agressively pursued additional fuel savings as a follow-on effort to the earlier revised flow control procedures. Extensive coordination with the airlines improved and further refined the techniques involved. The resulting new FAD procedures were given a real-time test for 6 hours in January 1976 at Chicago O'Hare; the fuel savings were extraordinarily promising. Because some airlines elected to hold on the ground at their departure point, they were allowed to proceed through the system with minimal further delay, thus eliminating the waste of fuel which would have been incurred in airborne holding. This one limited 6-hour test produced direct savings of almost 4,000 barrels of fuel for the 122 aircraft that held on the ground. Substantially greater fuel savings were realized on a system-wide basis as a result of the

FAD procedure. Further tests of this proposed new procedure are scheduled to assess its full feasibility on a broad scale.

(3) Runway capacity concepts. The FAA has developed runway capacity concepts to evaluate air traffic control performance at 16 highest density airports. These concepts provide a comparison between actual and maximum operations. When significant deviation is noted FAA acts immediately to improve the operation. In this way, FAA assures that excessive fuel is not used through overestimates of airport capacity and the resulting increase of aircraft delay. Concepts for eight additional airports are already being developed.

(4) Airport improvement program. Another significant fuel conservation benefit is being produced through joint FAA-industry cooperation in the area of airport improvement. In June 1974, the FAA, in cooperation with the Air Transport Association, major airlines, airport operators and others, initiated a high-level working group for identifying and implementing capacity improvements at specific high traffic airports. This effort was an outgrowth of an FAA study of eight airports requested from the FAA engineering and development program. Task forces are hard at work producing results at O'Hare, New York, Denver, Los Angeles, and Atlanta at this time. Detailed studies using the latest computer techniques to analyze delay and alternatives for capacity improvement action are being conducted. This effort will pave the way for further improvements that can be implemented on a priority basis to attain the greatest benefit in conserving fuel.

(5) Approach light systems. As an innovative and effective means to reduce aviation-related energy use, the FAA has taken action to save electrical energy in airport approach light systems. In the past, airfield lighting systems were not engineered for maximized energy conservation, but rather for optimal installation cost. This policy was changed by FAA to conserve the maximum energy possible. For this purpose two innovations have been developed by the FAA. First, pilots approaching an airport can activate the approach lights at locations which do not have manned air traffic coverage during the hours of darkness. The pilot simply keys the transmitter of the radio to turn the lights on. A timing switch on the ground turns the lights off after a period of 15 minutes. The potential saving from modification of 145 sites during FY 1976 and approximately 200 locations in FY 1977 is estimated at 8.3 million KWH. This is equivalent to 4,700 barrels of fuel saved annually.

The second means of savings in electrical energy is being attained through rewiring approach light systems. The past policy to wire these systems to provide a maximum number of lights regardless of the weather conditions is no longer an acceptable use of energy. The rewiring allows partial operation of the approach lighting system depending on current weather conditions is no longer an acceptable use of energy. The rewiring allows partial operation of the approach lighting system depending on current approximately 14 million KWH appear possible. This is equivalent to 8,000 barrels of fuel saved annually.

d. Long Range Prospects. Safety requirements, increased cost and other factors do constrain efforts to maximize energy efficiency. Some improvements in energy management will have to await technological developments such as fuel efficient aircraft propulsion systems and aerodynamic design concepts, and inexpensive, long-life electronic components. Other national interests such as environmental enhancement will also serve to limit some avenues for increased energy efficiency, particularly in the area of airspace management around major airports. In all cases there is the compelling requirement that safety remain the primary objective in our National Airspace System.

e. Summary of FAA Effort. The FAA, working closely with the aviation industry, has pursued an innovative and comprehensive program to conserve fuel in the operation of the Nation's airport and airway system. A keystone in the area of longer-range technological solutions is the development of the Upgraded Third Generation Air Traffic Control System. To fully tap the opportunities that will develop through technological progress the FAA is devising a comprehensive long-range strategy to enhance the overall efficiency of energy use in the National Aviation System. The principal techniques involve reducing or avoiding delay in the airport terminal airspace, increasing electrical energy efficiency at FAA facilities, and heightened aggressive promotion of energy conservation in operating procedures employed by system users. While the greatest measures of success are achievable through actions of aircraft operators, the FAA has refocused its long-range plans and development programs to capitalize on energy alternatives consistant with safety objectives.

360. ENERGY POLICY AND CONSERVATION ACT (1975).

a. Objective. The Energy Policy and Conservation Act (P.L. 94–163), signed into law by the President on December 22, 1975, sets forth major new policy directions to American industry and all levels of government on conserving domestic supplies and promoting the more efficient use of energy resources. The Act sets energy conservation targets for broad categories of industry and all forms of transportation. In the case of aviation, a ten percent increase in energy efficiency, in relation to 1972 levels, is the goal.

b. Progress and Response. To determine the progress already made, Congress required in Section 382(a)(1) of the Act that the Federal Aviation Administration, and other Federal regulatory agencies, report to the Congress on the successes already achieved in energy conservation programs since October 1973. The FAA has responded to that requirement and has established task forces to define future energy conservation efforts. One of these task forces will work with industry in planning for additional energy conservation in line with the ten percent goal referenced above. Another task force will review laws and regulations administered by FAA to determine whether or not they permit or induce inefficient use of energy. Finally, the FAA will in certain cases, include an energy impact statement in major regulatory actions.

Figure 78. Program Costs Attributable to Environment

	PLAN (Dollars in Millions)						
PROGRAM	1977	1978	1979	1980	1981	1982–86	1977–86
AIRPORT DEVELOPMENT AND PROGRAM (ADAP)	38.0	38.0	38.0	38.0	38.0	190.0	380.0
OPERATIONS	9.2	10.4	11.0	11.4	11.8	60.4	114.2
FE&D	7.0	8.4	8.4	8.4	8.4	42.0	82.6
TOTAL	**54.2**	**56.8**	**57.4**	**57.8**	**58.2**	**292.4**	**576.8**

APPENDICES

Appendix A, E, and D Funding Summary
Engineering and Development Program Plan

	PLAN (In millions of dollars)						Total
	1977	1978	1979	1980	1981	1982–86	1977–86
01 System	4.7	8.7	9.1	10.0	13.4	124.8	170.7
02 Radar	—	1.1	1.0	0.5	—	—	2.6
03 Beacon/DABS–IPC	11.0	14.4	8.0	5.0	4.0	12.8	55.2
04 Navigation	0.9	3.5	3.5	3.0	3.0	10.0	23.9
05 Airborne Separation Assurance	2.5	2.3	0.7	0.5	0.5	2.0	8.5
06 Communications	1.0	2.5	3.0	7.2	7.5	22.0	43.2
07 Approach and Landing Systems	17.0	6.9	13.0	7.0	3.1	12.3	59.3
08 Airport/Airside	4.8	3.9	4.2	5.1	5.1	19.2	42.3
09 Airport/Landside	—	0.3	0.5	1.0	1.0	3.0	5.8
10 Oceanic	—	—	—	1.0	1.3	6.5	8.8
11. ATC System Command Center Automation	0.8	0.5	0.5	1.0	1.0	5.0	8.8
12 En Route Control	8.5	11.1	11.0	11.0	11.0	47.5	100.1
13 Flight Service Station (FSS)	4.9	4.6	5.0	5.0	5.0	9.5	34.0
14 Terminal/Tower Control	8.5	9.5	10.0	10.0	10.0	46.5	94.5
15 Weather	3.2	4.0	4.0	4.0	4.0	17.0	36.2
16 Technology	1.0	0.2	0.5	2.1	3.0	55.0	61.8
17 Satellites (1)	5.9	—	—	—	—	22.7	28.6
18 Aircraft Safety	4.3	7.0	7.0	6.2	5.5	27.5	57.5
19 Aviation Medicine	3.7	4.3	3.9	3.9	4.0	19.9	39.6
20 Environment	7.0	8.4	8.4	8.4	8.4	42.0	82.6
21 Support	0.5	—	—	0.5	1.0	9.5	11.5
Program Total	90.1	93.3	93.3	92.5	91.8	514.7	975.7
R, E&D (Trust Fund)	76.7	75.0	75.0	75.0	75.0	430.5	807.2
F, E&D (General Fund)	13.4	18.3	18.3	17.5	16.8	84.2	168.5
Total Funding	**90.1**	**93.3**	**93.3**	**92.5**	**91.8**	**514.7**	**975.7**

(1) Current planning estimates for the Aerosat program are as follows:

Fiscal Year	78	79	80	81	82–86	78–86
Dollars in Millions	25.4	28.6	22.2	25.2	39.7	141.1

These amounts are not projected in the activity totals at this time as the precise requirements for the Aerosat program are subject to certain lease and contract negotiations. However, such amounts as are required to meet commitments relating to the program will be sought as part of FAA's E&D funding requirements in the regular budget process.

Appendix B, F&E Funding Summary *

PROGRAM	PLAN (in millions of dollars) FY 1977	1978	1979	1980	1981	1982–86	TOTAL 1977–86
EN ROUTE CONTROL FACILITIES**							
Long Range Radar	12.3	22.0	8.5	15.0	15.0	100.0	172.8
• Establish ATCRBS							
• Discrete Address Beacon Sys.							
Automation	12.7	15.0	8.0	6.0	6.0	75.0	122.7
Center Facilities	22.2	18.0	17.0	16.0	15.0	70.0	158.2
TOTAL	47.2	55.0	33.5	37.0	36.0	245.0	453.7
TERMINAL CONTROL FACILITIES*							
Terminal Area Radar	23.5	16.0	15.0	20.0	28.0	154.0	256.5
• Establish ASR/ATCRBS/ARTS II							
• Establish/Replace ASDE							
• Airport Surface Traffic Control							
• Discrete Address Beacon Sys.							
Automation	0.6	16.0	23.0	24.0	2.0	16.0	81.6
• ARTS II/ARTS III Enhancements							
• ARTS III Metering and Spacing							
• Conflict Prediction/Resolution							
• Terminal Information Processing Subsystem							
Control Tower Facilities	25.2	44.0	36.0	30.0	37.0	232.0	404.2
TOTAL	49.3	76.0	74.0	74.0	67.0	402.0	742.3
FLIGHT SERVICE FACILITIES							
Modernization/Automation	27.9	22.0	20.7	41.2	43.5	93.0	248.3
Communications	12.2	10.0	9.5	6.0	6.0	18.0	61.7
• Direction Finders							
Weather	3.2	6.0	11.5	8.5	7.5	25.0	61.7
Station Facilities	4.9	4.5	3.5	3.8	3.7	25.0	45.4
TOTAL	48.2	42.5	45.2	59.5	60.7	161.0	417.1
EN ROUTE NAVAIDS							
VORTAC System	12.3	14.5	26.5	15.0	22.5	100.0	190.8
• Establish							
• Add DME to VOR/TVOR							
• Off-Shore Navigation System							
Low/Medium Frequency Facilities	2.2	1.5	—	1.0	—	—	4.7
TOTAL	14.5	16.0	26.5	16.0	22.5	100.0	195.5
LANDING AIDS							
ILS/MLS	23.9	12.0	27.8	37.2	25.2	155.0	281.1
• Establish ILS/MLS							
• Improve ILS/MALS							
• Add DME to ILS							
• Provide Slant Visibility Range							
Visual Aids	11.9	16.0	15.6	7.7	15.4	39.0	105.6
• Establish REIL							
• Establish/Improve VASI							
• Establish Lead-in Lights (LDIN)							
• Establish MALS							
• Retrofit light structures with frangible towers							
Wake Vortex and Wind Shear	—	6.0	5.0	2.0	3.5	18.0	34.5
• Provide Aircraft Vortex Advisory System (VAS)							
• Provide Wake Vortex Avoidance System (WVAS)							
• Improve WVAS/VAS							
• Provide Wind Shear Detection							
TOTAL	35.8	34.0	48.4	46.9	44.1	212.0	421.2
SYSTEM SUPPORT							
Housing, Utilities and Misc.	27.9	12.5	10.0	10.0	12.0	70.0	142.4
Aircraft and Related Equip.	.07	9.0	7.4	1.6	2.7	35.0	56.4
Development, Test and Evaluation (NAFEC)	3.0	5.0	5.0	5.0	5.0	25.0	48.0
TOTAL	31.6	26.5	22.4	16.6	19.7	130.0	246.8
F&E TOTAL	226.6	250.0	250.0	250.0	250.0	1,250.0	2,476.6

* For planning purposes some new/improved facilities are included for which implementation decisions have not been made.
** Only major programs are identified

Appendix C
Operations Funding Summary

ACTIVITY	PLAN (in millions of dollars) 1977	1978	1979	1980	1981	1982–86	1977–86
Air Traffic	745.6	816.5	861.3	901.9	939.9	4,919.3	9,184.5
Airways Facilities	382.0	407.5	415.4	424.5	437.6	2,275.6	4,342.6
Installation and Materiel	148.2	163.9	172.9	181.6	190.2	989.1	1,845.9
Flight Standards	148.9	160.0	167.0	172.5	178.6	928.8	1,755.8
Medical	9.2	9.9	10.1	10.3	10.6	54.1	104.2
Development Direction	6.2	7.4	7.6	7.7	7.8	39.8	76.5
Airports	18.6	20.5	20.9	21.3	21.6	110.2	213.1
Centralized Training	72.0	87.1	88.4	89.0	89.8	458.0	884.3
Direction, Staff and Support	146.6	183.0	193.1	201.7	210.8	1,075.1	2,010.5
Total	1,677.5	1,855.8	1,936.7	2,010.5	2,086.9	10,850.0	20,417.4

Summary

Today we face the challenge of continuing and fostering aviation growth as an integral part of the Nation's transportation system. We are committed to meeting this challenge through consultative partnership with the aviation community. This partnership already is represented in this document through the inclusion of comments and suggestions relating to past editions of the plan, through information which has been exchanged between the Federal Aviation Administration and its constituency at the annual Aviation Review Conference and from the results of numerous consultative planning conferences and listening sessions. The plan periodically will be revised to accommodate changing conditions and new requirements. All parties interested in aviation are invited to participate in these modifications.

F. A. Meister

F. A. MEISTER
Associate Administrator for Policy
Development and Review (Acting)