Chapter 4

AVIATION GROWTH SCENARIOS

Photo credit: Federal Aviation Administration

A busy airport terminal

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AVIATION GROWTH SCENARIOS

INTRODUCTION

There is a general consensus that domestic aviation activity will increase over the next 10 to 20 years, and with it the demands placed on the Nation's airports and air traffic control (ATC) system. There is far less agreement, however, about how much growth there will be, how it will be distributed, and how it will affect the future characteristics of the National Airspace System (NAS). As a result, there is uncertainty about where system improvements will be needed, and how soon.

Federal Aviation Administration (FAA) plans for the modernization and expansion of the NAS are predicated on the continued rapid growth of air traffic and ATC workloads. Preliminary figures for the most recent FAA "Aviation Forecasts" indicate that the number of aircraft using the system will double by 2000 and that, between 1981 and 1993, total operations will increase by 56 percent at en route ATC centers, by 60 percent at FAA-towered airports, and by 88 percent at flight service stations.

Accommodating this anticipated demand growth has been a primary justification for proposed investments in system improvements, but FAA's forecasts have consistently proven to be too high in the past. In part, this is due to the way in which they are made: FAA makes its forecasts on the assumption that present trends will continue, that there will be no constraints on growth, and that proposed improvements will in fact be made.

Comparison with other aviation forecasts is difficult, since only FAA projects ATC workloads, but it is of interest that some recent forecasts of other measures of demand have been higher than FAA's. In all such projections, however, there is considerable uncertainty about a number of factors that might affect future growth and system requirements, such as U.S. economic growth, fuel prices and availability, airline profitability, new technology, and the possibility of significantly higher aviation user fees. Industry maturity may lead to a leveling-off of airline operations, and changes in route structure may lead to a more even distribution of these operations throughout the system. Even greater uncertainty surrounds the effects of airline deregulation and the long-term impacts of the Professional Air Traffic Controllers (PATCO) walkout.

As a result of these uncertainties, there are valid questions about the accuracy and usefulness of any projection of aviation activity over 10 or 20 years. At present, no individual projection—including FAA's-should be considered more than a broad estimate. Collectively, such projections indicate a likely range of possible futures for NAS and its ATC requirements; but because they are based on similar assumptions and similar forecasting procedures, they may also be subject to similar errors.

This chapter examines and compares a number of projections, but its main focus is on the procedures and assumptions underlying the aviation forecasts on which FAA will base its 1982 system plan. The purpose of this examination is to provide some sense of the range of possible future demand for aviation facilities and services, in order to assist Congress in making its decisions about long-lived investments in both airports and ATC equipment.

FAA AVIATION FORECASTS

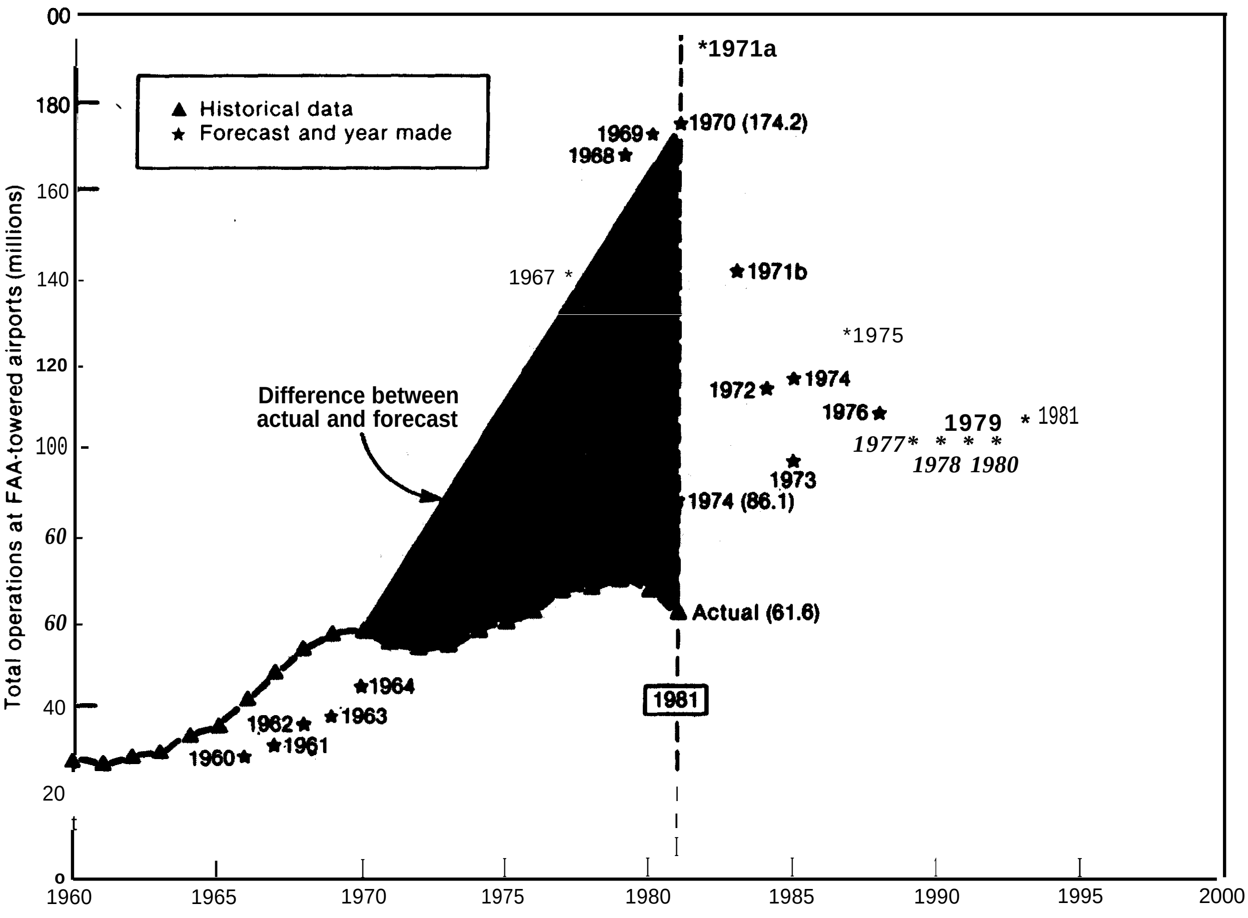
FAA is the most continuous, comprehensive, and detailed source of aviation projections. Its "Aviation Forecasts" are made annually by the Office of Aviation Policy and Plans (OAPP) in support of current operations and as a basis for long-range planning. Many other organizations also use FAA's forecasts as the basis for their own long-range planning activities.

However, FAA has a poor forecasting record: over the past 15 years its predictions have consistently been too high, often by 50 percent or more. Figures 9, 10, and 11 compare past forecasts with actual levels of operations at FAA towers, en route centers, and flight service stations. They show that the workloads originally forecast for fiscal year 1981 were between 50 and 180 percent higher than what actually occurred; in more recent forecasts this level of demand on the ATC system is not expected until the 1990's or later.

Several unforeseeable events combined to cause these errors, including the 1973 oil embargo, sharp increases in fuel prices, rising inflation and interest rates, and airline deregulation. These factors and other pertinent changes in historical trends are now reflected in FAA forecasts, but current expectations may once again be betrayed by unanticipated developments in the future. If key assumptions are overly optimistic, the resulting projections will once again be too high.

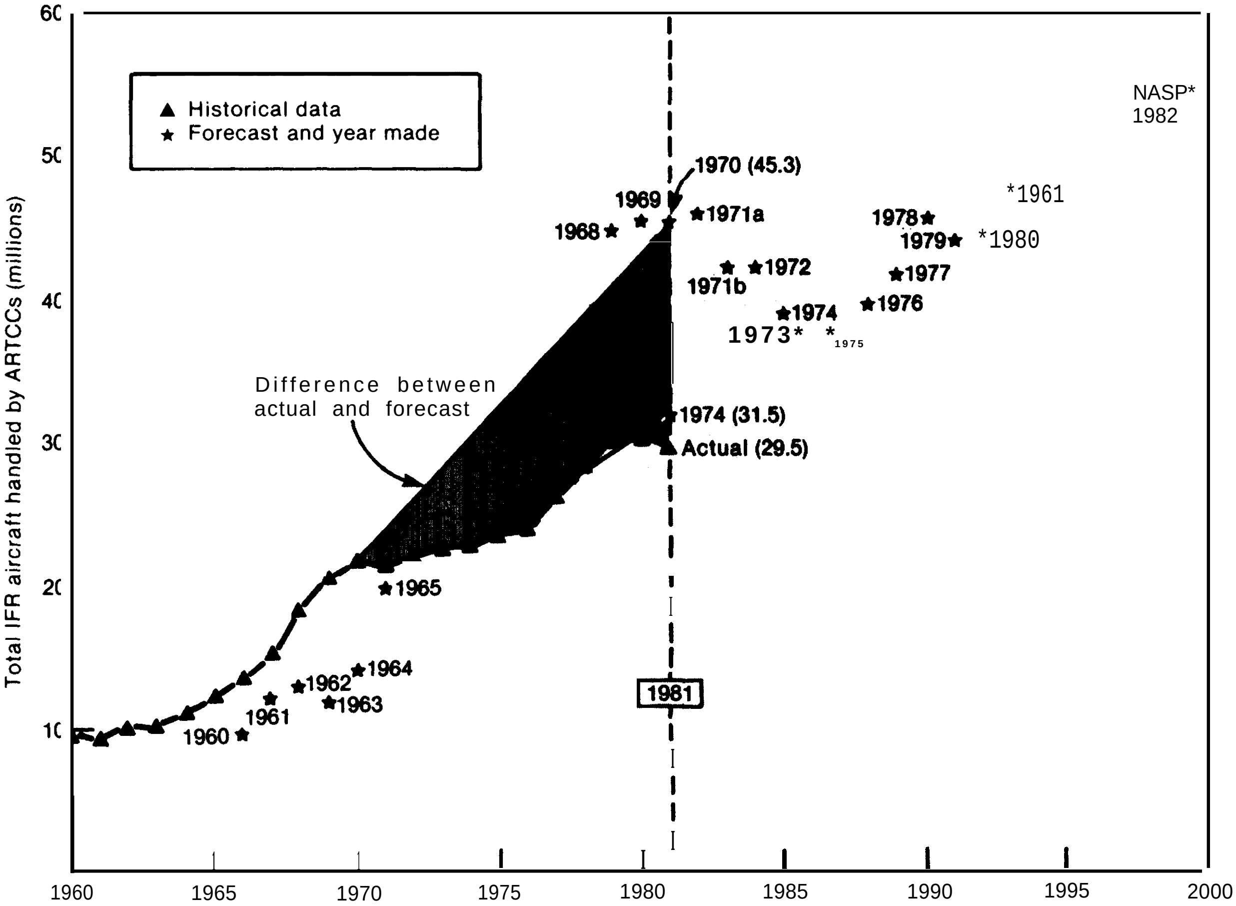
Three sets of FAA forecasts were compared in detail for this review: those of September 1978, which predate the Airline Deregulation Act, and those of 1979 and 1980. The year-by-year forecasts for 1982-93, due in October 1981, were "sent to the shredders instead of the printers" (in the words of the Director of OAPP) because the

Figure 9.— FAA Tower Workload, Actual and Forecast, 1960-93



Source. Off Ice of Technology Assessment, from Federal Aviation Administration data.

Figure 10.— FAA En Route Workload, Actual and Forecast, 1960-2000



Source Office of Technology Assessment, from Federal Aviation Administration data

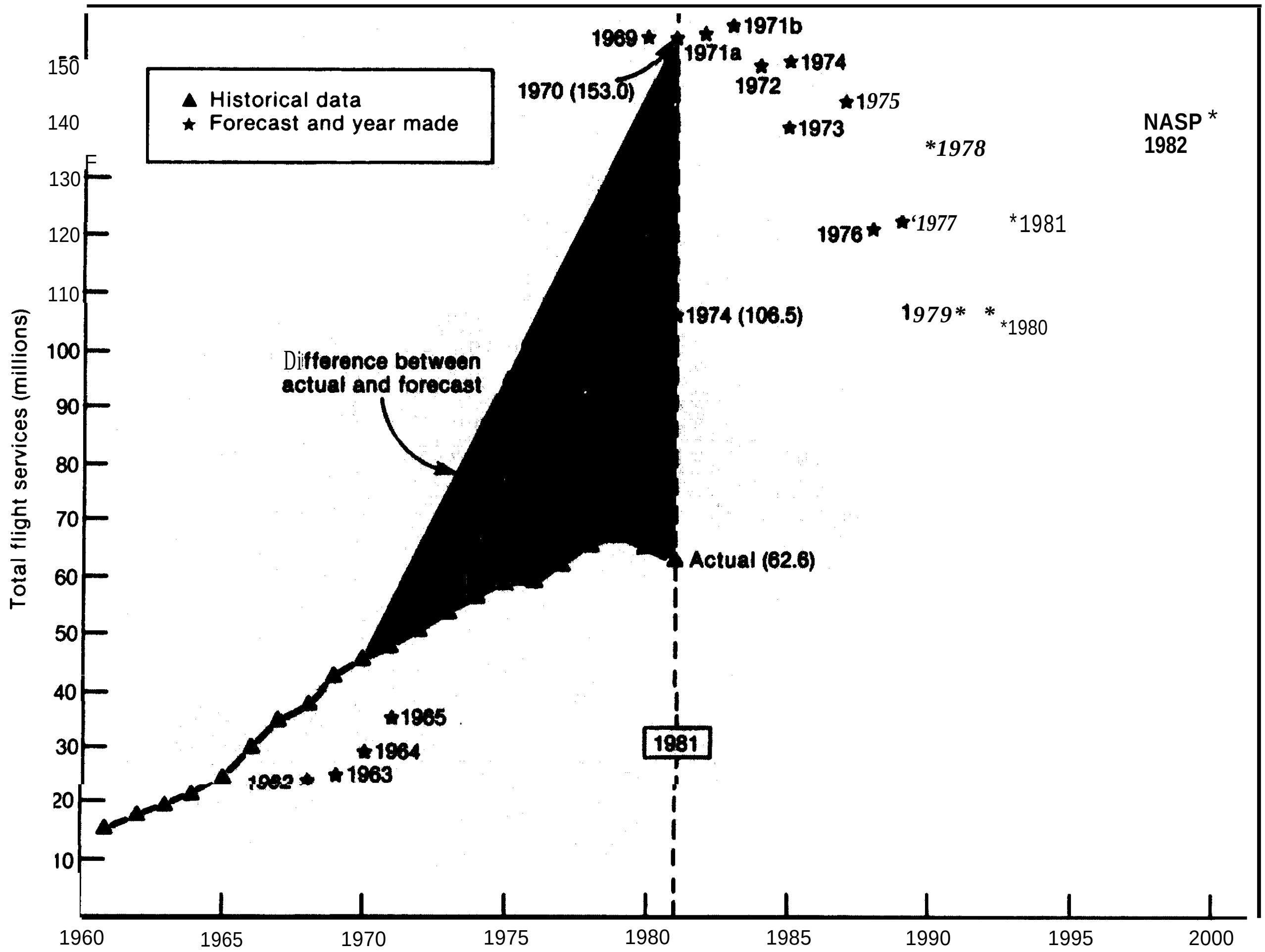
uncertain impacts of the PATCO walkout had invalidated the short-term projections. Preliminary long-term figures only are used in the following discussion and accompanying graphics, but these projections are somewhat higher than those of 1980 despite a decline in overall activity since 1979. Forecasting procedures, assumptions, and scenario specifications are based on the last published forecast, that of September 1980.

Baseline Scenarios: Procedures and Assumptions

As described in the 1980 "Aviation Forecasts, " FAA predictions are based on a combination of econometric modeling, trend extrapolation, and expert judgment. Forecasts of key economic indicators are prepared by Wharton Econometric Forecasting Associates, Inc., using their long-term industry and economic forecasting model. In the withdrawn 1981 forecasts, however, the baseline scenario is based on economic projections supplied by the Office of Management and Budget (OMB) rather than the Wharton model. Aviation activity levels and ATC workloads are derived from these economic indicators by means of aviation submodels designed and run by FM itself.

The baseline (or most probable) projections are based on the general assumption of unconstrained growth—that past trends will continue and that there will be no change in the relationships between economic activity and aviation variables. Specific assumptions about the various user groups include the following:

Figure 11.— FAA Flight Service Workload, Actual and Forecast, 1960-2000



Source. Of fice of Technology Assessment, from Federal Aviation Administration data.

- *Federal* policy—no change in Government policy toward the aviation industry (i.e., airline deregulation goes forward, existing noise and pollution standards are implemented, but no new environmental or policy constraints—such as higher user fees—are imposed).
- *General aviation* —continued rapid growth of business and commercial GA (i. e., larger turboprops and jets used as corporate aircraft or air taxis) and continued availability of aviation fuel, although prices rise more rapidly than the consumer price index.
- *Air* carriers—additional mergers, resulting in route optimization and more efficient fleet utilization, and continued replacement of older equipment with larger, quieter, more fuel-efficient aircraft.
- *Commuter carriers-a* decrease in the number of carriers as competition leads to mergers, no loss of competitiveness with the personal automobile, increases in average aircraft size and stage length, and a relatively stable, mature industry after 1984.
- *FAA* workloads—increases in the number of FAA-towered airports and terminal control areas, which will tend to increase the number of IFR operations and flight plan filings, and greater utilization of flight services due to increased convenience and improved services.

Photo credit: Business and Commercial Aviation Magazine

Business and commercial aviation—a growing sector

Alternative Scenarios

Because of the uncertainties involved in trying to predict the future, FAA forecasts include not only a baseline scenario (the most likely foreseeable outcome) but also alternative scenarios that reflect what might happen if there were major changes in the driving economic, societal, or political factors. Higher and lower economic projections from the Wharton model are run through FAA aviation submodels, and the formal techniques of trend-impact analysis and cross-impact analysis are used to determine the further effects of other events or changes.

Because FAA varies several factors at once, however, it is difficult to assess the sensitivity of the projections to changes in any specific variable. In some cases, moreover, the scenario specifications are so extreme that they undermine the credibility of the resulting projections. Finally, the resulting range of possible outcomes over an 12-year projection is so wide that the alternative scenarios may be of little value for long-range planning purposes. In the 1980 forecasts, for example, the alternative projections of FAA workloads in 1993 were as much as 40 percent higher *or 25* percent lower than the baseline. This "range of uncertainty" has increased in recent forecasts (see below).

In 1978 and 1979 there were two alternatives, "high prosperity/slow growth" and "rapid growth/stagflation," respectively. In 1980 there were three alternatives, with the following scenario specifications:

- *"Economic* expansion"—rapid economic growth accompanied by a resurgence of the work ethic, attempts to reestablish U.S. military and economic preeminence in the world, easing of Federal environmental *re*strictions and market intervention, "tremendous increases" in user fees (especially GA) for airports and ATC services as Federal subsidy of system costs is eliminated, but strong growth in corporate and per**sonal** flying due to continued business dispersal and mobile lifestyles.
- *"Energy* conservation"—aviation becomes a "special target" of Federal efforts to achieve energy independence through regulation and taxation, U.S. lifestyle shifts toward that of "a more slow-paced culture," increasingly stringent environmental standards and the closing of some metropolitan airports, reestablishment of Federal control over airline routes and fares, and severe constraints on GA (including higher user fees, fuel rationing, and banning from hub airports).
- *"Stagflation"* -prolonged worldwide ***reces***sion, strong Federal intervention through nationalization and reorganization of aviation and other industries, severe rationing

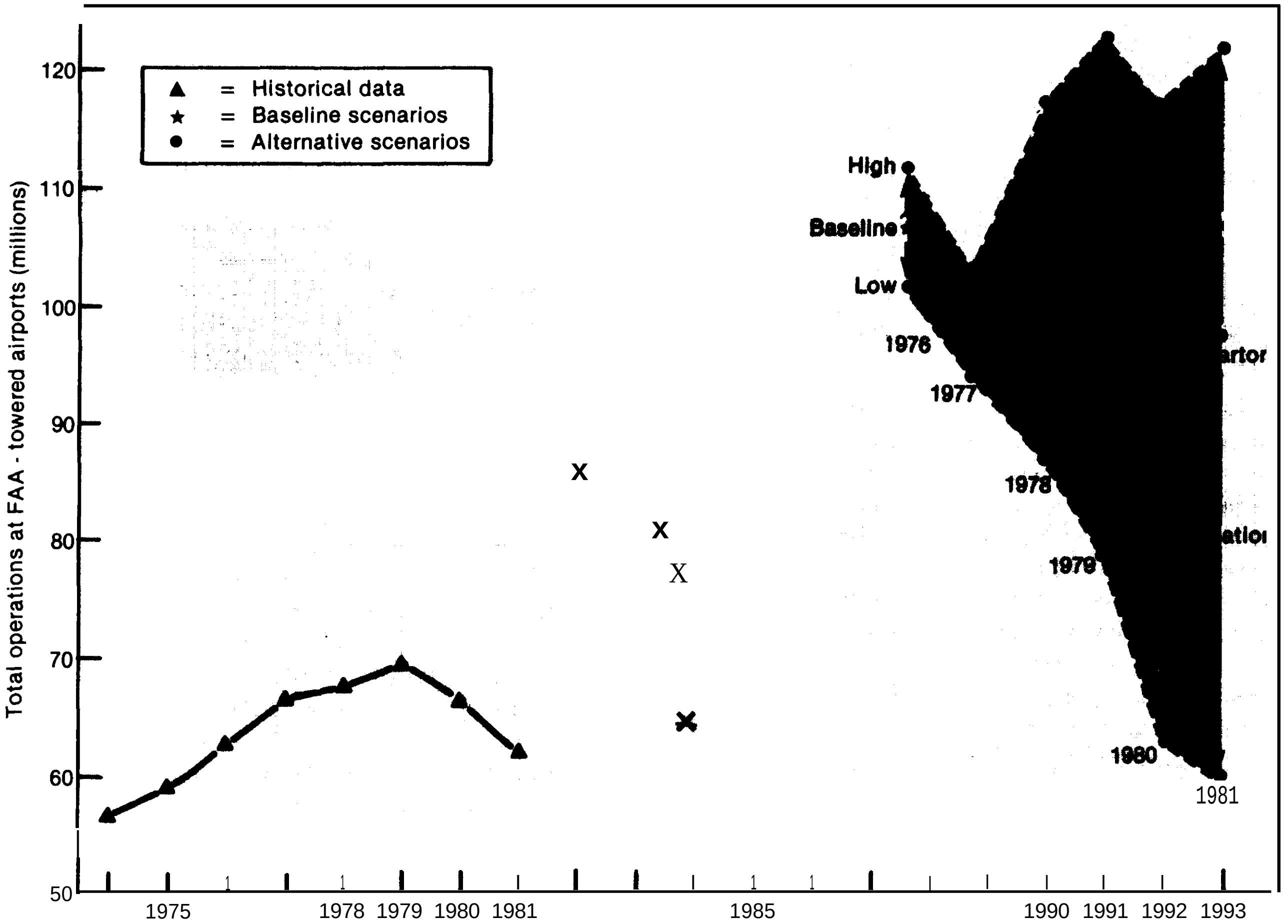
and high prices to encourage energy conservation, increased defense spending and welfare costs, Federal aid keeps major hubs open but many GA airports close and air service to small communities deteriorates, and both business and government make more use of teleconferencing and other substitutes for personal travel.

Preliminary projections for the 1981 "Aviation Forecasts" also include three alternative scenarios: "economic expansion, " "Wharton Econometric Model, " "stagflation. " The middle scenario reflects the baseline Wharton economic indicators and would have been called the "baseline" scenario in past years; the 1981 baseline, however, is based on OMB's economic projections, which are closer to those of 1980 "economic expansion" scenario (3.6 and 3.9 percent average real GNP growth per year, respectively). "Energy conservation" was dropped; the specifications for the other scenarios remain the same as for 1980.

FAA projections of ATC workloads from recent "Aviation Forecasts" are presented in figures 12 through 15. Several features of these projections are worth noting:

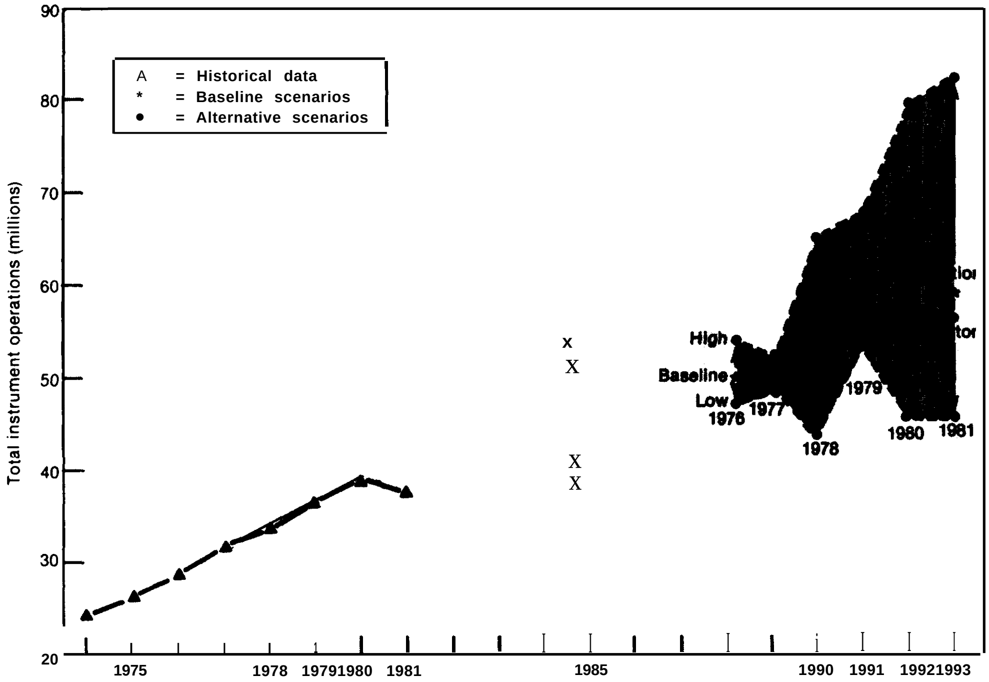
- the spread between high and low projections has increased dramatically, suggesting greater uncertainty about future trends;
- the overall range of the projections is lower, suggesting less-confidence 'about the probability of rapid growth;

Figure 12.—Tower Operations, Actual and Forecast, 1974-93



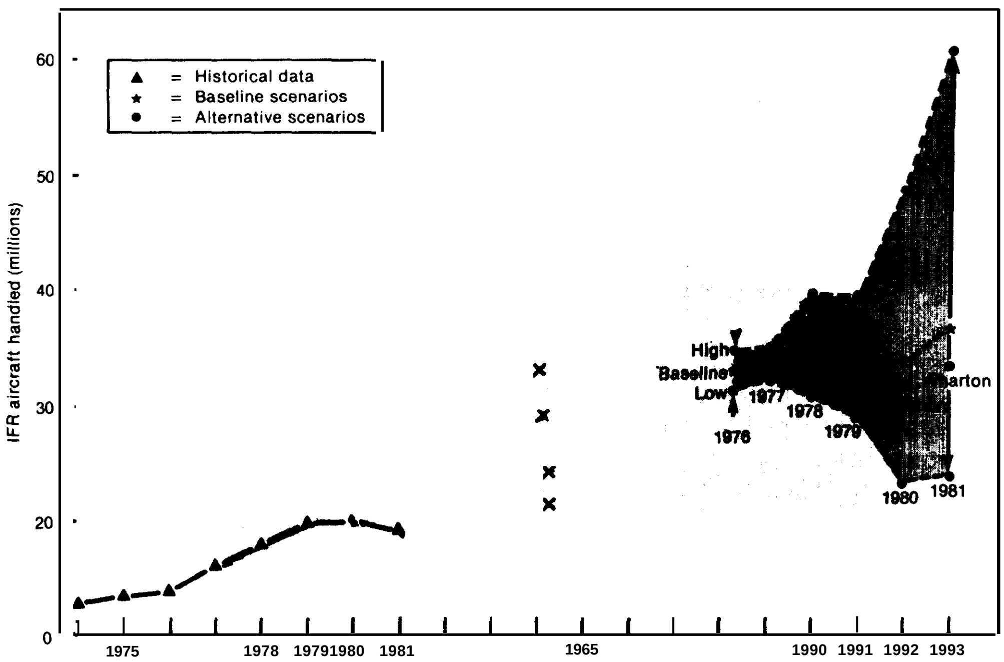
SOURCE: Office of Technology Assessment, from Federal Aviation Administration data.

Figure 13.—Instrument Operations, Actual and Forecast, 1974-93



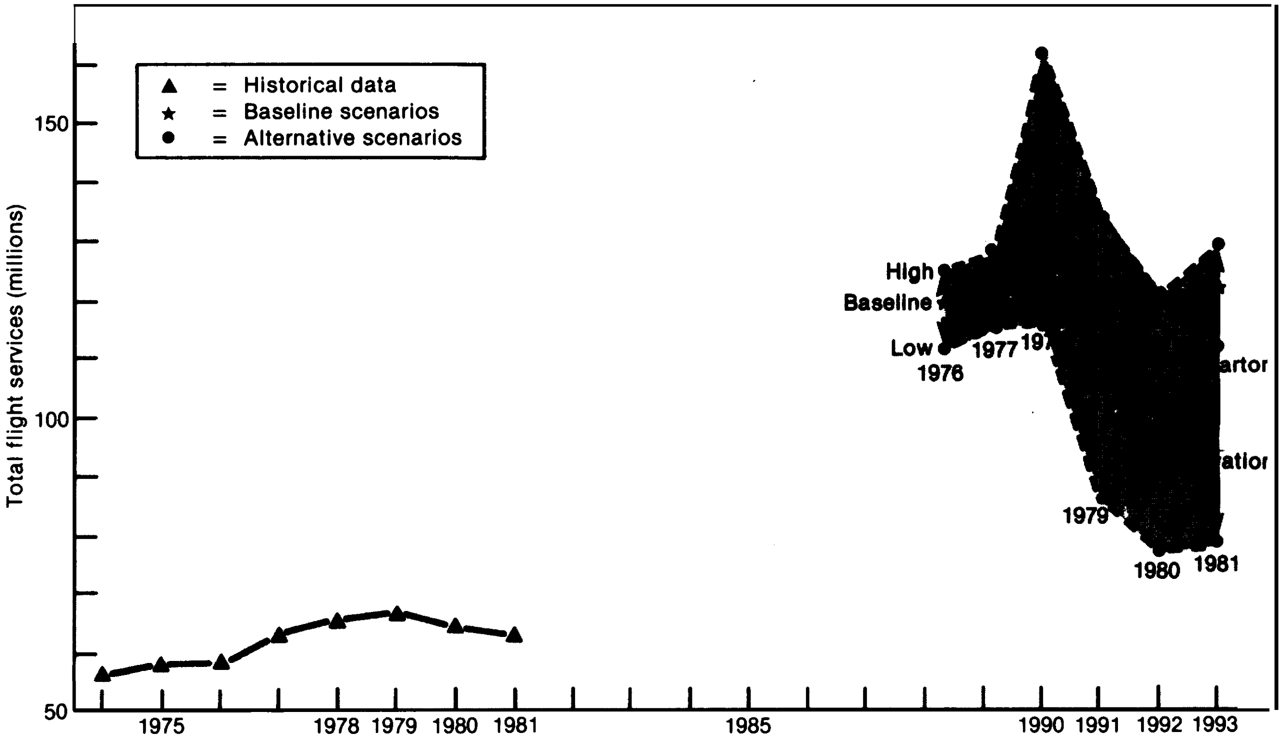
SOURCE: Office of Technology Assessment, from Federal Aviation Administration data.

Figure 14.—IFR Aircraft Handled by En Route Centers, Actual and Forecast, 1974-93



SOURCE: Office of Technology Assessment, from Federal Aviation Administration data.

Figure 15.—Total Flight Service Station Activities, Actual and Forecast, 1974-93



SOURCE: Office of Technology Assessment, from Federal Aviation Administration data.

- the baseline projections, on which FAA bases its system plans, have nevertheless moved from the middle of the overall range toward the upper end; and
- the baseline projections are higher in 1981 than in 1980, despite changes in the historical data that would seemingly have caused them to be lower.

The reason for the growing uncertainty in recent "Aviation Forecasts" is not immediately clear. However, in combination with FAA's poor forecasting record in the past (see figs. 9, 10, and 11), it raises questions about the usefulness of FAA forecasts as a guide to decisions about long-term investments in system improvements and expansion.

OTHER AVIATION FORECASTS

Long-range forecasts of aviation activity are also made by a number of organizations other than FAA, including airlines, aerospace manufacturers, investment firms, and private consultants. The scope and emphasis of these forecasts differ according to the purposes and interests of those who make them; understandably, only FAA projects FAA workloads. Nevertheless, they follow the same general approach and employ the same general techniques of analysis and projection. In some cases, however, there are significant differences in their assumptions about the specific variables, trends, or events relevant to the future growth of domestic aviation.

OTA reviewed several forecasts about which the available documentation was sufficiently detailed to permit comparison with FAA projections:

- *Boeing Commercial Aircraft Co,* —These forecasts aim primarily at identifying the world market for aircraft in the commercial fleet, rather than the level or patterns of airline operations. Two sets of projections were reviewed: "Dimensions of Airline Growth" (March 1980) and "Current Market Outlook" (November 1981); both are based on economic projections from Case Econometrics.

- *Transportation Research Board (TRB).* — This is not a regularly published forecast but rather a result of the ongoing activities of the Aviation Forecasting Committee of TRB, which is part of the National Research Council of the National Academy of Sciences. Published in August 1981 as "Assumptions and Issues Influencing the Future Growth of the Aviation Industry," the forecast represents the consensus of forecasting workshop participants representing most segments of the aviation community.
- *Office of Technology Assessment (OTA).* — These projections were commissioned by OTA to provide different kinds of information than was provided by the other major forecasts. In particular, its structure and assumptions are designed to project the *distribution* as well as the *volume* of future aviation activity, in order to determine its impact on airport congestion and ATC capacity (see below). It is thus a "conditional" forecast, since its different assumptions require a change in current traffic patterns and industry structure.
- *Other Aviation Forecasts.* —Recent updates to the 1975 Air Transport Association (ATA) forecast became available during the course of this study, as did the most recent edition of Lockheed-California Co. 's regularly published "World Air Traffic Forecast." The ATA forecast focuses on the financial performance and capital needs of the airline industry, while the Lockheed report emphasizes international rather than domestic traffic. However, neither report presents its forecast on a level of detail consistent with the above forecasts, and as a result they are given only cursory treatment in the discussion that follows. The judgments and informal forecasts of a number of other sources have also been considered in OTA's analysis.

Forecast Structures and Assumptions

Table 4 presents the specific features and results of the six forecasts that have been studied in detail. In each case, the forecast begins by assuming the macroeconomic indicators that are believed to be the driving force behind air traffic growth, and then uses these variables to generate the growth rates and absolute levels of aviation activity at the end of the forecast period. Although disposable personal income (DPI) appears to be the most important driving variable in most of the forecasts, the direct link between macroeconomic forecasts and traffic forecasts is seldom explictly given.

On the basis of their economic projections, the forecasts then derive growth rates and actual levels of commercial air traffic in terms of revenue passenger miles (RPMs). FAA and OTA forecasts are the only ones that include explicit reference to GA operations; given the increasing importance of GA activity, its absence is a major shortcoming in the other forecasts. Similarly, only FAA's "Aviation Forecasts" proceed from traffic levels to FAA workloads; lacking this further analysis, the other major forecasts (including OTA's) are useful only for purposes of comparison in evaluating the traffic growth and aircraft fleet mixes that the ATC system would need to accommodate.

All of the projections include alternative scenarios that reflect different assumptions about economic growth, typically referred to as low, medium, and high. The most recent FAA forecasts contain four scenarios, but only the baseline scenario is described in detail. Beyond these scenario specifications, none of the forecasts postulates specific events that might affect traffic growth of system evolution; all of them assume—explicitly or implicitly—that no "major catastrophe" will occur. (The PATCO strike and subsequent traffic restrictions may not constitute such a catastrophe, but they do affect the short-term prospects of growth and may affect long-term patterns. This has created sufficient

Table 4.-Comparison of Selected Economic Assumptions and Aviation Growth Predictions

Forecast		Real GNP[a] growth (percent/year) 1979-86	Real GNP[a] growth (percent/year) 1986-91	Real DPI[b] growth (percent/year) 1979-86	Real DPI[b] growth (percent/year) 1986-91	RPM[c] growth (percent/ year) 1979-86	RPM[c] growth (percent/ year) 1986-91	RPMs 1991 (millions)	Load factor 1991 (percent)
FAA 1978	high	4.4	4.6	4.4	4.4	6.8	4.6	406	60.0
	med	3.3	3.2	3.7	3.1	5.4	4.5	369	60.0
	low	2.8	2.5	2.9	2.2	2.8	4.4	308	60.0
FAA 1979	high	4.0	4.9	3.9	5.7	6.0	6.7	426	62.0
	med	2.8	2.8	2.5	2.8	5.5	4.2	365	62.0
	low	2.5	2.1	1.8	1.6	4.4	4.0	336	62.0
FAA 1980	high	3.7		3.8		5.8		405	63.3
	med	2.3	2.9	2.3	3.0	4.8	3.7	341	63.3
	alt	2.9		2.8		4.3		342	63.3
	low	2.1		1.9		3.6		314	63.3
FAA 1981	high	N/A		NIA		N/A		N/A	N/A
	OMB	3.6		3.3		4.9		346	N/A
	med	N/A		NIA		N/A		N/A	N/A
	low	N/A		N/A		N/A		N/A	N/A
Boeing 1980	high	3.0	3.1	N/A		6.5	5.5	434	66.2
	low	2.4	3.0	N/A		4.6	3.9	354	66.2
Boeing 1981	high	3.0		N/A		7.3		358	N/A
	low	2.6		N/A		4.6		336	N/A
TRB 1981	high	4.3	3.5	4.3	3.5	N/A		N/A	N/A
	med	3.2	2.8	3.2	2.8	7.0	7.0	450	63.0
	low	2.4	2.2	2.4	2.2	N/A		N/A	N/A
OTA 1981	high	4.3		4.3		7.5		443	60.0
	med	3.4		3.4		5.5		360	60.0
	low	2.5		2.5		4.1		311	60.0
Range of all forecasts	high	3.0-4.5		3.8-4.6		5.8-7.5		405-600	
	med	2.7-3.6		2.7-3.4		4.3-7.0		341-460	60.0 -66.2
	low	2.0-2.8		1.7-2.5		3.6-4.6		311-450	

[a]Gross national product.
[b]Disposable personal income.
[c]Revenue passenger miles.

uncertainty that FAA has delayed publication of the 1981 forecasts until the impacts can be assessed.)

Comparison and Critique of Forecasts

All of the major forecasts assume roughly similar economic growth rates. FAA's projections have tended to be lower than the others and had become more so in recent years, although the preliminary figures for the withdrawn 1981 forecast reflect OMB's optimism about future economic growth. Nevertheless, given the range of forecast growth rates, the differences between the individual economic assumptions are probably not significant. In terms of aviation-specific factors, there also seems to be general agreement among the projections about variables such as load factors, aircraft size, and stage length.

Not surprisingly, the resulting growth rates for domestic RPMs are also quite similar. OTA's projections for RPMs tend to be at the upper end of the range for all the forecasts. The 1980 FAA forecasts are slightly but not significantly lower than the others. Despite the more optimistic economic assumptions, the 1981 FAA forecasts (if and when published) will probably be somewhat lower as well. Lockheed's corresponding forecast, a single figure of *307* billion RPMs in 1990, is somewhat lower than any of the forecasts included in table 4.

Only the FAA and OTA-commissioned forecasts break down these RPM figures into projections of air carrier operations by type. FAA's operations forecasts are considerably lower than OTA's, particularly in the 1980 forecast. Where the OTA "low" scenario translates 4.1-percent RPM growth into 1.5-percent annual growth in air carrier operations, the 1980 FAA "baseline" scenario shows 4.3-percent RPM growth but no operations growth, and the FAA "stagflation" scenario translates 3.6-percent RPM growth into a 0.8-percent decline in operations. As a result, OTA's forecast range for air carrier operations in 1991 is 12.1 million to 19.6 million, while the FAA's is 9.2 million to 15.5 million. The corresponding projection from the Air Transport Association, reflecting the judgments of its airline members, is for 10.4 million air carrier operations in 1990. The overlap between these projections is sufficiently wide that the differences are probably not significant, particularly when structural differences between the models are considered. However, because the forecasts rely on common assumptions, they produce similar results all of which may be in error for the same reasons.

The TRB Aviation Demand Forecasting Committee's 2-day workshop on FAA aviation forecasts resulted in four principal recommendations, all of which also apply to the other forecasts considered here. In the opinion of the workshop participants, the following features are needed by planners and decisionmakers alike:

- high and low estimates of key assumptions to measure the extent of uncertainty about driving variables, and consequently an increase in the number of alternative scenarios (at present the FAA provides complete results only for its "baseline" scenario);
- a variety of techniques rather than a single technique, in order to produce better forecasts or competing scenarios;
- in particular, less reliance on econometric models and more on expert judgment (especially industry experts), taking account of nonlinear economic relationships and noneconomic factors; and
- forecasts of components rather than aggregates alone—regional and local activity rather than national, for instance, and point-to-point traffic levels rather than only total volumes.

FACTORS AFFECTING TRAFFIC GROWTH

The future growth of aviation activity in the United States will be affected by a number of factors that are not or cannot be anticipated adequately or with certainty in the models used for the forecasts discussed above. In some cases these factors may constitute "levers" through which the rate or pattern of growth might be influenced through appropriate policies or programs. In most cases, however, neither the direction nor the impact of these factors can be accurately foreseen. These factors include but are not limited to those discussed below.

U.S. Economic and Regulatory Policy

The preliminary figures for FAA's 1981 forecasts reflect considerable optimism about the implementation and success of the present administration's economic recovery plan. The growth and structure of the aviation system will be influenced significantly by the speed and strength with which the Nation recovers from the current recession. The growth of aviation will also continue to be influenced by air safety and air traffic regulations, by the way in which ATC system costs are apportioned through user fees and aviation taxes, and by the constraints imposed by present and future noise and environmental regulations. The potential impact of these economic and policy factors is uncertain and subject to future changes.

Deregulation

Airline deregulation has destabilized the industry's price and market structures. Some analysts believe that the transition toward a free marketplace is causing overcompetition, which in turn is undermining major airline profitability and reducing their ability to finance badly needed new equipment. Termination of Section 406 and 419 subsidies in 1985 and 1988 will also affect commuter airline profits and may affect air service to as many as 100 small- and medium-size cities. Some analysts feel that the demise of some carriers may be a natural and indeed desirable result of complete deregulation, since the elimination of financially ailing carriers would relieve the overcapacity that currently hinders healthier competitors. Some analysts predict the bankruptcy of a major carrier by mid-1982, and that by 1990 the industry will probably witness considerable consolidation through mergers, acquisitions, and outright failures. The survivors, however, may be in a far stronger financial and competitive position.

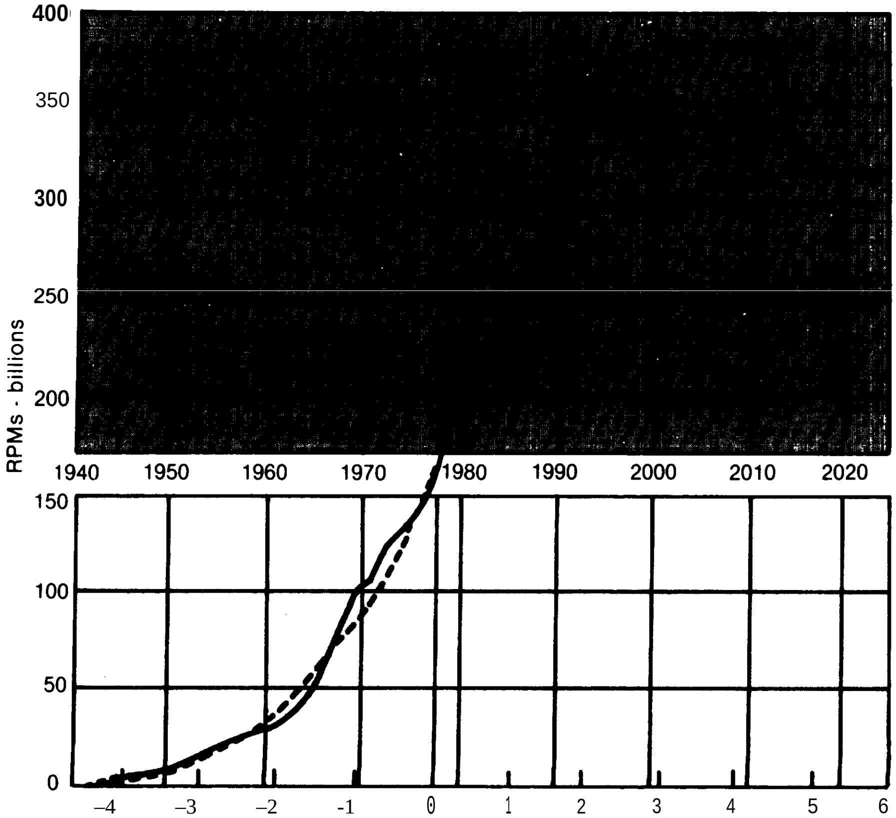
Industry Maturity and Structure

Rolls Royce, a major aerospace manufacturer, has suggested that even if positive steps are taken to reduce costs and increase efficiency, the U.S. airline industry has already reached about 60 percent of its mature size (see fig. 16). Others put the figure at closer to 80 percent. If this is so, then major air carrier passenger traffic may begin to level off before the end of the century, and tower operations might actually decline. The continued growth of commuter carriers and GA traffic might nevertheless result in a continued increase in the number of airport and ATC operations beyond 2000, but FAA expects commuters too to become a "stable, mature industry" after 1985 and GA may face growth constraints. It seems likely, in any case, that by 1990 there will be a smaller number of trunk carriers, offering primarily long-haul service; a declining number of specialized carriers, offering low-cost service in major hubs and major markets; and a large number of commuters of various sizes, including some that offer "regional" service.

Fuel and Labor Costs

The greatest uncertainty facing domestic aviation in both the short and the long term is the future price and availability of aviation fuels. This factor is crucial to the continued profitability of the airlines, which depends in a major way on their ability to absorb any differences between the increase in fuel prices and the increase in the CPI. The future course of fuel prices can only be

Figure 16.—Projected U.S. Certificated Air Carrier Growth



SOURCE: Rolls Royce, Inc., *U.S. Airlines Indicators and Projections*, July 1981, guessed at, particularly in view of uncertainty about future OPEC policy and the inherent instability of the Middle East. However, the current "oil glut" and price decreases are probably a transient event in the long-term price trend, although it is less certain whether or how rapidly the real price of fuel will rise in the future. No long-term shortage is expected. There are indications, however, that aviation gasoline (used by smaller piston-engined GA aircraft) may be increasingly difficult to obtain. GA activity is particularly sensitive to fuel prices, but rapid increases are more likely to reduce personal GA traffic than business and commercial GA (corporate and air taxi users, who generate greater demand for ATC services).

Labor costs are also a major factor in air carrier profitability, and airlines can be expected to seek long-term wage and benefit concessions from their unions during the 1982 round of contract negotiations. Financing costs may also become an increasingly important factor in the future.

Technology

Considerable optimism remains about the future impact of advanced air transport technology, but such improvements are likely to be introduced more slowly in the future than over the last 20 or 30 years. Recent improvements in airline efficiency and productivity have come through higher utilization and economies of scale (aircraft size and seating density) rather than technology (aircraft speed or fuel efficiency). Several promising new developments appear to be possible in the near future, but there is a considerable amount of aviation technology currently "on the shelf" that is only beginning to appear in the U.S. fleet. Whether the aerospace industry will continue to develop a new generation of advanced-technology aircraft will depend on the potential market, and this in turn depends on the ability of the airlines to generate profits and/or obtain financing. Several manufacturers have announced plans for a new 150-passenger aircraft for the late 1980's; several new commuter aircraft will be available even sooner. Some near-term increases in fleet efficiency could, however, be achieved by retrofitting engines and making other modifications to existing aircraft.

Financing

Reports by various airline and banking sources indicate that the equipment needs of the U.S. airline industry will impose capital requirements of $50 billion to $100 billion by 1990, compared to total capital additions of only $30 billion between 1960 and 1979 (current dollars). This capital requirement would demand an average annual corporate return on investment (ROI) of 13 to 15 percent for the entire decade. Industry ROI averaged 6.4 percent during the 1970's, and only once—in 1978—has it risen as high as 13 percent. There are signs of increasing reluctance on the part of insurance companies and even banks to provide long-term debt, even when secured by the leveraged-lease financing or equipment trust certificates that were used in the 1970's. Deregulation has further increased the risks and uncertainties of airline financing, although a restructuring of the industry through bankruptcies or mergers (see above) might alter this situation in the future. Without a firm market, furthermore, aerospace manufacturers might be less willing to develop and introduce more advanced aircraft in the future.

Substitution for Air Transport

Very little can be said with any certainty about the future impacts of developments in either substitute transportation modes (such as high-speed trains or, with higher speed limits and gas mileage, the personal automobile) or alternatives to travel (such as advanced telecommunication technologies and corporate teleconferencing). Neither is likely to cut into aviation's long-haul markets, although the industry may find it increasingly difficult to compete with the automobile and train in short-haul markets (under 200 or perhaps even 300 miles).

Strike Impacts

Ironically, the PATCO strike has in effect deregulated the industry by imposing traffic re-

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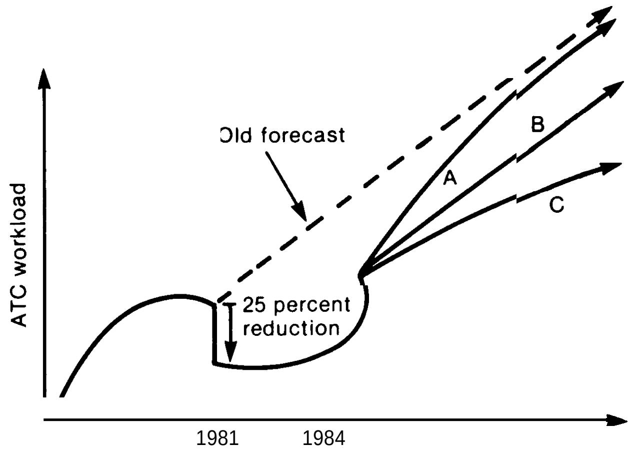
striations on the 22 busiest hubs and by placing severe constraints on GA traffic. Some observers feel that the strike may actually have helped airline profits by removing overcapacity and enabling major carriers to ground inefficient aircraft, lay off personnel, and reduce other costs. On the other hand, these same restrictions impose constraints on GA traffic and on the expansion of commuter carriers and new entrants.

Strike-related traffic restrictions will probably continue for at least 2 more years, and adjustments made by users during this period may permanently change aviation growth trends and traffic distribution. As a result, there is little certainty about the long-term impact on the level of operations: traffic might rebound rapidly, but previously projected levels might not be reached until later than anticipated, if at all (see fig. 17). In addition, these traffic restrictions (particularly at major hubs) could be extended or reimposed in the future as a means of addressing airport congestion and encouraging redistribution of operations to second-tier hubs (see the following section).

Figure 17.–Possible Long-Term Impacts of PATCO Strike on ATC Workload Levels



A = Built-up demand causes rapid recovery and workload quickly matches projected levels.
B = Steady recovery and projected rate of growth, but workload matches projection later than anticipated.
C = Strike stunts demand growth and ATC workload never achieves projected level.

NOTE For Illustrate purposes only, and not based on specific FAA forecasts
SOURCE Off Ice of Technology Assessment

IMPLICATIONS FOR AIRPORT CONGESTION

Despite the uncertainties involved in forecasting precise rates of growth, there is a general consensus that air traffic and the demand for ATC services will increase in the next 10 to *20* years. There is also a consensus that much of this growth will come from the GA sector rather than the airlines, and within the GA sector from business and commercial aircraft rather than personal flying. There is far less agreement on how this growth will be distributed through the system or how it will affect the problem of airport congestion and delay.

FAA forecasts indicate that continued rapid growth of air traffic, if it occurs along existing patterns at existing airports, will result in severe airside congestion at *46* air carrier airports by 2000. FAA's forecasts have consistently overestimated growth in the past, and a number of factors may constrain growth in the future (see above). Nevertheless, airside capacity could become an increasingly serious problem at more of the Nation's airports by the end of the century unless there are improvements in airport capacity or traffic management (see ch. *6).*

An alternative to this prospect, however, is the redistribution of air carrier operations across more of the top *50* airports, in combination with improved facilities at additional GA reliever airports. This alternative is discussed below; specific improvements in ATC technology and airport management that would complement it are examined in chapters 5 and *6*. The economic and aviation growth rates on which the following discussion is based are presented in table 5.

Continued Growth and Airport Saturation

The primary measure of aviation activity as it bears on airport and ATC decisions is "opera-

Table 5.—Aviation Growth Assumptions for "Redistribution" Scenarios, Domestic Service, 48 States

	Jets			Propeller aircraft		
1978:						
Revenue passenger miles		200 billion			1.7 billion	
Operations at top 50 commercial airports.		7.2 million			1.8 million	
	Low economic growth	Average economic growth	High economic growth	Low economic growth	Average economic growth	High economic growth
2000:						
Revenue passenger miles: average annual growth rate ... ...percent...	4.1	5.5	7.5	4.1	5.4	6.9
Revenue passenger miles: year 2000 . . . . billions. .	450	600	900	- 4	- 5	- 7
Operations: average annual growth rate . . . . percent. .	1.6*	2.2*	3.0*	2.4	1.6*	2.4*
Operations at top 50 commercial airports ... ... .millions. .	10*	11 .2*	13'	2.9	2.5*	2.9*

"Assuming effects of airport capacity constraints.

NOTE: Real GNP growth rates: Low 2.5
Average 3.4
High 4.3

tions''—landings and takeoffs, or arrivals and departures (each flight generates two operations). Figure 18 illustrates the 1978 mix of air activity at the top 50 commercial airports, ranked by air carrier operations and aggregated into sets of 5 airports to simplify presentation. Most of the operations at these airports are generated by scheduled passenger flights, but although there are few local operations at the top 15 airports, GA traffic (predominantly corporate aircraft and air taxis) is seldom less than 10 percent of operations.

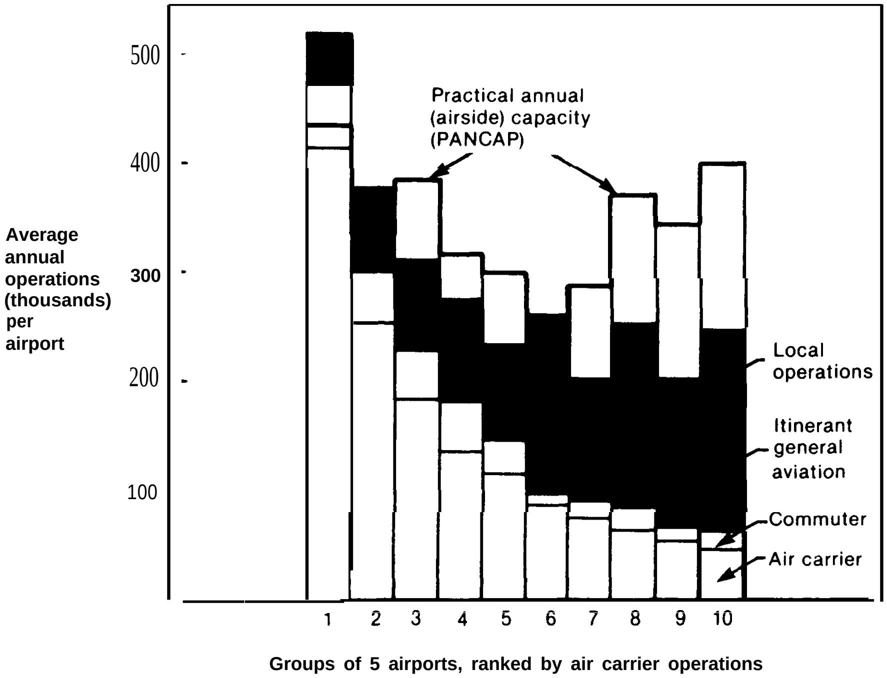
Figure 18 also shows the estimated airside capacity of these airports, expressed in terms of the "practical annual capacity" (PANCAP) that can be handled safely, as estimated by FAA in 1978. Actual airside capacity is variable, however, changing with weather conditions or aircraft mix; the balance is a delicate one, and at busy hubs even a slight deterioration from optimum conditions can cause long lines of delayed aircraft. PANCAP—the level of operations at which 80 percent of aircraft encounter delays of 4 minutes or longer— thus represents an approximate figure based on assumed average utilization of the existing number and configuration of runways, rather than an absolute or reliable measure of capacity.

Saturation—the level at which delay is chronic— may not occur at a given airport until operations are as much as 100 percent *above* PANCAP, so that small differences between actual operations and PANCAP are not necessarily significant. Large differences, on the other hand, indicate a rising probability of encountering delays at the airport at least part of the time. The discrepancy at most of the top 10 airports in figure 18 represents a significant capacity shortage relative to demand (the desired level of operations), and in most cases this situation has existed since the late 1960's. * It is assumed in the following discussion that when operations are more than 10 percent above PANCAP, the result will be airport saturation and chronic delay.

Figures 19 through 21 show the PANCAP, the 1978 level of operations, and the levels of operations in 2000 projected under three aviation growth scenarios. These projections assume that traffic growth will occur at the same rate across existing airports, irrespective of capacity limita-

*The discrepancy between PANCAP and actual operations in the sixth airport group (which includes Phoenix, Fort Lauderdale, Orlando, San Diego, and Portland) does not indicate a significant capacity problem. These airports handle a large volume of GA traffic that is discretionary as to time of day and weather conditions, both of which increase actual capacity over a PANCAP figure.

Figure 18.–Activity at Top 50 Commercial Airports, 48 States, 1978

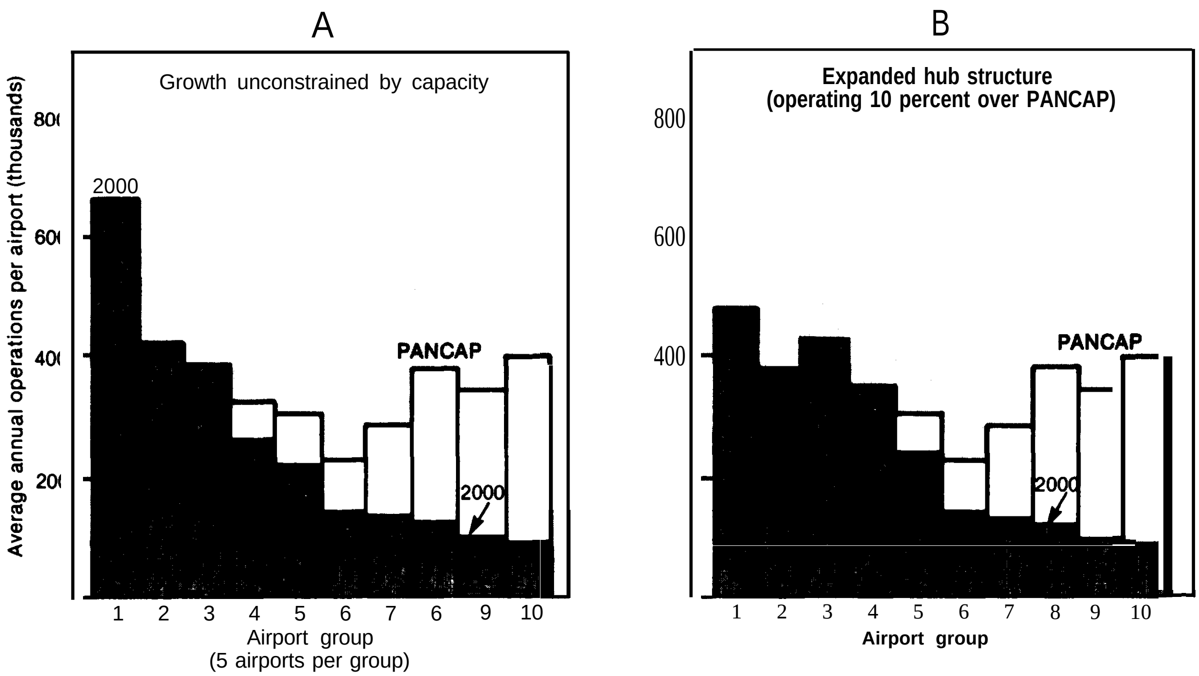


SOURCE: Office of Technology Assessment.

Figure 19.—Airport Airside Capacity Perspective—Low Economic Growth Scenario

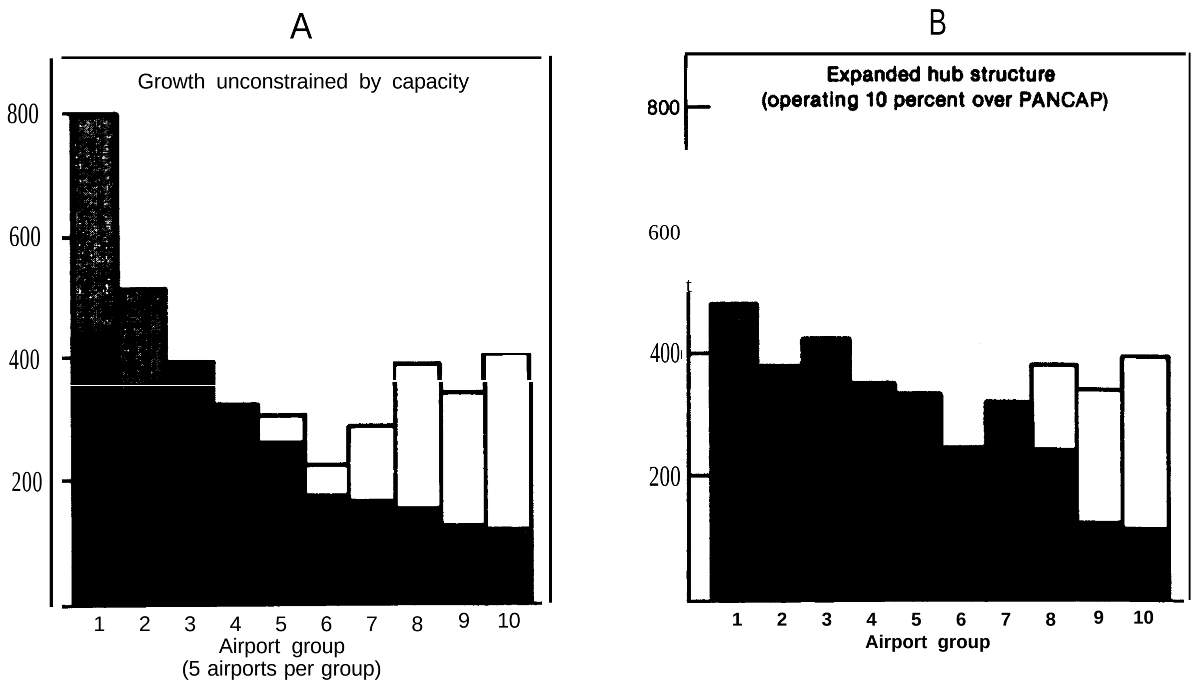
(Jets plus propeller service plus 10 percent for general aviation)

(1.3 percent average growth rate in operations)



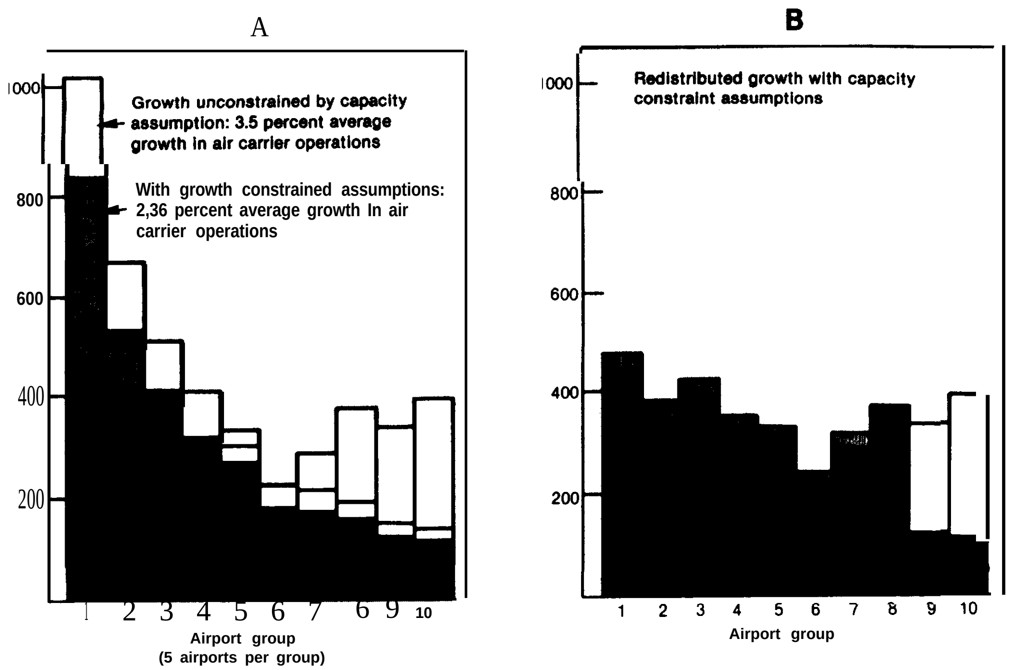
SOURCE: Office of Technology Assessment.

Figure 20.—Airport Airside Capacity Perspective—Average Economic Growth Scenario
(Jets plus propeller service plus 10 percent for general aviation)
(2.3 percent average growth rate in operations)



SOURCE: Office of Technology Assessment.

Figure 21.—Airport Airside Capacity Perspective—High Economic Growth Scenario
(Jets plus propeller service plus 10 percent for general aviation)



SOURCE: Off Ice of Technology Assessment tions. Under conditions of low economic growth, desired operations exceed PANCAP only at the top 10 airports; at the top 5 airports, however, demand will be about 50 percent above PANCAP (fig. 19A). Under conditions of *average economic growth*, **desired operations would exceed PANCAP at the top 20 airports, and traffic at the 5 busiest hubs would be almost 200 percent of PANCAP (fig. 20A). Under conditions of** *high economic growth*, desired operations would be higher than PANCAP at over 30 airports, and the tops hubs would experience almost 250 percent of PANCAP (fig. 21A). To avoid these conditions, the carriers would probably increase aircraft size and drop service points, particularly in short-haul markets, in order to reduce overall operations. This adjustment, also shown in figure 21A, could reduce overall traffic levels by roughly 24 percent, but there would still be serious congestion problems at the top 10 or 15 hubs.

Redistribution of System Operations

In 1978 the level of scheduled commercial operations at the top 50 airports was about 52 percent of their combined PANCAP. However, these operations were heavily concentrated toward the five largest airports (where traffic levels exceeded PANCAP by 20 percent), while considerable excess capacity existed at the other 45 hubs. In addition, over half of the passengers arriving at the five largest hubs did so only to change planes.

OTA examined the effect of redistributing the expected increases in operations to these less crowded airports. In the following discussion it will be assumed that 110 percent of PANCAP—i.e., saturation—represents a desirable level of operations (or an acceptable level of delay) at any given airport. The results, shown on the right side of figures 19 through 21, indicate that the combined existing capacity of the top *50* airports could accommodate substantial increases in commercial operations if they were redistributed.

Low *economic growth* would result in *20* airports at 110 percent of PANCAP, instead of 5 airports at 150 percent (fig. 19 B). *Average economic growth* would result in 38 airports at 110 percent of PANCAP, instead of 10 airports over 150 percent and the top 5 at almost 200 percent (fig. 20B). *High economic growth* would result in traffic levels of 113 percent of PANCAP at all of the top 50 airports even if redistributed, instead of almost 15 airports at 150 percent and the top 5 airports at almost 250 percent; but if airlines respond to capacity constraints by increasing aircraft size and dropping some service points, as well as redistributing operations, the result would be levels of 110 percent of PANCAP at only 38 of the top so air carrier airports (fig. 21 B).

Such a redistribution would be accomplished primarily by "rehubbing" airline route structures-that is, by moving the interline function (that of providing a transfer point) from congested airports to the "second tier" hubs where excess capacity still exists. There are indications that such changes in the airline network are already taking place. United Airlines, for instance, has been shifting some of its operations from Chicago-O'Hare to St. Louis over the past 5 years; in addition, Denver (the western hub) has been growing in importance relative to Chicago in United's overall system. Similar shifts by other carriers can be detected from Chicago to Kansas City, from Atlanta to Birmingham, from Dallas-Fort Worth to Houston, from Miami to Tampa, and from Memphis to Nashville. FAA, for its part, has been trying for years (with only limited success) to shift airline operations from Washington-National to Dunes International.

Market forces will continue to promote this redistribution, as will the traffic restrictions imposed by FAA at the 22 largest hubs as a result of the PATCO strike. Direct-service links already exist between most of these new transfer hubs, but the frequency and aircraft size of traffic between them would increase. Nevertheless, some hub airports will continue to experience higher than desirable levels of traffic and delays unless further measures are employed, such as peak-hour landing fees, access quotas, or slot-allocation schemes. Commuter airlines would be hardest hit by these restrictions, and even with new hubs available they would be hard pressed to improve service at existing points or add new service points to their networks. In addition, it would eventually be necessary to shift most GA traffic out of the top 20 or more airports (down to the supposedly "irreducible" 10 percent), which implies the need for improved facilities at reliever and other IFR-equipped airports if future GA growth is to be accommodated.

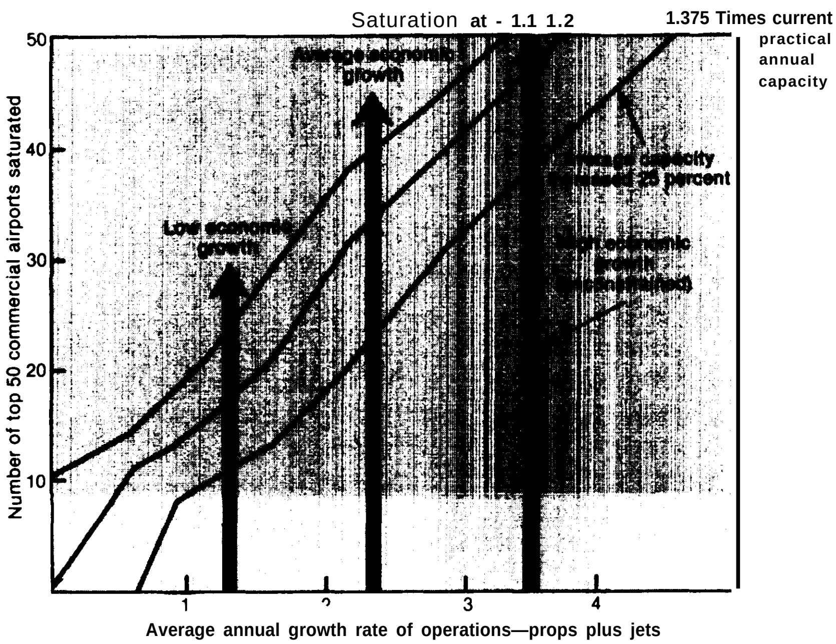
Expanded Capacity and Improved Management

The above scenarios indicate that attempting to accommodate expected aviation growth within the existing airport capacity will have mixed effects on the air service network. Although the adverse effects of growth, such as increasing delays or reductions in service, might be tolerable, it would nevertheless seem both prudent and desirable to increase capacity, where feasible, if this can be done at a reasonable cost and to the benefit of system efficiency. However, it is not feasible to supply the amount of new capacity required to eliminate or even appreciably reduce airside delay, particularly in major urban areas. In the short and long term, the alleviation of delay will be best achieved through tighter control over the level and distribution of airport operations, rather than the addition of new capacity (see ch. 6).

However, both commuter access and overall capacity constraints could be addressed by the construction of short, independent "stub" runways for turboprop aircraft where feasible, and especially at the most congested airports. This alternative (discussed in detail in ch. 6) would increase propeller capacity as an addition—rather than a detriment—to jet capacity, thereby reducing the severity of hub saturation and allowing GA and commuter aircraft to compete more effectively with jets for airport access. Figure 22 shows the effect of such runways in relieving saturation at commercial airports in 2000: by adding about 25 percent to the effective capacity of an average hub, they would allow a considerably higher level of traffic growth or, alternatively, reduce the number of airports saturated by any given level of economic and traffic growth. However, the addition of stub runways would also result in more complex traffic patterns, which might require new landing systems and improved traffic management in terminal areas.

Figure 22.—Number of Commercial Airports Over Capacity–Year 2000, 48 Contiguous States

(Jet **plus propeller operations plus** 10 percent allowance for general aviation)



SOURCE Off Ice of Technology Assessment