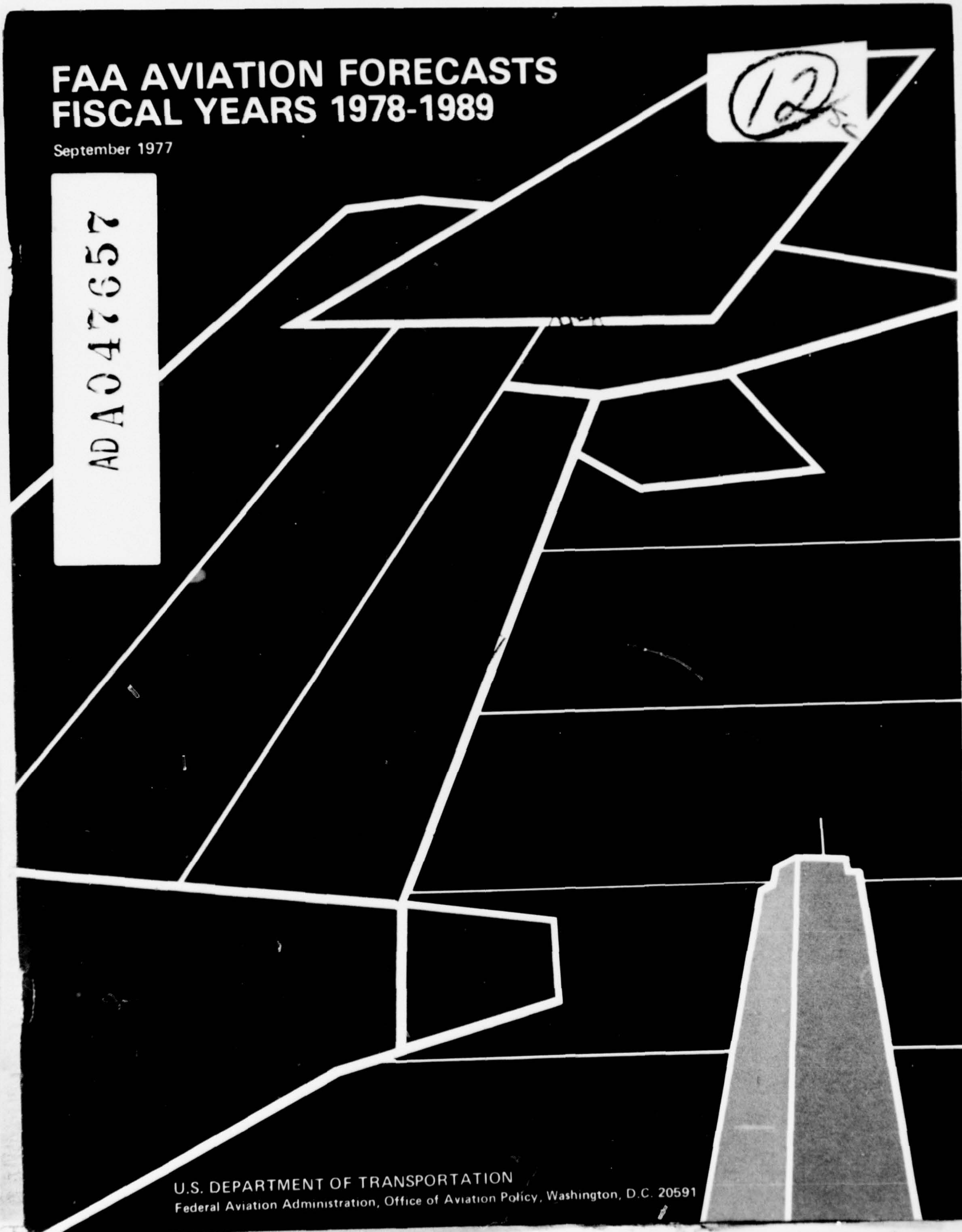
FAA AVIATION FORECASTS FISCAL YEARS 1978-1989

September 1977



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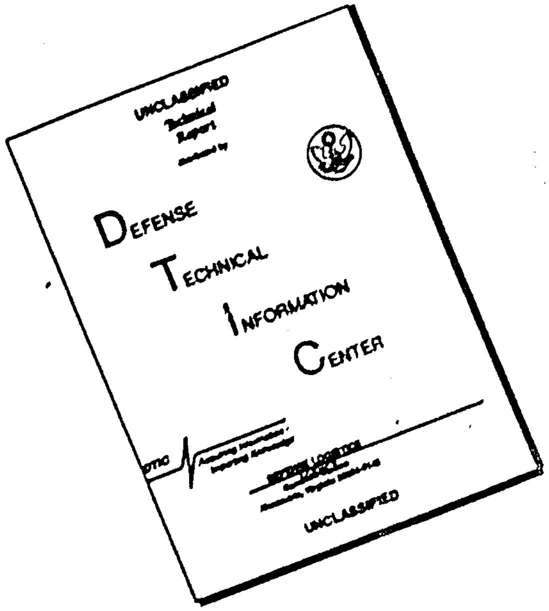

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16. Abstract

This report contains the Fiscal Years 1978 to 1989 Federal Aviation Administration (FAA) forecasts of aviation activity and measures of workload at FAA facilities. These include airports with FAA control towers, air route traffic control centers, and flight service stations. Detailed forecasts were made for the four major users of the national aviation system: air carriers, air taxi, general aviation and the military. This report also contains for the first time a specific forecast for commuter airlines. The forecasts have been prepared to meet the budget and manpower planning needs of the constituent units of FAA and to provide information that can be used by state and local authorities, by the aviation industry and the general public.

The overall outlook throughout the forecast period is for moderate economic growth, declining unemployment, and decreasing inflation. Based on these assumptions, aviation activity is forecast to increase by Fiscal Year 1982 by 29 percent at towered airports, 32 percent at air route traffic control centers and 49 percent in flight services performed. The corresponding percentage increases for Fiscal Year 1989 are 49, 64 and 104, respectively. General aviation and air taxis (including commuters) will account for most of the growth in activity at FAA facilities.

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A GUIDE TO THE ANNUAL REPORT

The 1977 Federal Aviation Administration (FAA) annual report on aviation forecasting contains the official FAA forecasts of future domestic aviation activity for the Fiscal Years 1978–1989. In addition, the rationale underlying the forecasting effort is explained, those forces that have an impact on aviation are assessed, the assumptions upon which the forecasting models are based are summarized, and the models themselves are presented. The theme for this report is forecasting for decisionmaking.

As in past years, this report contains the latest FAA forecasts of activity at towered airports, air route traffic control centers, and flight service stations. These forecasts are required for use by all elements of FAA for policy and program development and budget support. Forecasts are also provided for air carriers, air taxis, general aviation, and the military—the four major users of the National Aviation System (NAS). In addition, this report contains for the first time a forecast of the future activity of commuter airlines.

Chapter 1 is an overview of the FAA forecasting effort. It presents the rationale that motivates aviation forecasting at the FAA, describes the on-going development of the forecasting process, and reviews the nature and scope of the forecasts. The overview also summarizes the composite 1977 aviation forecasts.

Chapter 2 describes the forecasting process used by the FAA. The currently employed econometric and system dynamics forecasting methods are compared, with an explanation of the characteristics and relative advantages of each. The users of the forecasts and their requirements are also identified. These requirements are compared with currently provided forecasts, and a course is mapped for future developmental activity designed to improve the forecasting capability of the FAA.

Chapter 3 contains the 1977 FAA aviation forecasts. Besides relating current status and projecting future growth for each forecast variable, Chapter 3 summarizes the methodology and assumptions used in deriving each forecast. The forecasts include total aviation growth projections for major aviation sectors (i.e., air carrier, air taxi, general aviation, the military), and the operational workloads expected at FAA towered airports, enroute air traffic control centers, and flight service stations. In addition to the baseline forecasts, Chapter 3 also contains long-range forecasts for alternative economic scenarios that might occur under conditions other than those assumed for the baseline forecast. These forecasts, which are based upon various economic and regulatory combinations, show how aviation activity can be expected to respond to various events. Such forecasts aid the FAA in responding rapidly to otherwise unanticipated events.

Chapter 4 contains complete tables of the 1977 FAA aviation forecasts for Fiscal Years 1978 through 1989.

The Appendices describe the major forecasting models employed by the FAA. More detailed analysis of other models can be found in the special reports noted on pages 39 and 40.

Forecast Program Theme

The FAA forecasts of aviation activity are designed to be useful to policy decision makers, both within and outside the Government. The forecast outputs are formulated to provide information that can be used by decision makers to choose among alternative modes of action.

The FAA is continuously engaged in efforts to improve the management utility of its aviation forecasts. New forecasting models, new data sources, and a variety of simulation capabilities are being developed. The agency is deeply concerned that these expansions in capability be analytically sound and of practical benefit. Therefore, the current initiative includes efforts to involve members of the aviation community and the general public in the development and critical review of new forecasts and forecasting methodologies.

The next major step in the process of upgrading the FAA aviation forecasts will be the Aviation Forecast Conference to be held in early December 1977, in Washington, D.C. As in this report, the theme for the conference will be forecasting for decision making, and the conference will include a presentation and discussion of the most recent aviation forecasts by the FAA.

Your analysis and evaluation of these forecasts, methodologies, and assumptions would be appreciated. To obtain additional information, contact the Aviation Forecast Branch, AVP–120, Federal Aviation Administration, Washington, D.C. 20591, Phone (202) 426–3103.

CHAPTER 1.

OVERVIEW

THE NEED FOR AVIATION FORECASTS

The forecasts in this report aid the FAA in budgeting and managing the current national aviation system. Equally important, they also support the Department of Transportation and other Federal agencies involved in domestic aviation policy. The forecasts are used at the state, regional, and local levels to assist in designing specific terminal sites and major aviation hubs. The aviation community may use these forecasts for future decisions about R&D and investment in new aircraft. The forecasts also serve as a source of information for the general public.

In addition to these needs, long-range forecasting is essential to a proper understanding of technology-intensive industries such as aviation. Advancements in air transportation require long lead times—10 to 15 years in advance of actual implementation. Forecasts help managers to make informed decisions in such a risky and uncertain environment.

SCOPE OF CURRENT FAA FORECASTS

The FAA generates forecasts of future activity for four major user categories of aviation:

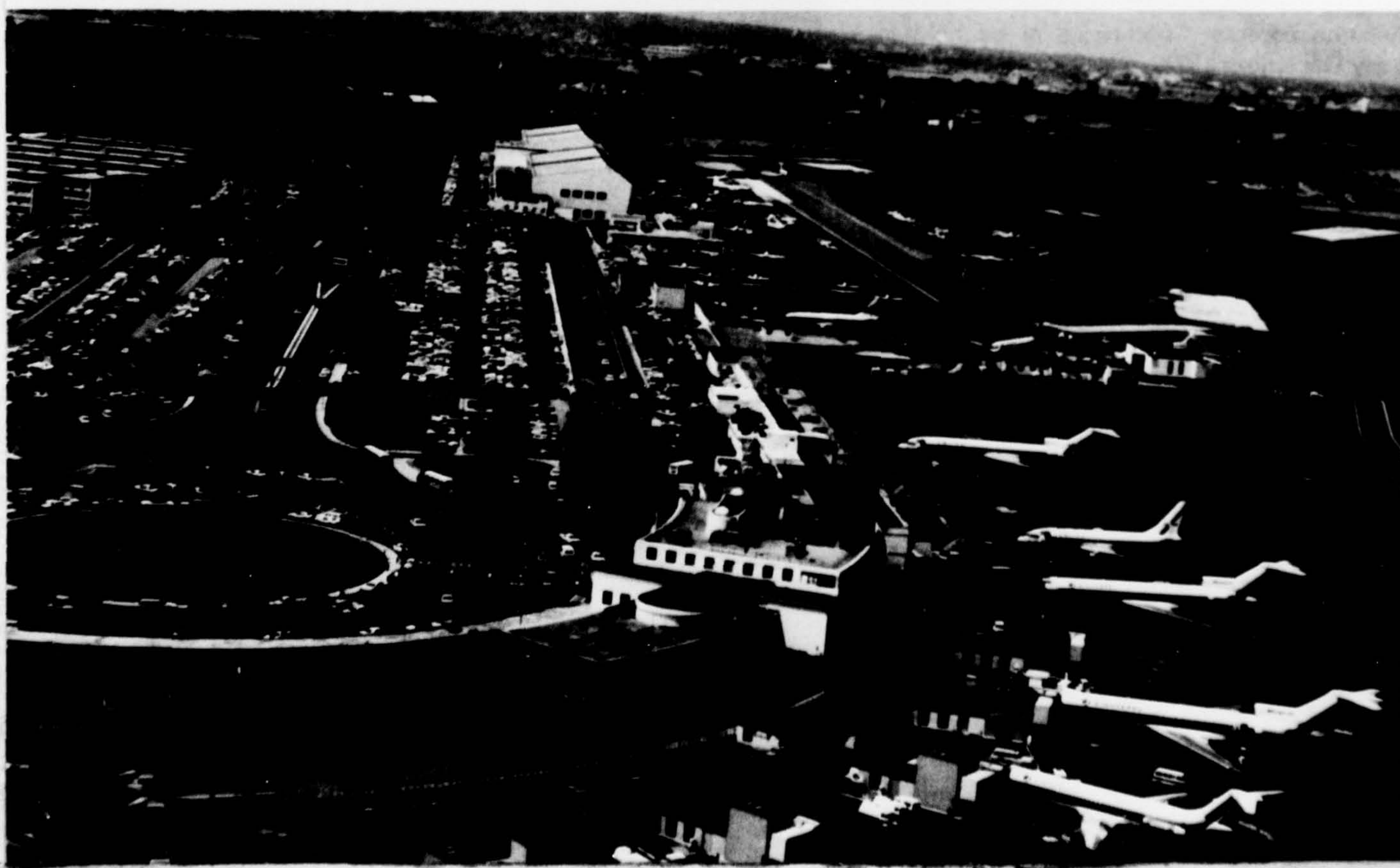
Air Carriers: The FAA forecasts certificated route air carrier scheduled passenger traffic, operations, and revenue; cargo and mail volumes; fleet size, composition, and utilization; aircraft production; and international aviation activity.

Air Taxi: The FAA forecasts operations, commuter fleet size and utilization, and passenger traffic.

General Aviation: The FAA forecasts operations; fleet size, composition, and utilization; and aircraft production and airmen.

Military Aviation: The FAA forecasts operations. Fleet size and utilization forecasts are based on information supplied by the Department of Defense and the U.S. Coast Guard.

From these specific forecasts, as shown in *Figure 1*, the FAA produces aggregate forecasts for cumulative national aviation activity, and also generates forecasts for FAA operations at towered airports, air route traffic control centers, and flight service stations.



CURRENT INITIATIVES TO IMPROVE AVIATION FORECASTING

Improvement in any forecast must be a continuing process. Current efforts focus on both improvements in methodology and data and the utility of forecasts as management tools. Forecasting methodologies are being improved to provide more precise projections and to permit the tailoring of forecasts to the specific needs of various management functions. Forecasting capability is being applied to the analysis of alternative policy options and to the effects of possible future events. Also, to assure that these activities meet the needs of users, the FAA has co-sponsored a series of seminars and conferences soliciting inputs and comments from the public. These initiatives are described in more detail in Chapter 2.

SUMMARY OF 1977 FAA AVIATION FORECASTS

Current FAA forecasts of aviation activity for the years 1978 through 1989 are summarized in this section. Forecasts are provided for domestic and U.S. portions of international aviation activity and for FAA workload measures. They are based upon future projections of socioeconomic factors and incorporate such conditions as escalating fuel costs and regulatory reform. Other forecasts, which predict the course of aviation activity should events evolve differently from those assumed for the baseline forecast, are presented in Chapter 3.

Table 1 presents both average annual growth rates and total growth for the periods 1977 through 1982 (5-year forecast) and 1977 through 1989 (12-year forecast), and also reviews historical data for 1977 and the 5-year period 1972 through 1977. Thus historical growth can be compared with projected growth over the nearer term (1977–1982) and the longer term (1977–1989).

FIGURE 1. FAA AVIATION FORECAST PUBLICATION COMPOSITION

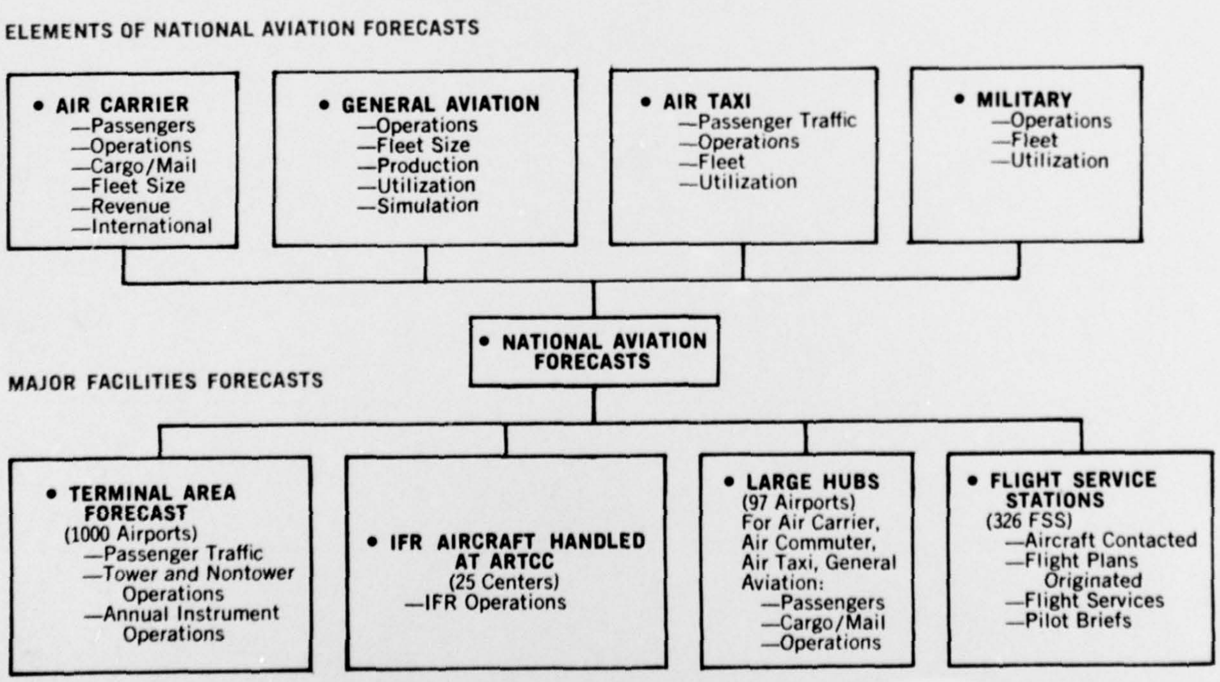


TABLE 1. SUMMARY OF 1977 FAA AVIATION FORECASTS

Growth Aviation Activity	Average Annual Growth (Percent) Historical 1972–1977	Historical 1977ᵃ	Forecast 1977–1982	Forecast 1977–1989	Total Growth (Percent) Historical 1972–1977	Forecast 1977–1982	Forecast 1977–1989
AVIATION ACTIVITY FORECASTS							
Air Carriers							
Revenue Passenger Enplanements	4.9	6.5	5.5	5.0	27	31	80
Revenue Passenger Miles	5.2	6.4	6.0	5.6	29	34	93
General Aviation							
Total Aircraft	6.2	5.8	5.6	4.2	35	31	63
Hours Flown	6.5	3.6	6.0	4.2	39	34	64
Air Cargo							
Revenue tons Enplaned	—	6.5	5.7	5.6	—	32	93
Revenue ton-miles	—	6.2	8.1	7.5	—	48	139
Commuter Carriers							
Operations	—	9.7	7.6	5.8	—	44	96
Enplanements	—	10.1	8.1	6.9	—	48	123
Revenue Passenger Miles	—	10.2	9.3	8.9	—	56	177

ᵃ 12 months ending September 30, 1977 over 1976, based on preliminary data.

Growth FAA Operations	Average Annual Growth (Percent) Historical 1972–1977	Historical 1977ᵃ	Forecast 1977–1982	Forecast 1977–1989	Total Growth (Percent) Historical 1972–1977	Forecast 1977–1982	Forecast 1977–1989
FAA WORKLOAD MEASURES							
Tower Operations							
Air Carrier	0.2	—	2.1	2.1	1.0	12	29
Air Taxi	9.9	—	11.5	8.2	60	72	156
General Aviation	5.7	—	5.5	3.3	32	31	48
Military	—	—	—	—	—	—	—
Total	4.4	4.9	5.2	3.4	24	29	49
Instrument Operations							
Air Carrier	0.6	—	2.3	2.1	3.1	12	28
Air Taxi	22.7	—	11.5	8.4	178	72	164
General Aviation	24.0	—	6.2	5.4	194	35	88
Military	—	—	—	—	—	—	—
Total	9.6	6.6	4.9	4.2	58	26	64
IFR Aircraft Handled							
Air Carrier	0.7	—	2.6	2.3	4.0	14	31
Air Taxi	13.5	—	15.6	10.4	88	107	227
General Aviation	11.4	—	11.0	7.2	72	69	131
Military	—	—	—	—	—	—	—
Total	2.8	5.0	5.6	4.2	15	32	64
Flight Services							
Pilot Briefs	4.0	—	10.5	7.5	21	65	139
Flight Plans Originated	5.1	—	7.1	5.8	29	41	96
Aircraft Contacted	0	—	2.3	0.1	0	12	1
Total	3.5	2.1	8.3	6.1	19	49	104

Also included in the section is a comparison between the 1976 and 1977 FAA aviation forecasts. Major differences are identified and discussed. In general, the forecasts are similar with differences basically a result of changes in national policies in the areas of energy and airline regulation.

AVIATION ACTIVITY FORECASTS

Air Carriers: The air carrier industry is expected to experience a moderate 5.6 percent average annual growth in total domestic scheduled revenue passenger miles between FY 1977 and FY 1989. Total enplaned passengers will increase from 232.1 million in FY 1977 to 418.4 million by FY 1989. Revenue passenger miles will increase to a greater degree than enplanements because of longer passenger trip lengths. The average passenger load factor is assumed to increase from 55.6 percent in 1976 to 58.0 percent by the early 1980s.

Both international and domestic air cargo shipments will increase strongly throughout the forecast period as a result of anticipated growth in time-sensitive cargo shipments and a favorable shift in the relative quality and cost factors between air and surface transportation modes. Growth will be concentrated in freight service, with mail increasing less rapidly. Domestic revenue ton-miles are forecast to more than double between 1977 and 1989, while international revenue cargo ton-miles will increase more than 160 percent.

General Aviation: A moderately strong increase (5.6 percent a year) is forecast through 1982 for the general aviation fleet as a consequence of improved economic conditions resulting in part from assumed stimulative Government fiscal policies. After 1982, however, the fleet is expected to grow at a lower rate as the cumulative impact of higher fuel costs take effect. Fleet composition is expected to shift somewhat toward multiengine piston and turbine aircraft as the sophistication of general aviation use grows. By 1989, such aircraft will represent 18.5 percent of the fleet as compared to 14.4 percent currently. Hours flown by general aviation are forecast to increase at a lower rate than predicted in 1976, again due to higher anticipated fuel costs.

Commuter Airlines: Air commuter activity is included as a separate forecast for the first time in this report as a consequence of its increasing importance, especially in meeting the service needs of small communities and rural areas. Commuter service is the scheduled portion of air taxi activity. Commuters must either transport mail on a regular schedule or perform at least five regularly scheduled round trips per week between two or more

points. The remaining air taxis, on the other hand, provide nonscheduled service on demand.

Since 1970, total domestic commuter passenger enplanements have risen from a little over 4 million to almost 7 million, an average annual increase of more than 8 percent. Commuter service is now provided at 789 airports. This trend is expected to continue throughout the forecast period as governmental policy evolves which encourages commuter service (subsidies, plus eased trunk and local carrier exit requirements), as population shifts and economic growth create new markets, and as public recognition and acceptance of commuter service grows. By 1989, approximately 14.5 million passenger enplanements are forecast for commuter carriers in the 48 contiguous states (plus Puerto Rico), up 123 percent from 1977.

Military Aviation: Both the number of active military aircraft and the number of hours flown will remain stable throughout the forecast period. During this time, the military proportion of the total national fleet will fall to 6 percent (10 percent currently), and its proportion of total hours flown will fall to 9 percent (12 percent currently).

Aircraft Fleet: The U.S. civil aircraft fleet now numbers approximately 181 thousand airplanes. General aviation is by far the largest sector, accounting for 98.7 percent of the total. In contrast, only 1.3 percent of the fleet are air carrier aircraft. In addition the military has approximately 20,000 aircraft stationed within the United States.

The civil fleet is forecast to grow to approximately 294 thousand aircraft by 1989, up 63 percent from the 1977 level. The general aviation proportion of the total fleet will remain virtually unchanged.

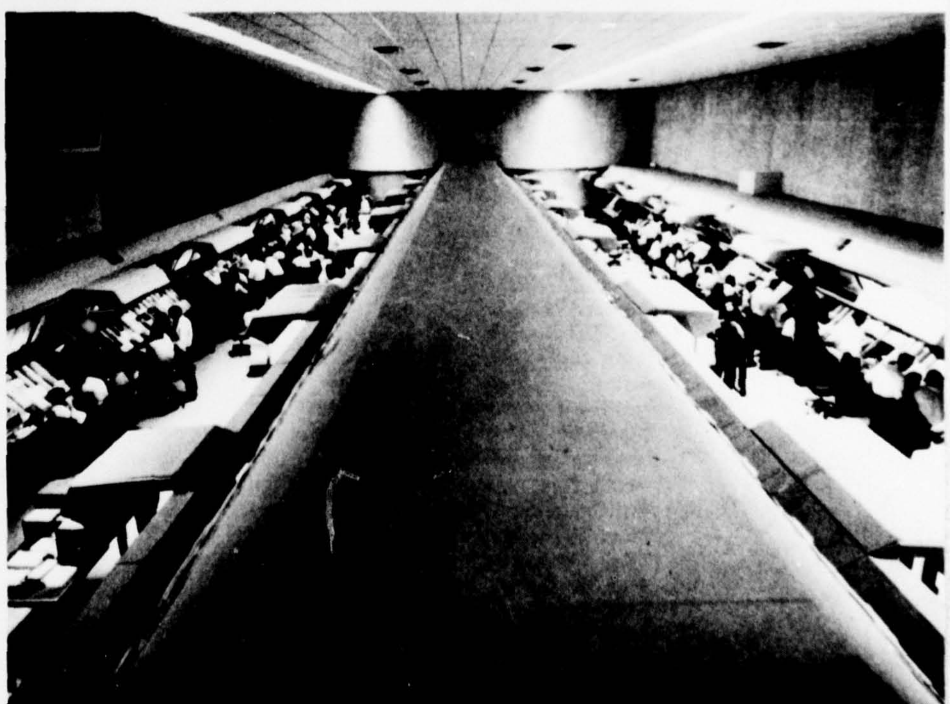
FAA Workload Measures

Aircraft Operations: In FY 1977 total aircraft operations at airports with FAA towers experienced a moderate growth of 4.9 percent over FY 1976. The increase was concentrated in the general aviation sector and was attributable primarily to continued improvement in the domestic economy. A net gain of 4 new ATC towers accounted for 0.1 percent of the gain. Total aircraft operations are forecast to climb 49 percent by 1989. This projection is 9.4 percent lower than last year's due primarily to a downward revision in anticipated general aviation growth. However, air taxi operations, which include commuter operations, are now forecast to be up 156 percent by 1989.

Instrument Operations: The FY 1977 increase of 6.6 percent over FY 1976 in instrument operations was concentrated in the general aviation sector, and reflected increased use of avionics by general aviation pilots. Instrument operations are forecast to increase 64 percent between FY 1977 and FY 1989. Again, the increase will be concentrated in the general aviation sector, where the percentage of instrument-rated pilots will rise from the current level of about 28 percent of total pilots to approximately 35 percent. There will also be strong growth (164 percent by 1989) in air taxi instrument operations as a result of increased commuter traffic and higher utilization of avionics by air taxi operators.

IFR Aircraft Handled: FAA Air Route Traffic Control Centers (ARTCCs) handled 25.3 million Instrument Flight Rules (IFR) operations during 1977, up 5.0 percent from 1976. All sectors of the aviation industry showed gains with general aviation growing most strongly. IFR forecasts through 1985 are essentially unchanged from last year. However, beyond 1985, the forecasts are higher because the number and percentage of IFR-rated general aviation pilots is expected to increase. Exceptionally strong growth (227 percent from FY 1977 to FY 1989) is forecasted for air taxi IFR operations, due to an expected surge in air taxi traffic. Overall, IFR operations are forecast to increase 64 percent between FY 1977 and FY 1989, the same as forecast for instrument operations.

Flight Service: Total flight services in FY 1977 rose slightly (2.1 percent) over FY 1976, resuming the historical upward trend that was interrupted briefly during 1976. Between the present and 1989, total flight services are forecast to experience the highest growth of the three major FAA operations services, rising 104 percent. Pilot briefs in FY 1989 are expected to increase 139 percent over FY 1977 while flight plans originated are expected to be up by 96 percent. In contrast, the number of aircraft contacted will be at about the FY 1977 level reflecting higher general aviation costs and recent historical patterns.



FORECAST COMPARISONS

Table 2 compares the 1977 FAA aviation forecasts with those made in 1976. Although the forecasts are similar, this section provides explanations *for those variations which have developed.* Comparisons are made for representative aircraft activity parameters and for indicators of the FAA operational workload. Forecasts are compared for 3 years:

- 1977: To compare 1976 forecast values with actual preliminary 1977 values for each aviation category.
- 1982: To highlight forecast changes that could affect FAA near-future budgetary actions on manpower, facilities, and equipment.
- 1988: To indicate perceived changes in the longer-term evolution of aviation.

Aviation Activity: Air carrier passenger activity is now forecast to grow slightly less rapidly than forecast last year, due basically to higher estimates of future costs and an anticipated slowing of consumer spending on services and continued transfer of points from certificated to commuter carriers. Air cargo, on the other hand, is expected to show significantly stronger gains due primarily to an expected *acceleration in time-value shipments.* These shipments involve commodities whose prompt delivery is important. The 1977 forecast for the general aviation fleet is higher both in 1982 and 1988 due to continued strong economic activity expected in the early 1980s. However, hours flown by general aviation are predicted to be sharply lower, particularly in the late 1980s, as a consequence of progressively higher fuel costs. Military aviation forecasts are essentially unchanged from 1976.

FAA Workload Measures: The 1977 forecasts for the FAA operational series are not significantly different from 1976 projections. The greatest deviation occurs in the 1988 forecast for total operations at airports with FAA Air Traffic Control (ATC) towers. The 9.4 percent lower forecast is due basically to an expected decline in the growth of hours flown by general aviation. However, this decline will not have as strong an impact on instrument operations because the percentage of instrument-rated pilots is projected to increase. The forecast for IFR-aircraft handled will actually increase slightly for the same reason. The forecasts for total flight services are essentially unchanged from 1976.

CHAPTER 2.

IMPROVING FAA AVIATION FORECASTS

The Office of Aviation Policy of the FAA is currently engaged in an effort designed to identify the major users of aviation forecasts and to ascertain specific forecast needs. The objective is to gain awareness of voids or deficiencies now existing in the overall aviation forecasting effort and to develop means for fulfilling unmet user requirements. Since forecast needs may evolve over time, this assessment is a continuing activity to help ensure that FAA aviation forcasts are responsive to current and future user needs.

Continuing initiatives to improve the management utility of FAA aviation forecasts are discussed in this chapter. These projects reflect current perceptions in the Office of Aviation Policy of ways in which its forecasts can be improved, and are representative of what the office hopes to achieve. The projects, of course, can be modified as new insights are gained from the users of these forecasts.

The forecast improvement projects can be categorized in the following four mutually supportive areas of effort:

Increase Forecast Specificity and Scope: Management forecast requirements are continually reviewed to identify opportunities for improving aviation forecasts. Developmental projects are then initiated to meet identified needs.

Improve Forecasting Methodoloy: The techniques employed in producing aviation forecasts are being improved to provide more reliable and timely forecasts, and to establish a data base for use by policy analysts.

Analysis of Alternative Policies: Techniques are being developed to examine possible aviation activity under various assumptions about alternative socioeconomic conditions. Alternative future scenarios, for example, span a range of plausible future economic and social conditions. This and other techniques facilitate evaluation of a large number of future conditions. Consequently, a wide range of policy options may be explored and developed for making current decisions.

Meeting the Needs of Users: Activities are planned to encourage and facilitate the dialogue between FAA forecasters and the forecast-using community. Critical feedback as to the requirements of user groups is sought in order to meet the needs of decision makers.

INCREASE FORECAST SPECIFICITY AND SCOPE

The primary thrust in expanding the utility of FAA forecasts resides in providing information tailored to the needs of specific management functions. Development is underway on forecasts of aviation activity for specific geographic regions, activity at specific terminals on a daily (or even hourly) basis, disaggregated air carrier forecasts (e.g., cargo, trunk, local, supplemental, etc.), and more detailed and comprehensive forecasts for general aviation at both towered and nontowered airports.

Forecast Users and Their Requirements

Table 3 summarizes current perceptions of the aviation forecast-using community and their forecast related functions. Aviation forecasts are of vital importance to the FAA. Shorter-term (2–5 years) forecasts are used as the base upon which the agency's budget is developed and supported, in maintaining the airspace system, determining facility, staffing, and equipment requirements and in upgrading the national air traffic control system to meet near-term needs. Longer-range (10–15 years) forecasts are used both by the FAA and the Office of the Secretary of Transportation (OST) when analyzing transportation policy and planning for the long-range transportation needs of the Nation.

Both the executive (OMB) and legislative (Congress) branches of the Federal Government employ aviation forecasts when determining appropriate budgets for the FAA and other aviation-oriented agencies (NASA, for example) and when formulating regulatory changes pertaining to the aviation sector. State, regional and local authorities also base their Airport Master Plans and State System Plans on FAA forecasts or on locally generated forecasts which are consistent with the official FAA forecasts.

TABLE 3

FEDERAL AVIATION ADMINISTRATION

ORGANIZATION	FORECAST RELATED FUNCTIONS
Office of Aviation System Plans	• Develop 10-year plan for FAA facility/equipment/staffing requirements. Establish criteria for equipping facilities.
Office of Aviation Policy	• Evaluate impact of legislative and regulatory actions on the aviation industry. Conduct special studies required for policy evaluation.
Office of Airports Programs	• Formulate a balanced airport/airway system designed to cope with the growth of aviation. Allocate resources for developing the National Aviation System.
Office of General Aviation	• Recommend and coordinate national policy with the general aviation industry. Maintain a dialogue with the industry.
Office of International Aviation Affairs	• Develop and coordinate international aviation policy (e.g., landing fees). Support the flag fleet internationally.
Office of Environmental Quality	• Establish policy regarding environmental issues (noise, air pollution). Coordinate impact of Environmental Impact Statements. Analyze environmental issues (e.g., impact of high altitude aircraft on ozone layer).
Office of Management Systems	• Support the Office of Budget in developing multiyear budget programs, estimates, and staffing authorizations.
Office of Budget	• Develop multiyear budget programs, budget estimates, and staffing authorizations. Submit forecasts of aviation activity to OMB and Congress, as part of the overall justification for budgetary submissions.
Air Traffic Service	• Develop staffing standards for the total FAA services system. Plan and budget for air navigation facilities and equipment.
Flight Standards Service	• Develop flight standards (e.g., pilot training, operation requirements). Monitor the safety of the industry and its adherence to Federal regulations. Determine the safety impact of projected growth.
Systems Research and Development Service	• Test and evaluate the impacts of aviation equipment performance and operating characteristics as they relate to future demands on the National Aviation System.
Office of Systems Engineering Management	• Develop and maintain a comprehensive plan for the conduct of FAA research, development, and related engineering efforts for improvements to the National Aviation System. Develop requirements for economic studies and analyses necessary to support approved engineering and development programs.
Office of Aviation Security	• Plan for the safety and security of agency facilities and equipment and the safety and security of the users of the National Aviation System.
Office of Public Affairs	• Develop speeches and position papers indicating future developments and impacts of the National Aviation System for public information. Distribute forecast publications to consumer organizations.
Office of the Chief Counsel	• Provide legal counsel and advice in all legal matters pertaining to FAA aviation forecasts in order to ensure conformance with all legal requirements of all applicable laws, rules, regulations, and orders.
Metropolitan Washington Airport Service	• Develop and coordinate policy for efficient operation of Dulles and National Airports.
Regional Offices	• Develop regional plans and budgets. Recommend installation of new facilities and equipment at airports. Authorize funding for various projects.

TABLE 3—Continued

	ORGANIZATION	FORECAST RELATED FUNCTIONS
AVIATION INDUSTRY	Air Transport Association	• Develop long-run and site-specific forecasts to support investment, scheduling, fleet-assignment, route development, and marketing decisions.
	General Aviation Operators Associations	• Determine trends in industry; disseminate forecast information among members.
	General Aviation Manufacturers Association	• Forecast general aviation activity to support planning for production and marketing. Predict demand for aircraft by type and region.
	Aerospace Manufacturers	• Develop and produce future engines, avionics, and airframes to meet the future needs of the aviation industry.
	Individual companies of aviation industry	• Produce the domestic air fleet and facilities. Develop forecasts for individual future need.
OTHER GOVERNMENT ORGANIZATIONS	Congress	• Appropriate resources for the FAA and other Federal aviation-related agencies.
	Office of Management and Budget	• Assist the President in the preparation of the Budget and in the formulation of the fiscal program of the Government.
	Office of the Secretary of Transportation	• Plan, direct and control departmental activities; formulate transportation policies, allocate resources, evaluate transportation programs and analyze intermodel transportation requirements. Plan for aviation within the context of total transportation policy.
	Civil Aeronautics Board	• Promote and regulate the civil air transport industry of the United States.
	Department of Defense	• Plan for assurance of Department of Defense participation in the continuity of Government and for military participation in civil and domestic emergencies and related emergency planning.
	Federal Communications Commission	• Regulate interstate and foreign communications by radio, TV, wire and cable. The National Aviation System is a major user of telephone and telegraph services of the United States.
	National Aeronautics and Space Administration	• Perform aviation research and development for the Nation. Estimate the impact of certain technological innovations.
	Department of Energy	• Plan national energy policy.
	Department of Justice—Immigration and Naturalization Service	• Plan for resource allocation in administering the immigration and naturalization laws and law enforcement activities.
	Treasury Department—U.S. Customs Service	• Plan for resource allocation in the collection of revenues and in the enforcement of customs and related laws.
	National Transportation Safety Board	• Plan for resource allocation in the investigation of accidents and the identification of safety problems.
	Local, State, Regional Airport Planning Authorities	• Plan total state/regional air terminal requirements. Develop state and individual airport plans.
	Foreign Governments	• Plan the integration of worldwide aviation.
OTHER	Financial/Investment Community	• Estimate future capital requirements.
	Airport Services Industry (Airport lodging and accommodations, car rentals, caterers, advertising)	• Provide the services required at domestic airports.
	Energy Suppliers	• Provide the fuel required by the aviation industry.
	Consumer Groups	• Determine effects of aviation activities in communities.

The private sector also relies on the FAA forecasts of aviation activity. The aviation industry refers to the forecasts when deciding about investments for the aircraft that will be required in future years. Also, car rental agents, airport caterers, advertisers, and airport lodging and accommodation industries all employ the forecasts to some degree in their investment decisions to meet future demand.

The forecasts currently perceived as required by the aviation community are listed in Table 4. This listing will be modified as new information becomes available.

Existing Aviation Forecasts

Many of the forecasts listed in Table 4, identified as required by one or more major organizations are currently supplied by the FAA or some other forecasting group (see Figure 2). The FAA, for example, generates 12-year activity forecasts for air carriers, commuter airlines, air taxis, general aviation, and military aviation for such system parameters as fleet size and composition, passengers and cargo tons enplaned, and hours flown. The FAA also provides 12-year forecasts on the activity levels expected for FAA operational services (total operations, instrument operations, IFR aircraft handled, and flight services), at individual airports, air route traffic control centers, and flight service stations and for composite national totals. In addition, the FAA produces many special forecasts, such as projections of future aviation activity based on plausible ranges of socioeconomic conditions different from what is generally expected to evolve.

TABLE 4. LIST OF FORECASTS REQUIRED BY THE AVIATION COMMUNITY

FAA OPERATIONAL SERIES

1. Total aircraft operations at airports with FAA ATC towers.
2. Instrument operations at FAA-towered airports.
3. IFR aircraft handled by ARTCCs.
4. FAA flight services.
5. Annual instrument approaches.

AVIATION ACTIVITY

6. Air carrier operations/traffic/fleet.
7. Air taxi operations/traffic.
8. Air commuter operations/traffic/fleet.
9. All cargo operations/fleet and total air cargo traffic.
10. General aviation operations/traffic/fleet.
11. Military operations/fleet.
12. International operations/traffic/fleet.

DISAGGREGATED AVIATION ACTIVITY

13. Nontowered aircraft operations.
14. Detailed activity at major terminal areas.
15. Geographical disaggregation/distribution.
16. Temporal disaggregation/peaking.
17. Total activity by state/region.
18. Aviation activity by city pairs.

SPECIAL

19. Future development of alternative modes.
20. Future development of the National Aviation System.
21. Long-range (20–25 years) total aviation activity.
22. Forecasts that simulate the effects of change (e.g., regulatory change, intermodal competition, sensitivity to price and services).
23. Trends in industry operating characteristics (e.g., average stage length, available seat-miles).
24. New technology and its impact.

FIGURE 2. CURRENTLY AVAILABLE AVIATION FORECASTS

FAA AVIATION FORECASTS

Aviation Activity Measures for:

- Air Carriers
- Air Taxis
- Air Commuters
- General Aviation
- Military Aviation

FAA Operational Series

- Total Operations
- Instrument Operations
- IFR Aircraft Handled
- Flight Services

FAA Organizational Forecasts

- Terminal Area Forecasts
- Major Hub Forecasts
- Air Route Traffic Control Centers
- Flight Service Stations

FORECASTS BY OTHER GROUPS

- OST—Air Carrier RPMs
- State and Regional Planning Groups—Air Traffic at Terminal Sites
- ATA—Long-run and Site-specific Forecasts
- GAMA—General Aviation Fleet Size and Composition
- Air Carrier—Future Aviation Activity
- FEA—Energy Consumption by Aviation
- Aircraft Manufacturers—Fleet Size and Aircraft Operating Characteristics
- Engine Manufacturers—Fleet Size and Aircraft Operating Characteristics

Other forecasting groups fulfill additional needs. The Office of the Secretary of Transportation (OST) generates broad-based transportation forecasts which, although heavily weighted by the automotive and mass transit modes, include an independent assessment of air carrier revenue passenger miles (RPM). The Department of Energy prepares total transportation forecasts which include aviation for various scenarios of fuel usage. The General Aviation Manufacturers Association (GAMA) forecasts future fleet size, composition, and production for general aviation aircraft. The Air Transportation Association (ATA) develops long-run and site-specific forecasts to support investment, scheduling, and fleet-assignment decisions by individual air carriers. The carriers generate internal forecasts upon which they base future fleet size and composition, draw up new air routes, and plan facility construction. State, regional, and municipal authorities produce independent forecasts of air traffic at terminal sites. These latter forecasts, which are funded under the FAA Planning Grant Program, constitute the basis for airport and terminal construction and expansion.

Opportunities for Improving Aviation Forecasts

A comparison between the forecasting needs of users (Figure 3) and existing aviation forecasts has identified several opportunities for improving FAA forecasts. The following section describes major unmet forecasting needs, and points the direction of current and future forecast improvements by the FAA.

Increased Geographic Disaggregation in the Forecasts: Forecasts of aviation activity at specific terminals and hubs across the Nation are required to support such activities as planning the capacity required for specific elements of the National Aviation System, determining the proper role of reliever and satellite airports, and understanding the consequences to the air carrier industry from changes in route authorizations.

Current Status and Planned Initiatives

The FAA now has research projects underway to generate forecasts for 24 major air transportation hubs and to provide forecasts on a state-by-state basis. The state level forecasts will be used as a basis for analyzing airport developmental programs generated under the FAA Planning Grant Program. The FAA is also upgrading its capability to forecast activity at more than 1,000 terminal areas, and it plans to develop an econometric model that can forecast activity levels at individual flight service stations, as well as a method for forecasting general aviation activity within specific geographic regions of the Nation.

Greater Temporal Distribution of Traffic at Specific Airports: The allocation of the airspace may be viewed as essentially a problem in determining peak activity at major airports. Analyses of the extent, causes, and consequences of temporal peaking of activity are essential. Such analyses are required to assure that adequate air traffic control equipment is installed, and to assist the aviation industry in making decisions related to scheduling service.

Current Status and Planned Initiatives

Most temporal forecasts (i.e., forecasts of aviation activity by hour of the day) are now made on an airport-by-airport basis. This is a very costly process. In response, the FAA is developing forecasting techniques that can be applied more broadly. Models are being developed to forecast temporal profiles of air carrier operations and passenger enplanements at specific terminals, and to establish the time-of-day preference patterns of general aviation. A quick-response computer program is available that can provide daily tower statistics for individual airports. New projects are planned that will produce temporal profiles of air cargo operations and instantaneous airborne counts at specific terminals.

Increased Activity Detail for Air Carriers: Although air carrier activity is widely studied and measured, certain forecasting requirements are unmet. As a consequence of differing growth patterns and special user requirements, there is a need to develop separate forecasts by trunk, local, supplemental, charter, commuter carrier, and air taxi. In addition, air cargo forecasts should be related to aggregate economic activity and patterns of spatial distribution.

FIGURE 3. CURRENT FAA INITIATIVES TO INCREASE FORECAST SPECIFICITY AND SCOPE

- Increase Geographic Disaggregation
- Expand Temporal Disaggregation
- Provide Greater Activity Detail for Air Carriers
- Improve Data Base and Methodology for General Aviation

Current Status and Planned Initiatives

Recently developed econometric models provide independent detailed forecasts for air cargo volume and commuter operations. Current activity is focused on development of techniques for providing forecasts of enplanements and operations anticipated for the supplemental air carrier industry, and on an econometric model to forecast international aviation activity. Planned projects will develop new models that forecast aviation activity levels for the Atlantic Basin and detail the market-share trends to be expected for the air carrier industry.

Improved Data Base and Methodology for General Aviation: More reliable data bases must be established to assist the development of forecasting methods for general aviation activity. At present, it is very difficult to translate general aviation activity into actual demands on the National Aviation System. Much of the problem is due to the fact that general aviation is the most dynamic and rapidly changing part of civil aviation and the fact that a large percentage of general aviation operates outside of the FAA system. Consequently, data on the composition of the fleet and its pattern of use and impacts on specific airports are sparse.

Current Status and Planned Initiatives

The FAA has recently developed a forecasting model for general aviation that is based upon system dynamics techniques. Not only does this model forecast the future course of general aviation activity, it can be used to analyze the impact of policy initiatives, such as increasing the number of student pilots or raising taxes on aviation fuel. A project is underway to develop a means for forecasting trends in the ownership and utilization of general aviation aircraft. The FAA has developed means for determining attrition patterns for general aviation aircraft, as well as for predicting the level of operations at nontowered airports and the traffic mix at high-density airports. A project is planned that will seek to ascertain if general aviation activity forecasts can be improved using new data to become available from the fixed-base operator industry survey. A second project will examine determinants of future structural changes in general aviation activity demand.

IMPROVE FORECASTING METHODOLOGY

The FAA is well along in its program to develop and improve its forecasting methodologies using econometric and system dynamics techniques. These techniques relate aviation activity forecast variables to fundamental measures of economic and social activity. Complete details on two of these models are included in the Appendices.

Econometric Forecasting

An important part of forecasting resides in understanding past behavior and quantifying basic relationships among factors that can be applied to the future. In recent years, the FAA has developed an extensive econometric forecasting capability based upon modeling relationships among economic variables. FAA econometric forecasting is based upon the assumption that measures of aviation activity are related fundamentally to the level of domestic economic activity. Consequently, these econometric forecasting models are responsive to changing socioeconomic patterns and can be used to forecast the consequences resulting from a wide variety of possible future economic conditions.

When developing econometric forecast models (see Figure 4), historical data are gathered on the aviation activity variables to be forecast (e.g., air carrier enplanements, FAA flight services) and on the economic variables (e.g., gross national product, inflation rate, fuel prices) expected to be important in determining the future course of aviation activity. The economic variables are empirically screened, and those proving to be the best predictors of the aviation variables are retained. Using standard linear regression techniques, a forecasting model is constructed that reflects the historic effect of economic variables upon the aviation activity measures. Next, assumptions are made as to the future course of the economic variables, and these values are incorporated into the forecasting equations to generate the resultant aviation forecasts.

The accuracy of an econometric forecast is limited by the appropriateness of historical relationships and the accuracy in predicting the basic exogenous variables. As a consequence, these elements are continually upgraded as new information, insight, or data become available.

FIGURE 4. ECONOMETRIC FORECASTING PROCEDURES

Current Status and Planned Initiatives

The majority of FAA forecasts are now generated using econometric techniques. Current activity is focused on disaggregation. These activities were discussed in the section on opportunities for improving aviation forecasts (page 24).

Dynamic Forecasting

In an attempt to focus forecasting on factors that actually cause change, rather than merely correlate with it, flexible dynamic forecasting techniques (such as system dynamics) are being combined with analytical techniques (such as cross-impact analysis and trend-impact analysis) and applied to various sectors within the National Aviation System. System dynamics attempts to describe the structure underlying behavioral patterns in order to develop an ability to simulate alternative futures. Cross impact analysis is used to determine the relationship among events. *Trend impact analysis* estimates the change in baseline projections due to the occurrence of one or more events.

By ascertaining the internal mechanisms that produce change, system dynamics can simulate the consequences of future action or events. As such, it can be used to design and evaluate the impact of alternative policy options. In addition, sensitivity tests applied to system dynamic models can indicate critical areas where action is likely to be most effective.

System dynamics models are based upon a mix of quantitative and qualitative data and expert opinion. The cardinal assumption is that system behavior derives primarily from feedback relationships, *that is, a change in one element affects and* is affected by changes in other elements. The major innovation is an ability to incorporate judgmental considerations into the structural model.

The primary advantage of system dynamics is its ability to simulate change. For example, it can be used to determine how future changes in technology can affect system capacity or user costs, as well as to analyze the impact of regulatory change or subsidy to competing modes of transportation. This "a priori" estimation of the effect of potential policy action will allow managers to evaluate the impact of change without having to first implement the change.

Current Status and Planned Initiatives

The FAA has in operation a system dynamics model designed to forecast the activity of general aviation. This General Aviation Dynamics (GAD) model synthesizes the causal interactions that exist between various measures of general aviation activity and the Nation's overall socioeconomic structure. Besides forecasting future general aviation activity, the GAD model is equipped to evaluate a range of alternative policy actions. It has been used by the FAA to evaluate the impact of the President's energy tax proposal on general aviation and by the aviation industry (GAMA) to determine the effect on general aviation resulting from an increase in the number of student pilots. The GAD model is available to both government and industry for use in evaluating the impact of policy initiatives on general aviation activity.

ANALYSIS OF ALTERNATIVE POLICIES

Traditionally, air transportation activity in the United States has been governed largely by the capabilities of aviation technology and by the level of domestic economic activity. However, recent events demonstrate that many additional forces may influence the development of aviation. The energy crisis, environmental concerns, social legislation, changing lifestyle, changing levels of regulation, and inflation are examples of factors that now have and may continue to have significant effects on aviation. Unfortunately the future course of these forces is highly uncertain, and an unexpected turn *in any one* could dramatically modify the most carefully formulated forecast. As a consequence, the FAA is expanding its aviation forecasts to provide a means of analyzing the consequences of alternative future events. The purpose is to determine ways in which current policy might best be modified to treat potential future conditions.

Current Status and Planned Initiatives

The primary current element in this effort is a series of aviation scenarios based upon a range of plausible alternative future social and economic conditions. The full scope of these "alternative scenarios" brackets the future within the limits of highly expansive (greater than 5 percent average *annual increase in GNP) and very limited* (less than 2 percent average annual increase in GNP) economic growth. Each scenario assumes internally consistent values for such social, economic, and

political parameters as business productivity, employment, population growth, environmental considerations, governmental regulation, and inflation.

A second approach assesses trends in the probable evolution of technologies that could have an effect on aviation; for example, the impact of developments in microcomputer technology. In addition, econometric sensitivity analysis and system dynamics models are being developed to aid in estimating the impact of unexpected socioeconomic events on future levels of aviation activity.

MEETING THE NEEDS OF USERS

The FAA has initiated a dialogue with the public users of forecasts. The objective of this dialogue is to obtain review and comment on the techniques currently used, to determine how the forecasts are employed and by whom, to identify forecast requirements that are currently unfilled, and to develop methods for assuring that forecasts meet the needs of management. The dialogue takes the form of publications, seminars, and conferences. Personal contact is emphasized, and critical review and feedback are the primary objectives.

Current Status and Planned Initiatives

Besides holding its annual Forecast Conference at Washington, D.C. in December 1976, the FAA cosponsored with universities several regional conferences and seminars during 1977 (see Figure 5). At each, baseline FAA aviation forecasts were presented for discussion. In addition, special forecasting topics were treated in detail. For example, commuter airline activity was the focus of attention at the Universities of Texas and Denver seminars in May and June of 1977, while activity at nontowered airports was the focal topic at the February 1977 University of California (Berkeley) Conference. Most recently, two seminars were conducted simultaneously in July at the University of Washington in Seattle. The topics were worldwide aviation activity and the general aviation dynamics model.

The next Annual Forecast Conference will be held in December 1977 in the Washington, D.C. area. Additional conferences and seminars are being considered for 1978. The Washington conference will serve as a near-term focal point in the current FAA initiative to upgrade its aviation forecasts. The major topic will be forecasting and the decision-making process. The conference will be structured to serve as a forum for interaction between FAA forecasters and key representatives from the aviation community and general public.

In order to promote user understanding of its forecast, the FAA publishes special documents (see Figure 6) on each of its basic forecasts. Besides presenting estimates of future aviation activity, these reports describe the methodology and assumptions employed in developing these forecasts.

FIGURE 5. FAA AVIATION FORECASTING CONFERENCES AND SEMINARS

Location		Topics
University of California Berkeley, California (February 1977)	Focus	• National Aviation Forecasts • Aviation Futures • Forecast of aviation activity nontowered airports
University of Texas Austin, Texas (May 1977)	Focus	• National Aviation Forecasts • Aviation Futures • Commuter Airline Activity
University of Denver Denver, Colorado (June 1977)	Focus	• National Aviation Forecasts • Aviation Futures • Commuter Airline Activity
University of Washington Seattle, Washington (July 1977)	Focus	• National Aviation Forecasts • Aviation Futures • General Aviation Dynamic Forecasting Model • International Aviation Activity Forecasting
Summary and Briefing Conference Washington, D.C. (December 1977)	Focus	• National Aviation Forecasts • Forecasting Methodologies and Assumptions • Future Directions in Aviation Forecasting

FIGURE 6. FAA FORECASTING PUBLICATIONS

Document	Report Number	Description
• Terminal Area Forecast	FAA–AVP–77–17 January, 1977	• Forecasts of enplanements, aircraft operations, and instrument operations for more than 800 individual airports.
• IFR Aircraft Handled	FAA–AVP–76–13	• Forecasts of Instrument Flight Rule (IFR) aircraft handled by the 24 FAA air route traffic control centers (ARTCC).
• Forecasts of Commuter Airlines Activity	FAA–AVP–77–28 July, 1977	• Forecasts of enplanements, revenue passenger miles, aircraft fleet and mix, and operations. Includes both a national forecast and individual terminal areas forecasts. Identifies those points that are likely prospects for future commuter service.
• Forecast of Air Cargo Activity	FAA–AVP–77–2 January, 1977	• Forecasts of total U.S. domestic and U.S. international air cargo demand for the time period 1977 to 1988. Contains forecasts of air cargo activity at the twenty-five large U.S. hubs and documents econometric models on which the forecasts are based.
• Major Hub Airports Forecasting Publications	Fall 1977	• A series of publications, one for each of 24 major hubs. Detailed forecasts for all categories of activity (air carrier, cargo, commuter, etc.) are provided as well as information on traffic profiles of passengers and operations, airport layout, and other facts.
• Aviation Forecasts FY 1977–88 Summary and Briefing Conference	FAA–AVP–77–16 December, 1976	• Summarizes FY 1977–88 aviation forecasts by the FAA. Presents forecasting models and assumptions.
• Forecasts of Worldwide Aviation Activity	FAA–AVP–76–18 November, 1976	• Describes an econometric model for forecasting worldwide aviation activity. Forecasts of the world's air carrier turbojet fleet through 1990.
• General Aviation Forecasts 1975–1987, State, Regional and National Operations	FAA–AVP–76–7	• Forecasts of total (towered plus nontowered airports) activity in terms of total local and itinerant operations.
• General Aviation Dynamics (four volume report)	FAA–AVP–77–20	• Presents a dynamic simulation model that can forecast general aviation activity, evaluate alternative policy actions, or perform sensitivity analyses.
• Military Aviation Forecasts Fiscal Years 1977–1988	FAA–AVP–76–15 September, 1976	• Forecasts of U.S. military aircraft in service, hours flown and military air traffic workload at FAA facilities for fiscal years 1977–1988.

CHAPTER 3.

1977 FAA AVIATION FORECASTS

The 1977 FAA aviation forecasts are presented in this chapter. Two categories of forecasts are provided, one measuring overall activity of the various aviation user groups and the other dealing with operational services provided by the FAA.

Aviation Activity	FAA Operational Services
• General Aviation	• Total Operations
• Air Carriers	• Instrument Operations
• Commuter Airlines	• IFR Aircraft Handled
• Military Aviation	• Flight Services

Current-year status and 12-year forecasts (FY 1978–89) are presented for each forecast variable. In addition, a brief sketch is given on the methodology and assumptions employed in each case. More detailed explanations of specific forecasting models can be found in the Appendices. The fundamental socioeconomic assumptions underlying all forecasts are also summarized in this chapter.

Besides these baseline forecasts, which chart the currently perceived "most likely" future for aviation activity and FAA operations services from 1978 through 1989, alternative growth scenarios are presented in an attempt to bracket the course future aviation might take should economic conditions occur that differ markedly from the baseline.

BASELINE SOCIOECONOMIC ASSUMPTIONS

In 1976, the economic outlook was characterized by short-term optimism evolving to greater caution over the longer term. This year the overall outlook remains similar. Recent economic programs enacted by Congress–tax incentives to spur employment and tax cuts to stimulate consumer spending—are expected to produce stronger growth through 1979 than predicted last year. However, over the longer term, strong growth is not expected to be sustained due to escalating fuel costs and the probable imposition of taxes on both domestic and imported petroleum. The overall outlook throughout the forecast period is for moderate economic growth, declining unemployment, and decreasing inflation (see Figure 7). The following basic economic assumptions–which are based upon the Wharton Long-Term Industry and Economic Forecasting Model–underlie all FAA aviation forecasts.

Economic Growth

The economic recovery that began in late 1975 is assumed to continue through 1978, with a 5.3 percent real growth anticipated for the Gross National Product (GNP) in 1977. Over the forecast period, annual growth for real GNP is expected to average approximately 3.5 percent, somewhat more optimistic than the 3.2 percent forecast last year. Growth will be greatest in the near future as a result of tax relief and the recently enacted jobs program. Beyond 1985, a 3.3 percent average growth rate is projected, which is consistent with last year's forecast.

Employment

Strong increases in employment (2.8 percent annually) are anticipated for the remainder of the 1970s, again due primarily to the recently enacted jobs program. This growth rate is expected to fall steadily through the 1980s (averaging approximately 1.8 percent) as the effect of the stimulus program fades and as the size of the labor force grows less rapidly.

Inflation

As measured by the GNP deflator, inflation rates of 6.2 percent are assumed for 1978 through 1980, followed by rates averaging 5.0 percent through 1989. The average annual inflation rate now anticipated for the forecast period is 5.7 percent, lower than the 6.2 percent predicted last year.

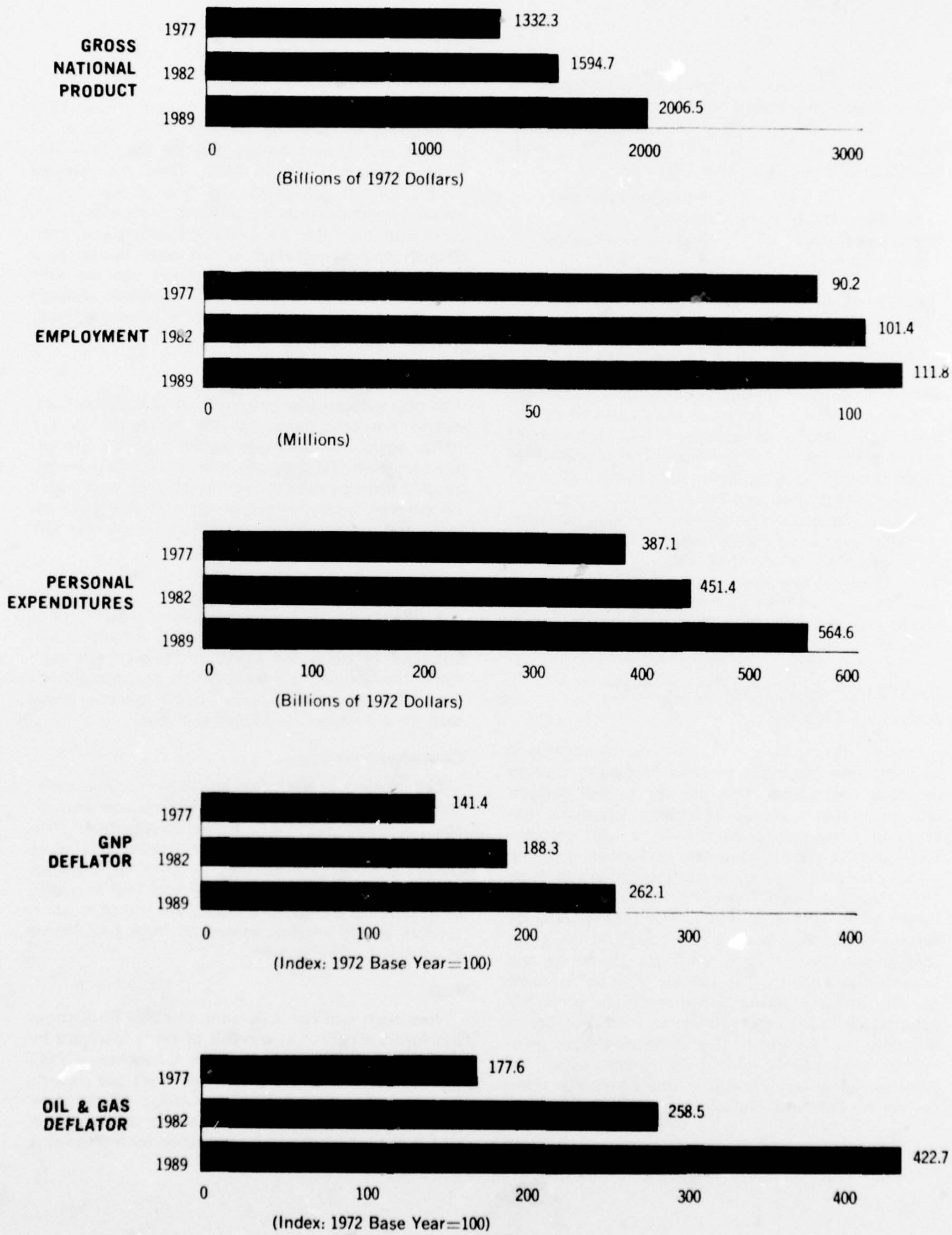
Consumer Spending

The increase in personal disposable income anticipated throughout the forecast period will encourage consumer spending. However, personal consumption of services is not expected to increase as rapidly as GNP. Consumption patterns are expected to shift toward the purchase of fuel and fuel-efficient durable goods. As a result, the use of aviation services would weaken somewhat from past trends in relation to GNP growth.

Fuel

Fuel costs will rise 7 percent annually throughout the forecast period as a result of price increases by the Organization of Petroleum Countries (OPEC) and domestic oil. This projection does not include increases due to possible imposition of domestic taxes on aviation fuel. The baseline forecast assumes that fuel usage will not be restricted by forces other than price.

FIGURE 7. ECONOMIC ASSUMPTIONS UNDERLYING BASELINE FISCAL YEAR 1978–1989 AVIATION FORECASTS



Regulatory Reform

Proposed regulatory reform now in the legislative process is designed to strengthen competitive market forces within the air carrier industry. Entry and expansion into existing and new markets would be facilitated, as would abandonment of unprofitable routes. Proposed regulatory reform would also provide carriers with greater discretion in fare-setting, encourage commuter service to small communities, and allow commuter carriers to operate larger aircraft.

The impacts of some form of regulatory change are anticipated to become effective by 1979 or 1980. As a consequence, the estimates of these impacts have been incorporated into the forecasts beginning in 1979. The principal effect has been a decrease in the air carrier operations forecast and an increase in commuter operations as some markets are transferred from air carrier to commuter service.

AVIATION ACTIVITY FORECASTS

General Aviation

METHODOLOGY AND ASSUMPTIONS

Most forecasts of general aviation activity are derived from an econometric model that relates measures of activity to economic and demographic variables. Both the independent exogenous variables, which come primarily from the Wharton Economic Forecasting Model, and the measures of aviation activity derived from this model are summarized in Figure 8. The fundamental assumptions underlying this approach are that the 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.

FIGURE 8. VARIABLES IN THE FAA GENERAL AVIATION ECONOMETRIC MODEL

Independent Variables

- Gross national product.
- Civilians employed.
- Plant and equipment expenditures by the aerospace industry.
- General aviation cost index.

Derived Activity Measures

- Number of aircraft.
- Active private, student, commercial, and instrument-rated pilots.
- Itinerant and local operations.
- IFR departures and over flights.
- IFR and VFR flight plans filed.
- Pilot briefs.
- Aircraft contacted.
- Instrument operations.

Activity measures not estimated by this model are generated from a time-series analysis. Forecasts of such variables as average hours flown per operation and average fuel consumption per hour are based on historical trends. These ratios are then applied to the operations forecasts to forecast hours flown and fuel consumed by general aviation.

STATUS AND FORECAST

Fleet Size

Status: There were 178,300 aircraft in the general aviation fleet as of January 1, 1977, up 5.8 percent from the preceding year. Distribution by FAA region is shown in Figure 9.

Forecast: The fleet is expected to increase to 234,400 by 1982 and reach 291,300 by 1989. This translates to a 63 percent increase during the forecast period, a 4.2 percent average annual increase (see Figure 10). By comparison, the average growth rate was 5.3 percent during the 1973-77 period. Strong average annual growth is forecast through 1982 (5.6 percent) as a consequence of domestic economic policies. However, after 1982, the general aviation fleet is expected to grow at a lower annual rate (3.2 percent) as significantly higher fuel costs take effect.

Fleet Composition

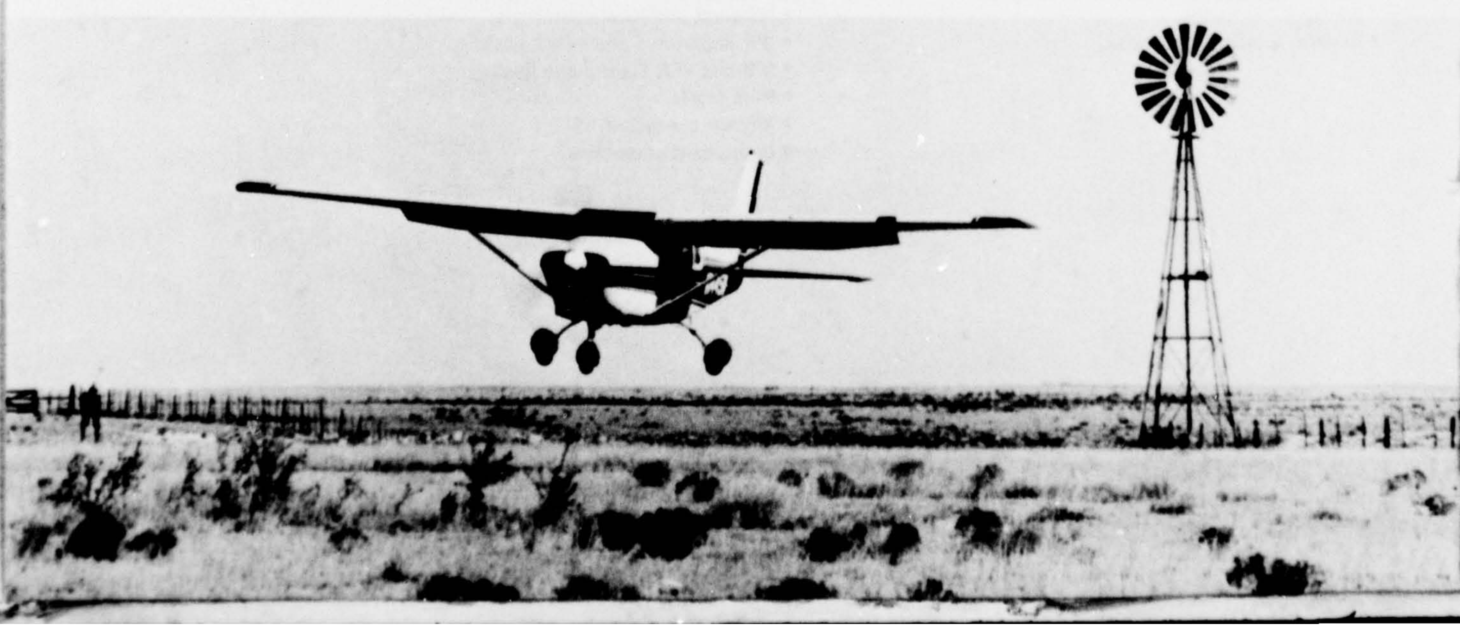
Status: Single-engine piston aircraft totaled 144,900 on January 1, 1977, representing approximately 81 percent of the general aviation fleet. The remaining 19 percent was distributed among multiengine piston aircraft (21,300), turbine aircraft (4,400), rotorcraft (4,500), and balloons, dirigibles, and gliders (3,200).

Forecast: By 1989, the number of single-engine piston aircraft is expected to increase to 225,800 and account for 77.5 percent of the fleet. By 1989, multiengine aircraft will represent 14.0 percent of the fleet, as compared to 11.9 percent in 1977. The higher relative growth rate in multiengine aircraft compared with single-engine piston aircraft points to increased sophistication among general aviation pilots.

Hours Flown

Status: *Based on preliminary data,* hours flown in general aviation aircraft reached 36.7 million in 1977, up from 35.1 million in 1976. The 3.6 percent increase for 1977 was slightly lower than the 5.4 percent growth in 1976.

Forecast: The number of hours flown is forecast to increase to 60.1 million by 1989, which is 64 percent higher than the 1977 total. As shown in Figure 10, this translates to a 4.2 percent average annual growth rate, down sharply from historical values (the average annual increase was 6.1 percent from 1973 through 1977). Again, the lower growth prediction is due to anticipated sharply higher fuel costs for general aviation.



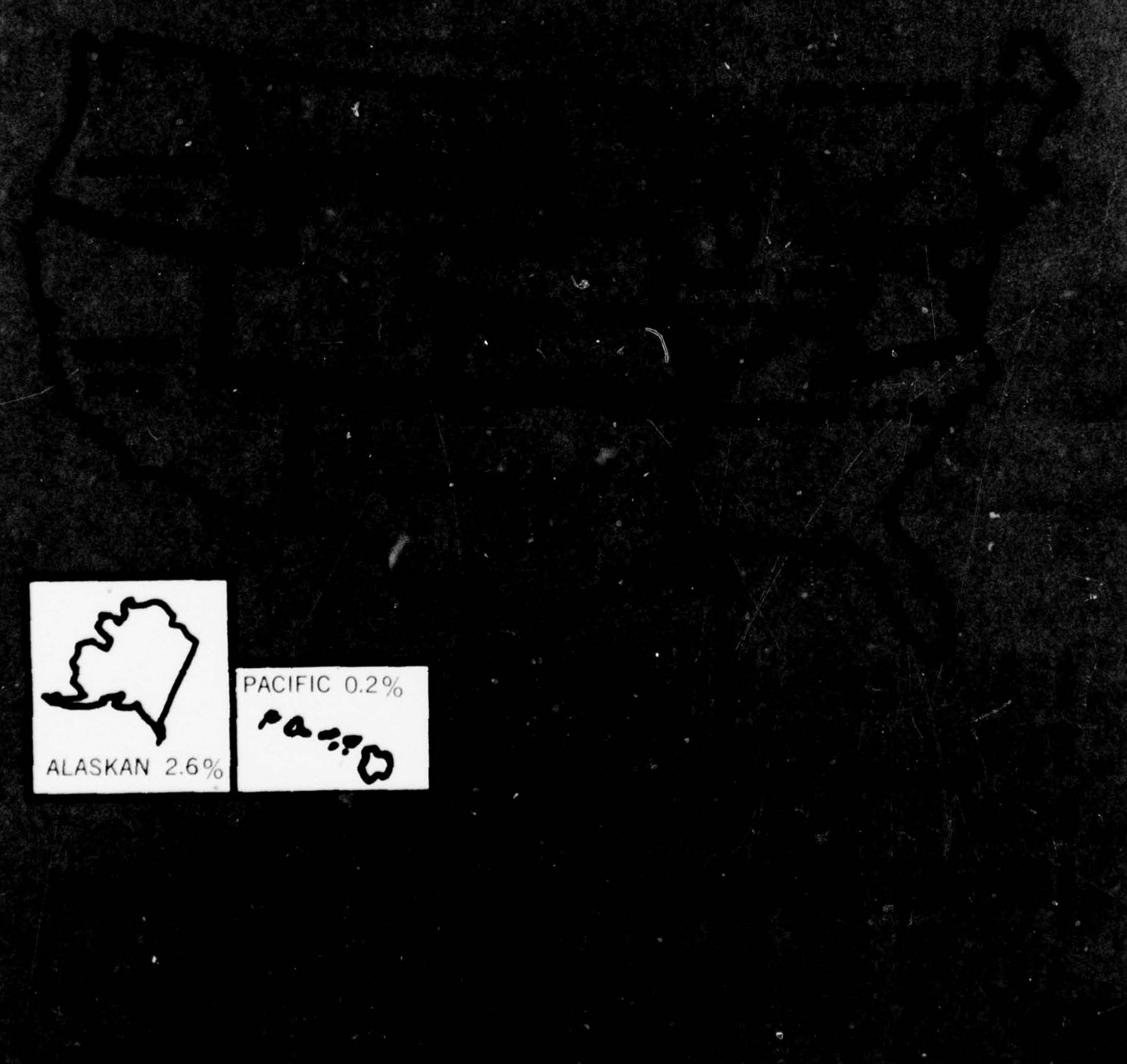
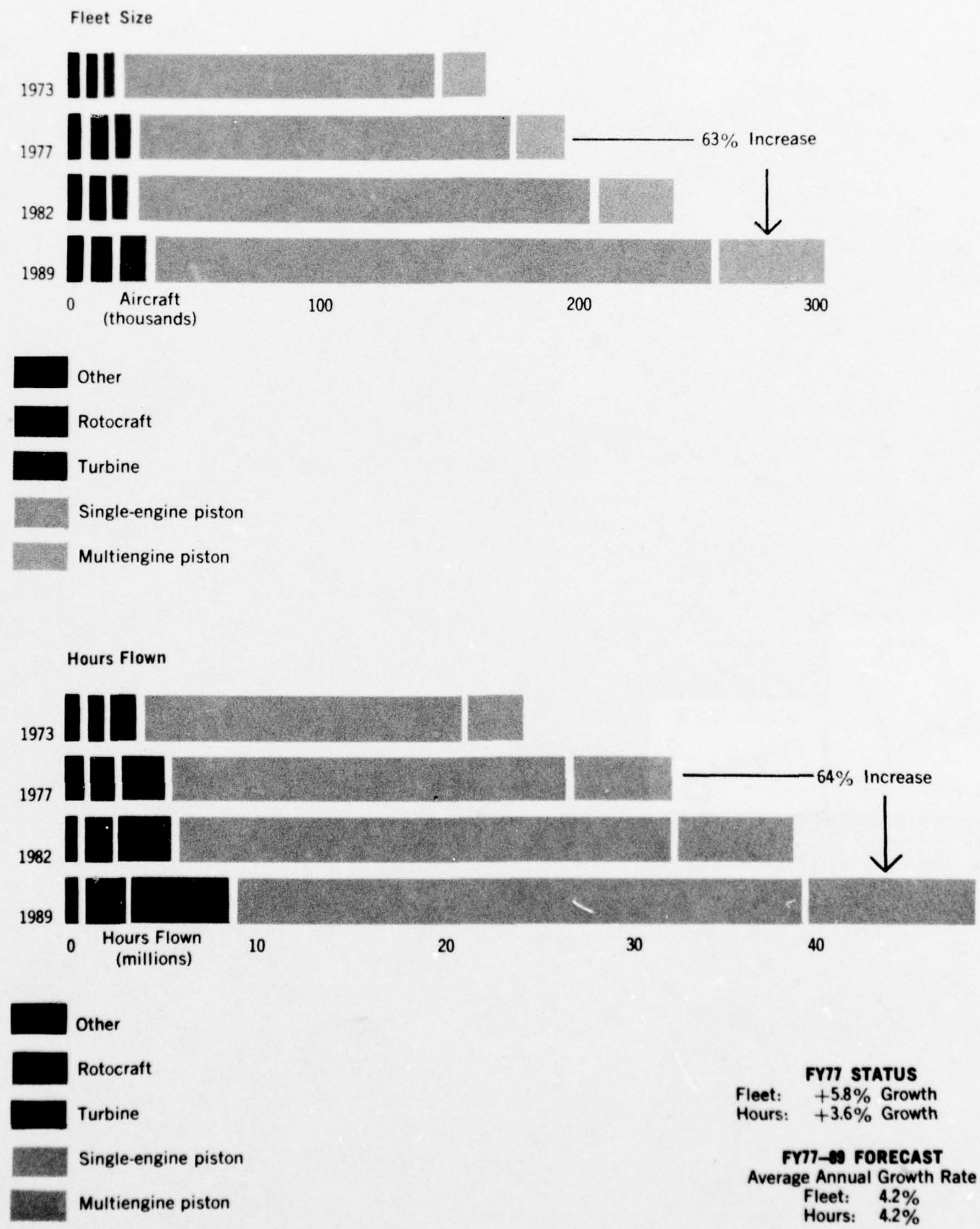

PACIFIC 0.2%
ALASKAN 2.6%

FIGURE 10. GENERAL AVIATION FLEET SIZE AND HOURS FLOWN



Active Pilots

Status: On January 1, 1977, there were 741,272 active pilots, up from the 725,059 reported one year earlier. Most of this increase was concentrated in the number of student pilots (up by 11,823). The number of instrument-rated pilots totaled 211,364 as of January 1, 1977, an increase of 7,410 over the previous year.

Forecast: The number of general aviation pilots is expected to increase to 906,800 by 1982 (22 percent) and to 1,122,800 in 1989 (51 percent) (see Figure 11).

Air Carriers

An air carrier is defined by the FAA as "any operator of large aircraft that transports passengers or cargo for hire." As seen in Figure 12, the FAA classifies the air carrier industry into eight groupings. At present, there are 79 carriers operating 2,505 aircraft. The operations at FAA-towered airports and ARTCCs by these 79 carriers, along with foreign air carriers serving FAA-towered airports, are the ones included in these forecasts.

METHODOLOGY AND ASSUMPTIONS

Passenger Forecasting Model

Air carrier demand forecasts of revenue passenger miles (RPMs) and enplanements (ENPs) are generated using an econometric forecasting model derived from historical relationships between various measures of economic activity and air carrier demand. The economic variables used in this model are summarized in Figure 13. For a more detailed discussion of this model, please refer to Appendix B of this report.

Generally, the model shows that demand falls as air fares increase, and that demand rises with income, population, and investment. Of course, the forecasts assume that historical relationships among these variables will continue into the future.

Operations Forecasting Models

Two additional models--a macro and a micro method--are employed to forecast the level of air carrier aircraft activity and the anticipated workload at FAA facilities. Forecasts from the two methods are compared and adjusted to achieve consistency.

THE MACRO MODEL forecasts towered aircraft operations for the total air carrier industry. Forecasts of passenger traffic and the industry's operating behavior form the basis for this model. The variables used and associated assumptions are as shown in Figure 14.

The revenue passenger mile forecast is generated from the econometric demand forecasting model. Operating characteristics forecasts are based on time-series analysis, with adjustments made for changes in costs and fares. When costs increase faster than fares, for example, airline profitability requires an increase in load-factor. Similarly, changes in aircraft size are reflected in the average seating capacity.

THE MICRO MODEL utilizes individual forecasts for each carrier in the industry as its basis. This model is used to forecast fleet size, hours and miles by equipment type and, in conjunction with the Macro Model, to forecast operations. The driving variable is the number of aircraft, by type, each carrier has on hand and on order. Estimates for future types and numbers are made after discussions with many air carriers and with all major domestic aircraft manufacturers. Estimates are made as to the number of additional aircraft orders, beyond those announced publicly, that will be required to meet anticipated traffic growth, provide for retirement of aircraft, and allow each individual airline to maintain a competitive position with other airlines. Judgment, based on discussions with knowledgeable people within the industry, is used to project forecasts beyond the years for which information is available. Service patterns and frequencies of service are also forecast in general terms after discussions with members of the industry. The micro variables used and associated assumptions are described in Figure 15.

STATUS AND FORECAST

Revenue Passenger Miles

Status: Revenue passenger miles (RPMs) increased 6.2 percent during FY 1977, with both domestic and international travel showing substantial growth. Domestic RPMs were up 6.4 percent, while international revenue passenger miles increased 5.1 percent, when compared with FY 1976.

Forecast: Total RPMs are expected to increase more rapidly than enplanements (93 percent growth by 1989 versus 80 percent), reflecting an expected rise in average passenger trip length. Domestic RPMs are forecast to increase from 151.3 billion in FY 1977 to 289.1 billion in 1989. In the international market, RPMs are forecast to grow to 70.2 billion in FY 1989 from 35.1 billion in FY 1977 (see Figure 16).

FIGURE 11. ACTIVE PILOTS BY TYPE OF CERTIFICATE (SELECTED YEARS)

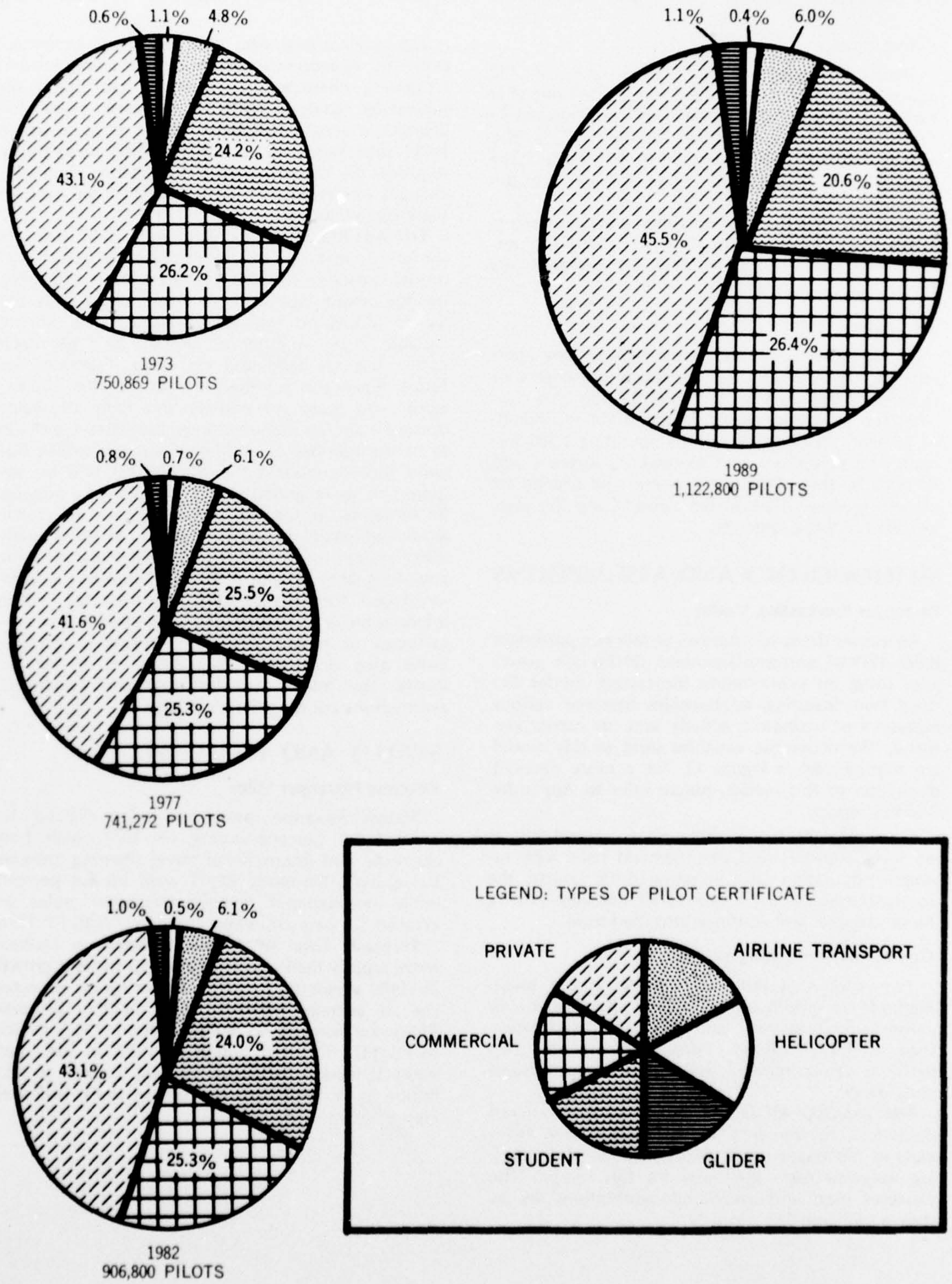


FIGURE 12. AIR CARRIER GROUPS

	No. of Carriers	Fleet Size
Trunk	11	1,736
Local Service	18	493
All Cargo	3	34
Supplemental	6	73
Helicopter	1	4
Intra-State	5	48
Contract	20	97
Travel Clubs	15	20
Total	79	2,505

FIGURE 13. EXOGENOUS VARIABLES EMPLOYED IN THE FAA AIR CARRIER ECONOMETRIC FORECASTING MODEL

Economic Variable	Function
• Personal consumption of services.	• Represent the impact of income.
• Number of civilians employed.	• Reflect the impact of population growth on demand.
• Gross investment by the air transport industry.	• Act as surrogate for the level of service available.
• Deflator for personal consumption of transportation.	• Reflect the impact of price competition from other modes.
• Index of air fares.	• Measure the cost of air transportation.

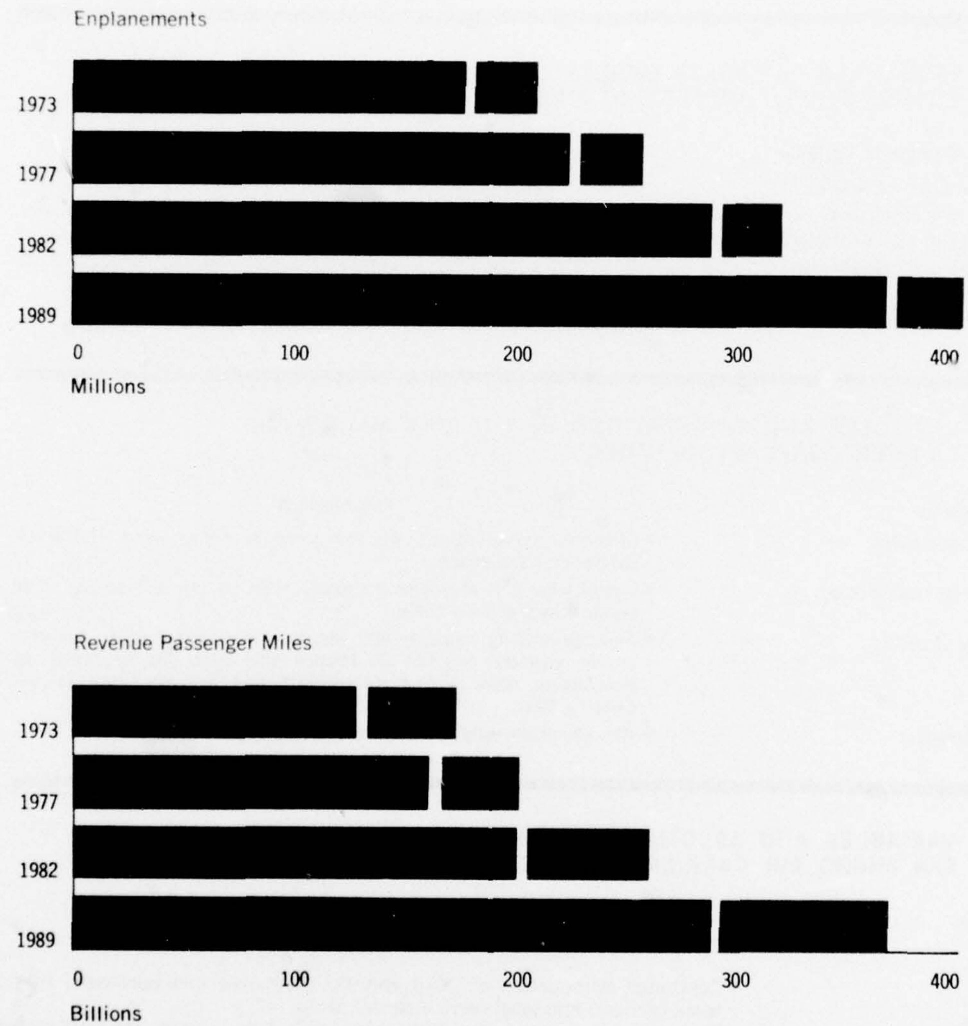
FIGURE 14. VARIABLES AND ASSUMPTIONS IN THE FAA MACRO AIR CARRIER FORECASTING MODEL

Variable	Assumptions
• Revenue passenger miles.	• Economic assumptions are the same as those used in the air carrier demand model.
• Average passenger load-factor.	• Load-factor will increase gradually from 55 percent to about 58 percent by the early 1980s.
• Average seating capacity.	• Average seating capacity will increase by about 4 seats per year as air carriers attempt to reduce the cost per seat-mile by purchasing more wide-body aircraft and adding seats to the existing fleet.
• Average stage-length.	• Average stage-length will increase by about 3 miles per year.

FIGURE 15. VARIABLES AND ASSUMPTIONS EMPLOYED IN THE FAA MICRO AIR CARRIER FORECASTS

Variable	Assumptions (Based on Discussions with Industry Members)
• Aircraft Type	
* Two-engine	• Continued introduction of DC–9 and 737 (both new and purchased from trunk carriers) into local service carrier fleets. • Replacement of remaining turboprops with twin engine standard-body aircraft in late 1970s. • Introduction of a new wide-body aircraft in early 1980s.
* Three-engine	• Continued introduction of wide-body aircraft and 727–200. • Introduction of new aircraft in early 1980s with seating capacity between 727–200 and wide-body aircraft. • Appearance of stretch versions of present wide-body aircraft in the mid-1980s.
* Four-engine	• Continued retirement of nonfan and older fan-jet aircraft. • Continued introduction of present wide-body aircraft.
• Seating Capacity	• Continued decrease in size of the first class section and a concomitant increase in the coach section. • Completion of the one-seat increase in the number of seats abreast in wide-body jets by the end of the 1970s.
• Passenger Load-Factor	• A gradual increase in the load-factor from the present 55 percent to 58 percent by the early 1980s and then remaining at this level through the forecast period.

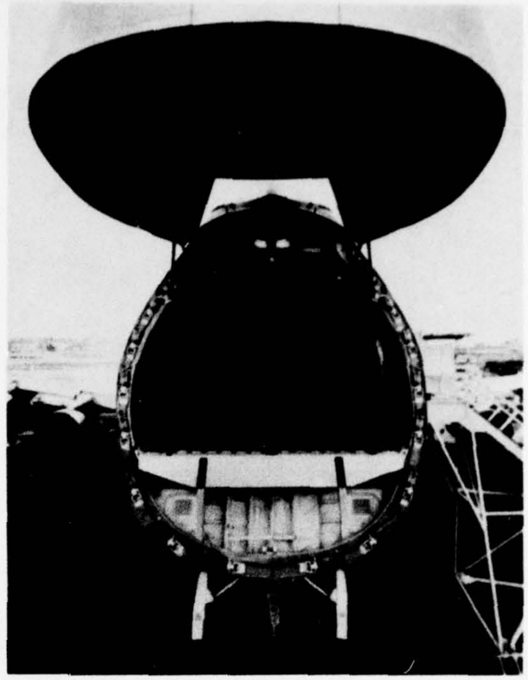
FIGURE 16. AIR CARRIER PASSENGER ENPLANEMENTS AND REVENUE PASSENGER MILES FISCAL YEARS 1973–1989



Domestic

International

	FY 1977 Status (Growth)	FY 1977–89 Forecast (Total Growth)
Enplanements	+6.5%	+80%
Revenue Passenger Miles	+6.4%	+93%



Commuter Air Carriers

METHODOLOGY AND ASSUMPTIONS

Forecasts of commuter airline activity are summarized in these FAA Aviation Forecasts for the first time. An econometric model was used to generate 12-year national and terminal area forecasts for commuter passenger enplanements, operations, and fleet composition for the 48 contiguous states and Puerto Rico. In addition, those points likely to become candidates for commuter service in future years were identified.

Two sets of national forecasts are provided, one for all points receiving commuter service in 1975 and one for new points having potential for commuter operations. These new points include 110 currently served by CAB certificated route air carriers, but averaging less than 40 enplanements daily in 1976. Of these, 12 are served by Air Midwest and Air New England (newly certificated route air carriers who are likely to continue service), and 24 are currently served by commuter carriers. There remain 74 points that have potential for transfer of service to commuters. There are also approximately 50 communities not currently served, but with a population base and degree of isolation deemed sufficient to support new commuter service.

Enplanements at Puerto Rico are presented as a separate forecast because of the different characteristics of that service. A detailed presentation of commuter air carrier forecasts is found in the FAA publication: ***Forecast of Commuter Airlines Activity*** (August 1977).

STATUS AND FORECAST

Passenger Enplanements

Status: Commuter service has expanded to the point where it is now available at 789 airports. Passenger enplanements have also climbed steadily, reaching 6.5 million in 1977, up (10.1 percent from 1976).

Forecast: Commuter enplanements are expected to total about 14.5 million by 1989, up 123 percent from 1977. This total includes 12.2 million enplanements from existing points served by commuters, plus an additional 2.3 million from potential future points of service. Average annual growth is forecast to be 7.5 percent throughout the forecast period. This strong growth continues recent trends, and is a reflection of the added impetus of anticipated regulatory change that would enable certificated air carriers to abandon unprofitable, low-volume points and would encourage, and at some points subsidize, commuter entry (see Figure 17).

Revenue Passenger Miles

Status: Commuter revenue passenger miles rose 10.2 percent during 1977 to an estimated 698.8 million.

Forecast: Commuters are expected to fly a total of 1.9 billion passenger miles in 1989. This is 177 percent higher than the estimated 1977 level and represents an 8.9 percent average annual growth rate (see Figure 17).

Aircraft Operations

Status: There were an estimated 2.5 million commuter aircraft operations during 1977, up 8.7 percent from 1976. These figures are based upon an estimated 4.8 passenger boarding factor.

Forecast: A total of 4.9 million operations are expected in 1989, 96 percent higher than the 1977 level. The passenger boarding factor for current points should increase to 6.0 (from 4.8 today) by 1989 and to 4.3 for transfers and new points (from 3.7 currently).

Air Cargo

METHODOLOGY AND ASSUMPTIONS

Air cargo forecasts are made using econometric forecasting techniques. Forecasts are made for freight, express, and mail. Activity is assumed to be a function of the general economy of the United States and its world trading partners, the growth in time-sensitive cargo shipments, and differences in quality and prices for air and surface transportation modes.

The relationship between these quantifiable variables and air cargo traffic is estimated in econometric forecasting models. One model forecasts revenue ton miles for domestic air cargo, while forecasts of revenue ton miles for imports from and exports to six world regions are accomplished by 12 other models.

FIGURE 17. COMMUTER CARRIER PASSENGER ENPLANEMENTS AND REVENUE PASSENGER MILES, FISCAL YEARS 1973–1989

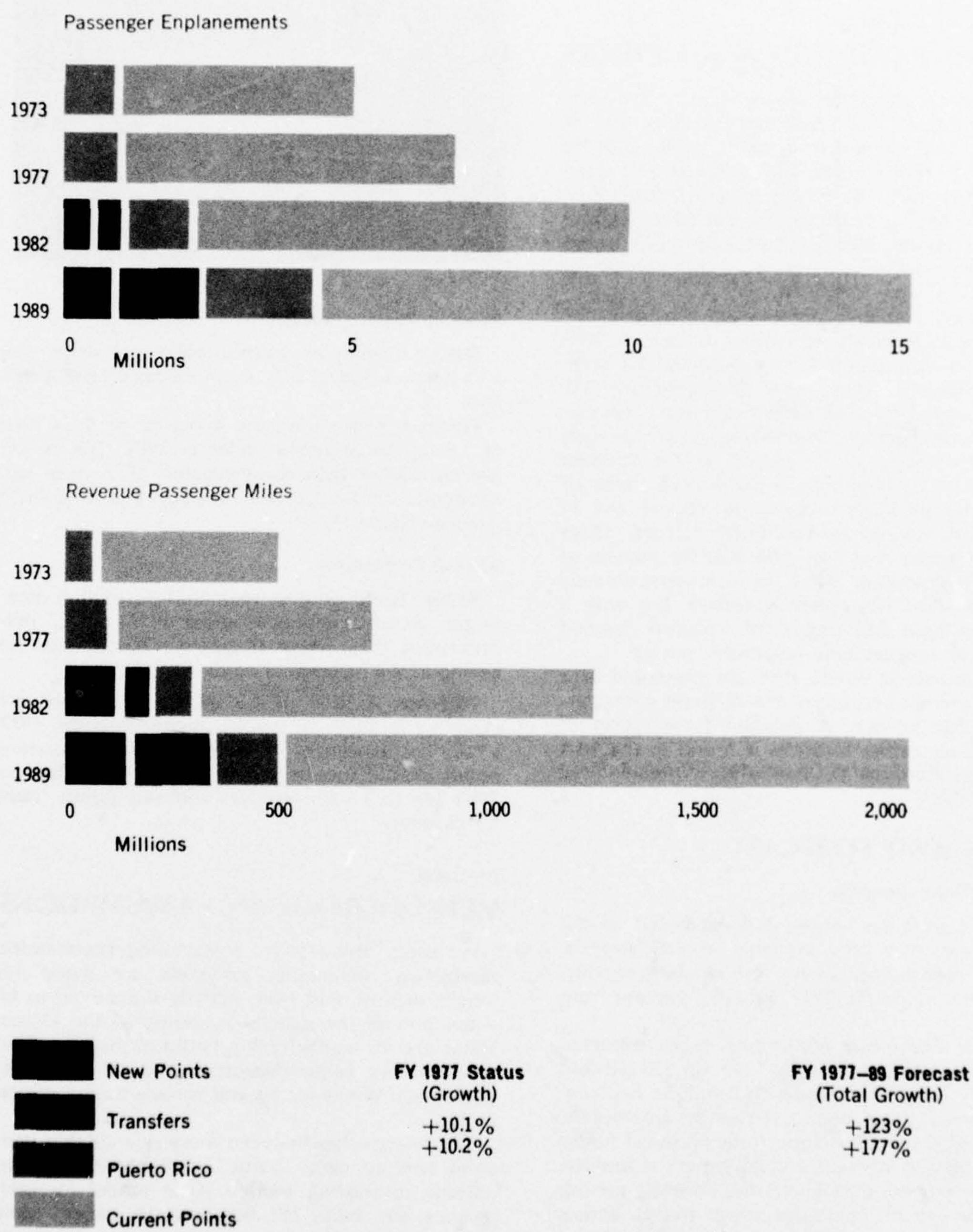
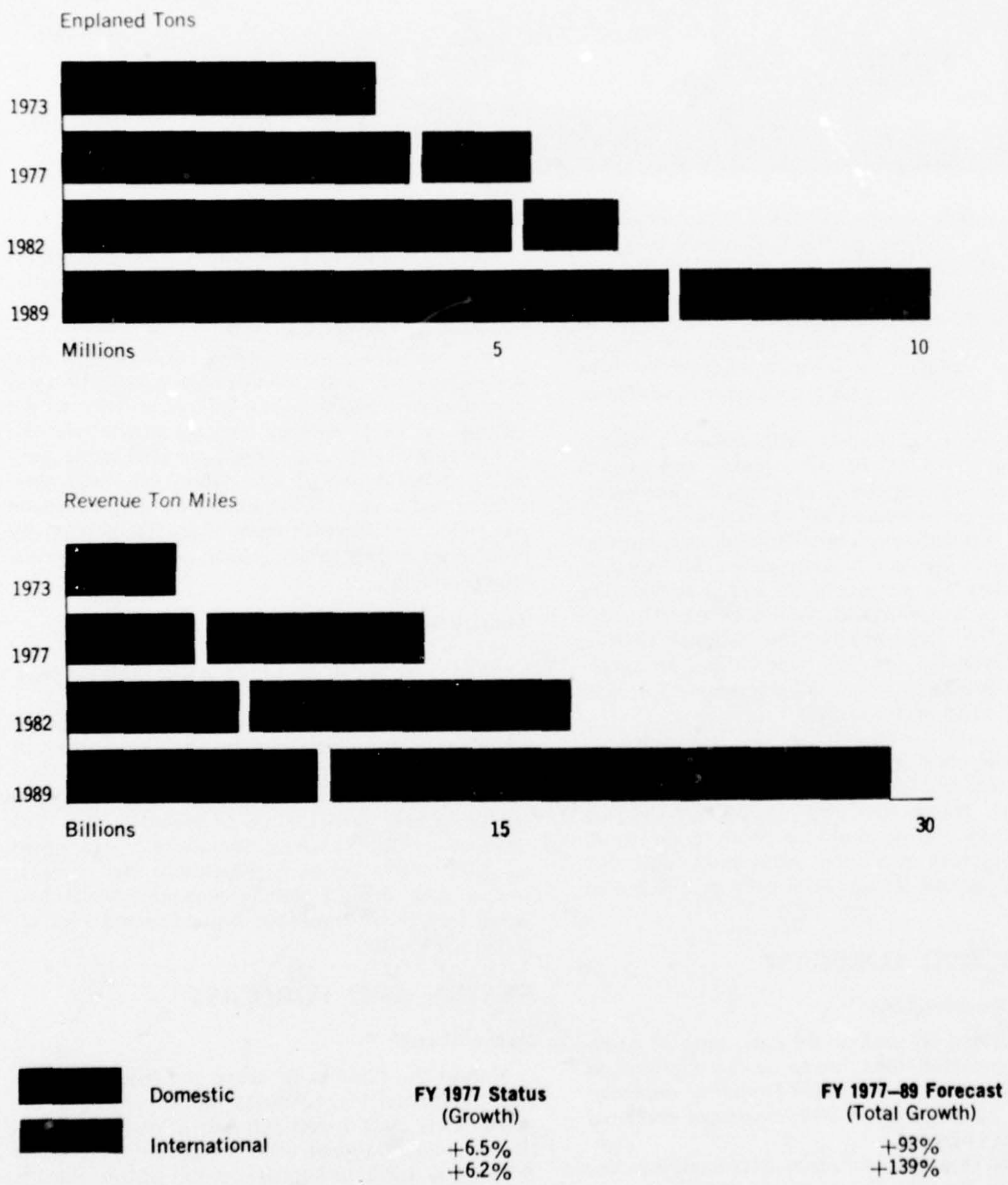


FIGURE 18. AIR CARGO ENPLANED REVENUE TONS AND REVENUE TON MILES, FISCAL YEARS 1973–1989



The domestic model is based upon historical GNP data as reported by the Department of Commerce, and upon revenue ton miles and average revenue yields (in constant dollars) for all scheduled and nonscheduled domestic air cargo services as reported by the CAB. This time period encompasses substantial variation in economic activity, technological innovation, and an increasing awareness of the benefits of air service.

The international models are based on a 10-year time series (1965–74) of U.S. imports and exports by air as reported by the Department of Commerce, and on average revenue yields (in constant dollars) for all scheduled and nonscheduled international air cargo services of U.S. flag carriers. Foreign flag revenue data are not available, and it is assumed that average revenue yields would be equal to the yields of U.S. flag carriers. The national GNP is used as a variable for U.S. imports, and an aggregate gross product (in U.S. dollars) is used for each of six world regions for exports.

The air cargo econometric model is founded on the premise that no dramatic technological or sociopolitical changes will occur in the forecast time frame. The models also assume that shippers and receivers choose their transport mode based upon economics and time sensitivities, and that these choices will remain essentially unchanged in the future.

STATUS AND FORECAST

Enplaned Revenue Tons

Status: Based on preliminary data, total air cargo enplaned revenue tons increased 5.9 percent to 5.14 million tons in FY 1977. Domestic enplaned tons rose 5.2 percent, while international enplaned tons rose 8.4 percent.

Forecast: Domestic air cargo enplaned tons are expected to increase 73 percent by 1989 at an annual growth rate of 4.7 percent. International enplaned tons are forecast to grow even more rapidly at a 8.3 percent annual rate. Total enplaned tons are forecast to rise 93 percent by 1989 (see Figure 18).

Revenue Ton Miles

Status: Total air cargo revenue ton miles were up 10.3 percent to 11.9 billion in 1977. Domestically, the increase was 6.3 percent, and internationally the total was up 18.9 percent.

Forecast: Domestic air cargo revenue ton miles are expected to more than double during the forecast period, rising from 4.4 billion in 1977 to 8.9 billion by 1989. Average annual growth will be 6.0 percent. Freight and express are forecast to grow at a 7 percent annual rate, while mail will grow 2.5 percent a year. International air cargo revenue ton miles will increase more than 160 percent by 1989 at an average yearly growth rate of 8.4 percent (see Figure 18).

Military Aviation

METHODOLOGY AND ASSUMPTIONS

All military aviation activity forecasts are based upon information provided by the Department of Defense and the United States Coast Guard. Detailed military planning extends through 1983, and remaining year forecasts are projected at the 1983 level by the FAA. Military operations are expected to hold nearly constant throughout the forecast period. Basic military activity elements (aircraft and flying hours) are translated into expected FAA air traffic workloads.

STATUS AND FORECAST

Active Aircraft

Status: The number of active military aircraft in the continental United States has remained at approximately 20,000 over the past 5 years. In 1977, 19,700 military aircraft were distributed as follows: 9,254 jets, 1,392 turboprops, 1,360 piston aircraft, and 7,694 helicopters.

Forecast: Active military aircraft are expected to continue to remain at about the present level of 20,000 for the entire forecast period. During this period, the military proportion of the total national fleet will fall to 6 percent from the current 10 percent. Composition of the military fleet will show little change except for a further decline in piston engined, fixed-wing aircraft to 3.6 percent of the total by 1982.

Aircraft Flying Hours

Status: Aircraft flying hours in the continental United States remained relatively stable in 1977 following a sharp 10.9 percent decline in 1976.

Forecast: Total flying hours of military aircraft are expected to fluctuate narrowly between 5.6 and 5.8 million hours through 1989, remaining essentially unchanged from the 5.8 million hours flown in 1977. Over this time period, the military proportion of total hours flown will fall to 9 percent from the current level of 12 percent.

FAA OPERATIONAL SERVICES FORECASTS

Methodology and Assumptions

The FAA provides the aviation community with three distinct operational services: air traffic control at selected airports, IFR enroute traffic control, and flight services, including pilot briefings, flight plan filings, and aircraft contacts. These services are provided to four major categories of users: the air carriers, the air taxis, general aviation, and the military. Because of the different relationships and growth trends among the four users, there is no one workload measure (such as airport operations) or aviation activity series (such as air carrier revenue passenger miles) which typifies past trends or future outlook for all FAA services. There have been, and there will continue to be, different socioeconomic and political forces which drive the growth trends in each major user category.

Forecasts for the FAA operational services have as their foundation forecasts for the major user categories (air carrier, air taxi, general aviation, military aviation). First, the underlying factors that influence the growth patterns of each major user are determined and forecast. Based on these trends and past relationships and through the use of econometric models, separate demand forecasts for FAA services are derived for each user category. Forecasts of total FAA operations and services are a summation of the individual forecasts for the major users.

Total Aircraft Operations

Status: Total aircraft operations (takeoffs and landings) at airports with FAA air traffic control towers rose 4.5 percent to 66.5 million, according to preliminary FY 1977 data. This increase is attributable partly to a net gain in FAA towers and partly to the impact of the general economic recovery.

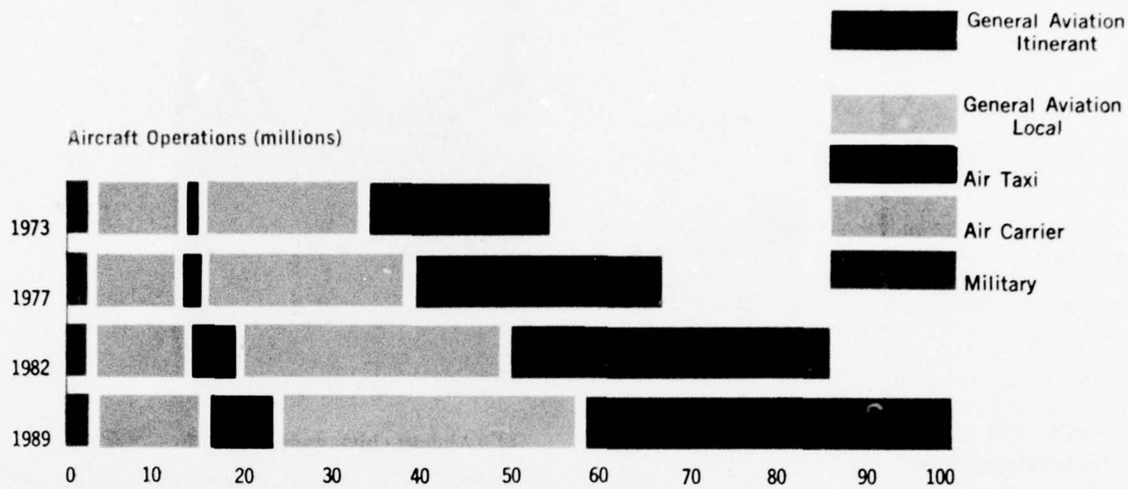
Forecast: Total aircraft operations at towered airports are forecast to climb an average of 3.4 percent each year, or by a total of 49 percent by 1989. Longer-term tower activity forecasts are markedly lower than those published last year, due primarily to anticipated lower general aviation growth after 1983. The forecasts for air carriers and military aviation are essentially the same as last year, while the forecast of air taxi operations is higher as a result of anticipated regulatory changes which will encourage the use of air commuters for short-haul travel (see Figure 19).

Instrument Operations

Status: A 6.6 percent increase in total instrument operations was recorded between FY 1976 and 1977. This growth reflects the increased use of avionics by the general aviation fleet, as well as strong growth in air taxi instrument operations. Air carrier instrument operations increased 3.1 percent, and military operations declined slightly from the 1976 level.

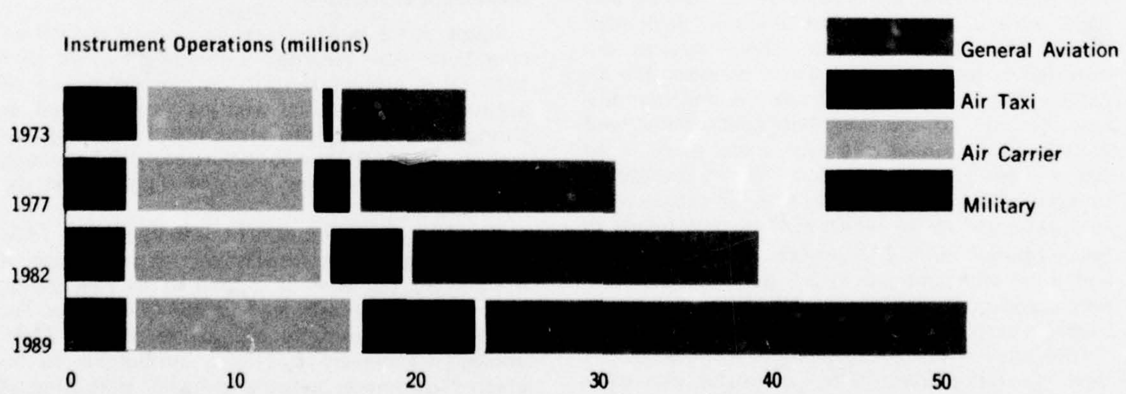
Forecast: Total instrument operations at FAA-towered airports are forecast to rise an average of 4.2 percent per year or a total of 64 percent by 1989. These forecasts are slightly lower than last year. Strong growth in air taxi instrument operations (164 percent by 1989), attributable to increased commuter traffic and higher utilization of avionics are expected to be more than offset by the lower forecast for general aviation instrument operations. The lower general aviation forecast is due to an assumed reduction in itinerant flying stemming from high fuel prices (see Figure 20).

FIGURE 19. TOTAL AIRCRAFT OPERATIONS AT AIRPORTS WITH FAA TRAFFIC CONTROL SERVICE, FISCAL YEARS 1973–1989



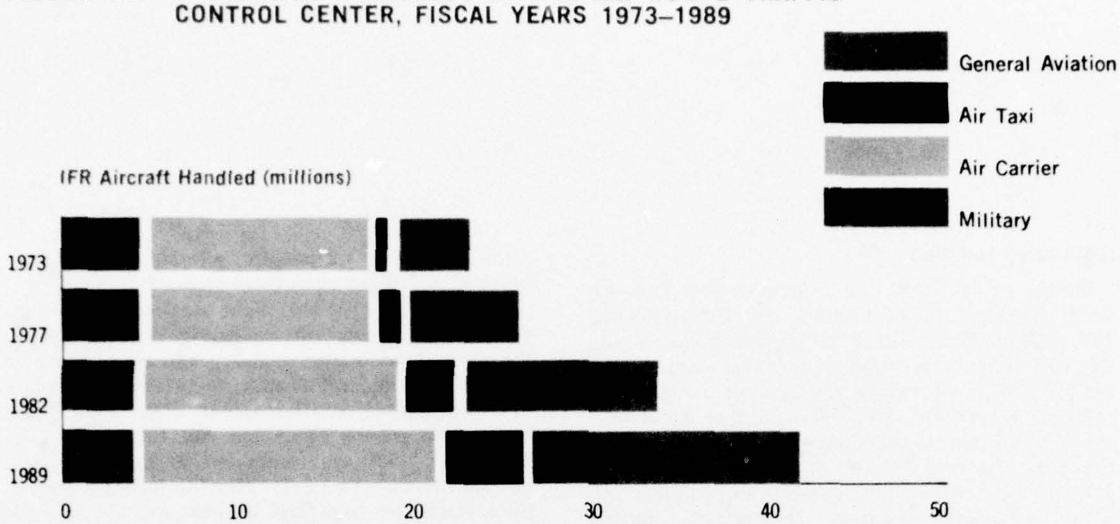
	FY 1977 Status (Growth)	FY 1977–89 Forecast (Total Growth)
Itinerant operations	+5.0%	+51%
Local operations	+4.7%	+45%
Total Operations	+4.9%	+49%

FIGURE 20. INSTRUMENT OPERATIONS AT AIRPORTS WITH FAA TRAFFIC CONTROL SERVICE, FISCAL YEARS 1973–1989



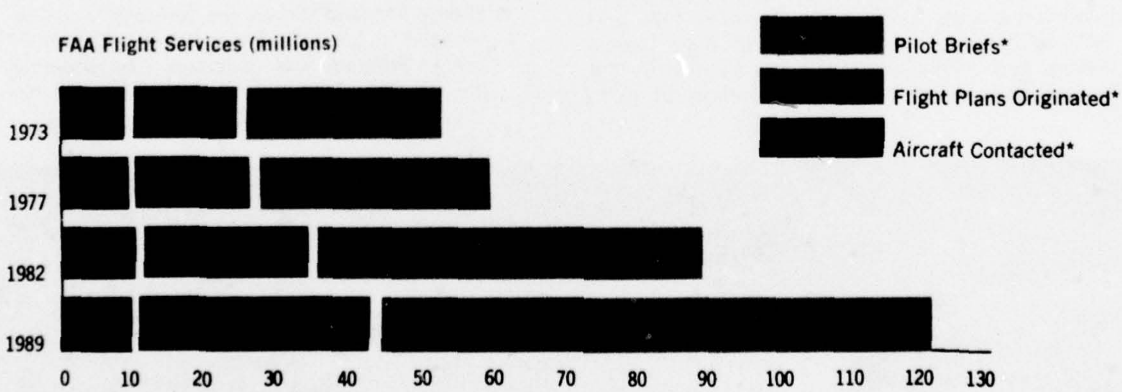
	FY 1977 Status (Growth)	FY 1977–89 Forecast (Total Growth)
Air Carrier	+3.1%	+28%
Air Taxi	+13.6%	+164%
General Aviation	+10.5%	+88%
Military	—%	—
Total	+6.6%	+64%

FIGURE 21. IFR AIRCRAFT HANDLED BY FAA AIR ROUTE TRAFFIC CONTROL CENTER, FISCAL YEARS 1973–1989



	FY 1977 Status (Growth)	FY 1977–89 Forecast (Total Growth)
General Aviation	+9.8%	+131%
Air Taxi	+7.0%	+227%
Air Carrier	+3.2%	+31%
Military	—	—
Total	+5.0%	+64%

FIGURE 22. TOTAL FLIGHT SERVICES AT FAA FLIGHT SERVICE STATIONS AND COMBINED STATION/TOWERS, FISCAL YEARS 1973–1989



* Total Flight Services is a weighted workload measurement derived by multiplying pilot briefs and flight plans originated by two and adding the number of aircraft contacted. This figure depicts the components in their weighted form.

	FY 1977 Status (Growth)	FY 1977–89 Forecast (Total Growth)
Pilot Briefs	+1.2%	+139%
Flight Plans Originated	+3.7%	+96%
Aircraft Contacted	+1.0%	+1%
Total	+2.1%	+104%

IFR Aircraft Handled

Status: In FY 1977, it is estimated that FAA Air Route Traffic Control Centers (ARTCCs) handled 25.3 million IFR aircraft, a 5.0 percent increase over the 24.1 million recorded in the year ending September 1976. Air carrier IFR aircraft handled increased 3.2 percent, while the number of general aviation IFR aircraft handled rose 7.1 percent over the same period. Air carrier traffic accounts for about 51 percent of the current IFR volume, followed by general aviation (26 percent), military (17 percent), and air taxis (6 percent).

Forecast: The forecast for workloads at ARTCCs through 1989 is higher than last year, primarily because the number of IFR-rated general aviation pilots is expected to increase. General aviation aircraft handled under IFRs are expected to grow at a 7.2 percent annual rate from 1977 through 1989. Complementing this will be an expected 10.4 percent annual growth in air taxi IFR aircraft handled. Air carrier IFR operations should grow at a 2.3 percent annual rate. Zero growth is projected for military IFR activity (see Figure 21).

Flight Services

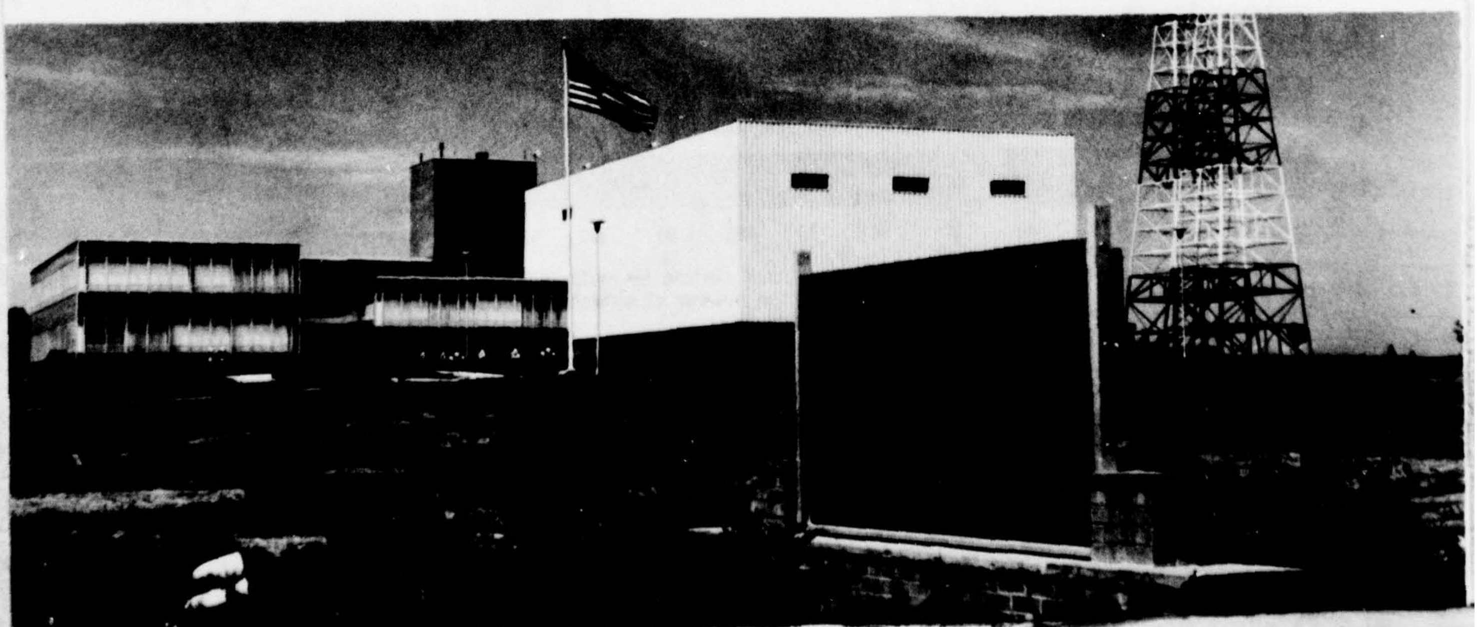
Status: FAA flight services include pilot briefings, the filing of flight plans, and the contacting of aircraft. Historically, general aviation has generated the primary demand for flight services, and this trend is expected to continue. Between 1976 and 1977, total flight services provided by flight service stations and combined station/towers rose by 2.8 percent from 58.2 million to 59.8 million. In 1977, pilot briefs rose 1.2 percent, aircraft contacted 1.0 percent, and flight plans originated 3.7 percent.

Forecast: By FY 1980, flight services are forecast to increase 31 percent, reflecting continuation of the general economic recovery and an increase in IFR flying by general aviation. A slower growth rate in overall general aviation activity after FY 1983 will temper this growth somewhat. Yet, total flight services in FY 1989 are forecasted to be more than double the current level. Over the forecast period, pilot briefs are expected to increase 139 percent and flight plans originated by 96 percent. In contrast, the number of aircraft contacted are expected to remain relatively unchanged throughout the forecast period (see Figure 22).

ALTERNATIVE ECONOMIC SCENARIOS FOR 1989

Long-term plans must anticipate changes in activity resulting from variations in economic conditions. The cumulative impact of various economic conditions and programs can have a significant effect on planning in the long-term. To give FAA management some perspective as to how such programs are expected to impact future aviation activity, two scenarios incorporating economic and energy programs not included in the Baseline Scenario are presented.

- **Energy Scenario**—When the forecasts were developed in June, the exact nature of the 1977 Energy Program was uncertain. Consequently, the Baseline Scenario does not include the



legislation proposed by the Carter Administration. To facilitate evaluation of FAA plans given such a program, the Energy Scenario summarized in Table 5 provides long-term forecasts based on the initiation of the Carter proposals. The main elements which impact on aviation are the well-head equalization tax and a 5 cent increase in the automobile gasoline tax. For the purpose of this analysis, these programs are not expected to impact aviation activity until FY 1978.

The economic assumptions consistent with the energy package imply lower real growth when compared to the Baseline Scenario. For example, real GNP for the Energy Scenario would be expected to increase at an average annual rate of 3.1 percent from FY 1977 to FY 1989, while the number of civilians employed would increase at a 1.6 percent rate. By FY 1989, these growth rates would represent a 3.8 percent decrease in GNP and a 1.6 percent decrease in employment when compared to the baseline. Moreover, the air fare would be expected to be 7.1 percent higher, while the variable cost of general aviation activity would be 5.6 percent higher than the baseline price levels.

- **Stimulation Scenario**—This scenario is based on the assumption that the Federal budget and monetary policy are more expansionary than those recommended by the Administration economists. When compared to the baseline, the Stimulation Scenario assumes an additional 2.5 billion dollars in Federal expenditures each year from 1980 through 1989. In addition, the money supply is assumed to increase one-half a percent faster per year in this scenario.

  As a result of these more stimulatory fiscal and monetary policies, by 1989 the forecast of real GNP is expected to be 0.8 percent higher than that of the Baseline Scenario. Similarly, the number of civilians employed would be about 1 percent higher. On the other hand, the increase in demand generated by higher income levels is expected to push the price of fuel up about 7 percent by 1989 vis-a-vis the baseline. The impact of such an increase would likely be to increase both the air fare and the variable cost of general aviation about 1 percent. The 1989 forecasts of aviation activity and FAA workloads based on the Stimulation Scenario are also shown in Table 5.

Comparing the forecasts derived from these two alternative scenarios to the Baseline Scenario shows that by 1989 FAA workload could be expected to be about 5 percent greater under the Stimulation Scenario and about 5 percent lower with institution of the energy program.

TABLE 5. ALTERNATIVE FORECASTS FOR FY 1989

	ENERGY SCENARIO	STIMULATION SCENARIO
Scheduled Domestic Passenger Traffic		
Revenue Passenger Miles (Billions)	270.0	292.6
Revenue Passenger Enplanements (Millions)	357.1	385.9
Fleet Size		
Air Carrier	2,950	3,225
General Aviation (Thousands)	287.2	309.1
Hours Flown (Millions)		
Air Carrier	7.5	8.1
General Aviation	57.4	63.2
Tower Operations (Millions)		
Total	93.1	103.6
Itinerant	61.0	67.9
Air Carrier	11.8	12.8
Air Taxi	7.9	8.9
General Aviation	40.1	45.0
Military	1.2	1.2
Local	32.1	35.7
General Aviation	30.6	34.2
Military	1.5	1.5
Instrument Operations (Millions)		
Total	48.6	52.7
Air Carrier	11.9	12.9
Air Taxi	6.3	7.1
General Aviation	26.9	29.2
Military	3.5	3.5
IFR Aircraft Handled (Millions)		
Total Handled	39.5	43.6
Total Departures	16.3	17.9
Total Overs	6.9	7.8
Air Carrier Handled	15.7	17.2
Air Taxi Handled	4.7	5.3
General Aviation Handled	14.9	16.9
Military Handled	4.2	4.2
Flight Services (Millions)		
Total	116.5	128.5
Pilot Briefs	37.1	41.0
Flight Plans Originated	16.2	17.8
Aircraft Contacted	9.9	10.9

CHAPTER 4.

YEAR-BY-YEAR DATA FOR FAA FISCAL YEARS 1978-1989 AVIATION FORECASTS

Chapter 4 provides summary data for the FAA FY 1977–89 Aviation Forecasts on a year-by-year basis.

- Tables 6 through 10 present forecasts of air carrier passenger and cargo traffic, fleet size, and hours and miles flown.
- Tables 11 through 13 are forecasts of general aviation fleet size and its use.
- Tables 14 and 15 provide the commuter air carrier forecasts for operations, enplanements, and passenger miles.
- Table 16 is a forecast of fuel consumption for the United States civil aviation fleet.
- Tables 17 and 18 show forecasts of the military fleet size and flying hours.
- Tables 19 through 27 display forecasts of the different measures of air traffic activity and workload at FAA tower, enroute, and flight service station facilities.
- Table 28 is a forecast of the number of active pilots by type of certificate.

TABLE 6. UNITED STATES CERTIFICATED ROUTE AIR CARRIER SCHEDULED PASSENGER TRAFFIC

Fiscal Year	Revenue Passenger Enplanements (millions)			Revenue Passenger–Miles (billions)		
	Total	Domestic	International	Total	Domestic	International
1973	197.3	178.4	19.0	157.9	122.6	35.4
1974	208.1	189.5	18.6	165.0	130.0	35.0
1975	201.9	184.9	17.0	159.0	127.7	31.3
1976	211.8	195.1	16.7	169.5	137.3	32.2
1977T	58.4	53.8	4.6	46.2	37.7	8.5
1977E	232.1	214.4	17.7	186.4	151.3	35.1
1978*	248.1	229.1	19.0	200.1	162.2	37.9
1979*	263.2	242.9	20.3	213.3	172.7	40.6
1980*	274.2	253.0	21.2	223.3	180.9	42.4
1981*	286.3	264.1	22.2	234.5	189.9	44.6
1982*	303.4	279.7	23.7	250.1	202.2	47.9
1983*	320.2	294.9	25.3	265.6	214.4	51.2
1984*	336.3	309.7	26.6	280.5	226.4	54.1
1985*	351.7	323.7	28.0	294.9	237.9	57.0
1986*	367.0	337.6	29.4	309.9	249.8	60.1
1987*	383.4	352.6	30.8	325.6	262.3	63.3
1988*	400.6	368.2	32.4	342.2	275.4	66.8
1989*	418.4	384.4	34.0	359.3	289.1	70.2

* Forecast. E Estimate.
1977T—This represents activity during the transition quarter, July 1, 1976, to September 30, 1976.
Note—Detail may not add to total due to independent rounding.

TABLE 7. UNITED STATES AIR CARGO TRAFFIC [1] ALL SERVICE AT UNITED STATES AIRPORTS [2]

Fiscal Year	Revenue Cargo Enplaned Tons [3] (thousands)			Revenue Cargo Ton-Miles [4] (millions)		
	Total	Domestic	International	Total	Domestic	International
1973	—	3,623	—	—	3,662	—
1974	4,356	3,427	929	9,479	3,632	5,847
1975	4,311	3,369	942	9,322	3,664	5,658
1976	4,782	3,752	1,030	10,511	4,111	6,400
1977E	5,136	3,996	1,140	11,889	4,438	7,451
1978	5,549	4,308	1,241	13,196	4,859	8,337
1979	5,867	4,518	1,349	14,296	5,157	9,139
1980	6,115	4,650	1,465	15,219	5,369	9,850
1981	6,412	4,826	1.586	16,283	5,639	10,644
1982	6,762	5,046	1,716	17,556	5,980	11,576
1983	7,127	5,268	1,859	18,863	6,324	12,539
1984	7,524	5,513	2,011	20,257	6,700	13,557
1985	7,940	5,766	2,174	21,684	7,079	14,605
1986	8,384	6,034	2,350	23,238	7,504	15,734
1987	8,856	6,317	2,539	24,879	7,945	16,934
1988	9,357	6,615	2,742	26,626	8,414	18,212
1989	9,887	6,926	2,961	28,484	8,908	19,576

E Estimated.
[1] Includes Freight, Express, and Mail.
[2] Includes scheduled and nonscheduled service of all U.S. and Foreign Flag Carriers.
[3] Exports only.
[4] Includes Imports plus Exports.

TABLE 8. TOTAL AIRCRAFT IN THE SERVICE OF UNITED STATES AIR CARRIERS (As of January 1)

Aircraft Type	Reported	Forecast											
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Total Aircraft	2505	2555	2613	2672	2733	2791	2846	2913	2975	3029	3079	3130	3183
Fixed-wing Aircraft	2501	2551	2608	2667	2728	2786	2840	2907	2969	3022	3072	3123	3175
Jet	2154	2229	2310	2393	2473	2550	2623	2703	2779	2845	2910	2982	3054
2-engine	536	560	603	663	723	779	846	906	960	980	1005	1042	1079
3-engine	1025	1080	1129	1155	1185	1213	1239	1308	1376	1416	1449	1475	1501
4-engine	593	589	578	575	565	558	538	489	443	449	456	465	474
Turboprop	247	235	223	211	201	191	181	171	161	151	138	119	101
2-engine	178	172	166	160	154	148	142	136	130	123	113	97	81
4-engine	69	63	57	51	47	43	39	35	31	28	25	22	20
Piston	100	87	75	63	54	45	36	33	29	26	24	22	20
1- and 2-engine	63	57	51	45	42	39	36	33	29	26	24	22	20
4-engine	37	30	24	18	12	6	—	—	—	—	—	—	—
Helicopter	4	4	5	5	5	5	6	6	6	7	7	7	8

Note—Included here are all passenger and cargo aircraft owned or leased by, and in the domestic or international service of the United States certificated route, supplemental, intrastate, and commercial air carriers. Aircraft used for training and aircraft that have been withdrawn from service and are awaiting disposal are not included here. Aircraft in the service of air taxi operators are shown in the general aviation aircraft fleet on another page of this report.

TABLE 9. TOTAL AIRBORNE HOURS UNITED STATES AIR CARRIERS
By Fiscal Year (Millions)

Aircraft Type	Estimated	Forecast											
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Total Aircraft	6.23	6.36	6.50	6.67	6.77	6.93	7.12	7.26	7.38	7.51	7.66	7.81	7.99
Fixed-wing Aircraft	6.22	6.35	6.49	6.66	6.76	6.92	7.11	7.25	7.37	7.50	7.65	7.80	7.98
Jet	5.73	5.90	6.09	6.29	6.41	6.59	6.81	6.97	7.10	7.27	7.44	7.62	7.84
2-engine	1.21	1.26	1.35	1.49	1.63	1.75	1.90	2.04	2.15	2.20	2.26	2.34	2.45
3-engine	2.73	2.87	3.00	3.07	3.07	3.14	3.25	3.40	3.55	3.65	3.74	3.81	3.88
4-engine	1.79	1.77	1.74	1.73	1.71	1.70	1.66	1.53	1.40	1.42	1.44	1.47	1.51
Turboprop	.42	.38	.35	.32	.30	.29	.27	.25	.24	.21	.19	.16	.12
2-engine	.30	.28	.26	.24	.23	.22	.21	.20	.19	.17	.15	.13	.10
4-engine	.12	.10	.09	.08	.07	.07	.06	.05	.05	.04	.04	.03	.02
Piston	.07	.07	.05	.05	.05	.04	.03	.03	.03	.02	.02	.02	.02
1 and 2 engine	.05	.05	.04	.04	.04	.03	.03	.03	.03	.02	.02	.02	.02
4 engine	.02	.02	.01	.01	.01	.01	—	—	—	—	—	—	—
Helicopter	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01

Note—Included here are hours flown by all passenger and cargo aircraft that are owned or leased by and are in the domestic or international service of the United States certificated route, supplemental, intrastate, and contract air carriers.

TABLE 10. TOTAL STATUTE MILES UNITED STATES AIR CARRIERS
By Fiscal Year (Millions)

Aircraft Type	Estimate	Forecast											
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Total Aircraft	2547	2608	2664	2742	2794	2855	2914	2945	2996	3071	3134	3199	3273
Fixed-wing Aircraft	2546	2607	2663	2741	2793	2854	2913	2944	2995	3070	3133	3198	3272
Jet	2436	2507	2572	2659	2716	2783	2847	2882	2938	3020	3089	3161	3242
2-engine	425	446	470	530	569	613	666	698	747	762	782	811	838
3-engine	1176	1231	1287	1322	1351	1383	1412	1465	1524	1585	1623	1652	1685
4-engine	835	830	815	807	796	787	769	719	667	673	684	698	719
Turboprop	96	88	80	73	69	65	61	58	54	47	41	35	28
2-engine	68	63	58	54	52	50	48	46	43	38	33	28	22
4-engine	28	25	22	19	17	15	13	12	11	9	8	7	6
Piston	14	12	11	9	8	6	5	4	3	3	3	2	2
1- and 2-engine	8	7	7	6	6	5	5	4	3	3	3	2	2
4-engine	6	5	4	3	2	1	—	—	—	—	—	—	—
Helicopter	1	1	1	1	1	1	1	1	1	1	1	1	1

Note—Included here are miles flown by all passenger and cargo aircraft owned or leased by, and in the domestic or international service of the United States certificated route, supplemental, intrastate, and contract air carriers. Miles for fiscal year 1977 are partially estimated.

TABLE 11. ESTIMATED ACTIVE GENERAL AVIATION AIRCRAFT BY TYPE OF AIRCRAFT
(In thousands)

As of January 1	Total	Fixed Wing: Piston: Single-engine	Fixed Wing: Piston: Multi-engine	Fixed Wing: Turboprop	Fixed Wing: Turbojet	Rotorcraft	Balloons Dirigibles Gliders
1973	145.0	120.4	17.3	1.5	1.1	2.8	1.9
1974	153.5	126.2	18.7	1.9	1.4	3.1	2.3
1975	161.5	131.9	19.8	2.1	1.6	3.6	2.5
1976	168.5	136.9	20.3	2.5	1.8	4.1	2.8
1977	178.3	144.9	21.3	2.5	1.9	4.5	3.2
1978*	186.6	151.2	22.4	2.8	2.1	4.8	3.3
1979*	198.6	160.4	24.3	3.3	2.3	4.9	3.4
1980*	212.0	170.4	26.8	3.7	2.6	5.0	3.5
1981*	223.6	179.2	28.6	4.1	2.9	5.2	3.6
1982*	234.4	186.8	30.7	4.5	3.3	5.4	3.7
1983*	244.8	194.6	32.1	4.9	3.7	5.6	3.9
1984*	254.6	201.1	34.1	5.6	3.8	5.9	4.1
1985*	263.5	207.4	35.8	5.8	4.2	6.1	4.2
1986*	271.6	212.7	37.2	6.8	4.3	6.3	4.3
1987*	278.7	217.1	38.7	7.2	4.7	6.5	4.5
1988*	285.1	221.1	39.9	7.7	5.1	6.7	4.6
1989*	291.3	225.8	40.8	7.9	5.2	6.9	4.7

* Forecast.

Note—An active aircraft must have a current registration and have been flown during the previous calendar year. It should be noted that historical data are estimates. Detail may not add to total due to independent rounding.

TABLE 12. ESTIMATED ACTIVE GENERAL AVIATION AIRCRAFT BY FAA REGION
(In thousands)

As of January 1	Total	ANE	AEA	ASO	AGL	ACE	ASW	ARM	AWE	ANW	AAL	APC
		FAA Region										
1973	145.0	5.3	18.6	21.1	28.1	10.6	19.5	7.6	22.8	7.9	3.0	.3
1974	153.5	5.5	19.8	23.2	29.1	11.1	20.7	7.9	24.0	8.3	3.3	.3
1975	161.5	6.2	21.2	24.4	30.7	11.6	21.7	8.3	25.1	8.6	3.4	.3
1976	168.5	6.4	21.2	24.9	31.0	12.3	23.1	9.3	25.9	9.8	4.2	.4
1977	178.3	6.4	21.7	26.2	32.6	13.3	24.2	10.0	27.5	11.0	4.7	.4
1978*	186.6	6.8	22.6	28.0	33.5	13.6	26.4	10.3	28.6	11.5	4.9	.4
1979*	198.6	7.5	24.3	30.0	35.8	14.1	28.2	10.7	30.3	12.0	5.3	.4
1980*	212.0	8.1	26.3	32.0	38.0	14.6	31.2	11.2	32.2	12.3	5.7	.4
1981*	223.6	8.5	27.7	34.0	40.1	15.3	33.1	11.6	34.2	12.7	6.0	.4
1982*	234.4	8.9	29.1	35.6	41.9	16.2	34.7	12.2	35.9	13.1	6.3	.5
1983*	244.8	9.5	30.1	37.5	43.3	16.6	37.0	12.5	37.7	13.5	6.6	.5
1984*	254.6	9.7	31.3	39.0	44.8	17.0	38.7	13.0	39.5	14.0	7.1	.5
1985*	263.5	10.0	32.1	40.6	46.5	17.7	40.0	13.4	41.1	14.2	7.4	.5
1986*	271.6	10.3	33.1	41.8	47.9	17.9	41.8	13.6	42.4	14.7	7.6	.5
1987*	278.7	10.6	33.7	43.2	48.9	18.4	42.6	13.9	43.7	15.0	8.1	.6
1988*	285.1	10.8	34.5	44.2	49.9	18.8	43.9	14.2	44.8	15.1	8.3	.6
1989*	291.3	11.1	34.9	45.1	51.1	18.9	44.9	14.6	46.0	15.4	8.7	.6

* Forecast.

Note—Totals include a small number of aircraft located in foreign countries. Also see Table 11 footnotes. Detail may not add to total due to independent rounding.

TABLE 13. ESTIMATED HOURS FLOWN IN GENERAL AVIATION BY TYPE OF AIRCRAFT (In millions)

Fiscal Year	Total	Fixed Wing: Piston: Single-engine	Fixed Wing: Piston: Multi-engine	Fixed Wing: Turboprop	Fixed Wing: Turbojet	Rotorcraft	Balloons Dirigibles Gliders
1973	28.5	20.8	4.7	1.1	0.6	1.1	0.2
1974	31.3	22.5	5.2	1.2	0.8	1.3	0.4
1975	33.3	23.9	5.4	1.3	0.8	1.5	0.4
1976	35.1	25.4	5.5	1.3	0.9	1.7	0.3
1977T	9.5	6.7	1.5	0.4	0.3	0.4	0.2
1977E	36.7	26.1	6.0	1.4	1.0	1.8	0.4
1978*	39.3	27.8	6.4	1.5	1.2	1.9	0.5
1979*	42.2	29.8	6.9	1.7	1.3	2.0	0.5
1980*	44.7	31.1	7.5	1.9	1.5	2.1	0.6
1981*	47.0	32.5	8.1	2.1	1.6	2.1	0.6
1982*	49.2	33.7	8.6	2.3	1.8	2.2	0.6
1983*	51.5	35.1	9.0	2.5	2.0	2.3	0.6
1984*	53.2	35.7	9.5	2.8	2.2	2.4	0.6
1985*	54.9	36.4	10.0	3.0	2.4	2.4	0.7
1986*	56.3	36.9	10.4	3.3	2.5	2.5	0.7
1987*	57.7	37.4	10.8	3.5	2.7	2.6	0.7
1988*	58.9	37.7	11.2	3.8	2.9	2.6	0.7
1989*	60.1	38.4	11.4	3.9	3.0	2.7	0.7

* Forecast. E Estimate.
Note—Detail may not add to total due to independent rounding. It should be noted that historical data are estimates.
1977T—This represents the transition quarter, July 1, 1976, through September 30, 1976.

TABLE 14. COMMUTER AIRLINES AIRCRAFT OPERATIONS

Calendar Year	Aircraft Operations (Millions): Current Points [1]	Puerto Rico	Transfers [2]	New Points [2]	Total
1973	1.5	.3	—	—	1.8
1974	1.7	.3	—	—	2.0
1975	1.9	.3	—	—	2.2
1976E	2.0	.3	—	—	2.3
1977E	2.2	.3	—	—	2.5
1978*	2.2	.3	—	—	2.5
1979*	2.3	.3	.1	.1	2.8
1980*	2.5	.3	.1	.1	3.0
1981*	2.6	.4	.2	.2	3.3
1982*	2.7	.4	.2	.3	3.6
1983*	2.8	.4	.3	.4	3.8
1984*	2.9	.4	.3	.4	4.0
1985*	3.0	.4	.4	.4	4.2
1986*	3.1	.5	.5	.4	4.4
1987*	3.2	.5	.5	.4	4.6
1988*	3.2	.5	.6	.4	4.8
1989*	3.3	.5	.6	.4	4.9

* Forecast. E Estimate.
[1] Based on a passenger boarding factor of 4.8 in 1975 increasing to 6.0 in 1989.
[2] Based on a passenger boarding factor of 3.7 in 1975 increasing to 4.3 in 1989.
Note—Detail may not add to total due to independent rounding.

TABLE 15. COMMUTER AIRLINES PASSENGER TRAFFIC [1]

Calendar Year	Revenue Passenger Enplanements (Millions)					Revenue Passenger Miles (Millions)				
	Current Points [2]	Puerto Rico	Transfers [3]	New Points [4]	Total	Current Points	Puerto Rico	Transfers [5]	New Points [5]	Total
1973	3.7	.9	—	—	4.6	407.8	56.8	—	—	464.6
1974	4.5	.9	—	—	5.4	517.1	58.4	—	—	575.5
1975	4.7	.9	—	—	5.6	542.9	55.6	—	—	598.5
1976E	5.0	.9	—	—	5.9	575.1	58.7	—	—	633.8
1977E	5.5	1.0	—	—	6.5	636.9	61.9	—	—	698.8
1978*	5.7	1.0	—	—	6.7	670.6	65.3	—	—	735.9
1979*	6.1	1.1	.1	.1	7.4	717.4	69.0	11.3	14.7	812.4
1980*	6.5	1.1	.2	.3	8.1	776.0	72.8	23.5	30.8	903.1
1981*	7.0	1.2	.3	.4	8.9	837.3	76.8	36.6	48.3	999.0
1982*	7.3	1.3	.4	.6	9.6	886.2	81.0	50.9	74.4	1,092.5
1983*	7.7	1.3	.5	.7	10.3	941.9	85.4	66.2	88.2	1,181.7
1984*	8.2	1.4	.7	.8	11.0	1,007.7	90.1	82.7	92.3	1,272.8
1985*	8.7	1.5	.8	.8	11.7	1,069.6	95.0	100.5	96.7	1,361.8
1986*	9.1	1.6	1.0	.8	12.4	1,130.8	100.2	119.5	101.2	1,451.7
1987*	9.5	1.6	1.1	.8	13.1	1,267.4	105.7	140.0	105.8	1,618.9
1988*	10.0	1.7	1.3	.9	13.9	1,393.6	111.5	161.9	110.8	1,777.9
1989*	10.5	1.7	1.4	.9	14.5	1,519.8	117.7	183.8	116.0	1,937.3

E Estimates. * Forecast.

[1] 48 contiguous states plus Puerto Rico.

[2] Enplanements at current points, exclusive of Puerto Rico.

[3] Based on 74 mainland certificated cities enplaning less than 40 passengers daily. These cities were grouped in the same c ·gories used for existing exclusive commuter points and the corresponding models used to derive estimates of same categories u ·d for existing exclusive commuter points and the corresponding models used to derive estimates of enplanements at these new p ·its. The estimates were then doubled to represent enplanements at the corresponding hubs, and phased in over 5 years be- ·ing in 1979.

[4] Based on 50 potential new mainland service points. The forecast methodolgy is similar to that used for the transfer points, the phase-in period is 10 years.

[5] Based on same average trip lengths as for current points.

Note—Detail may not add to total due to independent rounding.

TABLE 16. ESTIMATED FUEL CONSUMED BY UNITED STATES DOMESTIC CIVIL AVIATION
(In millions of gallons)

Fiscal Year	Total Jet Fuel and Aviation Gasoline	Jet Fuel			Aviation Gasoline		
		Total	Air Carrier	General Aviation	Total	Air Carrier	General Aviation
1973r	9,135	8,703	8,399	304	432	21	411
1974r	8,783	8,320	7,963	357	463	20	443
1975r	8,745	8,313	7,860	453	432	20	412
1976r	8,769	8,317	7,822	495	452	20	432
1977**	9,225	8,750	8,214	536	475	19	456
1978*	9,606	9,103	8,493	610	503	17	486
1979*	9,980	9,436	8,782	654	544	15	529
1980*	10,410	9,837	9,096	741	573	13	560
1981*	10,802	10,199	9,405	794	603	11	592
1982*	11,232	10,603	9,725	878	629	9	620
1983*	11,676	11,022	10,056	966	654	7	647
1984*	12,136	11,450	10,400	1,050	686	7	679
1985*	12,605	11,897	10,764	1,133	708	6	702
1986*	13,068	12,343	11,146	1,197	725	5	720
1987*	13,569	12,818	11,537	1,281	751	5	746
1988*	14,077	13,309	11,940	1,369	768	4	764
1989*	14,550	13,768	12,358	1,410	782	4	778

* Forecast.

** Estimate. New Fiscal Year beginning in October.

Note—Domestic civil aviation is defined for purposes of the table to include all civil aircraft flight which originate and terminate within the 50 states. Estimates of fuel consumed by airframe and aircraft engine manufacturers, whether for flight testing or ground testing, are not shown here because they are not available for the domestic industry as a whole and estimates cannot be developed with any assurance of accuracy. Estimates of fuel consumed by the supplemental, contract and intrastate carriers are included in the "Air Carrier" columns. It should also be noted that general aviation fuel consumption is not reported and historical series are estimates.

r The historical data have been revised to reflect new benchmark data.

TABLE 17. ACTIVE U.S. MILITARY AIRCRAFT IN CONTINENTAL UNITED STATES [1]

Fiscal Year	Total	Fixed-Wing Aircraft			Helicopter
		Jet	Turboprop	Piston	
1973	21,727	9,344	1,223	2,989	8,171
1974	21,143	9,091	1,207	2,854	7,991
1975	19,889	9,526	1,298	1,927	7,138
1976	19,775	9,255	1,511	1,360	7,649
1977E	19,700	9,254	1,392	1,360	7,694
1978*	19,641	9,220	1,561	965	7,895
1979*	19,243	9,193	1,541	843	7,666
1980*	19,412	9,346	1,543	817	7,706
1981*	19,572	9,511	1,546	733	7,782
1982*	19,791	9,711	1,542	714	7,824
1983*	19,584	9,770	1,545	693	7,576
1984* [2]	19,580	9,755	1,548	676	7,601
1985*	19,575	9,749	1,537	676	7,613
1986*	19,575	9,749	1,537	676	7,613
1987*	19,575	9,749	1,537	676	7,613
1988*	19,577	9,749	1,539	676	7,613
1989*	19,577	9,749	1,539	676	7,613

** Forecast.* E *Estimate.*

[1] Includes Army, Air Force, Navy and Marine regular service aircraft, as well as Reserve and National Guard aircraft.

[2] Detailed planning information not available beyond 1984. 1985–1989 projected at the 1984 level.

Source: Office of the Secretary of Defense, Department of Defense.

TABLE 18. ACTIVE U.S. MILITARY AIRCRAFT FLYING HOURS IN CONTINENTAL UNITED STATES[1] FISCAL YEARS 1973–1989
(In thousands)

Fiscal Year	Total	Fixed-Wing Aircraft			Helicopter
		Jet	Turboprop	Piston	
1973	7,381	3,785	524	1,108	1,964
1974	6,403	3,287	533	1,051	1,532
1975	6,510	3,478	677	902	1,453
1976	5,768	3,046	625	526	1,571
1977E	5,772	3,045	529	659	1,539
1978*	5,778	3,036	541	621	1,580
1979*	5,755	3,022	550	567	1,616
1980*	5,780	3,028	548	558	1,646
1981*	5,720	3,018	519	552	1,631
1982*	5,641	2,996	522	539	1,615
1983*	5,662	2,989	519	539	1,615
1984*[2]	5,662	2,989	519	539	1,615
1985*	5,662	2,989	519	539	1,615
1986*	5,662	2,989	519	539	1,615
1987*	5,662	2,989	519	539	1,615
1988*	5,662	2,989	519	539	1,615
1989*	5,662	2,989	519	539	1,615

* Forecast. E Estimate.

[1] Includes Reserve and National Guard aircraft for the Army, Air Force, Navy and Marines as well as regular service aircraft fleet.

[2] Detailed planning information not available beyond 1984. 1985–1989 projected at the 1984 level.

Source: Office of the Secretary of Defense, Department of Defense.

TABLE 19. TOTAL ITINERANT AND LOCAL AIRCRAFT OPERATIONS AT AIRPORTS WITH FAA TRAFFIC CONTROL SERVICE
(In millions)

Fiscal Year	Total	Itinerant	Local	Number of Towers
1973	53.9	34.0	19.9	362
1974	56.8	36.1	20.8	394
1975	59.0	37.6	21.4	416
1976	62.5	39.7	22.8	423
1977T	17.2	11.0	6.2	422
1977E	66.5	42.2	24.3	426
1978*	71.6	45.3	26.3	432
1979*	76.5	48.3	28.2	437
1980*	79.9	50.6	29.3	442
1981*	83.0	52.8	30.2	447
1982*	85.9	54.7	31.2	452
1983*	88 4	56.2	32.2	457
1984*	90.7	57.7	33.0	462
1985*	92.8	59.1	33.7	467
1986*	94.3	60.0	34.3	472
1987*	95.9	61.2	34.7	477
1988*	97.6	62.5	35.1	482
1989*	99.0	63.7	35.3	487

* Forecast. E Estimate.

Note—An aircraft operation is defined as an aircraft arrival at or a departure from an airport with FAA traffic control service. *A local operation is performed by an aircraft that:* operates in the local traffic pattern or within sight of the tower; is known to be departing for or arriving from flight in local practice areas; or executes simulated instrument approaches or low passes at the airport. All aircraft arrivals and departures other than local (as defined above) are classified as itinerant operations. Detail may not add to total due to independent rounding.

1977T—This represents activity during the transition quarter, July 1, 1976, to September 30, 1976.

TABLE 20. ITINERANT AIRCRAFT OPERATIONS AT AIRPORTS WITH FAA TRAFFIC CONTROL SERVICE
(In millions)

Fiscal Year	Total	Air Carrier	Air Taxi	General Aviation	Military
1973	34.0	9.8	2.1	20.6	1.5
1974	36.1	9.5	2.4	22.9	1.3
1975	37.6	9.4	2.8	24.2	1.3
1976	39.7	9.3	2.9	26.2	1.3
1977T	11.0	2.5	.8	7.4	.3
1977E	422.	9.8	3.2	28.1	1.2
1978*	45.3	10.1	3.6	30.4	1.2
1979*	48.3	10.4	4.1	32.6	1.2
1980*	50.6	10.6	4.5	34.4	1.2
1981*	52.8	10.8	5.1	35.7	1.2
1982*	54.7	11.0	5.5	37.0	1.2
1983*	56.5	11.3	5.9	38.1	1.2
1984*	58.0	11.5	6.4	38.9	1.2
1985*	59.3	11.7	6.8	39.6	1.2
1986*	60.2	11.9	7.0	40.1	1.2
1987*	61.4	12.2	7.4	40.6	1.2
1988*	62.7	12.4	7.8	41.2	1.2
1989*	63.7	12.6	8.2	41.7	1.2

* Forecast. E Estimate.
Note—See Table 19 for definition of itinerant operations. Detail may not add to total due to independent rounding.
1977T—This represents activity during the transition quarter, July 1, 1976, to September 30, 1976.

TABLE 21. LOCAL AIRCRAFT OPERATIONS AT AIRPORTS WITH FAA TRAFFIC CONTROL SERVICE
(In millions)

Fiscal Year	Total	General Aviation	Military
1973	19.9	18.1	1.8
1974	20.8	19.3	1.5
1975	21.4	20.0	1.4
1976	22.8	21.4	1.4
1977T	6.2	5.9	.3
1977E	24.3	22.8	1.5
1978*	26.3	24.7	1.6
1979*	28.2	26.6	1.6
1980*	29.3	27.7	1.6
1981*	30.2	28.6	1.6
1982*	31.2	29.7	1.5
1983*	32.2	30.7	1.5
1984*	33.0	31.5	1.5
1985*	33.7	32.2	1.5
1986*	34.3	32.8	1.5
1987*	34.7	33.2	1.5
1988*	35.1	33.6	1.5
1989*	35.3	33.8	1.5

* Forecast. E Estimate.
Note—See Table 19 for definition of local operations. Detail may not add to total due to independent rounding.
1977T—This represents activity during the transition quarter, July 1, 1976, to September 30, 1976.

TABLE 22. INSTRUMENT OPERATIONS AT AIRPORTS WITH FAA TRAFFIC CONTROL SERVICE
(In millions)

Fiscal Year	Total	Air Carrier	Air Taxi	General Aviation	Military
1973	22.5 (1.5)	9.8	1.1	7.4	4.2
1974	24.1 (2.6)	9.5	1.4	9.2	4.0
1975	26.2 (2.9)	9.5	1.9	10.8	4.0
1976	28.1 (6.2)	9.5	2.2	12.8	3.7
1977T	7.7 (1.9)	2.5	.6	3.6	.9
1977E	30.7 (6.8)	9.9	2.5	14.7	3.6
1978*	32.3 (6.8)	10.2	2.9	15.6	3.6
1979*	34.0 (6.9)	10.5	3.4	16.5	3.6
1980*	35.7 (7.1)	10.7	3.8	17.6	3.6
1981*	37.5 (7.2)	10.9	4.1	18.9	3.6
1982*	38.8 (7.3)	11.1	4.3	19.9	3.5
1983*	40.1 (7.5)	11.4	4.5	20.7	3.5
1984*	41.0 (7.5)	11.6	4.6	21.3	3.5
1985*	41.8 (7.6)	11.8	4.7	21.8	3.5
1986*	43.7 (7.7)	12.0	5.1	23.1	3.5
1987*	45.9 (7.8)	12.3	5.6	24.5	3.5
1988*	48.1 (7.9)	12.5	6.1	26.0	3.5
1989*	50.4 (7.9)	12.7	6.6	27.6	3.5

* *Forecast.* E *Estimate.*

Note—An instrument operation is defined as the handling by an FAA terminal traffic control facility of the arrival, departure, or overflight at an airport of an aircraft on an IFR flight plan or the provision of IFR separation to other aircraft by an FAA terminal traffic control facility. Non-IFR instrument counts at Terminal Control Area (TCA) facilities and Stage III of expanded area radar service are included in the totals and noted in parenthesis as an information item (see Table 23).

Includes instrument operations at FAA-operated military radar approach control facilities.

1977T—This represents activity during the transition quarter, July 1, 1976, to September 30, 1976.

TABLE 23. NON–IFR INSTRUMENT OPERATIONS AT AIRPORTS WITH FAA TRAFFIC CONTROL SERVICE
(In millions)

			Expanded Area Radar Service	
Fiscal Year	Total	Terminal Control Areas—TCA's	Stage III As of 6/30/75	Stage III After 7/1/75
1973	1.5	—	1.5	—
1974	2.6	—	2.6	—
1975	2.9	—	2.9	—
1976	6.2	1.7	3.7	.8
1977T	1.9	.5	1.0	.3
1977E	6.8	1.8	3.8	1.2
1978*	6.8	1.8	3.8	1.2
1979*	6.9	1.8	3.9	1.2
1980*	7.1	1.9	3.9	1.3
1981*	7.2	1.9	4.0	1.3
1982*	7.3	1.9	4.0	1.4
1983*	7.5	2.0	4.1	1.4
1984*	7.5	2.0	4.1	1.4
1985*	7.6	2.0	4.1	1.5
1986*	7.6	2.0	4.1	1.5
1987*	7.8	2.1	4.2	1.5
1988*	7.9	2.1	4.2	1.6
1989*	7.9	2.1	4.2	1.6

* *Forecast.* E *Estimate.*

1977T—This represents activity during the transition quarter, July 1, 1976, to September 30, 1976.

TCA count not available prior to 1976.

TABLE 24. IFR AIRCRAFT HANDLED FAA AIR ROUTE TRAFFIC CONTROL CENTERS (In millions)

Fiscal Year	Total Aircraft Handled	Total IFR Departures	Total Overs	Aircraft Handled Air Carrier	Aircraft Handled Air Taxi	Aircraft Handled General Aviation	Aircraft Handled Military
1973	22.8	8.9	5.1	12.6	.9	4.6	4.7
1974	22.9	9.0	4.9	12.4	1.1	5.1	4.3
1975	23.6	9.3	5.1	12.4	1.3	5.5	4.4
1976	23.9	9.4	5.1	12.4	1.4	6.0	4.2
1977T	6.3	2.5	1.3	3.3	.4	1.6	1.1
1977E	25.3	10.0	5.4	12.9	1.5	6.7	4.3
1978*	27.1	10.8	5.5	13.4	1.9	7.6	4.2
1979*	28.9	11.6	5.7	13.9	2.3	8.5	4.2
1980*	30.5	12.3	5.9	14.1	2.7	9.5	4.2
1981*	31.9	12.9	6.1	14.4	2.9	10.4	4.2
1982*	33.3	13.5	6.3	14.7	3.1	11.3	4.2
1983*	34.6	14.1	6.4	14.9	3.5	12.0	4.2
1984*	35.8	14.6	6.6	15.2	3.7	12.7	4.2
1985*	37.2	15.2	6.8	15.5	4.1	13.4	4.2
1986*	38.2	15.6	7.0	15.8	4.3	13.9	4.2
1987*	39.6	16.2	7.2	16.3	4.5	14.6	4.2
1988*	40.5	16.6	7.3	16.6	4.7	15.0	4.2
1989*	41.5	17.0	7.5	16.9	4.9	15.5	4.2

* Forecast. E Estimate.

Note—Detail may not add to total due to independent rounding. The aircraft handled count consists of the number of IFR departures multiplied by two plus the number of overs. This concept recognizes that for each departure there is a landing. An IFR departure is defined as an original IFR flight plan filed either prior to departure or after becoming airborne. An overflight originates outside the ARTCC area and passes through the area without landing. The forecast data assume present operating rules and procedures.

1977T—This represents activity during the transition quarter, July 1, 1976, to September 30, 1976.

TABLE 25. IFR DEPARTURES AND OVERS FAA AIR ROUTE TRAFFIC CONTROL CENTERS (In millions)

Fiscal Year	Air Carrier IFR Departures	Air Carrier Overs	Air Taxi IFR Departures	Air Taxi Overs	General Aviation IFR Departures	General Aviation Overs	Military IFR Departures	Military Overs
1973	4.7	3.2	.4	0	2.0	.6	1.7	1.2
1974	4.6	3.1	.5	0	2.2	.7	1.6	1.1
1975	4.6	3.1	.6	.1	2.4	.7	1.6	1.2
1976	4.6	3.2	.7	.1	2.6	.8	1.5	1.1
1977T	1.2	.8	.2	0	.7	.2	.4	.3
1977E	4.8	3.3	.7	.1	2.9	.9	1.6	1.1
1978*	5.0	3.4	.9	.1	3.3	1.0	1.6	1.0
1979*	5.2	3.5	1.1	.1	3.7	1.1	1.6	1.0
1980*	5.3	3.5	1.3	.1	4.1	1.3	1.6	1.0
1981*	5.4	3.6	1.4	.1	4.5	1.4	1.6	1.0
1982*	5.5	3.7	1.5	.1	4.9	1.5	1.6	1.0
1983*	5.6	3.7	1.7	.1	5.2	1.6	1.6	1.0
1984*	5.7	3.8	1.8	.1	5.5	1.7	1.6	1.0
1985*	5.8	3.9	2.0	.1	5.8	1.8	1.6	1.0
1986*	5.9	4.0	2.1	.1	6.0	1.9	1.6	1.0
1987*	6.1	4.1	2.2	.1	6.3	2.0	1.6	1.0
1988*	6.2	4.2	2.3	.1	6.5	2.0	1.6	1.0
1989*	6.3	4.3	2.4	.1	6.7	2.1	1.6	1.0

* Forecast. E Estimate.

1977T—This represents activity during the transition quarter, July 1, 1976, to September 30, 1976.

TABLE 26. TOTAL FLIGHT SERVICES, PILOT BRIEFS AND FLIGHT PLANS ORIGINATED AT FAA FLIGHT SERVICE STATIONS AND COMBINED STATION/TOWERS
(In millions)

Fiscal Year	Total Flight Services	Pilot Briefs	Flight Plans Originated		
			Total	IFR–DVFR	VFR
1973	53.7	14.7	7.2	4.5	2.7
1974	56.2	15.4	7.8	5.0	2.8
1975	58.3	16.2	8.0	5.2	2.8
1976	58.2	16.1	8.1	5.4	2.7
1977T	15.8	4.2	2.2	1.4	.8
1977E	59.8	16.4	8.5	5.6	2.9
1978*	65.1	18.4	9.0	6.1	3.0
1979*	72.5	21.1	9.8	6.8	3.2
1980*	78.5	23.3	10.5	7.2	3.3
1981*	84.3	25.2	11.4	8.0	3.4
1982*	89.4	27.1	12.0	8.5	3.5
1983*	94.5	29.1	12.5	8.9	3.6
1984*	99.6	31.1	13.1	9.4	3.7
1985*	104.5	32.9	13.8	10.0	3.8
1986*	108.7	34.5	14.4	10.5	3.9
1987*	113.4	36.1	15.3	11.3	4.0
1988*	117.8	37.6	16.2	12.2	4.0
1989*	121.9	39.2	16.7	12.6	4.1

* Forecast. E Estimate

Note—Total Flight Services is a weighted workload measurement derived by multiplying pilot briefs and flights plans originated by two and adding the number of aircraft contacted. A flight plan may be filed orally or in writing to qualify for inclusion in the activity count. The data forecast in Tables 26 and 27 are based upon the current number of and configuration of the FSS and CS/T. Any change in their number or operation would have a corresponding change on the forecast. Detail may not add to total due to independent rounding.

1977T—This represents activity during the transition quarter, July 1, 1976, to September 30, 1976.

TABLE 27. AIRCRAFT CONTACTED: FAA FLIGHT SERVICE STATIONS AND COMBINED STATION/TOWERS
(In millions)

Fiscal Year	Total	IFR–DVFR	VFR	Air Carrier	Air Taxi	General Aviation	Military
1973	9.9	1.5	8.4	.6	.7	8.0	.7
1974	9.9	1.5	8.4	.4	.7	8.1	.7
1975	10.0	1.6	8.4	.4	.8	8.1	.7
1976	9.8	1.5	8.3	.4	.8	8.0	.6
1977T	2.9	.4	2.5	.1	.2	2.4	.2
1977E	10.0	1.6	8.4	.5	.9	8.0	.6
1978*	10.3	1.8	8.5	.5	1.1	8.1	.6
1979*	10.7	1.9	8.8	.5	1.2	8.4	.6
1980*	10.9	2.0	8.9	.5	1.3	8.5	.6
1981*	11.1	2.1	9.0	.5	1.4	8.6	.6
1982*	11.2	2.1	9.1	.5	1.4	8.7	.6
1983*	11.3	2.2	9.2	.5	1.5	8.7	.6
1984*	11.2	2.1	9.2	.5	1.4	8.7	.6
1985*	11.1	2.0	9.1	.5	1.3	8.7	.6
1986*	10.9	1.9	9.0	.5	1.2	8.6	.6
1987*	10.6	1.8	8.8	.5	1.1	8.4	.6
1988*	10.3	1.6	8.6	.5	1.0	8.2	.6
1989*	10.1	1.6	8.5	.5	.9	8.1	.6

* Forecast. E Estimate

Note—Aircraft contacted represent a record of the number of aircraft with which FAA facilities (FSS, CS/T) have established radio communications contact. One count is made for each en route, landing or departing aircraft contacted by a facility, regardless of the number of contacts with an individual aircraft. A flight involving contacts with five different facilities, disregarding the number of contacts with each, would be counted as five aircraft contacted. Detail may not add to total due to independent rounding.

1977T—This represents activity during the transition quarter, July 1, 1976, to September 30, 1976.

TABLE 28. ACTIVE PILOTS BY TYPE OF CERTIFICATE

As of January 1	Total	Students	Private	Commercial	Airline Transport	Helicopter	Glider	Instrument Rated [1]
1973	750,869	181,477	323,383	196,228	37,714	7,987	4,080	187,909
1974	714,607	181,905	301,863	182,444	38,139	5,968	4,288	185,969
1975	730,541	180,795	305,848	192,425	41,002	5,647	4,824	199,323
1976	725,059	176,978	305,867	189,342	42,592	4,932	5,348	203,954
1977	741,272	188,801	309,005	187,801	45,072	4,804	5,789	211,364
1978*	758,600	197,600	315,300	187,800	46,800	4,700	6,400	222,200
1979*	807,300	212,100	343,000	191,500	49,000	4,700	7,000	236,400
1980*	856,100	217,100	367,000	207,800	51,100	4,600	8,500	258,200
1981*	884,500	216,200	379,600	221,900	53,200	4,600	9,000	279,200
1982*	906,800	217,800	390,500	229,200	55,200	4,600	9,500	297,100
1983*	937,500	223,100	407,400	235,600	57,000	4,500	9,900	312,400
1984*	971,700	226,500	426,200	245,500	58,700	4,500	10,300	327,800
1985*	1,005,100	229,100	443,800	256,500	60,500	4,500	10,700	343,100
1986*	1,036,000	230,500	460,700	266,900	62,200	4,600	11,100	357,100
1987*	1,065,500	231,400	477,200	276,700	64,000	4,600	11,600	369,200
1988*	1,094,500	231,700	493,900	286,400	65,700	4,600	12,200	380,400
1989*	1,122,800	231,200	510,700	296,300	67,200	4,700	12,700	391,100

* Forecast. [1] Not included in total.

Note—The total count includes all pilots with current medical certificates; it also includes pilots who no longer fly but desire to keep their active status by periodic medical examinations. At the close of 1973 the active pilot count totalled 714,607, compared with 750,869 at the end of 1972. The decrease in the number of airmen resulted from a purging of the Airmen Certification files. During this process approximately 26,000 duplicate or faulty records were eliminated. Helicopter pilots include pilots who hold only a helicopter certificate.

APPENDIX A

NATIONAL FORECASTS OF TOTAL GENERAL AVIATION OPERATIONS AT TOWERED AND NONTOWERED AIRPORTS

Systems Consultants, Inc.
James W. Hines, FAA, Contract Technical Officer

Operations forecasts for the entire general aviation community are included in this appendix. These forecasts include total activity estimates for airports with Federal Aviation Administration (FAA) traffic control service and at all the other airports of record.

The forecasts and referenced base data estimates shown in Appendix A have been taken from two reports prepared by Systems Consultants, Inc. (SCI) under FAA contract management:

(1) Report No. FAA–AVP–76–6, *Nationwide, Regional and Statewide Estimates for General Aviation (GA) Activity at Nontowered Airports During CY 1972 (Revised) and CY 1974*

(2) Report No. FAA–AVP–76–7, *General Aviation Forecasts, 1975–1987, State, Regional and National Operations*

The reports detail the results of the first formal investigation by the Office of Aviation Policy of the extent of total general aviation on a nationwide basis using aircraft operations at both tower and nontower airports as the unit of measure. Both reports can be obtained through the National Technical Information Service, Springfield, Virginia 22161, or by contacting the Office of Aviation Policy for any available copies in stock.

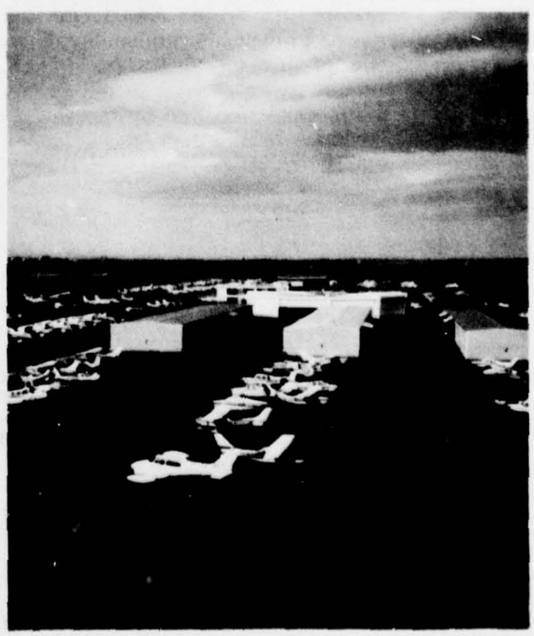
The national forecasts presented in Appendix A and the other general aviation base data estimates and forecasts in the above reports are not to be considered at this time as offical FAA estimates of general aviation air traffic activity. However, the 1972 and 1974 estimates and the 1975–1987 forecasts of total tower plus nontower activity now offer a total picture of aviation operations to correspond with the total general aviation fleet and hours flown. As such, the estimates are considered to be reliable and statistically accurate and will assist in developing future analyses of this segment of the aviation industry.

Yearly data for total, local, and itinerant operations are shown in Table A-1. In the subsequent 5 and 10 year period, nationwide general aviation tower plus nontower airport operations are forecast to increase 22 percent by 1979 and 52 percent by 1984, from a reference level of 125.7 million operations in 1974. It is estimated that 200 million aircraft operations will take place in 1985. At that time, an estimated 88.6 million itinerant operations will represent approximately 44 percent of the total, a slight percentage decrease from the 1974 level of 46 percent. By 1987, nationwide total tower plus nontower operations are expected to be 77 percent greater than 1974.

TABLE A–1. NATIONAL FORECASTS OF TOTAL GENERAL AVIATION OPERATIONS AT TOWERED AND NONTOWERED AIRPORTS [1]
(In millions)

CALENDAR YEAR	TOTAL OPERATIONS	LOCAL OPERATIONS	ITINERANT OPERATIONS
1972 [2]	115.4	63.8	51.6
1974 [2]	125.7	67.9	57.8
1975	130.7	70.2	60.5
1976	135.4	72.9	62.5
1977	141.2	76.4	64.8
1978	146.8	80.7	66.1
1979	153.4	84.5	68.9
1980	157.6	87.3	70.3
1981	163.6	90.7	72.9
1982	171.5	95.1	76.4
1983	180.8	100.3	80.5
1984	190.6	105.9	84.7
1985	200.4	111.8	88.6
1986	211.6	118.4	93.2
1987	222.5	125.0	97.5

[1] Taken from Report No. FAA–AVP–76–7.
[2] Estimates from Report No. FAA–AVP–76–6.



APPENDIX B

MACRO AIR CARRIER FORECASTING MODEL

Jonathan C. Tom
June 1977

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In its long range planning, the FAA is concerned about expected use of and its future ability to make improvements in the national airspace system. This appendix discusses a model which forecasts the contribution of the scheduled domestic air carriers both to the workload of the FAA and to funds designated for the improvement of the aviation system.[1]

The expected use of the FAA air traffic system by the air carriers and their contribution to developmental funds depend primarily on the amount of passenger traffic handled by the carriers and on the operating behavior of the airlines. The model describes the historical relationships between economic activity and air carrier passenger traffic, aircraft operations, and passenger revenues. These relationships extrapolated into the future form the basis for passenger, air carrier aircraft operations, and air carrier revenue forecasts. The model structure and the variables used in the model are reviewed first. Next is a discussion of the statistical results. The assumptions which form the basis of the forecasts are discussed in the third part.

The Model

The model discussed here is an extension of research presented in Appendix B of *Aviation Forecasts Fiscal Years 1977–1988*.[2] As in the previous work, demand for air transportation services as measured by revenue passenger miles (RPM) and passenger enplanements (ENP) is expected to be related to price, income, population, and quality of air carrier service. This demand along with airline operating constraints such as the load factor and aircraft size required to maintain profitability determines the number of air carrier flights. In addition, this demand combines with changes in the air fare to determine the revenues received by the air carriers. To describe these relationships, the following multi-equation model has been developed.

(1) $RPM = f_1\,(SRVC, PAT, REL, TQR, STR)$

(2) $ENP = f_2\,(CMP, PAT, REL, TQR, STR)$

(3) $OPS = \dfrac{2 * RPM}{LOAD * SEATS * STAGE}$

(4) $ATL = \dfrac{RPM * 100}{ENP}$

(5) $REV = f_3\,(PA, ATL, RPM)$

Equations 1, 2, and 5 represent linear relationships such that the variables in the right-hand side of the equations cause or explain the behavior of those on the left. Equations 3 and 4, meanwhile, are identities describing definitional relationships among the represented variables.

The variables endogenous to the model are:

1. RPM—Scheduled domestic revenue passenger miles are used to reflect overall demand for air travel. An RPM is counted when a paying passenger flies one mile. The data were computed as quarterly totals and include scheduled activity from all certificated domestic route air carriers. The data are in billions of RPMs.
2. ENP—Another measure of demand for air travel is scheduled domestic revenue passenger enplanements. Also computed on a quarterly basis, this variable reflects millions of passengers boarding scheduled domestic flights.
3. OPS—Air carrier itinerant aircraft operations at airports with FAA air traffic control service reflect the usage of FAA facilities. These data count thousands of landings and takeoffs by aircraft serving the airlines.
4. ATL—Average trip length represents the average distance an individual flies on one aircraft on one trip. To illustrate, a passenger boarding at point A and going to point B with three stops is flying one trip. However, a passenger changing planes at intermediate stop C is counted as two trips. As a result the ATL of the two trip lengths in the first case is twice that of the second. These data are based on enplanements and revenue passenger miles recorded for each quarter. ATL is expressed in hundreds of miles.
5. REV—Scheduled domestic passenger revenues represent all fares collected from scheduled flights beginning and ending on domestic points. The data in 100 millions of dollars are collected on a quarterly basis.

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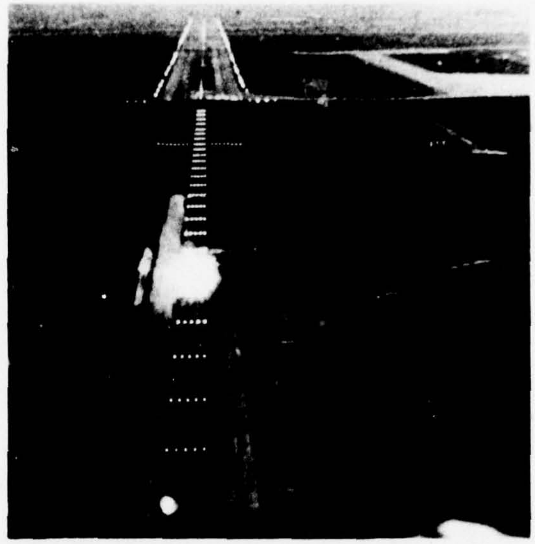
[1] Under the Airport and Airways Development Act of 1970, a trust fund was created from which airports can partially finance their expansion. A system of taxes based predominantly on air carrier revenues, general aviation fuel usage and air freight is the source of revenue for this fund. The ticket tax on domestic air carrier revenues has historically encompassed over 75 percent of the fund's revenues.

[2] Office of Aviation Policy, Federal Aviation Administration, *Aviation Forecasts–Fiscal Years 1977–1988*, September 1976. Document Number FAA–AVP–76–17.



The variables exogenous to the model are:

1. SRVC—Because the use of air transportation is the consumption of a service, income used for the personal consumption of services can be used to represent the effect of income on demand. SRVC should then be positively related to RPM. These data are in billions of 1972 dollars and are annualized and deseasonalized.
2. CMP—The number of civilians employed reflects that portion of the population which may use air carrier services. As the level of CMP increases so should the level of ENP. These data are in millions of people.
3. PAT—This variable measures plant, equipment, and other investment in the air transport industry. Given that such investment leads to an improvement in the quality of air transportation service, PAT should be positively related to demand. These data are in billions of current dollars and are annualized and deseasonalized.
4. REL—The price of air transportation relative to that of other modes of transportation should have a negative impact on demand. As air fares decline relative to the cost of these other modes, the quantity of service demanded will increase. REL then is a ratio between an index of adult coach air fares and the deflator for personal consumption of transportation services. Both these measures of price are based on 1967 dollars.
5. TQR—Demand for air carrier services is seasonal in that the third quarter of each year is a popular vacation period. This impact is represented by the dummy variable TQR and is expected to be positive. TQR is one for the third quarter of each calendar year and zero for all others.
6. STR—This dummy variable is used to estimate the effect of major airline strikes on the demand for air travel. The period most affected by a strike was the third quarter of 1966. The variable is one during this period, and zero otherwise.
7. LOAD—The average load factor is a measure of capacity utilization for the air carriers. It measures the percentage of available seat miles occupied during a given quarter. As the utilization rate increases, the number of aircraft operations is expected to decrease if the demand is held constant.
8. SEATS—The average number of seats per aircraft is one measure of the composition of the air carrier fleet. As aircraft become larger, SEATS can be expected to increase, while air carrier operations are affected negatively.
9. STAGE—The average stage length represents the distance from takeoff to landing of an average air carrier flight. As STAGE increases, the number of aircraft operations is expected to decline. This variable is expressed in miles.
10. PA—The price of flying is represented by an index for adult coach air fares. This variable is expected to be positively related to REV. The index developed by the Bureau of Labor Statistics uses 1967 as a base year. It reflects increases in adult coach fares for a specific group of domestic city pair markets. It is used instead of yield, because the consumer of transportation bases his decision on the price of a ticket, not on the average payment per passenger mile. In addition, the index is independent of shifts in traffic patterns from long-haul to short-haul and vice versa, while the average yield can change without changing fares or revenue passenger miles flown. On the other hand, the price index used does not include discount fares, so that changes in the status of youth and family plans will cause changes in the fares seen by these users, changes which are not reflected in the price index.

While the exogenous variables described above show how economic activity impacts on air carrier activity, at the same time, interdependencies between measures of aviation activity do exist. To account for such behavior, endogenous variables are included as explanatory variables in some equations. For example, as the amount of passenger traffic (RPM) increases, the amount of revenue received by the air carriers should increase. At the same time, ATL should be related negatively to REV. Because of the fare structure, as the average trip length increases with total passenger traffic remaining constant, the revenue per mile tends to decline.

In order to incorporate ATL and RPM as explanatory variables in the REV equation, they must be without stochastic or measurement error. By assuming that the specification of the ENP and RPM equations is accurate, the estimated values of these variables can be used in subsequent equations and identities without biasing the statistical results. This type of simultaneous equation specification is called a recursive system.[3] Such a system assumes that relationships between endogenous variables occur only in one direction. In this model, for example, RPM is assumed to influence REV, but REV does not affect RPM.

Statistical Results

Use of the recursive structure allows the application of the ordinary least squares estimation technique to equations 1, 2, and 5. The relationship between the endogenous and exogenous variables was assumed linear for all equations. The estimated equations are reported below. Variables ending in "E" are previously derived endogenous variables.

(1a) Estimated RPM =− 14.91 + 0.15 *SRVC
(23.28)

+1.74*PAT −0.069*REL
(3.94) (−1.94)

−5.09*STR +3.62*TQR
(2.94) (6.72)

Corrected R-squared	=	0.953
Durbin-Watson Statistic	=	2.255
Standard Error	=	1.629

(2a) Estimated ENP = −79.17 + 1.55*CMP
(26.55)

+1.74*PAT − 0.069*REL
(3.32) (−1.80)

−6.89*STR + 3.08*TQR
(−3.33) (4.77)

Corrected R-squared	=	0.961
Durbin-Watson Statistic	=	1.329
Standard Error	=	1.954

(5a) Estimated REV = −1.33 + 0.15*PA
(15.36)

+0.55*RPME − 0.24*ATLE
(11.46) (−4.36)

Corrected R-squared	=	0.987
Durbin-Watson Statistic	=	1.204
Standard Error	=	0.785

[3] A technical discussion of recursive systems can be found in Johnston, *Econometric Methods*, Second Edition, pages 377–380.

Note that all coefficients are of expected sign, substantiating the *a priori* hypotheses. The numbers in parentheses are Student t-statistics corresponding to each coefficient. These t-statistics indicated that all coefficients are significantly different from zero at a 95 percent confidence level. Moreover, the corrected R-squares indicate that the equations as specified explain over 95 percent of the variance in the dependent variables. The Durbin-Watson statistics, however, indicated that equations 2 and 5 have first degree autocorrelation.[4] To the forecaster, the main implication of autocorrelation is that predictions will have needlessly large variances.

To avoid such forecasting errors, the ENP equation was rerun with a correction for first order autocorrelation. The technique used was the Hildreth-Lu procedure for finding the autocorrelation coefficient. The result of this correction was:

(2b) Estimated ENP = −84.67 + 1.57*CMP
(19.33)

+1.46*PAT − 0.037*REL
(2.59) (−1.37)

−7.09*STR + 2.72*TQR
(−3.96) (5.29)

Corrected R-squared	=	0.966
Durbin-Watson Statistic	=	1.879
Standard Error	=	1.834
Rho	=	0.387

This version of equation 2 retains the high explanatory power of the earlier, uncorrected estimation. In addition, the Durbin-Watson statistic indicates that the correction procedure has eliminated the first order serial correlation. The value of rho shows how the estimation error in one time period is dependent on the error in the previous time period. Specifically,

$$e_t = u_t + rho^* e_{t-1}$$

where e_t is the estimation error for the current time period, u_t is random, or stochastic, error for the current time period, and e_{t-1} is the error for the estimate of ENP in the previous time period.

As in estimated equation 2a, the coefficients derived in estimate 2b are of expected sign. Moreover, except for the coefficient for REL, the estimated coefficients are significantly different from zero at a 95 percent level. Although confidence in the REL coefficient is not high, the variable was retained in the model, because it is consistent with economic behavior, and because it provides the analyst with some quantification of the impact of air fares on demand for air carrier services.

[4] Again, see Johnston, pages 243–266.

Using the estimates of ENP derived from equation 2b and the estimates of RPM, from equation 1a, a revised estimate of ATL was calculated. This estimate was applied to the REV equation. The results of this estimation are:

(5b) Estimated $REV = -1.38 + 0.16^{*}PA$
(16.71)

$-0.24^{*}ATLE + 0.55^{*}RPME$
$(-4.90) \quad (12.65)$

Corrected R-squared	=	0.989
Durbin-Watson Statistic	=	1.556
Standard Error	=	0.758

The statistics presented for this version of the REV equation are consistent with those for equation 5a. In fact, the Durbin-Watson statistic has improved, when compared to the earlier statistic, such that first degree autocorrelation is no longer indicated at a 99 percent level of confidence.

By using equations 1a, 2b, and 5b in conjunction with identities 3 and 4, a model has been developed which explains the historical behavior of the air carrier passenger traffic, operations, and revenues. Given that the relationships estimated by this model continue into the future, the model is a useful tool for forecasting and for analyzing and quantifying the impact of various policy alternatives on future aviation activity.

Forecast Assumptions

Economic forecasts from the Wharton Econometric Forecasting Associates, Inc., are the source of the economic assumptions used in this forecast. The baseline scenario assumes in general that the high growth rates of economic recovery will continue into 1979. Thereafter, the economy as measured using gross national product (GNP) is expected to stabilize at an average annual growth rate of about 3.4 percent. In addition to the economic assumptions, it was assumed that regulatory reform would be introduced into the aviation system by 1978. While the specific form of these regulatory changes has not been determined, the new regulations are expected to dampen the increase in air fares and to cause a shift in short-haul service from air carriers to air taxi and commuter operators.

The long term economic growth rate used in this baseline forecast is higher than that assumed in the September 1976 forecast despite continued increases in the price of fuel, primarily because of income tax cuts and tax incentives for hiring the unemployed. In the baseline forecast, the price of fuel was assumed to increase about 7 percent each year. As a result of this increase, however, the air fare is expected to increase relative to the cost of all transportation services in the long run. This phenomenon is expected to result from an increased use of fuel-efficient automobiles and public transportation, as petroleum prices rise.

The increasing cost of fuel is also expected to have an adverse effect on consumer consumption of services. Because expenditures on fuel and on fuel efficient consumer durables become more important, the proportion of GNP spent on services such as air transportation is expected to decline. Consequently, consumption of services is expected to increase by an annual rate of 3.4 percent from 1976 to 1980, while GNP will grow at a 3.9 percent rate for the same period. In the long term, personal consumption of services is forecast to increase 3.2 percent per year.

Paralleling the growth in overall economic activity is the growth in number of persons employed. The same tax incentives which are expected to stimulate real economic growth through 1979 are expected to increase employment 3.3 percent per year. These high growth rates will taper off by 1989 to 1.3 percent. The average annual growth in persons employed for the forecast period is 1.8 percent.

In addition to these economic assumptions, some assumptions about airline behavior were made. Because of continuing increases in operating costs, the air carriers will attempt to remain profitable by maintaining a load factor which will increase gradually to approximately 58 percent during the forecast period. Consistent with higher future costs, airlines are expected to increase their use of wide-body aircraft. In the face of continuing high costs, this policy will enable the airlines to increase the number of seats flown on each market, while maintaining aircraft operating frequencies and reducing costs per seat-mile. Finally, the substitution of commuter service in some short-haul markets and the introduction of more nonstop service are expected to cause the average stage length to increase gradually during the forecast period.

Generally, the economic assumptions used in the baseline forecast are more optimistic than those used in the previous forecast. This is dampened by expectations of higher fuel prices depressing aviation demand. The overall effect of these contradictory forces leaves the passenger demand forecasts substantially unchanged from the September 1976 forecast. The aircraft operations forecast is lower this year, however, primarily because higher operating costs are encouraging more rapid shifts toward aircraft with higher seating capacity and because of the transfer of many shorthaul segments from air carrier to air taxi service.

APPENDIX C

GENERAL AVIATION FORECASTING MODEL

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I. INTRODUCTION

Significant growth in the size of the general aviation (GA) fleet during the 1960's and the relatively recent trend toward larger multiengine and turbine powered fixed wing aircraft have lead to increased intensity of use of the National Aviation System (NAS) by general aviation aircraft. The effect of increased fleet size and the trend toward larger general aviation aircraft are reflected in the increase in general aviation operations (takeoffs and landings) at Federal Aviation Administration (FAA) towered airports—between 1959 and 1976 general aviation operations more than tripled in size (growth in air carrier operations over the same period was only 32 percent), and general aviation currently accounts for over 80 percent of total aircraft operations at towered airports in the United States. Since general aviation represents such a significant component of NAS activity, forecasts of general aviation activity are critical measures of future demands on the NAS. Thus, the forecasting model presented in this appendix represents an important basis for aviation planning purposes.

The structure of this appendix is as follows: Section II discusses the model and relevant economic hypotheses; Section III presents the empirical results; and Section IV discusses the general economic assumptions upon which the forecasts are based.

II. MODEL AND HYPOTHESES

The fundamental assumptions underlying the general aviation model are that the various measures of general 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 (i.e., without feedback). The latter assumption accounts for the construction of the model as a recursive system (see Johnston, ***Econometric Methods***, p. 377) and justifies the estimation technique.

Figure C–1 incorporates these assumptions and illustrates the general structure of the model. Figure C–2 defines the endogenous and exogenous variables in the model, and Figure C–3 presents the system of equations summarizing the behavioral assumptions included in the model. The same exogenous or explanatory variable may appear in more than one equation with the same expected sign. Accordingly, the following discussion of the behavioral hypotheses underlying the relationships between the variables are applicable to each equation in which the relevant explanatory variables appear.

Since the structure of the model is recursive, endogenously determined variables are used as explanatory variables in some equations. The level of structural dependence is related to the number of exogenous or predetermined variables which must be known or estimated before a specific equation can be used. For example, the general aviation fleet (GAAA) estimating equation is of the first level. In arriving at the estimate of the GAAA for 1978, the independent variables are completely predetermined. Three of the variables are national economic variables, the fourth, GAAA(−1), is a lagged variable which is known either from historical data for 1977 or from a forecast.

To determine the number of instrument rated pilots (INSTP) in 1978, however, we must know the index of fixed cost (DTO–RATAFAVIND) and the number of pilots in the previous year (PILOT(−1)) as well as the number of general aviation aircraft in 1978. Thus, for the year for which the estimate is being made (1978 in this example), GAAA must be estimated before INSTP. Therefore, by our definition, INSTP is structurally dependent at the second level. As can be determined from the set of equations in Figure C–3, the highest level of structural dependence (level five) is reached by the IFRO equation. For this equation, GAAAE, INSTPE, IFRFE, and IFRDE must be determined sequentially before IFRO can be estimated. The discussion of the specific equations follows the logic dictated by the recursive system. Thus, we begin with Level I variables—specifically GAAA, STD, PP, and COM.

Aircraft and pilots are primary inputs into the use of the National Aviation System. Initially, the number of general aviation aircraft (GAAA), student pilots (STD), private pilots (PP) and commercial pilots (COM) are estimated directly as functions of predetermined variables only.

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FIGURE C-1. GENERAL AVIATION FORECASTING MODEL

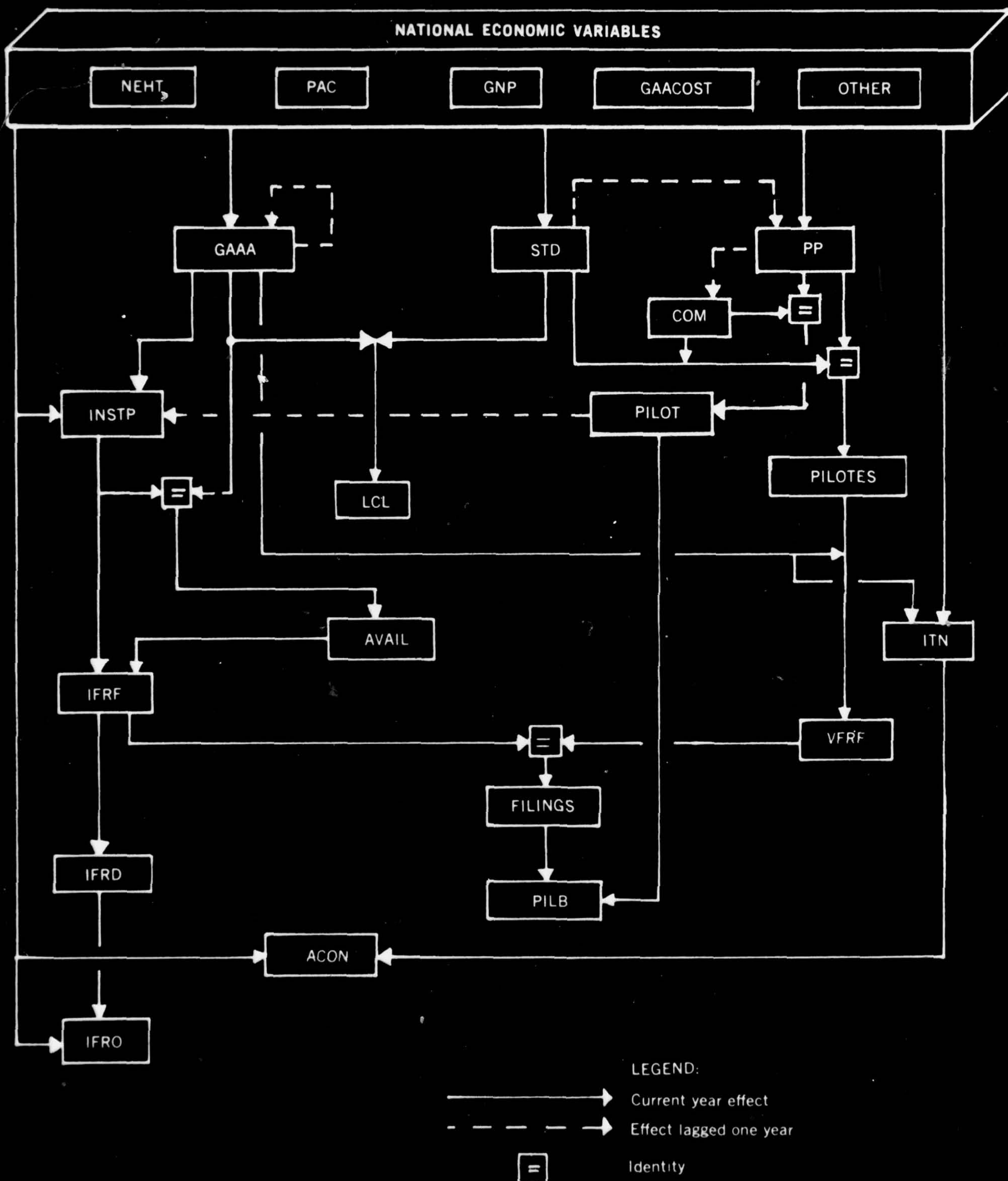

FIGURE C-2. ENDOGENOUS AND EXOGENOUS VARIABLES IN THE MODEL

Endogenous Variables	Definition
GAAA	Number of general aviation aircraft
PP, STD, INST	Number of active private, student, and instrument rated pilots, respectively
COM	Number of commercial pilots
ITN, LCL	Number of itinerant and local operations, respectively. General aviation and air taxi operations are included in these measures of activity at airport traffic control towers
IFRD, IFRO	Number of instrument flight rule (IFR) departures and over flights, respectively. General aviation and air taxi operations are included in these measures of activity at air route traffic control centers
IFRF, VFRF	Number of IFR and visual flight rule (VFR) flight plans filed
PILB	Number of pilot briefs
ACON	Number of aircraft contacted. General aviation, air taxi, air carrier, and military are included in this measure of activity at flight service stations
INSTOP	Number of instrument operations. General aviation and air taxi are included in this measure of activity at airports with FAA control service
NEHT	Number of civilians employed
PAC	Plant and equipment expenditures in aircraft industry
GNP	Gross National Product
AVAIL	Ratio of the number of general aviation aircraft to the number of instrument rated pilots (estimated)
FILINGS	Sum of IFRFE and VFRFE
PILOTE	Sum of active commercial and private pilots (estimated)
PILOTES	Sum of active student, commercial, and private pilots (estimated)
CLEAN73	Dummy variable, equal to 1 if year is 1973 or later. Accounts for purging of duplicate pilot records in 1973

FIGURE C-2. ENDOGENOUS AND EXOGENOUS VARIABLES IN THE MODEL —Continued

Endogenous Variables	Definition
GAACOST	Indices of fixed and variable costs of owning and operating general aviation aircraft, 1959 base year (see text)
USAF/FSS61	Dummy variable, equal to 1 in 1961 zero otherwise. Accounts for transfer of military flight service stations to FAA in 1961.
DTO–RATFCIND	Index of annual fixed cost of aircraft deflated by the price deflator for transportation output.
DTO–RATAFAVIND	Index of annual airframe and avionics cost deflated by the price deflator for transportation output.
RATVCIND	Index of annual variable cost of operating an aircraft.

FIGURE C-3. GENERAL AVIATION FORECASTING MODEL

Functional Equations

GAAA	= f	(NEHT, GAAA(—1),PAC,DTO–RATFCIND)
STD	= f	(PAC(—1), GNP, RATVCIND)
PP	= f	(STD(—1), GNP, CLEAN73)
COM	= f	(PP(—1), CLEAN73)
LCL	= f	(STDE, GAAAE)
ITN	= f	(GAAAE, PAC(—1), RATVCIND)
VFRF	= f	(GAAAE, PILOTES, USAF/FSS61)
INSTP	= f	(GAAAE, PILOT(—1), DTO–RATAFAVIND)
IFRF	= f	(INSTPE, AVAIL, USAF/FSS61)
ACON	= f	(ITNE, RATVCIND)
IFRD	= f	(IFRFE, USAF/FSS61)
PILB	= f	(PILOTE, FILING, USAF/FSS61)
IFRO	= f	(IFRDE, RATVCIND)

Identities

PILOT	=	(PPE + COME)
PILOTES	=	(PPE + COME + STDE)
AVAIL	=	(GAAAE/INSTPE) * 100
FILINGS	=	(IFRFE + VFRFE)

Note: The suffix "(—1)" indicates a one-period lag, and the suffix "E" indicates that the estimated values of the variable is used as an independent variable.

By the *a priori* reasoning presented below the signs of the coefficients of the completely exogenous variables, except those of the indices of general aviation aircraft costs, are expected to be positive. The equation for predicting GAAA is based on the stock adjustment principle.[2] The basic premise for such a formulation is that net additions to the fleet depend on a desired fleet size (GAAA*), the number of active aircraft in the previous year (GAAA(−1)), and the rate of adjustment (a) which measures how quickly the aviation community can respond to changes in the desired fleet size. Algebraically, this logic can be represented by:

(1) $GAA - GAAA(-1) = a(GAAA^* - GAAA(-1))$.

GAAA*, as a measure of demand for general aviation aircraft, is assumed to be dependent on the number of civilians employed, (NEHT), investment in the aircraft industry plant and equipment (PAC), and the annualized fixed cost of owning an aircraft (DTO–RATFCIND). An increase in NEHT, the portion of the population likely to purchase and use aircraft, is likely to increase GAAA*. (PAC) as a surrogate measure for improvements in aircraft design, avionics, and safety features should reflect a positive effect on GAAA*. On the other hand, increases in DTO–RATFCIND are expected to cause decreases in the desired number of general aviation aircraft.

Based on these assumptions, the following linear relationship can be assumed:

(2) $GAAA^* = g\,(NEHT, PAC, DTO\text{-}RATFCIND)$.

Algebraic manipulation of equation (1) to solve for GAAA yields

(3) $GAAA = aGAAA^* + (1 - a)GAAA(-1)$.

Substituting equation (2) into equation (3) yields

(4) $GAAA = a[g\,(NEHT, \ldots)] + (1-a)GAAA(-1)$.

Since equation (2) is assumed to be linear, equation (4) can be rewritten

(5) $GAAA = f\,(NEHT, PAC, DTO\text{-}RATFCIND, GAAA(-1))$.

Where the coefficient on GAAA(−1) is expected to be positive since a is between 0 and 1.

[2] For a discussion of this topic see *Macroeconomic Theory*, Ott, Ott, and Yoo, McGraw Hill, 1975, p. 130.

In estimating the STD equation, it is hypothesized that previous year's improvements in aircraft design, avionics, and safety features, as reflected by investment in the aircraft industry, will influence the number of student starts. As such, the lagged variable PAC(−1) is useful in explaining STD. To account for the effect of changes in income on student pilots, gross national product (GNP) is included as an explanatory variable. Since increases in the variable costs of flying are likely to reduce student starts and training flights an index of variable cost is included in the equation for student pilots. The coefficient of this variable is expected to have a negative sign.[3]

The hypothesized positive sign for estimated student pilots STD(−1) in the private pilot, (PP) equation is accounted for by the fact that private pilots are initially drawn from the student pilot pool. Because of the length of time required to train student pilots to reach proficiency, the student pilot population has a delayed effect in impacting the number of private pilots. Consequently, the variable, student pilots, is lagged one year in the PP equation. PP is also expected to be influenced directly by GNP—the income effect.

In 1973, the airman file was purged such that duplicate records were eliminated. For example, prior to 1973 a pilot may have been recorded on file as holding both a private and a commercial pilot rating. The 1973 purge and all subsequent updates to this file would count this pilot only as a commercial pilot. Since the effect of this purge is to reduce the previously artificially-inflated count in each of the various pilot classifications, the dummy variable, CLEAN73, is expected to be negatively related to PP.

Commercial pilots (COM) are assumed to be recruited primarily from the ranks of private pilots. Thus, the private pilot variable also enters the COM equation with a one-year lag.

The amount of local operations (LCL), primarily consisting of training and pleasure flights, is assumed to be positively related to the number of student pilots and the number of GA aircraft.

The size of the aircraft fleet and investment in the aircraft industry as reflected in the variable PAC(−1) are assumed to influence the number of itinerant operations (ITN) positively. In contrast, the variable cost of flying should affect such operations negatively. The lagged effect of PAC(−1) is based on the assumption that there is a considerable lapse

[3] Three cost indices appear in the model. They are subsumed under the variable name GAACOST in Figure C–1 and are discussed more fully in Section III, Empirical Results.

of time between the decision to "tool-up" and install new equipment and the time that new, better equipped aircraft come off the assembly line and are ready to join the active fleet.

Visual flight rule flight plans filed (VFRF) is considered to be a function of the estimated number of GA aircraft (GAAAE). Presumably the greater the number of active aircraft, the larger the VFRF. Similarly, the greater the number of student, commercial, and private pilots, the greater the expected number of VFRF. In 1961, a number of flight service stations previously operated by the United States Air Force came under the jurisdiction of the FAA. The dummy variable USAF/FSS61 adjusts for this "one-shot" increase in the number of flight service stations.

The number of instrument rated pilots (INSTP) is assumed to be a function of the number of private plus commercial pilots in the previous year, the number of aircraft in the fleet and the variable cost of flying. The cost variable, of course, is assumed to exert a negative influence on the number of instrument rated pilots.

Thus far, the recursive structure of the model has been described through two levels: Level I, the impact of national economic and other predetermined variables on GAAA, STD, PP, and COM; and Level II, the impact of national economic variables and other predetermined variables, including Level I variables, on LCL, ITN, INSTP, and VFRF. The variables, in turn, affect other national avaiation system activities.

The hypothesized positive effect of the number of itinerant operations (ITNE) in the aircraft contacted (ACON) equation is accounted for by the fact that itinerant operations are likely to involve flights passing over flight service areas for which different Flight Service Stations (FSS's) have responsibility. Such flights are likely to entail considerable contact with these Flight Service Stations for weather and other flight condition information.

The availability of aircraft to instrument rated pilots, as measured by the number of aircraft per instrument rated pilot, (AVAIL), is expected to be positively related to the number of IFR flight plans filed (IFRF). Independent of the effect of aircraft availability, the number of instrument rated pilots (INSTP) is expected to be positively related to IFRF. This relationship is clearly evident for the case where the ratio remains constant—e.g., due to a proportional increase in aircraft and instrument pilots—from year to year; but an increase in IFRF is also likely because of an increase in INSTP.

Estimated IFR flight plans filed (IFRFE) is used to explain IFRD and (with other variables) PILB. For the IFRD equation, the hypothesized positive parameter estimate is based on the fact that IFR flight plan filings are required for IFR departures. The variables FILINGS and PILOTE (the sum of VFRFE and IFRFE and the sum of COM and PP, respectively) are expected to have a positive effect in the PILB equation. The intent to fly is established through the filing of a flight plan and since weather and other flight condition information are essential to any flight, an increase in IFRFE or VFRFE as well as the number of pilots is likely to result in an increase in PILB.

Instrument Flight Rule Overs (IFRO) is expected to be positively affected by the number of IFR departures (IFRDE), and to be negatively affected by the variable cost of flying as represented by the variable cost index (RATVCIND).

The discussion of the structure of the model and the behavioral hypotheses is concluded. The following section addresses the empirical results derived from the model.

III. EMPIRICAL RESULTS

Figure C–4 presents the results of the estimates of the parameters of the GA model. Numbers in parentheses are the associated t-statistics, which indicate whether or not the estimated results are significant. The historical data are on an annual basis covering the period 1960 through 1976. All equations in the model are estimated using the ordinary least squares (OLS) estimating procedures.

The results presented in Figure C–4 are consistent with conventional economic theory. Without exception, the signs of the parameter estimates are as hypothesized in Section II. The Durbin-Watson statistics suggest that, with the exception of two equations in the undecided range, we may reject the hypothesis that there is either positive or negative first order autocorrelation at the 99 percent level of significance. All but one of the parameter estimates are significantly different from zero at least at the .90 level of significance (t-test) and the large majority are significant at the .99 level. The corrected R-squares, indicating the amount of variance in the independent variables adjusted for the degree of freedom are quite respectable, ranging from 93 to 99 percent.

The interpretation of the estimated coefficients is relatively straightforward. In the first equation, for example, an increase of 100,000 in the number of people employed is associated with an increase of about 220 general aviation aircraft. Similarly, a 100 percent increase in the fixed cost of an aircraft relative to 1959 prices is expected to reduce the number of active general aviation aircraft by approximately 200 units.

FIGURE C–4. ESTIMATING EQUATIONS FOR THE GENERAL AVIATION FORECASTING MODEL*

Dependent Variable	Constant	Coefficient	Variable 1	Coefficient	Variable 2	Coefficient	Variable 3	Coefficient	Variable 4	Durbin-Watson	Corrected R-Square
GAAA	= −825.589 (−2.86)	+ 0.0217 (3.86)	NEHT	+ 0.5817 (4.49)	GAAA(−1)	+ 131.6130 (2.31)	PAC	− 197.4750 (−1.47)	DTO–RATFCIND	1.86	.99
STD	= −95.568 (−6.03)	+ 66.8013 (6.44)	PAC(−1)	+ 0.2994 (10.85)	GNP	− 53.4690 (−6.34)	RATVCIND			2.17	.96
PP	= −136.492 (−8.57)	+ 0.7582 (8.34)	STD(−1)	+ 0.2671 (9.41)	GNP	− 22.0529 (−3.64)	CLEAN73			2.12	.99
COM	= +12.318 (2.40)	+ 0.5863 (25.74)	PP(−1)	− 5.6201 (−1.48)	CLEAN73					2.32	.98
INSTP	= −38.648 (−2.65)	+ 0.2061 (7.16)	PILOT(−1)	+ 0.1142 (4.47)	GAAAE	− 20.9977 (−1.09)	DTO–RATAFAVIND			2.11	.99
LCL	= −73.491 (−9.99)	+ 0.9101 (12.19)	STDE	+ 0.0662 (7.26)	GAAAE					1.76	.98
ITN	= −58.435 (−7.76)	+ 0.2236 (10.76)	GAAAE	+ 45.2756 (4.60)	PAC(−1)	− 28.0256 (−2.35)	RATVCIND			1.48	.99
IFRF	= −9271.57 (−10.00)	+ 43.7628 (21.67)	INSTPE	+ 6.8741 (9.72)	AVAIL	− 881.6490 (−5.53)	USAF/FSS61			1.18	.99
VFRF	= +810.562 (12.09)	+ 0.5750 (5.28)	GAAAE	+ 1.5875 (6.50)	PILOTES	− 590.2760 (−8.53)	USAF/FSS61			2.56	.98
IFRD	= −914.426 (−14.48)	+ 0.7523 (41.88)	IFRFE	+ 714.7840 (6.57)	USAF/FSS61					1.47	.99
IFRO	= +167.378 (3.38)	+ 0.3030 (11.35)	IFRDE	− 112.8040 (−2.17)	RATVCIND					1.20	.99
PILB	= −991.789 (−28.64)	+ 2.1791 (12.02)	PILOTE	+ 0.1870 (16.83)	FILINGS	− 240.6930 (5.91)	USAF/FSS61			1.67	.99
ACON	= +612.815 (24.43)	+ 2.5180 (9.16)	ITNE	− 114.8010 (−3.38)	RATVCIND					1.60	.93
**INSTOP	= a	+ b	ITNE								

* The units utilized are as follows: GAAA in hundreds; PP, STD, INSTP, COM, IFRD, IFRO, IFRF, VERF and NEHT in thousands; ITN, LCL, in hundred-thousands; PLB and ACON in ten-thousands; PAC in billions of current dollars; GNP in billions of constant dollars. 1959 equals 100 for all cost indices (see variables with suffix IND).

** This equation is an identity.

TABLE C–5. SINGLE-ENGINE PISTON AIRCRAFT ONE TO THREE SEATS
Operational Cost

AIRCRAFT TYPE CATEGORY—1

VARIABLE COSTS PER HOUR	1959	1960	1961	1962	1963	1964	1965	1966	1967
Fuel and Oil (Inc. Taxes)	2.84	2.99	3.15	3.32	3.50	3.69	3.88	3.78	3.92
Airframe and Avionics Reserve	.63	.66	.69	.73	.77	.81	.85	.98	1.07
Eng. Maint. and Overhaul Reserve	.71	.75	.79	.83	.87	.92	.97	1.06	.95
TOTAL	4.18	4.40	4.63	4.88	5.14	5.42	5.70	5.82	5.94
ANNUAL FIXED COSTS									
Annualized Investment	1,463.00	1,485.00	1,547.00	1,820.00	1,973.00	1,956.00	1,990.00	2,294.00	2,375.00
Ins. Hull	439.00	446.00	464.00	546.00	592.00	587.00	622.00	717.00	725.00
Ins. Lia. & Med.	175.00	175.00	175.00	175.00	175.00	175.00	175.00	175.00	175.00
Hgr. & Tie Down	270.00	280.00	295.00	310.00	325.00	342.0	360.00	388.00	415.00
Federal User Charges	—0—	—0—	—0—	—0—	—0—	—0—	—0—	—0—	—0—
Miscellaneous	54.00	56.00	58.00	60.00	63.00	66.00	69.00	72.00	75.00
TOTAL	2,401.00	2,442.00	2,539.00	2,911.00	3,128.00	3,126.00	3,216.00	3,646.00	3,765.00

VARIABLE COSTS PER HOUR	1968	1969	1970	1971	1972	1973	1974	1975
Fuel and Oil (Inc. Taxes)	4.02	4.27	4.69	4.84	4.95	5.61	7.14	7.65
Airframe and Avionics Reserve	1.16	1.33	1.50	1.67	1.82	1.99	2.37	2.42
Eng. Maint. and Overhaul Reserve	.98	1.08	1.18	1.27	1.36	1.48	1.77	1.81
TOTAL	6.16	6.68	7.37	7.78	8.13	9.08	11.28	11.88
ANNUAL FIXED COSTS								
Annualized Investment	2,686.00	2,635.00	2,702.00	2,892.00	2,997.00	3,217.00	3,700.00	3,773.00
Ins. Hull	802.00	770.00	727.00	803.00	899.00	965.00	1,110.00	1,132.00
Ins. Lia. & Med.	175.00	175.00	175.00	175.00	175.00	175.00	175.00	175.00
Hgr. & Tie Down	443.00	473.00	506.00	528.00	554.00	609.00	730.00	876.00
Federal User Charges	—0—	—0—	25.00	25.00	25.00	25.00	25.00	25.00
Miscellaneous	78.00	82.00	86.00	90.00	93.00	98.00	110.00	121.00
TOTAL	4,184.00	4,136.00	4,266.00	4,513.00	4,743.00	5,089.00	5,850.00	6,102.00

The general aviation instrument operations equation (INSTOP) in Figures C-4 is an identity. The parameter *a* varies between 3.5 and 3.7 over time, and is intended to account for expected increases in the number of airport towers becoming stage-three control areas—pilots flying into Stage III control areas must fly IFR. The parameters *b* varies between .32 and .49 over time, and is intended to account for the expected increase in the level of pilot sophistication. That is, it accounts for the effect of increases in the number of instrument rated pilots and the increased use of avionics.

Following Ratchford (Transportation Research, Vol. 8, pp. 193–203) a series of chain-link price indices were computed and incorporated in the relevant equations.

These indices were of the form:

$$R_t = \frac{\sum_{i=1}^{n} A^i_{t-1} C^i_t}{\sum_{i=1}^{n} A^i_{t-1} C^i_{t-1}} \cdot R_{t-1}$$

Where R_t represents the computed Ratchford index for year t; i goes from 1 to n; n equals 10, the number of aircraft types over which the summation is made.

C^i_t equals the appropriate elements of fixed and variable costs which enter into the computation of the index in year t for aircraft type i (see Table C–5).

When t is equal to zero, R_t is equal to 1 (the base year—1959). A^i_t equals the number of aircraft of type i in year t in the fixed cost index; or the number of hours flown by aircraft type i in year t in the variable cost index.

This method of computing the index takes into account shifting weights due to changes in the numbers and types of aircraft over time, changes in the utilization of various types of aircraft, and variations in the fixed and variable cost of owning and operating an aircraft. The data utilized for computing the index were developed by Aviation Data Services Inc., and do provide plausible results with respect to expected signs in all equations in which they were employed (for examples, see Table C–5). The coefficients were found to be significantly different from zero in all but the first equation.

To facilitate an understanding of how various policy alternatives might affect future aviation activity, the sensitivity of the model to assumed changes in selected economic variables was computed. These variables are gross national product (GNP), the index of variable cost (RATVCIND) and the index of fixed cost (DTO–RATAFAVIND). The sensitivities, generally described as the coefficient of elasticity, relate the percentage change in the dependent variable to a 1 percent change in one of the independent variables, other independent variables remaining constant.

GNP enters explicitly in two equations—STD and PP. The responsiveness of both variables STD and PP were found to be elastic with respect to changes in GNP (absolute value of the coefficient of elasticity greater than 1.0). Using the baseline forecast for the year 1980 for our example, a 1.0 percent increase in GNP would cause a 2.11 percent increase in the number of student pilots and a 1.96 percent increase in the number of private pilots (see Table C–6).

Although GNP does not enter explicitly in any other equation, STD and PP influence other dependent variables directly and indirectly. Thus, because of the recursiveness of the model, the effects of changes in GNP are distributed to other variables through secondary impacts. The most significant of these are commercial pilots, local operations, aircraft contacted, and total flight services.

In principle, it might be expected that a change in GNP would affect the number of active aircraft. However, GNP does not enter explicitly into the GAAA equation and there is no feedback link to GAAA from any of the variables which are affected by GNP. Thus, in this model, the sensitivity of GAAA to variations in GNP cannot be computed directly. In the generation of the forecast, the variable NEHT which is highly correlated with GNP but which performs better than GNP in the specific equation employed in the model serves as a proxy for GNP. Consequently, the data presented in the forecast on GAAA are not completely immune from the influence of GNP.

The responsiveness of selected variables to changes in both fixed and variable costs of owning and operating an aircraft were also computed. In the early forecast years, the coefficients of elasticity were found to be inelastic (absolute value less than 1.0) for all variables (see Tables C-7 and C-8). For example, when the fixed cost of owning and operating an aircraft was raised by 1.0 percent in 1980, the number of aircraft in the fleet declined by 0.38 percent. Since the fleet size is an independent variable in many of the other equations, the effect of changes in fixed cost is transmitted to other dependent variables. Similarly, a 1.0 percent increase in the variable cost of flying impacts the student pilot population directly (coefficient of elasticity equals 0.94 in 1980). An increase in the variable cost of flying also reduces the values of other variables such as the number of local operations and the number of aircraft contacted.

IV. ASSUMPTIONS FOR FORECAST YEARS 1978–1989

The national economic variables and the behavioral relationships underlying the GA model are discussed in Section II. The values of the key variables, gross national product and civilian employment, for the forecast period were derived from forecasts made by Wharton Econometric Forecasting Associates Inc.

Reflecting strong economic recovery in the early part of the forecast period, GNP is expected to grow at a rate of 5.9 percent in 1978. By 1980, however, the growth rate is forecast to decline to a low 2.2 percent. On an annual average rate, GNP is forecast to grow at approximately 3.5 percent during the 1977–1989 period.

Civilian population employed is also expected to show relatively strong growth during the early years, 3.6 percent increase in 1978, and to decline to a 1.8 percent growth rate in 1980. Civilian employment is forecast to grow at an annual average rate of 1.8 percent during the 1977–1989 period.

Investment in the aircraft industry is assumed to grow at a rate of 3.5 percent annually during the 1977–1989 period. The index of variable cost of operating general aviation aircraft is expected to increase by 7 percent annually during the 1977–1989 forecast period. This increase reflects the anticipated rise in the real cost of fuel prices mainly.

TABLE C–6. SENSITIVITY ANALYSIS OF SELECTED DEPENDENT VARIABLES

Dependent Variable	Percentage Change From Baseline Forecast Relative to a One Percent Increase in Gross National Product					
	1978	1980	1982	1984	1986	1988
Student Pilots (STD)	2.00%	2.11%	2.16%	2.25%	2.37%	2.54%
Private Pilots (PP)	1.98	1.96	1.91	1.88	1.86	1.86
Commercial Pilots (COM)	1.09	1.90	1.88	1.84	1.83	1.82
Instrument Rated Pilots (INSTP)	0.31	0.83	0.79	0.78	0.78	0.79
Local Operations (LCL)	1.51	1.50	1.48	1.51	1.56	1.63
IFR Departures (IFRD)	0.26	0.77	0.76	0.77	0.79	0.82
IFR Overs (IFRO)	0.28	0.85	0.85	0.89	0.94	0.99
IFR Flight Plans Filed (IFRF)	0.21	0.67	0.67	0.69	0.72	0.74
VFR Flight Plans Filed (VFRF)	0.61	0.69	0.69	0.71	0.73	0.75
Pilot Briefs (PILB)	1.28	1.62	1.52	1.48	1.46	1.45

TABLE C–7. SENSITIVITY ANALYSIS OF SELECTED DEPENDENT VARIABLES

Dependent Variables	Percentage Change From Baseline Forecast Relative to a One Percent Increase in Fixed Cost of GA Aircraft					
	1978	1980	1982	1984	1986	1988
Active General Aviation Fleet (GAAA)	–0.22%	–0.38%	–0.40%	–0.41%	–0.41%	–0.42%
Instrument Rated Pilots (INSTP)	–0.21	–0.35	–0.36	–0.36	–0.36	–0.36
Itinerant Operations (ITN)	–0.28	–0.49	–0.52	–0.54	–0.56	–0.58
Local Operations (LCL)	–0.11	–0.21	–0.22	–0.23	–0.23	–0.24
IFR Departures (IFRD)	–0.40	–0.63	–0.62	–0.60	–0.58	–0.57
IFR Overs (IFRO)	–0.43	–0.69	–0.69	–0.69	–0.69	–0.70
IFR Flight Plans Filed (IFRF)	–0.33	–0.54	–0.55	–0.53	–0.53	–0.52
VFR Flight Plans Filed (VFRF)	–0.07	–0.13	–0.15	–0.15	–0.15	–0.16
Pilot Briefs (PILB)	–0.23	–0.37	–0.37	–0.36	–0.35	–0.34
Aircraft Contacted (ACON)	–0.22	–0.41	–0.46	–0.51	–0.57	–0.65

TABLE C–8. SENSITIVITY ANALYSIS OF SELECTED DEPENDENT VARIABLES

Dependent Variables	Percentage Changes From Baseline Forecast Relative to a One Percent Increase in Variable Cost of GA Aircraft					
	1978	1980	1982	1984	1986	1988
Student Pilots (STD)	–0.81%	–0.94%	–1.03%	–1.15%	–1.29%	–1.48%
Private Pilots (PP)	–0.35	–0.38	–0.40	–0.42	–0.44	–0.47
Commercial Pilots (COM)	0.0	–0.35	–0.38	–0.40	–0.42	–0.45
Instrument Rated Pilots (INSTP)	0.0	–0.15	–0.16	–0.17	–0.18	–0.19
Itinerant Operations (ITN)	–0.26	–0.27	–0.28	–0.31	–0.35	–0.39
Local Operations (LCL)	–0.61	–0.67	–0.71	–0.77	–0.85	–0.95
IFR Departures (IFRD)	0.0	–0.14	–0.15	–0.16	–0.18	–0.20
IFR Overs (IFRO)	–0.31	–0.44	–0.45	–0.49	–0.53	–0.59
IFR Flight Plans Filed (IFRF)	0.0	–0.12	–0.13	–0.15	–0.16	–0.18
VFR Flight Plans Filed (VFRF)	–0.14	–0.18	–0.19	–0.21	–0.23	–0.26
Pilot Briefs (PILB)	–0.17	–0.32	–0.32	–0.34	–0.35	–0.38
Aircraft Contacted (ACON)	–0.54	–0.59	–0.66	–0.77	–0.93	–1.14

APPENDIX D*

HOW TO FORECAST AVIATION ACTIVITY LEVELS

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July 1977

I. INTRODUCTION

This appendix is intended to provide more detailed information to the interested public on the approach that is utilized to generate the aviation activity forecasts. The technique described below has been used to arrive at this year's national activity forecasts. It may also be viewed as a useful tool to arrive at activity forecasts on the regional, state, or airport level of disaggregation—assuming data or other limitations are overcome. A basic knowledge of econometric methodology and nomenclature is assumed on the part of the reader.

Since the discussion focuses on operations levels, a few definitions are valuable. Local operations are defined as operations which are at all times within view of the airport tower, within the local traffic pattern, which remain in the local practice areas within a twenty-mile radius of the control tower, or which execute simulated instrument approaches or low passes at the airport. All other operations are by definition itinerant operations. Instrument operations may be either itinerant or local; they are operations conducted in accordance with Instrument Flight Rule (IFR) flight plans and other operations in which aircraft are provided IFR flight separation from other aircraft by terminal air traffic control facilities.

II. SHORT RANGE FORECASTING USING TREND ANALYSIS

Short range forecasting (within one year) of itinerant, local, and instrument operations may be accomplished using trend analysis or econometric models (described in Section III). Trend analysis assumes that recent past periods are the best predictors of the immediate future. Thus, forecasts are obtained solely from the historical values of the variable to be forecasted. This type of modeling ranges from the very simple to more complex models.

A. **Simple Trend Analysis.** There are several ways of incorporating trends in forecasts.

(1) An average of past absolute changes may be used to incorporate trends in forecasts:

(2–1)

$$\hat{X}_{t+1} = X_t + \sum_{i=0}^{n} \frac{[X_{t-i} - X_{t-(i+1)}]}{n+1}$$

Where X stands for the variable to be forecast, the subscript t refers to the period of time involved, and the circumflex (^) identifies a forecast value as distinguished from an observed datum. The n is the arbitrarily chosen number of changes averaged, and i is the sequential index (i assumes all integer values from 0 through n). For example, if we wish to forecast itinerant operations for January 1976 and the historical series for this data are given in Table D–1, the forecast is obtained as follows.

Table D–1: Itinerant Operations

Month	1974	1975
January	323	349
July	473	512
August	554	600
September	544	589
October	374	400
November	305	350
December	299	310

For n=2, using equation (2–1) the computation is:

$$\hat{X}_{t+1} = \frac{310 + (310-350) + (350-400) + (400-589)}{3}$$

$$= \frac{310 + (-40-50-189)}{3} = 310 - 93$$

$$= 217 \text{ operations}$$

(2) An average of past absolute change or rates of change may be used to incorporate trends in forecasts, according to:

(2–2)

$$\hat{X}_{t+1} = X_t \left[\sum_{i=0}^{n} \frac{X_{t-i}}{X_{t-(i+1)}} \right] \frac{1}{n+1}$$

For example, using the data from Table 1, for n=2 the forecast is:

$$\hat{X} = 310 \quad \frac{\frac{310}{350} + \frac{350}{400} + \frac{400}{589}}{3}$$

$$= 310 \quad \frac{.8857 + .8750 + .6791}{3}$$

$$= 310 \quad \frac{2.4398}{3} = 252 \text{ operations}$$

* Since the final responsibility for all official FAA aviation forecasts rests with the Office of Aviation Policy, this appendix should not be construed to in any way delegate or relinquish any part of that responsibility.

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In the preceding two examples, forecasted operations for January 1976 are lower than those experienced during December 1975, or during January 1975. This is because the number of operations for December 1975 and for the three (n+1=3) immediately preceding months were decreasing monotonically. That is, the example data shows that operations during 1975 peaked-out during August, and then declined continually for each succeeding month. This peak-trough pattern within one year is commonly referred to as a seasonal variation, and it is not accounted for in the preceding two forecasting techniques. Had the number of operations from September through December 1975 been continually increasing (i.e., no seasonality), the techniques illustrated in equations (2–1) and (2–2) would have resulted in a higher forecasted level of operations for January 1976 than observed for December 1975.

Thus, the present examples are double-edge in that they illustrate the mathematical technique for particular forecasting tools, but they also show the danger of not accounting for seasonality when it is present. The following section presents a method to incorporate seasonal variations into the forecasts.

B. Accounting for Seasonal Fluctuations in Trend Analysis.

Seasonal variations can be described as within-year fluctuations in the data which occur with some consistency over time. These fluctuations may be due to such things as weather conditions, calendar events, tradition, etc., and may strongly influence activity levels. Table D–1 shows that operations reach their lowest level during December of each year and that they rise again for January, and that despite the seasonal fluctuations, operations are growing (1975 monthly levels of operations exceed their corresponding monthly level for 1974) over time. Trend analysis may be used to combine the seasonality and trend factors are given in the following example.

(2–3)

$$\hat{X}_{t+1} = X_{t-11} * 12\left[1 - \left\{\frac{X_t(X_{t-13})}{X_{t-1}(X_{t-12})}\right\}\right]$$

For example, using the data from Table 1, the forecast is:

$$\hat{X}_{t+1} = 349\left[12*\left\{\frac{1 - 310(305)}{350(299)}\right\}\right]$$

$$= 349\left[12*\left\{\frac{1 - 94550}{104650}\right\}\right]$$

$$= 349\left[12*(1 - .90348)\right]$$

$$= 349\left[12*(.09651)\right]$$

$$= 349 \quad (1.1581) = 404 \text{ operations}$$

This illustrative technique incorporates the seasonality and trend influences by computing a seasonally adjusted monthly rate of growth over the past two corresponding pairs of months. The forecast is obtained by multiplying the observed level of itinerant operations for the relevant month one year earlier by the estimated yearly rate of growth.

III. SHORT-SPACE LONG-RANGE FORECASTING USING REGRESSION ANALYSIS

Because of the complexity and volume of mathematical manipulations involved in econometric forecasting, computer solution is warranted and recommended. The illustrative procedure presented below will not discuss the mathematical formulae for computing the various statistics essential to regression analysis; explaining and illustrating these would cover the same ground illustrated in any good econometrics text and would require an equal amount of space. Rather, it will focus on how to interpret and use these essential statistics so that the analyst will be able to construct a model, evaluate its worth and generate forecasts based on the model.

Econometric modeling may be used for short-range forecasting and is widely accepted for long-range forecasts. The key to regression analysis is the construction of a formal model. The model should be based on the premise that the various measures of aviation activity (dependent variable or the variable to be forecast) are related to the level of economic activity. The model development and forecasting procedure can be described in the five basic steps shown below.

A. **Data Gathering.** The first step in econometric forecasting is to gather data on those variables which the analyst expects to be important in determining the past and future course of the aviation variable to be forecast. Considerable effort should be devoted to discerning which socio-economic and demographic variables significantly influence aviation activity and only these data should be collected. Sound and defensible economic and sociological hypotheses—explaining the reason(s) the forecaster expects a particular variable to be important and the manner (positively or negatively) each variable—should accompany each variable chosen for data collection.

(1) At the national level aggregate variables such as U.S. income, population, the number of student and private pilots, air fare costs, transportation costs of competing modes, etc., relate activity levels to economic conditions. Similar variables may be available for the regional, state, or airport level. At these lower levels of disaggregation additional characteristics, such as the number of based aircraft, land area, and airport quality (e.g., length of runway, existence of runway lights, average hours per day of aircraft operations), may be important considerations. Variables other than the above may be used, relevance of socioeconomic and demographic variables may be peculiar to the idiosyncrasies of the particular demographic area under consideration. Most commonly the variables to be used in forecasting are collected as a time series. Monthly or quarterly series are recommended for short-term econometric forecasting. While long-term forecasts may be generated using the latter series, they are generally obtained from data collected on an annual basis. A combination of time series and cross sectional data may also be used for forecasting.

B. **Screening Process.** The second step is to empirically screen the economic variables which have been selected for inclusion on theoretical grounds. This screening process consists of plotting and conducting statistical tests of the relationship of the economic variables to the aviation activity variable. The purpose of these tests is to determine whether there is any empirical relationship between the economic and the aviation variaables, whether the relationship is the one hypothesized, and whether the relationship is linear or non-linear. The correlation matrix and equation (3–1) presented below are a derivative of the model used to forecast the number of general aviation aircraft on a national level. They are intended to be illustrative of the techniques only. The following two methods should be utilized in assessing the nature of the relationship among the variables selected for inclusion on theoretical grounds.

(1) Coefficient of correlation (r)—this statistic may be thought of as the square root of the proportion of the total variation in the dependent variable that has been explained by use of the independent variable. Its squared value is called the coefficient of determination and, roughly, it tells how well the independent variable explains the movements (increases or decreases) in the dependent variable over time—the domain of this statistic is from zero to one. The higher the coefficient of correlation, the more useful the independent variable. The correlation matrix, presented below, illustrates how this statistic is used to empirically screen variables selected on theoretical grounds. The acronyms heading each column and row are defined in the key. Each cell in the correlation matrix gives the coefficient of correlation between the indicated row and column variables.

First consider the variables GAAA and CMP. The hypothesis supporting the data gathering and testing process is that the number of general aviation aircraft is likely to increase as the number of people likely to purchase aircraft increase. Thus, the relationship between the dependent variable (GAAA) and the independent variable (CMP) is expected to be positive—i.e., an increase in the dependent variable is expected to be associated with an increase in the independent variable. Table D–2 shows the correlation coefficient for the GAAA, CMP relationship to be .9959. The relatively high correlation coefficient and the positive sign (a negative sign would precede the number if an inverse relationship existed) support further consideration of this variable in the equation that will be used to forecast GA fleet size.

(a) The correlation matrix also illustrates a very critical concept in constructing a forecasting model. That is the problem of multicolinearity. Multicolinearity means that two or more of the independent variables are highly cor-

TABLE D–2. CORRELATION MATRIX

	GAAA	STD	CMP	PPDPI	LIPAC
GAAA	1.0000	0.8444	0.9959	0.9826	0.4190
STD	0.8444	1.0000	0.8375	0.8630	0.7653
CMP	0.9959	0.8375	1.0000	0.9907	0.3888
PPDPI	0.9826	0.8630	0.9907	1.0000	0.4047
LIPAC	0.4190	0.7653	0.3888	0.4047	1.0000

KEY

GAAA —number of active general aviation aircraft
STD —number of active student pilots
CMP —number of civilians employed
PPDPI—per capita personal disposal income in constant 1958 dollars
LIPAC—plant and equipment expenditure in the aircraft industry lagged by one period

related. Its most common form of manifestation is a sign reversal in the estimated (forecast) equation. That is, after the set of variables are selected, via the screening process, they will be used to form the estimating equation (see subsection C: Regression Analysis). As one output, estimating this equation (utilizing some regression technique) provides estimates of the effect of a unit change in each independent variable on the dependent variable. Obtaining signs for these independent variables which are contrary to expectations (i.e., the behavorial hypothesis) may be a result of high correlation between the independent variables in the equation. This problem may be confronted and avoided, or at least the forecaster will be aware of possible problems, with the help of the correlation matrix. For example, the above correlation matrix indicates that per capita personal disposable income is a good predictor ($r = .9826$) of fleet size. However, it also shows that the correlation between PPDPI and CMP is very high ($r = .9907$). Because of this intercorrelation, if both of these variables were used as independent variables in the GAAA estimating equation, it is very likely that the regression program would assign one of them a negative sign. Since economic theory indicates that it is unlikely that an increase in PPDPI or CMP would imply a decrease in GAAA, such results would be unacceptable. Since CMP is more highly correlated with GAAA than PPDPI, PPDPI would tentatively be excluded from the set of variables used to forecast GAAA, and CMP would be retained. On the other hand, if forecasts of student pilots (STD) were desired, PPDPI would be retained and CMP would be excluded.

(b) It should be noted that while a high coefficient of correlation does lead to a greater feeling of security about the hypothesized relationships, a high r value is not the only goal. Where a sound theoretical reason exists for including a particular economic variable as a predictor of the aviation variable, such variables may be included in the forecasting equation with only reasonable regard to the correlation coefficient. For example, the above correlation matrix indicates that plant and equipment expenditure (LIPAC) is reasonably influential in determining fleet size and is not so highly correlated with either PPDPI or CMP that it would result in a sign reversal. LIPAC, a surrogate measure for previous year aircraft order, is expected to reflect the positive effect on GAAA of the annual increment to the active GA fleet stemming from new aircraft. This variable is lagged one year, because it takes approximately one year to translate such orders into a finished product. Thus, LIPAC could be useful in helping to explain those movements in GAAA not accounted for by CMP, and would be included in the set of variables considered as possible predictors for GAAA.

(2) Plots. Graphing the intersection of the historical data on the aviation and economic variables over time is most useful in determining whether a nonlinear relationship is present. Further, for the most part, nonlinear relationships will not be indicated by a high coefficient of correlation. If a plot of the data reveals a nonlinear relationship exists, the estimating equation should reflect this fact (see subsection C: Regression Analysis, and its related subparts).

C. **Regression Analysis.** The forecaster is interested in the levels some aviation variable (dependent variable) will assume in the future. From the foregoing steps, he knows that the level of the aviation variable he wishes to forecast is caused or is at least associated with the level of other variables. In a simplistic world, this relationship would be linear; in the real world many things cause minor deviations from the straight line. Assuming that such disturbances are on balance small and generally unpredictable, the forecaster can be satisfied with coming as close as possible to the observed data points. In the two-variable case, what regression analysis does for the forecaster is to compute a line (with three variables—a plane; in more than three dimensions—a hypersurface) which comes closer to connecting the observed data points than any other line that could be drawn.

This line, represented by an equation (the estimating equation), describes the relationship between the variable to be forecast (dependent variable) and the list of variables (derived from the preceding steps) expected to influence the past and future course of the dependent variable. There are many good regression analysis programs available from computer vendors which perform the rigorous mathematical manipulations required to produce the analytical statistics useful to evaluate the forecasting equation. While there are many complex multiple regression techniques available, by far the most widely used method is ordinary least squares. Avoiding the supporting mathematics, presented in any good econometric text, the key analytical statistics are presented below. The following equation and supporting statistics provide an example of the typical results generated by a computer regression program, and provide a focus for the discussion.

(3–1) GAAA = −1944.33 + 42.40 CMP + 35.78 LIPAC
(39.31) (2.27)

Durbin-Watson Statistic = 1.61
Corrected R-square = .99
Number of historical data observations (n) = 15

(1) The left-most number (−1944.33) is the ordinal intercept for the equation. It simply indicates the value of the dependent variable (GAAA) if all other variables assume a zero value. The second and third numbers from the left are the regression coefficients. They indicate the effect on the dependent variable of a one-unit change in the independent variable. If the historical series on fleet size were given in hundreds, employment in millions, and investment in billions of dollars, then the coefficient for CMP means that a one-million increase in civilian employment results in a 4,240 increase in GAAA. Similarly, a one-billion increase in LIPAC would result in a 3,578 increase in GAAA.

(2) The numbers in parenthesis below each regression coefficient are the t-statistics. The t-statistic tells us whether or not the estimated coefficients are significantly different from zero. The t-statistic resulting from the regression program is relatively meaningless in and of itself. Referring to the Student's t-distribution table (generally, the two-tail test is applicable and available in many econometric texts) for the appropriate degrees of freedom (number of variables less number of parameters estimated, including the constant term), a comparison value may be found. In the above example, there are 12 (15–3) degrees of freedom, and according to the t-table the .99 percent confidence value for t is 3.055, and the .95 percent confidence value is 2.179. Without regard to the sign (negative t-values accompany negative coefficients), a t-value of 39.31 for the estimated coefficient of CMP means that the estimated coefficient differs from zero at better than the 99 percent confidence level. Thus, there is only one chance in 100 that the sign of the coefficient is other than that given in the regression equation. The t-value of 2.27

for the estimated coefficient of LIPAC means that the estimated coefficient differs from zero at the .95 percent level of confidence. The 95 percent level is commonly used as the lower acceptable cut-off level in regression analysis.

(3) The R-squared (multiple coefficient of determination) indicates the proportion of total variance in the dependent variable that is explained by all the independent variables in the regression equation. In the present example, 99 percent of the variance in GAAA is explained by CMP and LIPAC. The domain of this statistic is zero to one. Further, the example presents the "corrected" R-square; that is, the R-square adjusted for the degree of freedom. The corrected R-square is more useful than the R-square unadjusted for degrees of freedom, because the former can be used to compare different versions of equations (i.e., equations with different degrees of freedom) attempting to estimate the same dependent variable. It would be misleading to compare the unadjusted R-square among equations with different degrees of freedom.

(4) The Durbin-Watson statistic tests for autocorrelation in the data. Autocorrelation means that one observation or data point tends to be correlated with the next. While some computer programs provide an option for adjusting the estimated coefficient for first order autocorrelation, some do not. If significant autocorrelation is present, the magnitude of the estimated coefficients will be distorted (generally underestimated) and the R-square cannot be believed with any degree of confidence. Tables of the Durbin-Watson statistic are available in many econometric texts. For the given number of independent variables ($k = 2$) in equation (3–1) and the given sample size ($n = 15$), there are two values in the Durbin-Watson tables, forming the lower (d_L) and upper (d_U) bound, for testing the significance levels of the computed Durbin-Watson statistic ($d = 1.61$). If the computed d is less than d_L, positive autocorrelation exists. If the computed d falls between d_L and d_U the test is inconclusive; that is, one simply is not sure if autocorrelation is present. If the computed d is greater than d_U, autocorrelation is not present. This test may be conducted at either the 1 percent or the 5 percent level of significance; the latter is the commonly used cut-off level. For the example above, with $n = 15$ and $k = 2$, the Durbin-Watson table shows $d_L = .81$ and $d_U = 1.07$ at the 1 percent level of significance. Since the computed d is 1.61, greater than the upper bound, there is no positive autocorrelation. It should be noted that for values of the computed d greater than 2, the forecaster must also test against the hypothesis of negative first-order autocorrelation. This is done by subtracting the computed d from 4 and refer to the table values of d_L and d_U as if one were testing for posi-

(5) Before concluding the discussion on regression analysis, it should be noted that if a plot of the data reveals a nonlinear relationship between the dependent and independent variables, this should be accounted for in the model. A nonlinear relation may be incorporated in the model in several ways. For example, if the relationship between the dependent and an independent variable is the general form of a parabola, the forecaster feeds in the data on the dependent variables (Y) and the independent variable (X). For convenience, X may be renamed X_1 and the computer asked to generate $X2 = X_2$. The regression is then run as $Y = c + b_1X_1 + b_2X_2$. All of the foregoing analysis applies to the results. If there is more than one independent variable having a nonlinear relationship with the dependent variable, the multiplicative (log-linear) form may be used. For example, the general functional form may be $Y = CX_AQ_B$ where A and B are the exponents. Taking the log of this function gives $\ln Y = \ln C = A \ln X + B \ln Q$.

Since most regression programs have the log transformation built in, there is no need to look up the logs of the historical data. The regression program, in most cases, will perform the transformation and compute the regression coefficients on the transformed variables. If the log-linear form is used, the forecaster should be aware that the estimated coefficients (A, B) are elasticities and should be interpreted as the percent change in the dependent variable resulting from a one percent change in the independent variable. Further, the forecaster should be aware that a regression line fitted to the observed data via the log form, will have the same elasticities everywhere. Since elasticities are likely to change, especially over the forecasted period, the forecaster should be aware of this peril.

D. **Assumptions.** Having satisfied all of the above requirements, the forecaster now has a viable model (equation) which may be used to generate forecasts of the desired aviation variable. The fourth step in the forecasting procedure involves making assumptions about the future course of the economic (independent) variables. This is a particularly sensitive part of any forecast because we do not know the future with certainty. Various Government agencies and private forecasting services provide forecasts for numerous national, state, and regional socioeconomic and demographic variables. If the level of disaggregation (or for other reasons) of the independent variables is such that the forecasts cannot be obtained in this manner, the forecaster may also draw on his own expertise (or other recognized experts in the field) for assumptions as to the future course of the independent variables.

E. **Substitute.** The final step in the forecasting procedure is to substitute the forecasted values of the economic variables into the forecasting equation. This is strictly an arithmetic procedure. For example, if the historical data base used to generate the regression equation extends from 1960 to 1974, the forecasted values for 1975 through the end of the forecasted period are substituted for the independent variables. The mathematical operation, as indicated by the regression equation (3–1), is performed and the result is one forecasted value for each year.

GLOSSARY OF TERMS

AERIAL APPLICATION

Aerial application in agriculture consists of those activities that involve the discharge of materials from aircraft in flight and a miscellaneous collection of minor related activities that do not require the distribution of any materials.

AIRCRAFT CONTACTED

Aircraft with which the Flight Service Stations have established radio communications contact. One count is made for each enroute, landing or departing aircraft contacted by Flight Service Station regardless of the number of contacts made with an individual aircraft during the same flight.

AIRCRAFT OPERATION

An aircraft arrival at or departure from an airport with FAA airport traffic control service. There are two types of operations—local and itinerant.

1. Local operations are performed by aircraft which:
   - (a) Operate in the local traffic pattern or within sight of the tower.
   - (b) Are known to be departing for, or arriving from, flight in local practice areas located within a 20-mile radius of the control tower.
   - (c) Execute simulated instrument approaches or low passes at the airport.
2. Itinerant Operations:
   All aircraft arrivals and departures other than local operations.

AIRPORT TRAFFIC CONTROL TOWER

A central operations facility in the terminal air traffic control system, consisting of a tower cab structure, including an associated IFR room if radar equipped, using air/ground communications and/or radar, visual signaling and other devices, to provide safe and expeditious movement of terminal air traffic.

AIR ROUTE TRAFFIC CONTROL CENTER

A central operations facility in the air route traffic control system using air/ground communications and radar, primarily providing enroute separation and safe, expeditious movement of aircraft operating under instrument flight rules within the controlled airspace of that center.

AIR TAXI OPERATIONS

Air taxi operations and commuter air carrier operations (takeoffs and landings) carrying passengers, mail or cargo for revenue in accordance with FAR Part 135 or Part 121.

AIR TAXI OPERATORS

Operators of small aircraft "for hire" for specific trips. They operate under CAB Part 298 and FAR 135 which apply to aircraft of 12,500 pounds or less except under special exemption.

AIR TRAFFIC HUB

Air traffic hubs are not airports; they are the cities and Standard Metropolitan Statistical Areas requiring aviation services and may include more than one airport. Communities fall into four classes as determined by each community's percentage of the total enplaned passengers.

Large: 1.00% (2,071,729 passengers and over in FY 1976)

Medium: 0.25% to 0.99% (Between 517,932 and 2,071,728 passengers in FY 1976)

Small: 0.05% to 0.24% (Between 103,586 and 517,931 passengers in FY 1976)

Nonhub: Less than 0.05% (under 103,585 passengers in FY 1976)

ALL-CARGO CARRIER

One of a class of air carriers holding certificates of public convenience and necessity issued by the CAB, authorizing the performance of scheduled air freight, express, and mail transportation over specified routes, as well as the conduct of nonscheduled operations, which may include passengers.

APPROACH CONTROL FACILITY

A terminal air traffic control facility providing approach control service.

AVAILABLE SEAT-MILES

The aircraft miles flown in each flight stage multiplied by the number of seats available on that stage length for revenue passenger use.

BUSINESS TRANSPORTATION

Any use of an aircraft not for compensation or hire by an individual for the purposes of transportation required by a business in which he is engaged.

CERTIFICATED ROUTE AIR CARRIER

An air carrier holding a certificate of public convenience and necessity issued by the Civil Aeronautics Board to conduct scheduled services over specified routes. Certain nonscheduled, or charter, operations may also be conducted by these carriers.

COMMON IFR ROOM

A highly automated terminal radar control facility. It provides terminal radar service in an area encompassing more than one major airport which accommodates instrument flight operations.

COMMUTER OPERATOR

Operators of small aircraft of a maximum size of 30 seats and a 7,500 pound payload, who perform at least five scheduled round trips per week between two or more points or carry mail. They operate under CAB Part 298, FAR 135, and at times FAR 121.

CONTRACT OPERATOR

An air carrier operating on a private for-hire basis, as distinguished from a public or common air carrier, holding a commercial operator certificate (issued by the FAA under FAR 121) authorizing the carrier to operate aircraft over 12,500 pounds for the transportation of goods or passengers for compensation or hire.

GENERAL AVIATION

All civil aviation activity except that of certificated route air carriers and air commuter operations. The types of aircraft used in general aviation (G.A.) activities cover a wide spectrum from corporate multiengine jet aircraft piloted by professional crews to amateur-built single-engine piston acrobatic planes, balloons and dirigibles.

IFR AIRCRAFT HANDLED

The number of IFR departures multiplied by two plus the number of IFR overs. This definition assumes that the number of departures (acceptances, extensions, and originations of IFR flight plans) is equal to the number of landings (IFR flight plans closed).

INDUSTRIAL/SPECIAL FLYING

Any use of an aircraft for specialized work allied with industrial activity; excluding transportation and aerial application. (Examples: *pipeline patrol; survey;* advertising; photography; helicopter hoist; etc.)

INSTRUCTIONAL FLYING

Any use of an aircraft for the purposes of formal instruction with the flight instructor aboard or with the maneuvers on the particular flight(s) specified by the flight instructor.

INSTRUMENT OPERATION

An aircraft operation in accordance with an IFR flight plan or an operation where IFR separation between aircraft is provided by a terminal control facility or air route traffic control center.

INTERNATIONAL AND TERRITORIAL OPERATIONS

Operators of aircraft flying between the 50 States of the United States and foreign points, between the 50 States and U.S. possessions or territories, and between foreign points. Includes both the combination passenger/cargo carriers and the all-cargo carriers engaged in international and territorial operations.

DOMESTIC TRUNK CARRIERS

One of a group of certificated route air carriers which operates primarily within and between the 50 States of the United States and the District of Columbia over routes serving primarily the larger communities.

EXECUTIVE TRANSPORTATION

Any use of an aircraft by a corporation, company or other organization for the purposes of transporting its employees and/or property not for compensation or hire and employing professional pilots for the operation of the aircraft.

FAA
FLIGHT PLAN

Specified information relating to the intended flight of an aircraft, that is filed orally or in writing with a flight service station or an air traffic control facility.

FLIGHT SERVICE STATION (FSS)

Air Traffic Service facilities within the National Airspace System which provide preflight pilot briefing and enroute communications with VFR flights, assist lost IFR/VFR aircraft, assist aircraft having emergencies, relay ATC clearances, originate, classify, and disseminate Notices to Airmen, broadcast aviation weather and NAS information, receive and close flight plans, monitor radio NAVAIDS, notify search and rescue units of missing VFR aircraft, and operate the national weather teletypewriter systems. In addition, at selected locations, FSSs take weather observations, issue airport advisories, administer airman written examinations, and advise Customs and Immigration of transborder flight.

FOREIGN-FLAG AIR CARRIER

An air carrier other than a U.S. flag air carrier in international air transportation. "Foreign air carrier" is a more inclusive term than "foreign-flag air carrier," presumably including those non-U.S. air carriers operating solely within their own domestic boundaries, but in practice the two terms are used interchangeably.

INTRASTATE AIR CARRIER

A carrier licensed by a state to operate wholly within its borders but not permitted to carry interline passengers from out of state. They are not regulated by the CAB.

LOCAL SERVICE CARRIERS

Certificated domestic route air carriers operating routes of lesser density between the smaller traffic centers and between those centers and principal centers.

OTHER USE FLYING

Use of general aviation aircraft for purposes other than those in specific categories such as business, personal, air taxi.

PERSONAL AND PLEASURE FLYING

Any use of an aircraft for personal purposes not associated with a business or profession, and not for hire. This includes maintenance of pilot proficiency.

PILOT BRIEFING

A service provided by the Flight Service Station to assist pilots in flight planning. Briefing items may include weather information, NOTAMS, military activities, flow control information and other items as requested.

RAPCON

Radar Approach Control Facility (Air Force).

RATCF

Radar Approach Control Facility (Navy).

REGISTERED ACTIVE GENERAL AVIATION AIRCRAFT

A civil aircraft registered with the FAA that has been flown one or more hours during the previous calendar year. Excluded are aircraft owned and operated in regularly scheduled, nonscheduled, or charter service by an air carrier certificated by the Civil Aeronautics Board or aircraft in excess of 12,500 pounds maximum gross takeoff weight owned and operated by a commercial operator certificated by the FAA to engage in intrastate common carriage.

REVENUE PASSENGER ENPLANEMENTS

The count of the total number of passengers boarding aircraft. This includes both originating and connecting passengers.

REVENUE PASSENGER LOAD FACTOR

Revenue passenger-miles as a percent of available seat-miles in revenue passenger services, representing the proportion of aircraft seating capacity that is actually sold and utilized.

REVENUE PASSENGER MILE

One revenue passenger transported one mile in revenue service.

REVENUE TON-MILE

One ton of revenue traffic transported one mile.

SECONDARY AIRPORT

An airport receiving approach control service as a satellite to a primary approach control facility, or one at which control is exercised by the approach control facility under tower enroute control procedures.

SUPPLEMENTAL AIR CARRIER

One of a class of air carriers holding certificates, issued by the CAB, authorizing them to perform passenger and cargo charter services supplementing the scheduled service of the certificated route air carriers. They are sometimes referred to as non-scheduled carriers.

TOTAL FLIGHT SERVICES

The sum of flight plans originated and pilot briefs, multiplied by two, plus the number of aircraft contacted.

U.S.-FLAG CARRIER OR AMERICAN-FLAG CARRIER

One of a class of air carriers holding a certificate of public convenience and necessity issued by the CAB, approved by the President, authorizing scheduled operations over specified routes between the United States (and/or its territories) and one or more foreign countries.