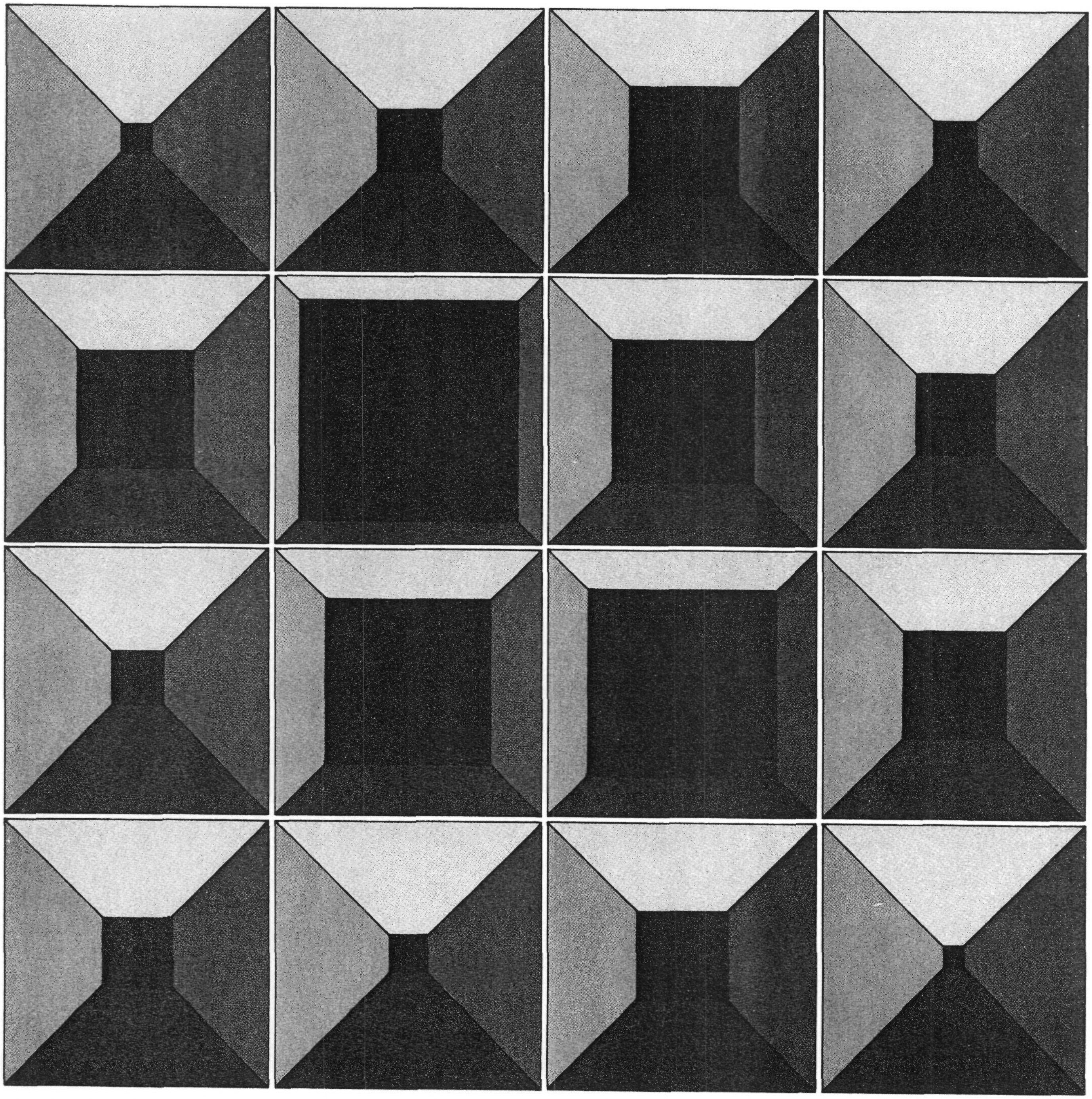
A CBO STUDY

Improving the Air Traffic Control System: An Assessment of the National Airspace System Plan

August 1983

Congress of the United States
Congressional Budget Office



IMPROVING THE AIR TRAFFIC CONTROL SYSTEM: AN ASSESSMENT OF THE NATIONAL AIRSPACE SYSTEM PLAN

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NOTE

Unless otherwise indicated, all dates are expressed in fiscal years, except those referring to legislative actions.

PREFACE

In the coming years, the Congress will consider legislation appropriating funds for the National Airspace System Plan, a comprehensive strategy for modernizing the nation's air traffic control system. At $11 billion over the next two decades, the costs of the Federal Aviation Administration (FAA) plan would exceed 36 times the total federal funding provided in 1982 for investment in air traffic control, making this one of the largest federal expenditures ever for a public works project. The Congress will, therefore, want to weigh the plan's costs against its potential benefits, judge whether it will prove a sound investment with a good rate of return, and assess its financial prospects. To provide information for these deliberations, the Congressional Budget Office has prepared this study of the FAA plan at the request of the Senate Committee on the Budget and the House Committee on Appropriations, Subcommittee on Transportation.

David L. Lewis prepared the study in the Congressional Budget Office's (CBO) Natural Resources and Commerce Division under the supervision of David L. Bodde and Everett M. Ehrlich. The author owes special thanks to Johanna Zacharias for editing the manuscript and to Kathryn Quattrone for typing the several drafts and producing it for publication. Patricia H. Johnston and Nancy H. Brooks also provided editorial assistance. For invaluable advice and assistance with the analysis, the author wishes to acknowledge Joseph S. Revis of J. S. Revis Associates; staff members of the World Bank, especially Pedro Taborga and Jenifer Wishart; Richard R. Mudge, of the CBO; Seymour Horowitz and S. B. Poritzky of the Federal Aviation Administration; as well as persons at the Office of Technology Assessment, the General Accounting Office and in other governmental, aviation, and electronics manufacturing organizations. Other staff members of the CBO who provided valuable comments include Robert Hartman, Robert Lucke, Suzanne Schneider, and Peyton Wynns. James N. Daukas, Jonathan Gifford, and Lauren Wasserman also assisted in preparing the analysis. In keeping with the CBO's mandate to provide objective analysis, this paper offers no recommendations.

Alice M. Rivlin
Director

August 1983

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SUMMARY

The Federal Aviation Administration (FAA) has formulated its comprehensive National Airspace System Plan to modernize and improve the efficiency of the nation's air traffic control system. Last year, the FAA spent more than $2.4 billion to equip, maintain, and staff the existing system. The system today is a blend of several generations' engineering and equipment, much of which has been outmoded by technological advances. Though still adequate to maintain a high standard of safety, the system is already the cause of rising operating costs, and its effectiveness may soon be limited by the demands of increased air traffic. Further, because the system is made up of numerous installations and is heavily labor intensive, there is significant potential for improved effectiveness with fewer facilities and less manpower.

The FAA plan would achieve such efficiency gains, but at considerable investment cost both to the federal government and to users of the air traffic control system. On the basis of FAA data, the Congressional Budget Office (CBO) has placed the total cost of implementing the plan at $10.7 billion (in 1982 dollars) between 1982 and the turn of the next century, while estimating savings in operating and maintenance costs alone at $24 billion over the same period.

If fully implemented, the FAA plan offers the nation a sound economic investment. Indeed, such an investment appears overdue. The cost effectiveness of the plan, however, depends on organizational changes in the FAA, including a consolidation of facilities and a reduction in staff. In the past, such changes have been of great concern to the Congress, the FAA work force, and aviation interests. Failure to follow through with these changes could result in investment costs that exceed benefits to the FAA.

LEGISLATIVE STATUS OF THE PLAN AND PENDING QUESTIONS

Recognizing the need to modernize the air traffic control system, the Congress has already authorized the first five years' funding for the FAA plan under 1982 legislation. What remain are decisions regarding the yearly appropriation of these considerable investment monies. In this context, two questions are of particular concern:

- **How do the plan's costs weigh against its potential benefits?** and

- **Does it have an assured source of funding?**

THE FAA PLAN--ITS AIMS AND ASSUMPTIONS

The FAA plan would automate and consolidate elements in the air traffic control system. Through automation, it would increase capacity to handle traffic, diminish risks of mid-air collision and other hazards, and shorten flight times by allowing aircraft to follow more direct routes. Facility consolidation and staff reductions would reduce operating and maintenance costs. The FAA assumes that the present 25 en route navigation centers and 188 airport approach facilities would be consolidated into about 30 facilities by the year 2000. In addition, the 317 flight service stations would be reduced to 61 by the year 2000. Staffing would be reduced accordingly, from its authorized level of 37,122 in 1983 to 30,600 in 1985, and to 23,500 by the turn of the next century. (The current FAA work force of about 33,700 is some 9 percent below its authorized strength because of the lingering effects of the air traffic controllers' strike of 1981.)

Key Assumptions

As with any long-range investment, the FAA plan's estimated benefits and costs would hinge on a number of forecasts and assumptions about the future. The major assumptions that underlie the FAA plan, and the doubts that may cloud them, include these:

- **Facility consolidation.** If accomplished, closure of facilities and attendant reductions of personnel would yield significant savings in operating costs. Resistance to such consolidation has been manifested not only by labor and aviation groups, however, but also by the Congress itself.

- **Rapid growth in air traffic.** Should the growth in air traffic resume the rapid rate seen in the late 1970s, both justification for and the resources to finance the plan would be available. Some analysts, however, see aviation traffic growing at a more moderate rate and suggest that an assumption of slower growth may represent a more realistic and certainly more stringent test for assessing the plan's economic value. (The assumption of slower air traffic growth is termed a "maturity scenario," reflecting the possibility that only gradual market expansion is to be expected.)

- **Sufficient revenues to the Airport and Airway Trust Fund.** Should air travel resume earlier rapid growth rates, revenues to the trust fund--which is now in sound financial shape--would be more than adequate to cover the FAA plan's costs. (Trust fund financing comes mostly from an 8 percent tax on airline tickets.) But economic recession and airline deregulation have caused a sharp reversal in the market, leading to depressed levels of patronage and to fare wars that have driven air travel prices steeply downward.

On the basis of its assumptions, the FAA has projected that its plan would save the federal government $24 billion (in 1982 dollars) between 1982 and the year 2000--about two-thirds the value of all the benefits it expects from the plan. The remaining one-third of the benefits, taking the form of lower operating costs and reduced delays, would accrue to the airlines and to general aviation (owners of small planes used for business or recreation). The FAA has made no attempt to place a dollar value on the improved safety expected from the plan.

Most of the $10.7 billion cost--about 72 percent--is public, representing direct federal investment in computer hardware and software and in other improved equipment. The remainder is private, representing investment expense for the airline industry and general aviation users. One key component of the plan's technological and economic success is institution of the microwave landing system, designed to hasten and improve the accuracy of airport landings. This sytem would require aviators to purchase compatible cockpit equipment.

RATE OF RETURN

On the basis of these benefit and cost projections, the CBO calculates that the annual rate of return to be expected from the FAA plan over the two decades is 24.3 percent--a healthy return by any standard (see Summary Table). Indeed, measured against the commonly used if somewhat arbitrary standard of 10 percent set by the Office of Management and Budget (OMB) for federal investment, the FAA plan appears to offer very good value.

Another useful guide to the economic value of a capital project is the present value of the expected benefits minus the costs. Using FAA assumptions and 10 percent as the discount rate to adjust future costs and benefits to their present-day values, the benefits of the FAA plan are estimated to exceed its costs by $9.1 billion.

The foregoing conclusions are, of course, only as valid as the assumptions and forecasts on which they are based, and these cannot be absolutely certain. Thus, it is useful to look at what could happen to the plan if things do not go as the FAA has assumed.

SUMMARY TABLE. ECONOMIC EVALUATION OF THE NATIONAL AIRSPACE SYSTEM PLAN UNDER ALTERNATIVE ASSUMPTIONS, 1982-2005

Assumptions	Annual Rate of Return (In percents)	Discounted Benefits Minus Discounted Costs (In billions of dollars) a/	Ratio of Benefits to Costs a/
Under FAA Assumptions	24.3	9.1	2.3:1
FAA Operating Cost Savings Delayed Five Years	13.9	3.1	1.5:1
FAA Operating Cost Savings of Half Those Assumed by FAA b/	9.1	-0.4	0.9:1
Traffic Forecasts Under Maturity Scenario c/	21.3	6.8	2.0:1

SOURCE: Congressional Budget Office and FAA data.

NOTE: The analysis period begins at 1982, the year of the plan's approval in the Congress.

a. All benefits and costs are discounted to their present (1982) values at the rate of 10 percent per year.

b. This line includes only federal investment costs and federal benefits in the form of savings in FAA operating costs. It excludes avionics costs to airlines and general aviation users, as well as direct benefits to them.

c. Assumes slower growth rate in air traffic than that assumed by the FAA.

Savings in Operating and Maintenance Costs

The plan's economic success would depend critically on the Congress' decision to close hundreds of manned facilities and to effect a personnel reduction of some 14,000 FAA employees. Failure to follow through with these changes could result in costs that exceed benefits. If the opposition--already expressed both by aviation groups and the Congress to similar changes--delayed the plan's changes by as much as five years, the project overall would still be worthwhile--with a rate of return of 13.9 percent. The project would take longer to pay off, though, and the Congress would be relying on more distant, and thus more speculative, forecasts to achieve an acceptable return on its investment. If reluctance to make organizational changes obviated half the total projected savings in operating costs, then the FAA would actually lose money by implementing the plan. That is, the discounted federal investment costs would exceed the discounted savings in FAA operating and maintenance costs (see Summary Table).

Growth in Air Traffic

In other areas, however, even quite pessimistic assumptions appear not to weigh heavily against the plan. Analysis by the CBO suggests that, under conditions considerably less advantageous than the FAA assumes, the plan would still yield worthwhile savings.

For example, although modernization can yield sizable gains in efficiency independent of traffic growth, slower growth than expected would diminish the benefits of the FAA plan. The FAA's forecasts assume that the relationship between the growth in air traffic and in the economy as a whole will continue as it has in the past, with economic recovery bringing robust new growth to aviation. The CBO's statistical analysis of recent trends, however, suggests the possibility that future demand for aviation services could mature and grow at a slower rate than the FAA assumes because of gradually slowing demand for commercial air travel and for general aviation planes. Such a pattern has, for example, affected the market for passenger cars. Under such a "maturity scenario" in aviation, activity could fall below FAA projections by 11 percent in 1987 and by 30 percent in the year 2000.

Even under the slower growth predicted by a maturity scenario, however, the overall annual rate of return of the FAA plan would exceed 20 percent, and discounted benefits would exceed discounted costs by about $6.8 billion (see Summary Table). This is because system modernization and consolidation would yield sizable savings in FAA operating costs even if there were little growth in traffic.

Financing the Plan

Financing for the FAA plan is subject to some of the same uncertainty that shrouds the plan's investment value. Like most other federally financed aviation activity, the FAA plan would be financed by taxes on aviation users that are paid into the Airport and Airway Trust Fund. The most important of these taxes is the 8 percent tax on commercial airline tickets. At present, the trust fund is on solid financial ground, with an uncommitted cash surplus of $1.8 billion projected for the end of 1983.

The trust fund's present financial solidity, however, derives from the rapid growth in air travel of several years ago. With a great many high-priced tickets being sold and 8 percent of the price of each going to the trust fund, revenues--and interest-bearing balances--were high. In a much changed market climate today, however, the trust fund may be looking ahead to leaner times. As stated earlier, economic recession has depressed ridership, and the lifting of federal regulation has triggered a round of price wars and competition for service on routes. Together, these factors have caused a drop in the projected yield to the trust fund from taxes on ticket sales, and the FAA plan therefore faces some risk of finding the trust fund inadequate to cover investment costs.

Even with a slow recovery in ticket prices, however, outlays and receipts would remain in overall balance. Although unpaid authorizations would temporarily exceed available cash by a minor amount in 1986, the fund would remain financially sound. Financial problems could arise if, in addition to low ticket prices, passenger traffic is lower than expected by the FAA. This could necessitate a small tax increase in 1986 or 1987. But the risk of lower traffic would be diminished by the attraction of lower-cost air travel.

Appropriations from the trust fund for 1984 have now been set at half the authorized levels. Although this reduces the risk of a shortfall in trust fund revenues, it raises important questions of economic efficiency and equity. By slowing the pace of air traffic control system improvements, this action diminishes the economic timeliness of the FAA plan. In addition, the entire burden of operating the air traffic control system would fall on the general taxpayer, in contradiction of the user-pays principle embodied in the trust fund philosophy.

CONCLUSION

Modernization of the air traffic control system seems to be well timed, and the FAA's National Airspace System Plan appears to offer the nation a good return on its $10.7 billion investment. This conclusion holds even after allowing for a wide range of uncertainty and possible major errors in some of the plan's underlying assumptions. On the basis of ranges, that CBO estimates for major costs and benefits, the FAA plan has a 20 percent chance of falling below an acceptable (10 percent) rate of return. Though the risk of economic failure appears to be fairly small, the Congress will need to ensure that the potential savings in FAA operating costs are actually achieved; closure of hundreds of facilities and a substantial reduction in FAA personnel will be necessary to guarantee the plan's financial success.

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CHAPTER I. INTRODUCTION

Flight in the nation's airspace is controlled and monitored by a system of 25 en route navigational centers, 188 terminal area approach stations, and 444 airport terminal control towers: the air traffic control system. In addition, 318 flight service stations provide aviation maps, weather reports, and other flight services to general aviation pilots--that is, operators of small planes used for private business or recreation. To equip, maintain, and staff this system, the Department of Transportation's Federal Aviation Administration (FAA) spent more than $2.4 billion in 1982, of which about 12 percent paid for capital improvements, and nearly 90 percent was devoted to air traffic controllers' salaries and other operating and maintenance costs. Although only about half of the FAA's operating expenses are financed by fees collected from aircraft operators and passengers, all capital investment is financed this way.

In 1981, the FAA published its National Airspace System Plan, a comprehensive strategy for improving the air traffic control system. The plan aims to accomplish four goals:

- Reduce the cost of operating the system,
- Accommodate anticipated growth in air traffic,
- Improve the safety of air travel, and
- Upgrade the quality of flight services.

Funding for the plan's first five years was authorized under the Airport and Airway System Development Act of 1982; in the coming years, the Congress will face major decisions regarding the annual appropriation of these investment dollars.

PLAN OF THE PAPER

The remainder of this chapter retraces the past two decades of air traffic control spending and outlines assumptions and factors that introduce uncertainty about the success of the FAA plan for the system's future. The economic and financial appraisal of the FAA plan begins in Chapter II. The chapter outlines the FAA's projections of the plan's costs and benefits and isolates factors that could cause the assumptions to go awry. Chapter III evaluates the economic performance of the plan, the timing of intended investments, and the effects of risk and uncertainty. In particular, the chapter examines what could happen to the investment value of the plan if things did not go as assumed. The chapter also outlines two ways the Congress could help minimize the economic and budgetary risks associated with the FAA's investment strategy. Chapter IV assesses the financial status of the plan's funding source, the Airport and Airways Trust Fund, evaluates the risk of trust fund receipts' being inadequate to pay for the FAA plan, and examines the possible implications of recent Congressional decisions regarding FAA's 1984 appropriations.

Appendixes A through E provide supporting data and display techniques for the analysis presented in the body of the paper. Appendix A presents the FAA's planned schedule for capital outlays, and Appendix B the expected time path of projected benefits. Appendix C reviews the FAA's past air traffic forecasting performance and outlines the methods now used to project future growth. In particular, the FAA projections are compared against alternative forecasts generated by the Congressional Budget Office on the basis of other methods. Chapter III uses these alternative forecasts in analyzing the economic risks underlying the FAA plan. Appendix D outlines the investment appraisal methodology used in the body of the report, while Appendix E reviews one of the most difficult valuation problems in investment appraisal--the value of time.

HISTORICAL PERSPECTIVE

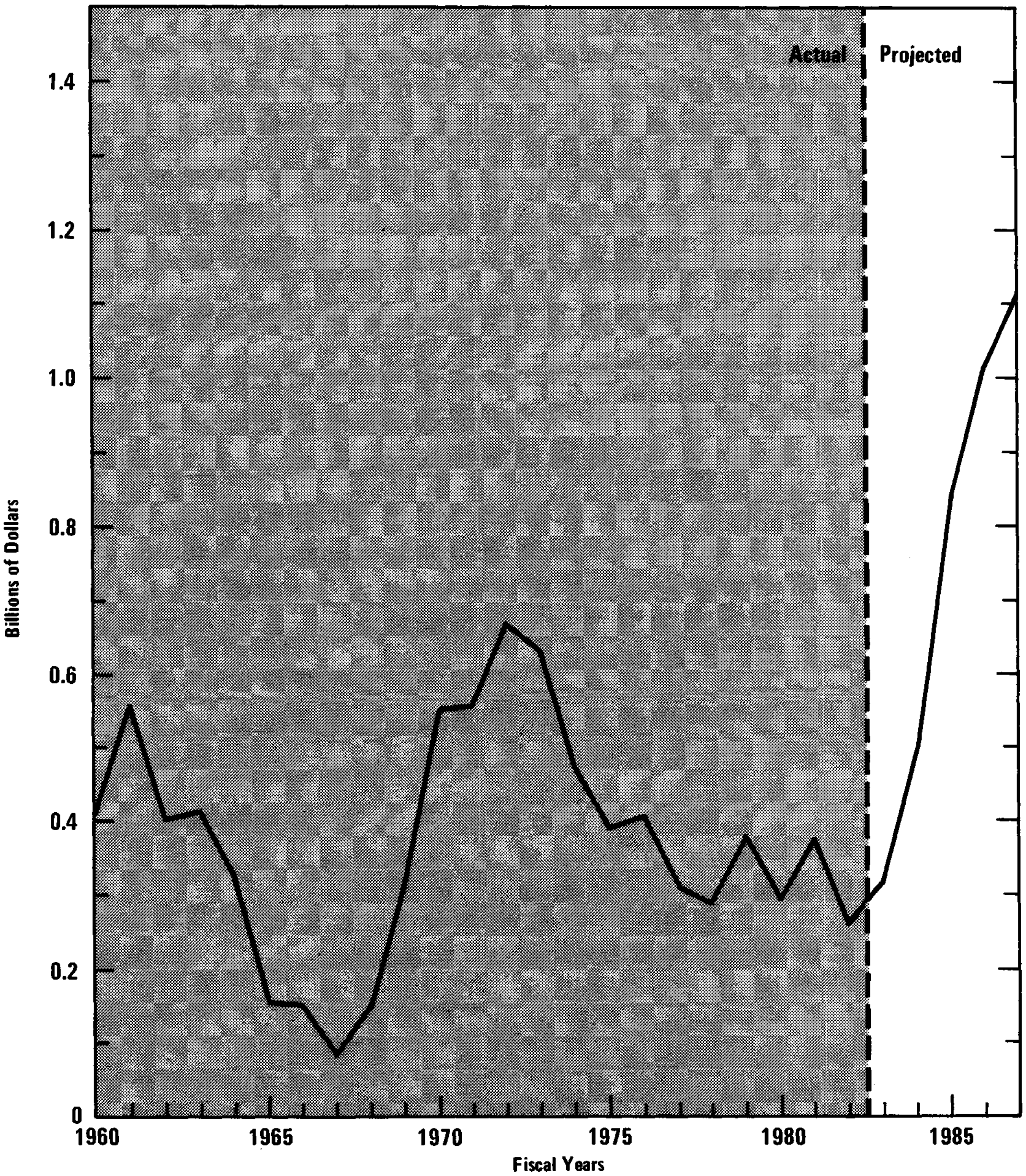
Today's air traffic control system is a blend of several generations' technologies and equipment, much of it labor intensive and obsolete by modern standards. Although air transportation remains a very safe means of travel, as air traffic continues to grow in the future, the present system may not be able to maintain the highest standards of safety. Already, limitations in the system cause delays for air travelers, as well as very high operating and maintenance costs for the FAA. These costs can be expected to rise in proportion with traffic growth.

System Development--1960-1973

Cumulative federal capital investment in the nation's air traffic control system since 1960 has totaled $8.5 billion (in 1982 dollars). Over the years, federal spending for air traffic control has displayed an erratic pattern, reflecting swings between periods of high-cost system expansion and periods of low-cost routine repair and replacement (see Figure 1). The

Figure 1.

Actual and Projected Federal Capital Spending on Air Traffic Control, 1960-1987 (In billions of 1982 dollars)



SOURCE: Congressional Budget Office from data provided by the Federal Aviation Administration.

NOTE: Outlay figures for 1983-1987 are based on authorizations in the Airport and Airway Improvement Act of 1982.

1950-1960 decade was one of expansion, as the system grew to accommodate the postwar boom in commercial aviation; the number of airports equipped with control towers rose by more than 50 percent, and five en route centers were added (see table below).

	1960	1973	1982
Number of Airport Towers	256	365	444
Percent change in ten years	+53	+43	+22
Number of En Route Traffic Control Centers	35	27	25
Percent change in ten years	+17	-23	-7
Number of Flight Service Centers	448	328	318
Percent change in ten years	-6	-27	-3

System capacity stabilized between 1960 and 1967, but growing numbers of reroutings, lengthy holding patterns, and forced airline schedule reductions necessitated another round of system expansion and automation from 1967 to 1972. By 1973, an additional 109 airports were equipped with control towers, and automation at en route control centers--by means of digital computers with more advanced software, and better displays--increased the hourly number of flights handled by 30 percent, while permitting an actual reduction in the number of centers from the 35 of 1960 to 27.

Declining Investment--1973-1982

The last ten years have witnessed a return to declining investment in the air traffic control system. Some equipment has been replaced only after it has physically worn out, even though replacement of functioning equipment might have been less costly on the basis of life-cycle costs. This means that the system has relied on system maintenance expenditures and the addition of more air traffic control personnel to handle growing demands for service. Since the Professional Air Traffic Control union (PATCO) walkout in 1981, the system has been kept operating with a reduced work force by the FAA's administratively limiting air traffic. As of February 1983, there were 23,257 air traffic controllers employed--10.9 percent fewer than the 26,088 authorized, owing to the lingering effects of the strike.

Since technological opportunities now permit greater automation, the air traffic control system could be operating with much greater efficiency than it does now. For example, controllers now manage their workload on the basis of flight plan data that are coded on paper strips torn by hand from teleprinters. 1/ This is a costly mechanical system requiring coordination and input by the air traffic controllers. The handoff by telephone of aircraft en route from one controller to another is also primitive by today's technological standards. Automating these functions would sharply reduce requirements for facilities and manpower while simultaneously curbing the reliability problems common in labor-intensive mechanical operations.

Compounding the problems of obsolete equipment, anticipated traffic growth--projected by the FAA to increase by 80 percent over the coming decade--promises to place demands on the system that it could not meet effectively with present capacity. The number of commercial jets is expected to rise by one-fourth, and the number of planes in the general aviation fleet could grow by up to 50 percent, with numbers of business jets--the most active general aviation users of air traffic control--more than doubling. In addition, greater use of avionics (radar transponders that enable pilots to communicate with approach stations, control towers, or en route centers) by existing general aviation planes could exert pressure on the system to expand.

The Prospective Cost of Declining Investment--From 1983

Without sufficient investment to modernize the air traffic control system, significant costs could arise in the form of higher system running costs and insufficient capacity. To maintain safe separations between aircraft during busy periods, traffic controllers require air carrier planes to use routings that require more fuel and time than would be the case if more modern equipment were available. Thus, failure to improve the system could result in significant costs for air carriers as well as general aviation. By the late 1980s, commercial airlines might be constrained to schedule some flights at inconvenient times. Inefficient routings could add millions of hours to passengers' flight times; airlines would waste an estimated

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1. For a description of how the air traffic control system operates, see Office of Technology Assessment, Airport and Air Traffic Control System (January 1982).

200 million gallons of jet fuel. And the FAA's operating costs would be some 30 percent higher than today's $2.5 billion. 2/

A NEW INVESTMENT STRATEGY--THE FAA PLAN

Approved by the Congress in 1982, the National Airspace System Plan charts a new investment strategy for the air traffic control system. 3/ With annual authorizations of roughly $1.2 billion--a four-fold increase over previous levels for capital spending on the air traffic control system (see table below)--the FAA plan would automate and consolidate its key components.

CAPITAL OUTLAYS FOR AIR TRAFFIC CONTROL, 1960-1986
(In millions of 1982 dollars)

Actual			Projected Under FAA Plan		
1970	1975	1980	1984	1985	1986
550	390	295	532	811	1,043

Through automation, the plan would increase traffic handling capacity, diminish the risk of mid-air collision and other hazards, and shorten flight times by allowing aircraft to use more direct routes. By consolidating

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2. From Federal Aviation Administration, Aviation Forecasts (February 1983); and U. S. Department of Transportation, National Airspace System Plan (December 1981, updated April 1983). The Congressional Budget Office has published a less detailed analysis of the FAA plan in Public Works Infrastructure: Policy Considerations for the 1980s (April 1983), Chapter VI on "Air Traffic Control." See also statement of Alice M. Rivlin, Director, Congressional Budget Office, before the House Committee on Appropriations, Subcommittee on Transportation (April 6, 1983).

3. See Federal Aviation Administration, National Airspace System Plan--Facilities, Equipment, and Associated Development (December 1981; updated April 1983).

facilities and reducing staff, the plan would lower FAA operating and maintenance costs by an estimated $24 billion (in 1982 dollars) over the 1983-2000 period, according to FAA estimates. 4/

Pending Congressional Decisions

The Congress now finds it necessary to consider the economic and budgetary implications of the FAA's plan. 5/ The costs of making the changes are projected by the CBO (on the basis of FAA data) to total about $10.7 billion (in 1982 dollars) over the next ten years--36 times the previous $295 million annual capital outlays for air traffic control, and one of the largest ever federal public works investments. The expenditures would include investment expense for the airline industry and for general aviation users.

CHOOSING AN INVESTMENT STRATEGY-- SOME ASSUMPTIONS AND UNCERTAINTIES

The weight of technical opinion is that the nation needs a more modern air traffic control system. The economic question is how and when to make this effort. 6/ Any attempt to answer this question must rely on assumptions and forecasts that are inevitably uncertain. As with any long-range investment, the FAA plan is subject to a number of economic

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4. At the time this study was conducted, data were available from the National Airspace System Plan as reported in December 1981. The updated plan published in 1983 projects somewhat smaller savings in operating costs ($21 billion versus the $24 billion reported in 1981). Subsequent CBO analysis showed that this difference has no substantial significance for the results presented here.

5. For assessments of the technological and management issues associated with the FAA plan, see Office of Technology Assessment, Review of the FAA 1982 National Airspace System Plan (August 1982); U. S. General Accounting Office, Examination of the Federal Aviation Administration's Plan For The National Airspace System--Interim Report (April 20, 1982); and FAA's Plan To Improve The Air Traffic Control System: A Step In The Right Direction But Improvements And Better Coordination Are Needed (February 16, 1983).

6. See Office of Technology Assessment, Review of the National Airspace System Plan.

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assumptions and unpredictable factors, among which six are crucial to the plan's ultimate performance:

- **Consolidation and staff reduction.** The FAA plan assumes that hundreds of manned facilities would be closed as a result of automation. Institutional difficulties, however, could slow or completely obstruct the consolidation of facilities;

- **Growth in air traffic.** In forecasting the potential benefits of the plan, the FAA foresees rapid and sustained growth in air traffic. But growth that is slower than anticipated could diminish the benefits of the plan;

- **Capital costs.** The FAA assumes that planned expenditures are based on accurate cost projections, and that authorizations will suffice to cover the plan's costs. But few long-term federal or private undertakings have escaped cost overruns, which could also affect the FAA plan's cost effectiveness and financial outlook;

- **Technological change.** The FAA assumes that equipment introduced under the plan would serve for a period of at least 20 years. Earlier-than-expected technological obsolescence, however, could require system replacement on a hastened schedule;

- **Economics of major components.** The FAA assumes economic gains to result from the time saved by new equipment. The dollar value of time saved, however, may not in itself justify sizable investment; and

- **Pricing.** The FAA also assumes that federal subsidies to certain aviation users would continue. But federal subsidies that encourage aviation activity could necessitate a premature system expansion with poorly integrated, and thus inefficient, equipment.

Compounding the plan's economic uncertainty is the financial outlook for the Airport and Airways Trust Fund, the principal source of revenue that pays for federal aviation investments. The trust fund is financed primarily with collections from an 8 percent federal excise tax on passenger tickets. Continuing price wars in airline fares, however, have diminished the value of this revenue source. The FAA forecasts sufficient trust fund revenues to pay for the FAA plan. But these projections assume an end to fare wars and a strong recovery in ticket prices; should these assumptions prove false, the trust fund might not be capable of supporting the FAA plan without an increase in the ticket tax.

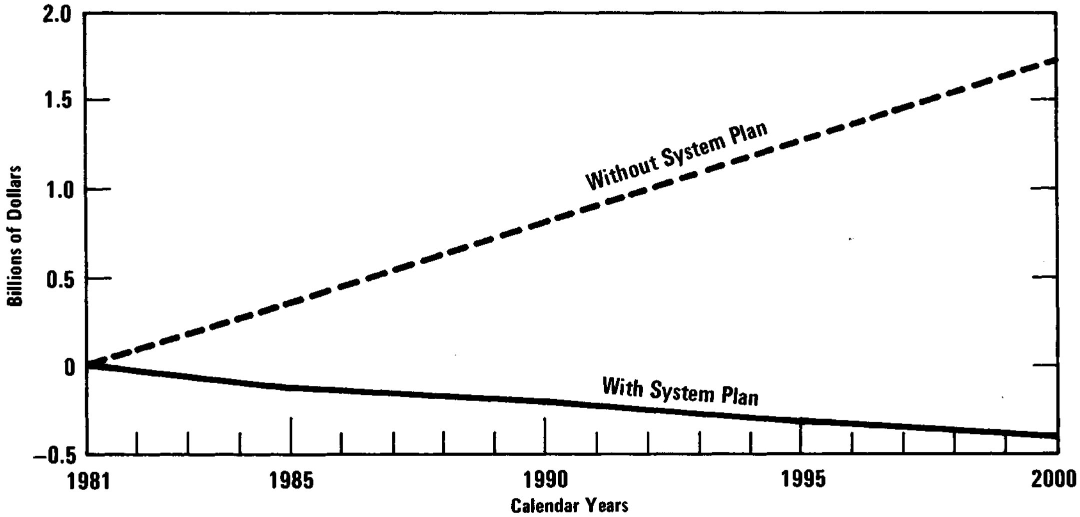
CHAPTER II. COSTS AND BENEFITS OF THE FAA PLAN

In justifying the National Airspace System Plan, the Federal Aviation Administration has projected operating and maintenance cost savings to total $24 billion (in 1982 dollars) within two decades (see Figure 2). To illustrate the possible composition of these and other possible gains achieved by the plan, this chapter weighs the potential costs and benefits on the basis of FAA data. Such analysis must rely on assigning dollar values to the plan's several potential costs and benefits. (Supporting data are presented in Appendixes A and B.) The Congressional Budget Office analysis provides a basis for the economic appraisal and financial assessment presented in Chapters III and IV.

Figure 2.

Air Traffic Control Operation and Maintenance Costs With and Without National Airspace System Plan, FAA Forecast, 1981-2000

(In billions of 1982 dollars)



SOURCE: Congressional Budget Office adapted from FAA, *National Airspace System Plan* (April 1982).

COSTS

On the basis of FAA cost data, the CBO estimates the major cumulative cost of modernization at $10.7 billion (in 1982 dollars) over two decades, as shown in Table 1. 1/ Two kinds of capital costs are associated with the FAA's plan--capital expenditures by the federal government, and investment expenses for the airline industry and for general aviation users.

TABLE 1. PROSPECTIVE COST ESTIMATES OF IMPLEMENTING THE NATIONAL AIRSPACE SYSTEM PLAN, 1983-2005

	Total Costs 1983-2005 (In 1982 dollars)		Present Value with 10 Percent Discount Rate a/	
Sources of Costs	Dollars (In billions)	As Percent of Total	Dollars (In billions)	As Percent of Total
Federal Investments	7.65	71.7	5.73	82.7
Avionics Costs to Users				
Transponders and TCAS b/	2.42	22.7	0.88	12.7
Microwave Landing System	0.59	5.6	0.32	4.6
Total	10.66	100.0	6.93	100.0

SOURCE: Congressional Budget Office from FAA data.

a. Ten percent represents the minimum rate of return set by the Office of Management and Budget for capital investments.

b. Traffic Alert and Collision Avoidance System.

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1. For FAA cost data and analysis, see Federal Aviation Administration, National Airspace System Plan (December 1981), and Congressionally Requested Update (April 1983). See footnote 4 in Chapter I for explanation of update. See also Federal Aviation Administration, Preliminary Analysis of the Benefits and Costs to Implement the National Airspace System Plan (June 1982).

Costs to the Federal Government

Most of the cost, some \$7.7 billion (in 1982 dollars), represents direct federal outlays: \$5.9 billion would pay for new computers and related equipment and the costs associated with system consolidation, and \$1.7 billion for ground installations associated with the microwave landing system, a new method of guiding planes in bad weather to automatic landings. On the basis of FAA equipment and software procurement schedules, about 90-95 percent of these budgetary expenditures would occur between 1983 and 1990. The remaining 5-10 percent represents future microwave landing system installations, introduction of advanced computer software, and consolidation costs that would continue through the turn of the next century. If costs beyond 1983 are discounted to their present-day value, at 10 percent a year, the present value of all federal investments would total \$5.7 billion, as shown in Table 1. 2/

These cost estimates assume that all federal equipment and software installations would be in use for a period of 20 to 25 years, roughly equivalent to their engineered design lives. In economic terms, this assumes that new technologies--such as satellite versus ground-based navigation systems--would not be cost-effective over that period, or that, as a matter of policy, such technologies would not be introduced until the equipment it replaces is physically worn out.

Costs to Aviation Users

An estimated \$3.0 billion (in 1982 dollars) represents equipage costs for aircraft owners and operators. They would have to install two types of cockpit equipment: a new radar transponder for improved route planning, weather information service, and collision avoidance; and a signal receiver for the microwave landing system.

The estimated user costs assume that all commercial aircraft operators and general aviation corporate jet owners would outfit their planes with both kinds of equipment. In addition, all other general aviation aircraft would carry a transponder (about 30 percent of propeller-driven aircraft are so equipped today), although at most half are assumed to purchase advanced transponders to receive the improved safety and weather information

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2. Ten percent represents the real rate of discount prescribed by the Office of Management and Budget for federal investments.

services planned by the FAA. 3/ Assuming a 20-year phase-in period for these users, the present value of total user investment costs is estimated at $1.2 billion.

BENEFITS

On the basis of FAA data, CBO projects $60 billion (in 1982 dollars) in quantifiable benefits associated with the FAA plan. Given the time path of these benefits, their discounted present value totals about $16 billion, of which about 67 percent represents savings to the FAA in reduced operating and maintenance costs, and 34 percent stands for direct gains to aviation users in the form of diminished fuel requirements, lower aircraft operating costs, and shortened delays (see Table 2).

Benefits to the Federal Government

Achieving the projected $10.6 billion (discounted) savings in the FAA's operating and maintenance costs will depend on improved labor productivity and staff reductions. Both of these are linked to facility consolidation.

Consolidation and Automation. At present, the FAA operates 20 automated air route traffic control centers in the continental United States, three automated off-shore centers, and two manual off-shore centers. Consolidation would lead to 18 continental and three off-shore centers by 1985, and 16 continental and two off-shore facilities by 1990. In addition, many terminal area navigation facilities would be merged into the air route centers, transforming today's system of 25 en route and 188 terminal centers into approximately 30 air traffic control facilities by the turn of the next century. Although each major airport would still be equipped with a traffic control tower for guiding planes within the immediate vicinity of the airport, automation would permit many of the activities now undertaken by tower staff to be performed instead at one of the 30 consolidated control centers.

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3. In the technical language of the FAA plan, the cost estimates assume that all aircraft would carry a Mode A/C/S transponder; all commercial (including commuter) aircraft, corporate jets, and 10 percent of all multiengine propeller general aviation aircraft would carry TCAS II; and half of all remaining multiengine and single-engine propeller general aviation aircraft would carry TCAS I.

TABLE 2. PROSPECTIVE BENEFIT ESTIMATES OF THE NATIONAL AIRSPACE SYSTEM PLAN, 1983-2005

Sources of Benefits	Total Benefits 1983-2005 (In 1982 dollars): Dollars (In billions)	Total Benefits 1983-2005 (In 1982 dollars): As Percent of Total	Present Value with 10 Percent Discount Rate: Dollars (In billions)	Present Value with 10 Percent Discount Rate: As Percent of Total
Savings in FAA Operating Costs from Increased Productivity	37.09 a/	62.2	10.64	66.5
Savings in Fuel				
Air carriers	11.29	18.9	2.62	16.4
General aviation	5.07	8.5	1.13	7.0
Savings from Microwave Landing System				
Improved safety	0.28	0.5	0.08	0.5
Reduced disruptions	2.52	4.2	0.66	4.1
Reduced outages	0.24	0.4	0.07	0.4
Reduced ground and air restrictions	1.99	3.3	0.50	3.1
Reduced path length	1.12	1.9	0.30	1.9
Total	59.60	100.0	15.99	100.0

SOURCE: Congressional Budget Office from FAA data.

NOTE: Details may not add to totals because of rounding.

a. The FAA estimates that savings in operating costs would total $24 billion by the year 2000. The CBO has projected another five years of savings to allow comparison of projections. However, the discounting of future costs makes this difference of very little significance (see Appendix B).

Automation could also permit a substantial consolidation of flight service stations. These stations offer a broad range of pre-flight and in-flight services for general aviation pilots; they prepare flight plans, provide en route communications with pilots flying under visual (rather than instrument-assisted) conditions, help pilots in distress, and operate a national weather reporting service. Today, most of these services are provided at 318 local stations around the country. Through automation and the provision of remote communication outlets, the FAA plan would eliminate 257 stations. To receive much of the information now obtained in person, users would connect by telephone with one of 61 regional computers.

Improved Productivity. Automation and consolidation would result in substantial gains in labor productivity, which is measured in numbers of operations per employee. For example, the average number of operations per controller at air route centers is projected to increase from 2,437 in 1981 to 4,274 in 1990, and to more than double by the year 2000 (see Table 3). The consolidation of air route and terminal control facilities

TABLE 3. PROJECTED PRODUCTIVITY IMPROVEMENTS FROM THE FAA PLAN, BY AIR TRAFFIC CONTROL SYSTEM COMPONENT, TO YEAR 2000

System Component	Actual 1981	Projected 1985	Projected 1990	Projected 2000
	(In operations per employee)			
Air Route System (En route navigation service)	2,437	3,415	4,274	5,914
Terminal Systems (Towers, terminal radar control)	5,470	7,749	9,293	12,420
Flight Service Systems (Flight plans, briefings)	12,044	16,355	25,432	53,640

SOURCE: Congressional Budget Office from Federal Aviation Administration, National Airspace System Plan--Facilities, Equipment, and Associated Development (December 1981, updated April 1983).

would allow airport tower controllers to handle more than 9,200 takeoffs and landings a year by the decade's end, compared to 5,470 in 1981--a 70 percent increase in productivity. And flight service specialists would improve their output four-fold by the turn of the century.

The productivity of maintenance staff is also projected to improve. For example, the FAA operates hundreds of unmanned radar stations that require close monitoring by peripatetic maintenance crews. When something goes wrong, personnel must visit the site, determine the problem, and possibly go away, and then come back with the appropriate tools and spare parts. Under the FAA plan, unmanned units would be equipped with microprocessors that relayed diagnostic information to remote maintenance facilities, eliminating the need for pre-checking and multiple personal visits.

Staff Savings. Improved labor productivity would permit significant long-term reductions in staff (see Table 4), and hence a substantially smaller wage bill. Staff savings are projected to occur as follows:

- **Air traffic controllers.** Compared to the current staffing level, the number of air traffic controllers would drop by 6.8 percent in 1985, by 14.7 percent in 1990, and by 30.0 percent in the year 2000.

- **Maintenance staff.** Maintenance staffing would be 14.8 percent lower in 1985 than the 1983 actual level, 26.8 percent lower in 1990, and 31.1 percent lower by the year 2000.

- **Total employment.** The FAA plan would reduce total system employment by 9.3 percent in 1985, compared to the 1983 actual level of 33,697 employees. By 1990, the total work force would be 26.0 percent smaller than in 1983, and by the year 2000, it would have dropped 36.8 percent from the 1983 staffing level.

- **Attrition.** FAA plans to make all staff reductions through attrition only. 4/

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4. Some analysts have questioned the feasibility of making all planned employment reductions through attrition. CBO has not examined this assumption in detail, however.

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TABLE 4. PROJECTED AIR TRAFFIC CONTROL EMPLOYMENT UNDER THE FAA PLAN, TO YEAR 2000

Type of Employee	1983 Authorized	1983 Actual	FAA Plan 1985	1990	2000
Air Traffic Controllers	26,088	23,257	21,669	19,841	16,282
Percent change a/	--	--	-6.8	-14.7	-30.0
Maintenance Staff	11,034	10,440	8,900	7,642	7,194
Percent change a/	--	--	-14.8	-26.8	-31.1
Total	37,122	33,697	30,569	27,483	23,476
Percent change a/			-9.3	-18.4	-30.3

SOURCE: Congressional Budget Office from Federal Aviation Administration, National Airspace System Plan--Facilities Equipment, and Associated Development (December 1981, updated April 1983).

a. Percent changes from the 1983 actual levels.

Direct Benefits to Aviation Users

Modernization of the air traffic control system would reduce fuel requirements and diminish aircraft operating costs and passenger delays.

Fuel Savings. By permitting flight paths to be less circuitous, automating air route traffic control centers would save fuel. The magnitude of these savings would depend, of course, on the volume of aviation activity. On the basis of its forecasts of aviation activity for 1993, the FAA foresees fuel consumption increasing 40 percent without system modernization but rising just 32 percent if the plan is phased in according to schedule. The present value of these savings would amount to some $3.8 billion, as shown in Table 2. 5/ Since commercial jets consume a great deal more fuel than general aviation aircraft, commercial airlines would benefit from about 70 percent of the fuel costs saved.

Shortened Delays. Ascertaining the value of reduced aircraft operating costs is fairly straightforward; it depends largely on fuel and aviation labor costs. Shortened delays would stem chiefly from introduction of the newly developed microwave landing system. Today, an aircraft making an instrument landing receives fixed beam radio signals from transmitters located near the runway, and it follows the signals from a distance of about six miles from the airport to a precision touch-down on the runway pavement. A constraint under current technology is that aircraft must line up six miles from the runway and follow a straight-line path to touch-down, a time-consuming activity unless a flight en route happens to be along this path anyway. Microwave technology (using a scanning beam rather than a fixed beam) would permit angled or curved approaches and would reduce the number of flight and ground procedural restrictions. The new technology, based on advanced solid state componentry, is also thought to be more reliable than the existing systems, most of which are still powered by vacuum tubes. Improved reliability would reduce system outages and disruptions. Together, shortened approach paths and improved reliability would diminish landing times and thus reduce aircraft operating costs and passenger delays. On the basis of the projected future number of landings, FAA data translate these savings into a present value of $1.6 billion by the year 2005 (see Table 2).

A secondary benefit claimed for the microwave landing system is reduced air and noise pollution. By shortening landing time, the system will also shorten the airborne time of in-bound aircraft, thus diminishing the period when a plane emits noxious exhaust fumes in close proximity to communities lying near to airports. Similarly, with incoming planes approaching in a radial pattern around a runway rather than queued up on a single path, the objectionable engine noise of landing jets would be dispersed over a broad area rather than concentrated along one approach route. Such environmental benefits are, however, almost as difficult to quantify as the value of time.

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5. Estimated fuel savings are reported in Federal Aviation Administration, Preliminary Analysis of the Benefits and Costs to Implement the National Airspace System Plan (June 1982). Commercial aviation jet fuel cost $1.00 per gallon in 1982; general aviation jet fuel cost $1.73 per gallon in that year, while general aviation gasoline used in propeller planes cost $1.92 per gallon.

Assigning a value to time is far less straightforward than assessing aircraft operating costs. Time is an intangible commodity, the value of which is determined largely subjectively. It is an economic resource, however, in the sense that delay reduces time spent in productive work or other activities; its monetary worth depends on the estimated value of time savings. Taking one objective approach, the FAA has valued time savings at workers' average hourly earnings. On that basis, the FAA estimates the present value of benefits from the microwave landing system to total $1.6 billion by the year 2005. Other analysts, however, estimate the value of time savings at as little as one-third of hourly earnings. 6/ If that lower value were assumed, the benefits of MLS would be reduced by some 35 percent to just more than $1 billion, and the system's cost effectiveness--taken up in the next chapter--might thus be brought into question.

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6. Analysts at the World Bank, for example, apply this lower measure (see Appendix E).

CHAPTER III. COST EFFECTIVENESS OF THE FAA PLAN

In the coming years, the Congress will consider legislation to appropriate funds for the National Airspace System Plan. Failure to appropriate the necessary sums would allow a decline in system productivity, while implementing the FAA plan would involve massive capital outlays with unassured benefits. As a compromise, aspects of the plan could be delayed or implemented selectively. The first part of this chapter examines the rate of return to be expected from the FAA plan as it would compare to a continuation of the current system. Since the assumptions underlying the plan are inherently uncertain (see Chapter I), the second section explores what could happen if things did not go as expected, concluding with an assessment of the plan's risk of achieving an unsatisfactory rate of return. The final section outlines some alternative approaches the Congress could take to help minimize such risks. (Appendixes C, D, and E provide technical background to the methodology used in the chapter.)

RATE OF RETURN

On the basis of benefit and cost projections (compare Tables 1 and 2 in Chapter II), the annual rate of return to be expected from investment in the FAA plan over the next 20 years is 24.3 percent--a healthy return by any standard. Indeed, compared with the commonly used, if perhaps arbitrary, projected rate of return standard of 10 percent (after inflation) set by the Office of Management and Budget for federal investment, the FAA plan appears to represent very good value. 1/ Another useful guide to the economic merit of a capital project is the present value of the expected benefits, minus the present value of the costs. Using FAA assumptions and 10 percent as the discount rate to adjust future costs and benefits to their present-day values, the plan's benefits are estimated to exceed its costs by $9.1 billion, for a benefit-to-cost ratio of 2.3:1 (see table below).

The 24.3 percent rate of return noted above does not indicate how quickly the FAA plan would begin to pay off. A long waiting period would

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1. For a discussion of discount rates and rates of return, see Appendix D, which notes that, in applying the 10 percent rate to judge whether a project is worth undertaking, OMB is subjecting proposals to a test that is both quite rigid and valid by private-sector standards.

INVESTMENT VALUE OF THE FAA PLAN
UNDER FAA ASSUMPTIONS, 1982-2005

Return on Investment: Rate of Return (In percent)	Return on Investment: Benefit-to Cost Ratio a/	Return on Investment: Benefits Minus Costs a/	Timing: Return in the First Year After Completion (In percent)
24.3	2.3:1	$9.1 billion	14.9

a. Benefits and costs are discounted to 1982 values at the annual rate of 10 percent.

mean that the overall success of the plan would hinge on ever more distant forecasts, and such distant forecasts inevitably tend toward speculation. On the basis of the FAA estimates of costs and benefits, the plan would have paid for itself by the sixth year. The FAA's forecasting record in looking this far ahead has improved markedly in recent years (see Appendix C), suggesting that going ahead with the project now would avoid unnecessary speculative risk.

An index of whether a project is well-timed is the ratio of benefits in the first year after a project's completion--1990 in this case--to its total cost (including interest). A first-year benefit ratio below 10 percent (the OMB **passmark**) indicates that the government could find more productive investments in the near-term. Based on the FAA estimates of costs and benefits, the expected first-year benefit is 14.9 percent, indicating that the FAA plan may actually be overdue.

EFFECTS ON THE RATE OF RETURN OF ERRORS IN ASSUMPTIONS

The foregoing conclusions are, of course, only as valid as the assumptions and forecasts on which they are based, and these cannot be absolutely certain. Thus, a look at what could happen to the plan if events did not materialize as assumed can be useful. As stated in Chapter I, key uncertainties exist in six areas:

- o System consolidation;
- o Growth in air traffic;
- o Capital costs;
- o Technological change;
- o Economic effectiveness of separable components; and
- o Pricing policy.

System Consolidation and Savings in Operating and Maintenance Costs

Savings in operating costs depend critically on closure of hundreds of manned facilities, and ultimately on a 40 percent reduction in the air traffic control system's authorized personnel level of more than 37,000 employees. Such changes have encountered opposition in the past in the Congress and among aviation groups. Evidence of this includes:

- o Resistance to closing air route traffic control centers. In the past, the House Appropriations Committee has refused to fund the consolidation program for en route centers without prior notification of the center or centers proposed for closure. The requirement appears to have resulted from concern in localities over possible reductions in local employment.

- o Statutory restriction of flight service station closings. Current legislation stipulates that only five flight service stations may be closed in 1983. Some general aviation interests continue to favor such restrictions, fearing a reduction in flight services. The FAA plan, however, calls for the closing of 75 stations in 1984.

- o Opposition to regional office cutbacks. The FAA's 1981 proposal to cut back its regional offices from eleven to six faced employee protest, state resistance, and Congressional opposition. As a result, the FAA modified its consolidation plan, reducing the number of proposed 1983 closings from five to two.

Even if such reluctance delayed the changes by as much as five years, the overall project would still be worthwhile--with a rate of return of 13.9 percent. The project would take longer to pay off, however, and the first-year benefit ratio would fall below 10 percent, indicating that the plan's implementation now would be premature (see Table 5). This would also necessitate relying on more distant, less reliable forecasts rather than on the FAA's more accurate shorter-term forecasts.

TABLE 5. EFFECTS OF ALTERNATIVE PRODUCTIVITY ASSUMPTIONS ON EVALUATION OF THE FAA PLAN, 1982-2005

	Return on Investment			Timing
Assumption	Rate of Return (In percents)	Benefit-to-Cost Ratio a/	Benefits Minus Costs (In billions of dollars) a/	Return in the First Year After Completion (In percents)
Under FAA Assumptions	24.3	2.3:1	9.1	14.9
Five-Year Delay in Operating Costs Savings	13.9	1.5:1	6.8	8.6
Operating Costs Savings Improved by 50 Percent Less Than FAA Assumes b/	9.1	0.9:1	-0.4	5.5

SOURCE: Congressional Budget Office and FAA data.

a. Benefits and costs are discounted to 1982 values at annual rate of 10 percent.

b. Includes federal investment costs and federal benefits in the form of savings in FAA operating costs. Excludes avionics costs to airlines and general aviation users, and corresponding user benefits.

If opposition to organizational changes obviated half the total projected savings in operating costs, then the FAA plan would not prove worthwhile. That is, the discounted federal investment costs would exceed the discounted savings in FAA operating and maintenance costs.

Growth in Air Traffic

Independent of traffic growth, modernization can yield sizable gains in efficiency. But if FAA's traffic forecasts should prove to be too high, overall benefits would be lower than anticipated. Past FAA forecasts of the long-range growth in air traffic have been too high (discussed below), and this has led some analysts to question whether the FAA plan is well founded. 2/ The CBO has evaluated the forecasts from two perspectives: FAA's past forecasting performance, and its interpretation of recent trends.

Past Performance. In the past, the FAA's long-range air traffic projections have averaged 50 percent or more above the levels that actually materialized. In 1968, for example, the FAA forecast that 61 percent more aircraft would use en route navigation services in 1980 than actually occurred, 33 percent more take-offs and landings, and 63 percent more aviation fuel consumption. The last verifiable long-range (12-year) forecast was made in 1970, however, and evidence suggests that the FAA's forecasting record has improved. Examination of the FAA's medium-term (five-year) projections reveals substantially more accurate results (see Appendix C). Within this general improvement, however, FAA forecasts have been better in some areas than in others. Its forecasts of general aviation traffic--which accounts for roughly two-thirds of all anticipated growth--have been somewhat less accurate than its forecasts of total civilian aircraft traffic.

Trend Interpretation. The FAA's interpretation of recent trends in passenger travel and general aviation aircraft ownership underlies its forecast of the demand for air traffic control services. Critically, the FAA assumes continuation of the past relationship of the growth of passenger travel and the ownership of private planes to the economy as a whole. This results in forecasts that appear as rough extensions of past trends (see Figures 3 and 4).

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2. See Office of Technology Assessment, Review of the National Airspace System Plan (August 1982); and General Accounting Office, Examination of the Federal Aviation Administration's Plan For The National Airspace System--Interim Report (April 20, 1982).

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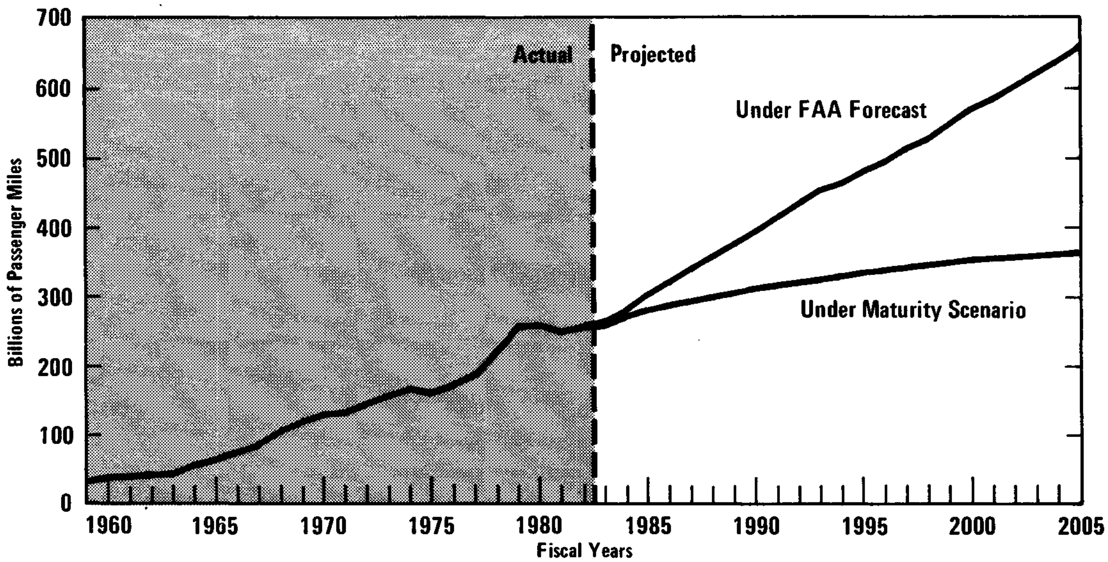
Figure 3.

Actual and Projected Commercial Airline Passenger Miles, 1959-2005 (In billions)



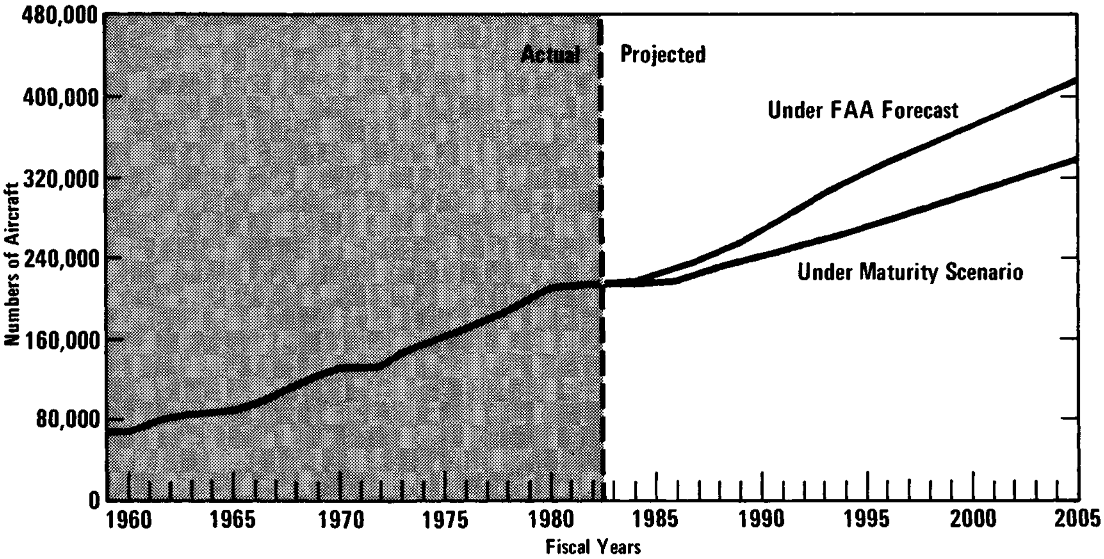
SOURCES: Congressional Budget Office and Federal Aviation Administration.

The CBO's statistical analysis of recent trends (see Appendix C) suggests the possibility that the demand for aviation services could mature and grow at a slower rate than the FAA assumes, because of gradually diminishing demand for commercial air travel and for privately owned airplanes. Similar cycles have affected other markets, such as that for automobiles. A market that is "mature," or saturated, is one in which major future growth in sales is not to be anticipated. Substantial growth in numbers of new consumers is not expected to exceed population growth. Whereas the statistical evidence that the aviation industry is indeed approaching maturity is no stronger than that underlying a projection of a resurgence of growth (see Appendix C), a "maturity scenario" represents a particularly stringent, and therefore useful, test to which to subject the

Figure 4.

Actual and Projected General Aviation Activity, 1959-2005

(In numbers of aircraft)



SOURCES: Congressional Budget Office and Federal Aviation Administration.

FAA plan for evaluating its economic worth. 3/ Under such a maturity scenario, the demand for air traffic control services could fall below FAA projections by 11 percent in 1987, by 20 percent in 1993, and by 30 percent in 2005.

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3. Compared to forecasts made by commercial aircraft manufacturers, the FAA forecasts are in the central to low range. The manufacturers' forecasts probably reflect marketing targets, however, making such comparisons difficult. But at least one commercial manufacturer (Rolls Royce) forecasts that the U.S. airline industry has already reached about 60 percent of its mature size.

Lower than expected growth in air traffic would diminish--but not completely eradicate--the projected benefits of the FAA modernization plan. Since the FAA's operating and maintenance costs in the absence of modernization would grow more or less in line with air traffic, lower growth would reduce the potential for cost savings with modernization. Even with no traffic growth, however, modernization would yield some cost savings because of increased productivity in handling current traffic levels. In fact, the FAA plan estimates that, of the $24 billion in operating and maintenance cost savings expected over the next 20 years, about half would occur irrespective of traffic growth, and half is roughly proportional to that growth. Thus, lower than projected air traffic would have a less than proportional effect on the expected savings in FAA operating and maintenance costs. For example, if the demand for air traffic service in 1993 turned out to be 20 percent below the FAA projection (as under the maturity scenarios), then cost savings would be only about 10 percent lower.

On the other hand, projected benefits to commercial and general aviation in the form of fuel savings and shortened flight times would be more or less proportional to traffic growth. Thus, the influence of possible forecasting errors on the economic performance of the FAA modernization scheme would depend on the relative importance of productivity improvements versus user benefits in the overall plan.

Effects on the FAA Plan. Even under the slower traffic growth implicit in a maturity scenario, the overall annual rate of return on investment in the FAA plan would exceed 20 percent, and discounted benefits would exceed discounted costs by about $6.8 billion over the projection period (see Table 6). The FAA plan appears cost-effective with lower forecasts for two reasons. First, system modernization and consolidation could yield productivity improvements sufficient to reduce FAA operating costs even if there were no growth in traffic. Second, projected divergence between the FAA forecast and the maturity scenarios emerges gradually, with the bigger differences occurring in the mid-1990s and beyond. The cumulative process of discounting future benefits (see Appendix D), however, diminishes the economic significance of these different projections, especially as the separation between them widens in more distant years.

Capital Costs

Although CBO has not made a detailed assessment of FAA's cost estimates, cost overruns are common in both private and public investments. Higher costs would of course diminish the plan's value, but the overruns would have to be quite large to cause its economic failure. (Though unlikely

TABLE 6. EFFECTS OF ALTERNATIVE TRAFFIC FORECASTS ON EVALUATION OF THE FAA PLAN, 1982-2005

Forecasts	Return on Investment: Rate of Return (In percents)	Return on Investment: Benefit-to-Cost Ratio a/	Return on Investment: Benefits Minus Costs (In billions of dollars) a/	Timing: Return in the First Year After Completion (In percents)
Under FAA Assumptions	24.3	2.3:1	9.1	14.9
Under Maturity Scenario	21.3	2.0:1	6.8	13.1

SOURCE: Congressional Budget Office and FAA data.

a. Benefits and costs are discounted to their 1982 values at the annual rate of 10 percent.

to endanger the plan's investment value, cost overruns could cause significant financial difficulties in its implementation. This problem is dealt with in Chapter IV.) For example, a 25 percent cost overrun would still yield cumulative net benefits of $5 billion over the projection period, even with lower traffic than forecast. In fact, capital costs would have to double before the costs exceeded the benefits, even with the lower traffic forecasts (see Table 7).

Technological Change

Another risk common to projects of this type is that technological advances can render new facilities obsolete before their full benefits have been realized. Although the FAA plan calls for the introduction of "state-of-the-art" computer hardware and software technology, rapid technological developments could make such equipment obsolete before the end of its

TABLE 7. EFFECTS OF ALTERNATIVE CAPITAL COST ASSUMPTIONS ON EVALUATION OF THE FAA PLAN, 1982-2005

	Return on Investment			Timing
Alternative Capital Cost Assumptions	Rate of Return (In percents)	Benefit-to-Cost Ratio a/	Benefits Minus Costs (In billions of dollars) a/	Return in the First Year After Completion (In percents)
Under FAA Assumptions	24.3	2.3:1	9.1	14.9
Cost Contingency of 25 percent	19.6	1.9:1	7.3	11.9
Maturity Scenario and Cost Contingency of 25 percent	17.1	1.6:1	5.0	10.5

SOURCE: Congressional Budget Office and FAA data.

a. Benefits and costs are discounted to 1982 values at the annual rate of 10 percent.

currently planned economic life. The CBO analysis indicates, however, that from an economic point of view the FAA plan is reasonably safe from the risks of technological obsolescence. Even with lower than projected traffic, if the equipment were to be replaced again in the mid-1990s (rather than early in the twenty-first century, as is planned), cumulative net benefits would still be positive--somewhat over $2 billion. Although this is below the $9 billion of net benefits the FAA assumes, it remains an acceptable investment, with an annual rate of return of about 16 to 17 percent (see Table 8).

TABLE 8. EFFECTS OF TECHNOLOGICAL OBSOLESCENCE ASSUMPTIONS ON EVALUATION OF THE FAA PLAN, 1982-2005

Assumptions	Return on Investment: Rate of Return (In percents)	Return on Investment: Benefit-to-Cost Ratio a/	Return on Investment: Benefits Minus Costs (In billions of dollars) a/	Timing: Return in the First Year After Completion (In percents)
Under FAA Assumptions	24.3	2.3:1	9.1	14.9
Technological Obsolescence by Mid-1990s	20.0	1.5:1	3.3	14.9
Maturity Scenario and Technological Obsolescence by Mid-1990s	16.5	1.3:1	2.1	13.1

SOURCE: Congressional Budget Office and FAA data.

a. Benefits and costs are discounted to 1982 values at the annual rate of 10 percent.

Effectiveness of Major Components

Although the FAA plan as a whole appears to offer the nation a good return on its money, questions might be raised about individual components. One important part of the FAA plan is the microwave landing system, the new instrument landing device that allows shorter flight times by reducing the approach path for incoming aircraft (see Chapter II). The economic worth of the microwave landing system (MLS)--projected to cost $2.3 billion over the next two decades--depends on the monetary value assigned to the time gained as a result of reduced delay. As stated in Chapter II, time is an economic resource with somewhat elusive value. The FAA, having equated the value of time to passengers' hourly earnings, estimates the net benefits of the microwave landing system to total $583 million. If the lower value of 30 percent of hourly earnings suggested by other analysts (see Appendix E) is applied, the microwave landing system, under the lower than projected traffic scenario, would be estimated to "lose" $177 million, since discounted costs would exceed discounted benefits by that amount (see Table 9). On the other hand, this ignores unquantifiable benefits expected with MLS, in the form of diminished noise and air pollution (see Chapter II).

TABLE 9. EFFECTS OF ALTERNATIVE ASSUMPTIONS ON EVALUATION OF THE MICROWAVE LANDING SYSTEM, 1982-2005

Assumptions	Return on Investment: Rate of Return (In percents)	Return on Investment: Benefit-to-Cost Ratio a/	Return on Investment: Benefits Minus Costs (In millions of dollars) a/
Under FAA Assumptions	19.8	1.6:1	583.0
Time Savings Valued at 30 percent of Passengers' Earnings	10.8	1.0:1	38.6
Maturity Scenario and Time Savings Valued at 30 percent of Passengers' Earnings	6.0	0.8:1	-176.9

SOURCE: Congressional Budget Office and FAA data.

a. Benefits and costs are discounted to 1982 values at the annual rate of 10 percent.

This suggests a possible mid-course, namely selective rather than system-wide application of the microwave landing system. Indeed, for certain specific problems, introduction of the microwave landing system might offer substantial and cost-effective relief. For example, improved signal reliability with the microwave landing system could allow safe landings in difficult siting situations. This means, for example, that airports located in mountainous terrain could provide precision landing aids where none are now available. Since airlines cannot offer regularly scheduled service unless precision guidance is available, the system could offer important economic benefits to certain communities. In addition, microwave landing systems could improve airport capacity use in certain large metropolitan areas. 4/

On the other hand, selective application of the microwave landing system could mean that some aircraft would need to carry both current and modernized avionics equipment. These costs would have to be weighed against the advantages of an approach that would introduce the microwave landing system selectively.

Pricing Policy

The FAA plan assumes that the current structure of federal user fees would remain in place as the chief financing mechanism for the National Airspace System Plan. Of the total federal cost of the plan (about $7.6 billion in 1982 dollars), an estimated 30 percent, or $2.3 billion, is attributed to general aviation. 5/ Over the plan's entire implementation period, however, general aviation user fees (taxes of 12 cents per gallon of

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4. See Mitre Corporation, Potential MLS Applications to Airport Capacity (November 1982). For example, when poor weather conditions require instrument approaches, landings at Kennedy Airport's runway 31 (two parallel runways, 31 right and 31 left) are limited to one runway or alternating runways even though these parallel runways are sufficiently far apart to permit their simultaneous use. This is because current landing aids could not guide two aircraft simultaneously if both blunder on the approach and need to circle around and try again. The microwave landing system, however, could double the landing capacity of runway 31 by providing more precise guidance that allows two aircraft to fly out on independent paths.

5. Based on cost allocation factors in Federal Aviation Administration, Financing the Airport and Airway System: Cost Allocation and Recovery (November 1978).

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gasoline and 14 cents per gallon of jet fuel) would generate only about $900 million, 6/ some of which would be used to finance airport improvements rather than the FAA plan. The gap in revenues would be made up by the ticket taxes paid by commercial airline passengers.

The result could be support from airline passengers for the benefits received by general aviation users, a situation commonly called "cross-subsidization." 7/ Even if general aviation were to pay its proportional share, however, the FAA plan appears cost-effective. Elimination of cross-subsidies from commercial air travel to general aviation would indeed require a very significant increase in the latter's user fees; such an increase would likely result in a substantial reduction in their demand for air traffic control services and thus in reduced benefits from the FAA plan. Nonetheless, the nongeneral aviation benefits of the FAA plan appear sizable enough to ensure a rate of return of 17 percent to 18 percent, even if three-fifths of all general aviation flights were eliminated by user charges set high enough to recover general aviation's full share of the costs of the control system.

A still more efficient plan for system modernization, however, might be possible under a system of full cost recovery. Presumably, reduced general aviation demand would permit fewer or less costly flight service stations and other general aviation services. Moreover, if higher fees were introduced soon, the capacity of today's air route center computers would be exhausted later than is now anticipated. This, in turn, could permit a more efficient schedule of air route center modernization. In particular, rather than introducing new computers now, the FAA could await the development of further advanced software and ensure that any new hardware is fully compatible.

On the other hand, a sudden shift to full cost recovery could exact high transition costs, such as reduced employment in the general aviation industry, and such costs would need to be weighed against the benefits of a different approach to computer replacement. Inasmuch as the computer replacement program is already underway, the use of a sudden increase in user fees to moderate the program would probably not be desirable.

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6. Based on U. S. Treasury forecasts.

7. See Congressional Budget Office, Public Works Infrastructure, Chapter VII on "Airports," which offers further information on the structure of user-fee financing of airports and cross-subsidies among airport users.

THE RISK OF ECONOMIC FAILURE

Although it is instructive to explore the potential effect of errors in individual assumptions one at a time, several such errors would inevitably occur simultaneously. At the most pessimistic extreme, for example, one can compute the rate of return under a "worst case" condition. If the worst cases in all assumptions reviewed above were combined, the rate of return for the FAA plan would be only 2.8 percent. But this approach is also of little practical value, simply because the possibility of everything's going wrong seems just as remote as the possibility of everything's going as initially assumed.

A better guide to the risk associated with an investment is given by the estimated probability, or chance, that the rate of return will fall below 10 percent (the OMB minimum standard). This probability is estimated by assigning ranges (that is, probability distributions) to the various outcomes for each individual parameter, and then making repeated rate-of-return calculations using assumptions drawn at random from each range. This procedure generates not a point estimate but a probability distribution for the rate of return.

On the basis of ranges that CBO estimates for productivity improvements, fuel savings, capital costs, and benefits from the microwave landing system, the FAA plan has a 20 percent probability of falling below the 10 percent rate-of-return mark (as shown in the table below). There is, however, considerable skew toward the 10 percent to 15 percent range in the overall probability distribution of the rate of return. This means that the average or expected value is a 13.5 percent return--considerably lower than the 24 percent rate of return calculated from FAA assumptions, and not far above the OMB minimum standard.

Thus, though the risk of economic failure appears fairly small, it is not insignificant, and steps to help minimize it might be in order. This chapter concludes with a brief discussion of options that could help avert a poor economic return from so large a public investment.

Managing the Risks--Congressional Options

What can the Congress do to make sure that the National Airspace System Plan achieves its objectives in a cost-effective and timely manner? Two related and key variables associated with the plan's success--system consolidation and staff reduction--are readily controllable by the Congress, giving ready access to two options.

RISK ANALYSIS FOR THE NATIONAL AIRSPACE SYSTEM PLAN

Possible Rates of Return (In percents)	Chance of a Lower Rate of Return (In percents) a/
2	6
6	7
10	20
15	70
20	97

NOTE: The following assumptions are reflected:

- o Average capital costs are 25 percent higher than FAA assumptions, with a standard deviation of 10 percent;
- o Average productivity improvements are one-third below FAA forecasts, with a standard deviation of 15 percent;
- o Air carrier fuel savings fall 20 percent below FAA forecasts, with a standard deviation of 20 percent;
- o General aviation fuel savings fall 40 percent below FAA forecasts, with a standard deviation of 20 percent; and
- o Benefits from the microwave landing system fall 25 percent below FAA forecasts, with a standard deviation of 25 percent.

a. The distribution mean rate of return is 13.5 percent. The distribution standard deviation is 4.1 percent.

First, the Congress could ensure that the FAA is allowed to close facilities according to its plan. As mentioned earlier, the Congress has refused to allow consolidation in the past, in some instances because of local employment implications. Though legitimate public policy concerns, these issues could impede progress in making the facility consolidations critical to the FAA plan's economic success.

Second, the Congress could make the FAA's planned schedule for consolidation and staff reductions part of the appropriations process. This could include setting progressively lower appropriations in line with the projected savings in operating costs, thus creating an incentive for the FAA to consolidate facilities and reduce staff according to schedule. Obviously, if slippages did occur, the FAA would have to seek supplemental appropriations to meet a revenue shortfall. Nevertheless, the rationales for such supplemental appropriations would have to be spelled out, thereby providing a device for monitoring FAA's progress in implementing the plan.

CHAPTER IV. FINANCING THE FAA PLAN

Like other federally funded aviation projects, the National Airspace System Plan would be financed with aviation taxes paid into the Airport and Airway Trust Fund. Financing the plan is subject to some of the same uncertainties that influence its potential cost-effectiveness. In particular, if FAA's projection of growth in air traffic or airline fares proves too high, or if its estimates of capital costs proves too low, revenues could fall short of the required level of authorizations. The present financial condition of the trust fund does not support such apprehension. The fund is projected to end 1983 with a cash balance of $4.6 billion, of which $2.2 billion would remain uncommitted. On the other hand, the present price wars among commercial airlines and excess numbers of seats suggest a less sanguine outlook.

The first two sections of this chapter assess the trust fund's financial status and analyze key aspects of the risk of trust fund receipts' being inadequate to finance the FAA plan. The third section evaluates the possible implications of recent appropriation legislation that limits radically the Federal Aviation Administration's claim to trust fund revenues in 1984. The projection period of this analysis stops at 1987--far short of the projection period examined elsewhere in this study--because the trust fund is currently authorized only through 1987.

THE AIRPORT AND AIRWAY TRUST FUND

In 1970, the Congress created the Airport and Airway Trust Fund as a repository for the tax monies paid by aviation users for federal aviation programs. By holding aviation revenues separate from other federal income, the trust fund has accomplished three purposes. It has assigned the capital costs of airports and traffic control specifically to users of aviation services and prevented those costs from burdening taxpayers in general. It has ensured that the taxes paid by aviation users be used for aviation purposes. And it has provided an assured mechanism for financing long-term capital aviation projects. The trust fund finances all federal spending on airport capital projects, including the air traffic control system. 1/ Only about

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1. Exceptions are Washington, D. C.'s National and Dulles Airports, which, though owned and operated by the federal government, are financed largely outside the trust fund.

three-quarters of the operating and maintenance costs of the air traffic control system are financed in this way, however, with the balance being drawn from general federal revenues. 2/

The trust fund is simple in concept: aviation users pay into the fund, and expenditures to support federal aviation programs are drawn from the fund. 3/ As shown in the table below, users pay through separate taxes in five categories:

Items Taxed	Current Tax Rate a/	Percent of Total Trust Fund Receipts in 1982
Commercial Airline Tickets	8 percent of ticket price	87.0
International Departures	$3.00 per passenger	3.3
Freight Waybills	5 percent of waybill	4.4
General Aviation Fuel		
Gasoline	12 cents per gallon	2.1
Jet fuel	14 cents per gallon	3.2

a. Unless renewed, these rates will drop to permanent levels in 1987.

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2. The limited use of trust funds for operating costs is attributable in large part to disagreement between the Congress and the Administration over the use of the fund when it was first set up in the early 1970s. In general, restrictions on the purposes for which user fees can be spent stem from the view that general taxpayers benefit from the military and other "public goods" applications of the airway system, making it fair for general taxpayers to cover at least part of the system's costs. This argument is inconsistent with the operation of certain other federal trust funds, however. The Highway Trust Fund, for example, is financed fully by highway users, despite any indirect defense or other benefits that nondirect beneficiaries might receive.

3. As stated in Chapter III, separate classes of users do not pay into the fund in proportion with their particular use; general aviation pays proportionately less while commercial aviation overpays. See also Congressional Budget Office, Public Works Infrastructure, Chapters VI and VII.

Receipts from these taxes--estimated to total $2.7 billion in 1983 and rise to $4 billion by 1987--go into the trust fund as they are collected, and subsequently they are withdrawn to pay for qualifying airport and air traffic control projects and for operation of the air traffic control system.

Projected Trust Fund Outlays

On the basis of authorizations in the Airport and Airway Development Act of 1982 (which includes authorizations for the FAA plan), outlays from the trust fund are expected to increase from about $2.0 billion in 1983 to $3.9 billion by 1987 (see Table 10). In 1983, almost 60 percent of this spending would go for air traffic controllers' salaries, equipment repairs, and other costs to operate and maintain the air traffic control system. In 1983, the federal share of airport development projects would use 22 percent of spending, while 15 percent would pay for initial procurements under the FAA plan. The remaining 7 percent would pay for research and development.

Over the period 1983 to 1987, total trust fund outlays are projected to nearly double; in addition, the mix of investments would change quite substantially. By 1987, trust fund outlays would total $3.9 billion, as against $2.0 billion in 1983, and capital spending for air traffic control is planned almost to triple its share of total trust fund spending, from 15 percent in 1983, to 35 percent in 1987.

STATUS OF THE TRUST FUND AND MAJOR FINANCIAL RISKS

Though income from the 8 percent tax on passenger tickets is the trust fund's chief source of financing, it is also the most difficult revenue source to forecast. Ticket tax revenues can vary according to two factors: numbers of passenger miles flown, and revenue produced by each passenger mile (called the "passenger yield"). Together, these two factors determine the revenue base for ticket tax collections and thus for trust fund revenues. Uncertainties underlying future trends in passenger miles are considered in Chapters II and III. This section evaluates trends in passenger yields and the associated financial risks for the National Airspace System Plan.

Trends in Passenger Yield

Passenger yield has been declining steadily since August 1981. Between September 1981 and March 1983, the average revenue per passenger mile for the previous 12 months fell by 14 percent, from 13.6 cents to

TABLE 10. BREAKDOWN OF PROJECTED AIRPORT AND AIRWAY TRUST FUND OUTLAYS, 1983-1987 (In billions of dollars)

Fiscal Year	Air Traffic Control: Capital Investments	Air Traffic Control: Operations and Maintenance	Airport Grants	Research, Engineering and Development	Total
1983 a/	0.31	1.17	0.44	0.11	2.03
1984 b/	0.56	1.24	0.80	0.22	2.83
1985 b/	0.91	1.26	0.95	0.26	3.38
1986 b/	1.24	1.30	1.00	0.24	3.78
1987 b/	1.35	1.36	1.04	0.20	3.95

SOURCE: Congressional Budget Office, projected from authorizations in the Airport and Airway Development Act of 1982.

NOTE: Details may not add to totals because of rounding.

a. Includes only appropriation action taken to date.

b. Assumes full appropriation of amounts authorized under the Airport and Airway Improvement Act of 1982 and the Surface Transportation Assistance Act of 1982. The impact of much lower appropriations under the Department of Transportation and Related Agencies Appropriations Act of 1984 is analyzed later in this chapter.

11.7 cents (in 1982 dollars--see Figure 5). For many carriers, this declining yield has imposed a heavy financial toll. Last year, the 12 largest domestic carriers lost a total amount exceeding $730 million. 4/

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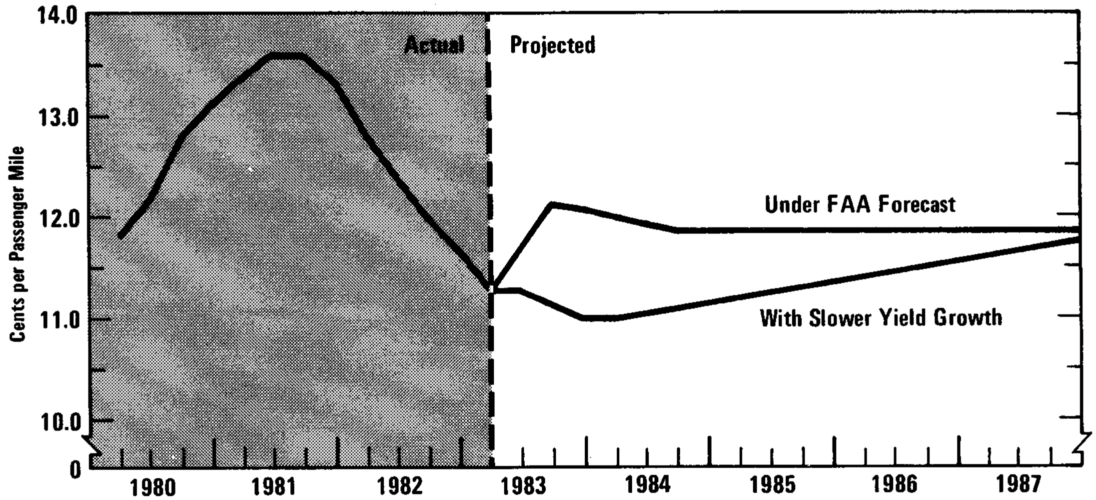
4. Some of this loss can be ascribed to the now-bankrupt Braniff Airlines. The 11 largest domestic airlines are American, Continental, Delta, Eastern, Northwest, Pan American, Republic, Trans World, United, USAir, and Western.

Figure 5.

Actual and Projected Revenue Yield to Commercial Airlines Per Passenger Mile, 1980-1987[a]

(Twelve-month moving average, in June 1982 dollars)



SOURCE: Congressional Budget Office from Civil Aeronautics Board and Federal Aviation Administration data.

[a] Excludes passengers on international flights.

The decline in yield, a result of heavy fare cutting, has two major causes:

- o Airline deregulation, which permitted competition among airlines for both prices and routes; and
- o Economic recession, which, by causing an oversupply of airline seats, encouraged price wars.

Airline Deregulation. The Airline Deregulation Act of 1978 progressively released U. S. airlines from virtually all constraints on access to air routes and on pricing. Predictably, competitive forces came into play as airlines expanded into markets that had previously been the exclusive territories of other carriers. In many cases, airlines used reduced fares to attract passengers from competitors and to encourage new travelers. By October 1982, 80 percent of all domestic fares were discounted by an average of 53 percent from the full fare (and some by more than 70 percent). The result was greatly diluted passenger yield.

Fare wars have also resulted in part from new entrants into the airline industry since deregulation. Offering "no-frills" service--often with less costly aircraft (for example, previously owned planes requiring less debt service per seat) and with nonunion labor--these carriers could offer fares as much as 70 percent below earlier rates. Moreover, because of their lower cost structure, many such carriers appear able to make money despite lower fares. People Express, for example, turned an operating profit of $10.6 million in 1982, while Eastern Airlines lost $14.2 million.

Economic Recession. In addition to competitive forces, economic recession further depressed airline fares. Between 1979 and 1982, the number of airline passengers increased by only 1 percent, while the seating capacity of the aircraft fleet grew by 13 percent; many new aircraft had been ordered in the mid-1970s, when passenger demand was growing at a rate of 7.7 percent a year. As a measure of the problem, fully 10 percent of the world's 6,000 commercial jets were up for sale last year. Thus, by adding seats to a stagnant market, the airlines needed to sell tickets at a cut price determined not by the need for profit but by the market.

The outlook for passenger yields--critical to airline and trust fund revenues--in the years ahead is subject to various factors, some related to the economy as a whole and others affected by the behavior of the airline industry. Economic recovery could bring a resurgence of demand, diminishing surplus capacity and permitting price increases. Retreat from recovery, however, might again depress demand for air travel, thus leading to another period of overcapacity and, in turn, to renewed price wars. Independent of these factors, the airline industry itself might put a stop to this downward spiral, adopting a course of self-discipline to stop price wars; this would make possible some increases in fares but with possibly adverse effects on demand. Higher fares, of course, could invite more low-cost carriers to enter the market.

The FAA's Forecast and Major Assumptions. Before October 1978, while airline fares and routes were still tightly regulated, the FAA's record in forecasting passenger yield was quite good. Since then, however, most forecasters have underestimated the extent of price cutting.

The FAA is now projecting a sharp decline in price cutting this year and a return to the mid-1982 real dollar yield of 12.1 cents per passenger mile by September (see Figure 5). To achieve this, average ticket prices must increase by about 10 percent between March and September 1983. The forecast is predicated on an optimistic view of the economy and a corresponding surge in air traffic.

On the basis of these assumptions, federal aviation user taxes would generate about $2.3 billion in 1983, with nearly 90 percent coming from taxes on commercial airline tickets (see Table 11). In addition, the substantial cash balance in the trust fund will earn about $500 million in interest, bringing total receipts to around $2.8 billion.

Over the period 1983 to 1987, the FAA forecasts that annual trust fund receipts (not including interest on the cash balance) will grow by about 12 percent a year, increasing from $2.3 billion in 1983 to $3.7 billion in 1987. Revenues from the most important revenue source--ticket taxes--will grow by 13 percent a year, producing collections of some $3.3 billion in 1987.

Given these revenue forecasts and the outlay projections presented earlier, the trust fund would continue in sound financial condition, being fully capable of funding all authorized aviation programs with receipts exceeding outlays in each year through 1987 (see Table 12). At the start of 1983, the trust fund had a cash balance of $3.9 billion. Part of this sum is needed to pay commitments that have already been made, but because of normal delays between authorization and completion of construction, it has not yet been spent. These unpaid authorizations are projected to total $1.7 billion, leaving $2.2 billion as uncommitted surplus. In large part because of the higher authorizations required by the FAA plan, the uncommited surplus in the trust fund would be drawn down from $2.2 billion to about $900 million by the start of 1987. (There is no compelling financial reason for maintaining such a surplus, and indeed, the existence of uncommited user fee revenues has long been a source of concern to aviation users.) Thus, under the conditions projected by the FAA, the trust fund appears headed for a period of financial stability.

Major Uncertainties. Signs of renewed economic growth and a recovery in passenger mileage--the underpinnings for FAA's projected yields--are already visible, and yields appear to have stabilized, at least for the time being. But yields are unlikely to increase over the short run to the level projected by the FAA. The nation's real gross national product grew by 0.5 percent in the January-March quarter of 1983, relative to the same quarter in 1982, while airline traffic increased by 10 percent over the rate recorded for the previous year. But as yields dropped by 3.5 percent in January and February, this increase appears due in part to continued price wars.

TABLE 11. BREAKDOWN OF PROJECTED AIRPORT AND AIRWAY TRUST FUND REVENUES, 1983-1987 (In millions of dollars)

Receipts by Tax Source	1983	1984	1985	1986	1987	Annual Average Growth (In percents)
Passenger Tickets	2,010	2,318	2,606	2,908	3,254	12.8
Freight Waybills	100	117	132	150	170	14.2
International Departures	74	84	88	92	97	7.0
General Aviation Fuel a/	129	138	149	161	166	6.5
Tires and Tubes	1	b/	0	0	0	0.0
Total	2,314	2,657	2,975	3,311	3,687	12.4

SOURCE: Congressional Budget Office from Office of the Secretary of the Treasury, Office of Tax Analysis (FAA estimates).

a. Combines taxes on jet fuel and gasoline.

b. Less than $1 million.

Some evidence of an end to the current price wars appears to be emerging. American Airlines recently proposed a simplified fare structure based on mileage--not unlike fare structures prior to deregulation. The response has been uneven, with three other major airlines (Trans World, Continental, and United) appearing to follow suit and at least one (Pan Am) refusing. Without such self-imposed discipline, the airline industry would be relying solely on increased demand to absorb excess capacity and lessen the

TABLE 12. ANALYSIS OF AIRPORT AND AIRWAY TRUST FUND UNDER FAA ASSUMPTIONS, 1983-1987
(In billions of dollars)

	1983	1984	1985	1986	1987
Authorization a/	3.12	3.92	3.93	3.91	3.74
Outlays	2.03 b/	2.83 c/	3.38 c/	3.78 c/	3.95 c/
Receipts d/	2.78	3.16	3.48	3.79	4.15
Cash Balance					
Start of year	3.88	4.63	4.96	5.06	5.07
End of year	4.63	4.96	5.06	5.07	5.27
Change	+0.75	+0.33	+0.10	+0.01	+0.20
Uncommitted Surplus					
Start of year	2.16	1.81	1.05	0.60	0.48
End of year	1.81	1.05	0.60	0.48	0.90
Change	-0.35	-0.76	-0.45	-0.12	+0.42

SOURCE: Congressional Budget Office.

a. Figures shown are the amounts authorized under the Airport and Airway Improvement Act of 1982, and the Surface Transportation Assistance Act of 1982.

b. Outlay projections for 1983 assume appropriations action taken to date.

c. Outlay projections for 1984 through 1987 assume the full appropriation of amounts authorized in the 1982 legislation cited in footnote b.

d. Includes accrued interest on the cash balance.

downward pressure on yields. However, if the 20 biggest U. S. carriers were to fly their planes as often as they did in 1979, they would need a traffic increase of 22 percent to fill as high a fraction of seats. 5/

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5. Calculations by Banker's Trust, reported in The Economist (June 3, 1983).

Such a large increase seems highly unlikely, and FAA's projected rate of recovery in passenger yields thus appears unlikely as well. Indeed, preliminary indications are that yields continued their decline in April 1983, although a slight increase (about 0.1 percent) was apparent in May. Against these recent trends, a scenario of more gradual recovery in passenger yields (see Figure 5) could result in 8 percent lower trust fund revenues in 1983 than the FAA forecasts, 6 percent lower revenue in 1984, and 4 percent lower revenue in 1985.

Even assuming this more gradual increase in yields, outlays and receipts would remain in overall balance. Unpaid authorizations would exceed cash on hand by some $160 million by the end of 1986 but a small uncommitted surplus would reappear in 1987, indicating a sound financial picture for the FAA plan (see Table 13).

Financial problems could arise, however, if in addition to lower yields, passenger mileage grew more slowly than expected under the FAA projections--say, along the path predicted by the "maturity scenario" presented in Chapter III. Although the risk of lower traffic is diminished by the likelihood of lower yields themselves encouraging further growth in air travel, the combined impact of gradual recovery in yields and a maturity path in passenger miles would reduce trust fund revenues below the FAA forecast by 10 percent in 1983 and 1984, and by nearly 12 percent in 1985.

Assuming this much lower growth in receipts, unpaid authorizations would exceed cash on hand by some $400 million at the end of 1985, and by more than $1 billion by the end of 1987 (see Table 14). To maintain the past trust fund management practice of no unfunded authorizations, an increase in aviation user fees--equivalent to about one percentage point on the 8 percent ticket tax--would be called for. Alternatively, the fund could be operated along the lines of the federal Highway Trust Fund, which does permit a certain level of unfunded authorizations as long as adequate receipts (including interest) are available over the life of the trust fund. 6/ This would require extending the Airport and Airway Trust Fund beyond the last year of the aviation program. Since this would place the trust fund on a less sound financial footing, however, the Congress could

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6. The most important of these restrictions is called the Byrd Amendment and has been part of the Highway Trust Fund since it was founded in 1956. Basically, this requires the Department of the Treasury to ensure that there is adequate cash available over the remaining life of the fund to cover the projected outlays.

TABLE 13. ANALYSIS OF AIRPORT AND AIRWAY TRUST FUND, ASSUMING GRADUAL RECOVERY IN PASSENGER YIELDS, 1983-1987 a/ (In billions of dollars)

	1983	1984	1985	1986	1987
Authorization b/	3.12	3.92	3.93	3.91	3.74
Outlays	2.03 c/	2.83 d/	3.38 d/	3.78 d/	3.95 d/
Receipts e/	2.60	2.99	3.32	3.66	4.05
Cash Balance					
Start of year	3.88	4.45	4.61	4.55	4.43
End of year	4.45	4.61	4.55	4.43	4.53
Change	+0.57	+0.16	-0.06	-0.12	+0.10
Uncommitted Surplus					
Start of year	2.16	1.63	0.71	0.10	-0.16
End of year	1.63	0.71	0.10	-0.16	0.16
Change	-0.53	-0.92	-0.61	-0.26	+0.32

SOURCE: Congressional Budget Office.

a. Assumes 8 percent lower yield than the FAA projection in 1983, 6 percent lower in 1984, 4 percent lower in 1985, 3 percent lower in 1986, and 1 percent lower in 1987.

b. Figures shown are the amounts authorized under the Airport and Airway Improvement Act of 1982 and the Surface Transportation Assistance Act of 1982.

c. Outlay projections for 1983 assume appropriation action taken to date.

d. Outlay projections for 1984 through 1987 assume the full appropriation of amounts authorized in the 1982 legislation cited in footnote b.

e. Includes accrued interest on the cash balance.

TABLE 14. ANALYSIS OF AIRPORT AND AIRWAY TRUST FUND, ASSUMING GRADUAL RECOVERY IN PASSENGER YIELDS a/ AND MATURITY SCENARIO FOR PASSENGER MILES b/ (In billions of dollars)

	1983	1984	1985	1986	1987
Authorization c/	3.12	3.92	3.93	3.91	3.74
Outlays	2.03 d/	2.83 e/	3.38 e/	3.78 e/	3.95 e/
Receipts f/	2.50	2.83	3.08	3.33	3.61
Cash Balance					
Start of year	3.88	4.35	4.36	4.06	3.62
End of year	4.35	4.36	4.06	3.62	3.27
Change	+0.47	+0.01	-0.30	-0.44	-0.35
Uncommitted Surplus					
Start of year	2.16	1.53	0.45	-0.40	-0.97
End of year	1.53	0.45	-0.40	-0.97	-1.10
Change	-0.63	-1.08	-0.85	-0.57	-0.13

SOURCE: Congressional Budget Office.

a. Assumes 8 percent lower yield than the FAA projections in 1983, 6 percent lower in 1984, 4 percent lower in 1985, 3 percent lower in 1986, and 1 percent lower in 1987.

b. Assumes 5 percent fewer passenger miles than the FAA projection in 1983, 6.5 percent fewer in 1984, 8 percent fewer in 1985, 9.1 percent fewer in 1986, and 11 percent fewerin 1987.

c. Figures shown are the amounts authorized under the Airport and Airway Improvement Act of 1982, and the Surface Transportation Assistance Act of 1982.

d. Outlay projections for 1983 assume appropriation action taken to date.

e. Outlay projections for 1984 through 1987 assume the full appropriation of amounts authorized in the 1982 legislation cited in footnote b.

f. Includes accrued interest on the cash balance.

consider placing restrictions on the cash balance similar to those applying to the Highway fund. 7/

IMPACT OF RECENT APPROPRIATION LEGISLATION

The preceding analysis assumes the full appropriation of amounts authorized under the Airport and Airway Improvement Act of 1982. Although this generous assumption would severely test the trust fund's capacity to fund the FAA plan, it does not take into account recent appropriation action that sharply curtails trust fund expenditures in 1984. 8/ Against authorizations of $1.39 billion for the National Airspace System Plan in 1984, the appropriation act allows only $750 million. FAA operating expenditures from the trust fund are eliminated entirely, representing a reduction of $1.2 billion, (sums for FAA operating costs would be drawn from general revenues instead). 9/ In addition, spending from the trust fund for airport development and research and development is reduced by $194 million and $23 million, respectively. In sum, appropriation decisions for 1984 reduce expenditures from the trust fund by $2 billion, 49 percent below the authorized level.

This large reduction has important implications for the trust fund. By the end of 1984, the fund's uncommitted surplus would exceed $2 billion, and would climb to nearly $3 billion by 1987, (see Table 15). Revenues from user fees would exceed outlays by more than 26 percent over the 1984 to 1987 period, a condition that could justify a reduction in aviation user fees.

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7. See Congressional Budget Office, Financial Options For the Highway Trust Fund (December 1982).

8. Department of Transportation and Related Agencies Appropriations Act of 1984 (P. L. 98-78).

9. To encourage the timely appropriation of all funds authorized for the FAA plan, the Airport and Airway Improvement Act of 1982 stipulates that any reduction in the authorized amounts for the National Airspace System Plan be matched with a reduction in trust fund expenditures for operations and maintenance on a two-to-one basis. Thus the reduction of $640 million under the Department of Transportation Appropriations Act of 1984 translates into a $1.3 billion reduction in trust fund operating billion reduction in trust fund operating expenditures.

TABLE 15. ANALYSIS OF AIRPORT AND AIRWAY TRUST FUND, UNDER FAA APPROPRIATIONS FOR 1984 (In billions of dollars)

	1983	1984	1985	1986	1987
Authorization	3.12	2.68 a/	3.93	3.91	3.74
Outlays	2.03 b/	1.56 b/	3.03 c/	3.57	3.94 d/
Receipts e/	2.78	3.23	3.65	3.99	4.36
Cash Balance					
Start of year	3.88	4.63	6.30	6.91	7.33
End of year	4.63	6.30	6.91	7.33	7.75
Change	+0.75	+1.67	+0.61	+0.42	+0.42
Uncommitted Surplus					
Start of year	2.16	1.82	2.37	2.09	2.17
End of year	1.82	2.37	2.09	2.17	2.79
Change	-0.34	+0.55	-0.28	+0.08	+0.62

SOURCE: Congressional Budget Office.

a. Excludes $1.2 billion in unappropriated funds for operating expenses.

b. Includes appropriation action taken to date.

c. Assumes that $250 million in unappropriated 1984 authorizations for the FAA plan are brought forward to 1985.

d. Assumes that $393 million in unappropriated 1984 authorizations for the FAA plan are brought forward to 1987.

e. Assumes FAA forecasts of trust fund revenues. Also includes accrued interest on the cash balance.

In addition to the above budgetary implications for the trust fund, reduced appropriations from the trust fund raise important economic and equity questions. By slowing the pace of investment in the FAA plan, appropriation action delays an investment that already appears overdue by economic standards (see Chapter III).

In addition, shifting the entire burden of the cost of operating the national airspace system to the general taxpayer represents a significant shift from the user-pays principle embodied in the trust fund concept. If the Congress were to continue these expenditures from general revenues, aviation user fees could be reduced. This would increase the overall federal deficit, however.

CONCLUSION

Under the FAA's projections of travel demand and passenger yields, trust fund receipts appear adequate to ensure a sound financial base for implementation of the National Airspace System Plan while also meeting other federal aviation commitments. Considerable uncertainty surrounds the projections, however, and passenger yields in particular show signs of less brisk recovery than the FAA projects. If trust fund receipts fell below expectations, or if costs ran higher than expected, a user fee increase--or a shift in trust fund management--might prove necessary at some point in order fully to implement the plan. On the other hand, by sharply curtailing the level of trust fund expenditures, particularly for FAA operations and maintenance, recent appropriation decisions would allow the fund's uncommitted surplus to increase sharply.

APPENDIXES

APPENDIX A. ESTIMATED TIME PATH OF CAPITAL COSTS UNDER FAA ASSUMPTIONS AND FORECASTS

On the basis of Federal Aviation Administration data, the Congressional Budget Office has projected the time path for the three major cost streams associated with the National Airspace System Plan (see Table A-1). These projections support the analysis in Chapter II. The cost streams are:

- Federal investment costs;
- User costs for avionics associated with updated transponders and the new traffic alert and collision avoidance system (TCAS); and
- User costs for avionics associated with the microwave landing system (MLS).

Federal Investment Costs

The FAA estimates that implementation of the plan would cost about $7.6 billion in 1982 dollars, or $5.7 billion in Net Present Value (NPV), discounting at 10 percent. 1/ To estimate the schedule of these expenditures, CBO used data from the FAA's eight-year Facilities and Equipment Plan, covering the period 1983 through 1990 (see Table A-1).

Transponder Costs

The FAA projects that users would begin installing new transponder equipment in 1986. This would result in $158 million in annual user investment expense over the period 1986-1995 and $84 million thereafter for replacement and growth. Over the period 1982-2005, total transponder user cost would total $2.4 billion (in 1982 dollars).

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1. Federal Aviation Administration, Preliminary Estimates of the Benefits and Costs to Implement the National Airspace System Plan.

TABLE A-1. PROJECTED FEDERAL INVESTMENT AND USER COSTS FOR AVIONICS EQUIPMENT (In millions of dollars)

Fiscal Year	Federal Investment Costs	User Avionics Costs: Transponders/ TCAS	User Avionics Costs: MLS a/
1982	690.5	0	57.2
1983	1,261.8	0	59.1
1984	1,218.2	0	61.0
1985	1,198.6	0	62.8
1986	979.0	158	64.7
1987	896.4	158	13.8
1988	776.0	158	-16.1
1989	625.8	158	-46.1
1990	b/	158	60.6
1991	b/	158	74.0
1992	b/	158	-7.8
1993	b/	158	-7.7
1994	b/	158	-7.6
1995	b/	158	-7.4
1996	b/	84	-7.4
1997	b/	84	40.4
1998	b/	84	40.5
1999	b/	84	40.7
2000	b/	84	40.8
2001	b/	84	40.9
2002	b/	84	8.6
2003	b/	84	9.0
2004	b/	84	9.1
2005	b/	84	9.3
Totals in 1982 dollars			
1982-2000	7,646.3	2,000	515.5
1982-2005	7,646.3	2,420	592.4
Total Present Value (At 10 percent discount rate)			
1982-2000	5,729.3	821.6	309.8
1982-2005	5,729.3	878.9	321.2

SOURCE: CBO from FAA data.

a. Continued use of the existing precision landing system would necessitate a costly frequency adjustment between the late 1980s and the mid-1990s and the costs associated with MLS in those years would actually be lower than the costs associated with such an adjustment. This explains the "negative" cost figures in this column.

b. Costs beyond 1989 are projected to remain within the approximate range of $100 million a year.

Avionics Costs for the Microwave Landing System

Over the period 1982-2000, the FAA projects MLS equipment to cost users some $515.5 million (in 1982 dollars), with a present value of $309.8 million (see Table A-1). This assumes an implementation period of 20 years. The FAA's MLS cost projections compare the installation of an MLS unit with the cost of continued use of the current system, called the instrument landing system (ILS). In other words, the estimates represent the incremental cost of implementing the MLS systemwide.

The FAA expects that, if the ILS system is to continue to operate over the next 20 years, a major investment in radio frequency conversion would be required. In recent studies, the FAA has assumed that the entire investment to achieve this conversion would be made in 1989. 2/ The year 1989 was apparently designated by the FAA as the date in which users would have to make frequency conversion investments to be permitted to use major terminal areas and facilities. Communication with the FAA indicates, however, that it would not be unreasonable to assume a somewhat earlier implementation of the frequency conversion costs by some users, and the MLS data shown in Table A-1 provide for a greater spread of these avionics costs. This results in a slightly higher cost value of $515.5 million than the FAA's $511.4 million.

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2. See Federal Aviation Administration, An Analysis of the Requirements for and the Benefits and Costs of the National Microwave Landing System (June 1980), vol. 1, pp. 1-78, Table 1.3-19.

APPENDIX B. ESTIMATED TIME PATH OF BENEFITS UNDER FAA ASSUMPTIONS AND FORECASTS

Using FAA data, CBO has projected the time path for the three major benefit streams associated with the National Airspace System Plan (see Table B-1). These projections support the analysis in Chapter II. The benefit streams are:

- o Savings in FAA operating costs;
- o Fuel cost savings; and
- o Savings attributable to the microwave landing system.

Savings in FAA Operating Costs

Savings in FAA operating costs account for the major benefits resulting from implementation of the FAA Plan--about two-thirds of the total. The savings reflect staff reductions associated with anticipated increases in labor productivity, facilities closures, and lower maintenance and operating costs. Over the period 1982-2000, the FAA estimates a total saving of $24.3 billion (in 1982 dollars). Extending these savings to the year 2005 increases the total to $37.1 billion. The present value of these savings for the period 1982-2005 amounts to $10.6 billion.

The FAA's analysis of operating costs indicates that, with no growth in air traffic, net savings would fall to $11.1 billion. 1/ In other words, about half of the operating cost savings would result from the anticipated productivity increases and facility closures.

Fuel Cost Savings

The fuel cost savings shown in Table B-1 result from more direct routing of flights, the elimination of altitude restrictions, and the elimination of arrival delays caused by the inefficient use of available airport capacity. More efficient route planning, en route metering, terminal flight

1. From FAA unpublished working notes supplied to CBO.

TABLE B-1. PROJECTED FEDERAL AND DIRECT USER BENEFITS (In millions of dollars)

Fiscal Year	FAA Net Operating Cost Savings	Fuel Cost Savings: Air Carriers	Fuel Cost Savings: General Aviation	Fuel Cost Savings: Total
1982	90	0	0	0
1983	280	0	0	0
1984	470	0	0	0
1985	660	0	0	0
1986	780	150	50	200
1987	910	150	50	200
1988	1,000	150	60	210
1989	1,125	160	60	220
1990	1,220	160	60	220
1991	1,310	170	60	230
1992	1,410	170	70	240
1993	1,530	530	220	750
1994	1,630	540	240	780
1995	1,720	680	300	980
1996	1,840	760	330	1,090
1997	1,940	780	350	1,130
1998	2,030	800	360	1,160
1999	2,130	820	370	1,190
2000	2,220	830	390	1,220
2001	2,380	850	400	1,250
2002	2,470	870	410	1,280
2003	2,550	890	420	1,310
2004	2,640	910	430	1,340
2005	2,750	920	440	1,360
Total in 1982 dollars				
1982-2000	24,295	6,850	2,970	9,820
1982-2005	37,085	11,290	5,070	16,360
Total Present Value (At 10 percent discount rate)				
1982-2000	8,902.0	2,001.9	843.1	2,845.0
1982-2005	10,638.6	2,622.0	1,127.2	3,749.2

SOURCE: CBO from FAA data.

planning and traffic management, strategic clearance planning, and tactical clearance generation all provide the basis for the FAA's estimates of benefits attributable to improved fuel use efficiency.

Estimated fuel savings are based on an estimated potential of 6 percent savings in fuel consumption, not expected to be realized fully before 1996.[2] A lower savings rate is applied for the interim period. Specifically, a fuel savings rate of 1.5 percent is applied for the period 1986-1992, 4.5 percent for 1993-1995, and 6 percent for 1996-2005.

Over the period 1982-2005, fuel savings represent $16.4 billion (in 1982 dollars)--$11.3 billion saved by the commercial air carriers and $5.1 billion by general aviation. The present values are $2.6 billion and $1.1 billion, respectively.

Savings from the Microwave Landing System

Estimated savings from the MLS are derived from five specific sources (see Table B-2):

- Safety benefits associated with reduced property damage and fatalities;
- Reduced system disruptions;
- Reduced system outages;
- Savings from reduced restrictions on the ground and/or in the air; and
- Savings associated with reduced path length in the approach to runways.

With the exception of the safety benefits, the major savings associated with the MLS relate to two factors: savings in time that are translated into direct reductions in operating costs (such as crew costs); and savings in time that are converted to direct savings in passenger time (based on an estimate of the value of that time).

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2. See Federal Aviation Administration, Preliminary Analysis of the Benefits and Costs to Implement the National Airspace System Plan (June 1982).

TABLE B-2. PROJECTED MICROWAVE LANDING SYSTEM BENEFITS (In millions of dollars)

Year	Safety Benefits	Reduced Disruptions	Reduced Outages	Ground/Air Savings	Path Length Reductions	Total
1982	0	0	0	0	0	0
1983	0	0	0	0	0	0
1984	0	0	0	0	0	0
1985	0	0	0	0	0	0
1986	4.8	34.8	8.5	26.0	19.5	93.6
1987	6.4	44.3	8.9	33.9	24.6	118.1
1988	8.1	58.2	9.3	42.7	30.1	148.4
1989	10.1	74.8	9.7	52.5	36.0	183.1
1990	12.3	93.7	10.2	63.5	42.2	221.9
1991	13.9	109.1	10.3	75.6	49.1	258.0
1992	14.2	115.5	10.4	80.8	51.3	272.2
1993	14.5	120.1	10.4	86.2	53.4	284.6
1994	14.8	125.1	10.5	91.7	55.5	297.6
1995	15.1	130.3	10.6	97.9	57.5	311.4
1996	15.3	135.2	11.2	104.0	59.7	325.4
1997	15.7	141.8	11.8	110.5	61.8	341.6
1998	15.8	146.5	12.5	117.4	63.7	355.9
1999	16.1	151.8	13.2	124.6	66.0	371.7
2000	16.3	157.4	13.9	132.0	68.3	387.9
2001	16.6	163.5	14.5	137.9	70.7	403.2
2002	16.9	169.7	15.1	144.1	73.2	419.0
2003	17.1	176.3	15.8	150.6	75.7	435.5
2004	17.4	183.1	16.5	157.4	78.4	452.8
2005	17.7	190.1	17.2	164.5	81.1	470.6
Total in 1982 dollars						
1982-2000	193.4	1,638.6	161.4	1,239.3	738.7	3,971.4
1982-2005	279.1	2,521.3	240.5	1,993.8	1,117.8	6,152.5
Total Present Value (At 10 percent discount rate)						
1982-2000	63.1	536.5	58.4	398.2	247.1	1,303.3
1982-2005	76.7	655.4	69.1	500.3	298.3	1,599.8

SOURCE: CBO from FAA data.

Over the period 1982-2005, estimated MLS benefits total $6.2 billion (in 1982 dollars), with a present value of $1.6 billion. On the basis of FAA data, these estimates value time savings at the average wage rate. An assessment of this assumption is presented in Appendix E.

Safety Benefits. Safety gains from the MLS are expected to generate benefits of $0.3 billion (in 1982 dollars), with a present value of $0.1 billion. Approximately 20 percent of the FAA's safety benefits are attributable to reduced property damage and 80 percent to reduced fatalities. About 35 percent of the safety benefits accrue to air carriers, 10 percent to commuter airlines, and 55 percent to general aviation.

Disruptions, Outages, Ground/Air and Path Length Savings. Over the period 1982-2005, savings associated with reduced disruptions, outages, ground/air restrictions, and path length reductions are estimated by the FAA to be $2.5, $0.2, $2.0, and $1.1 billion, respectively (see Table B-2). The FAA data indicate that benefits commence in 1986.

APPENDIX C. EXPLAINING AND FORECASTING PAST TRENDS IN AIR TRAFFIC

To support the analysis in Chapter III, this appendix presents a historical overview of FAA aviation forecasts, reviews current FAA forecasting methodology and assumptions, and assesses how projections could change under alternative explanations of past trends.

HISTORICAL OVERVIEW

The examination of FAA forecasts of aviation activity over the last 23 years indicates three distinct chronological periods (see Table C-1). The first period, 1959-1965, is characterized by consistent underestimates of air traffic. The worst five-year forecasting error was made in 1963, when FAA's forecast of 1968 take-offs and landings turned out to be 33 percent too low.

The second distinct period, 1966-1973, is marked by a dramatic reversal in forecasting performance--instead of being consistently too low, the FAA projected consistently more traffic than actually materialized (see Tables C-2, C-3, and C-4). Five-year forecast errors averaged 33 percent, the worst year producing a 58 percent overestimate of take-offs and landings.

The third period, from 1974 on, shows two important shifts from the past. First, the FAA adopted more sophisticated methods of analyzing trends in air traffic. Previously, FAA analysts had simply extrapolated past trends. Starting in 1974, however, FAA forecasters made statistical analyses of aviation activity, attempting to explain and quantify the causal relationships between aviation trends and macroeconomic activity, fuel prices, and other possible explanatory factors. Secondly, while past forecasts had been consistently either too high or too low, forecast results since 1974 have been more mixed. Inasmuch as no economic forecast can ever be "correct," it is better for investment planning that errors be randomly distributed rather than uniformly biased, and recent FAA performance can thus be regarded as having substantially improved.

TABLE C-1. SUMMARY OF FAA FORECASTS, BY PERIODS

Periods in which Forecasts Made	Method	Performance Five Years Ahead	Market Environment
1959-1965	Trend forecasting: unspecified links to economy, business cycle, population, fares, competition from other modes	Average error -18.7 percent Worst year -32.5 percent	Expanding, prosperous economy. Rapidly growing population. Declining first-class and coach fares, (declining unit costs because of increasing use of jets)
1966-1973	Trend forecasting: unspecified links to economy, business cycle, population, fares, competition from other modes	Average error +32.5 percent Worst year +58.4 percent	Softening trends in aviation activity. Increasing ticket taxes, rising fares. Forecasts made in 1969 (published January 1970) assumed 4.25 percent growth rate in 1973, to continue at that rate through decade. Inflation 2 percent per year from 1973
From 1974	Linear econometric models	Average error +21.2 percent Worst year +34.7 percent	Airline deregulation, economic recession, fare wars, and depressed airline revenues

SOURCE: CBO from FAA data.

TABLE C-2. ACCURACY OF FAA FORECASTS OF NUMBERS OF AIRCRAFT HANDLED BY AIR ROUTE CENTERS (Twelve-year and five-year errors, in percents)

Fiscal Year in Which Forecast Was Made	Air Carriers a/		General Aviation		Total Civilian Aircraft	
	12 Years	5 Years	12 Years	5 Years	12 Years	5 Years
1966	21.9 b/	-3.1	30.4	23.7	24.7	3.0
1967	57.7	30.3	67.1	38.5	61.0	32.2
1968	41.8	25.2	95.5	26.1	60.6	25.4
1969	49.4	28.1	89.9	15.7	64.0	24.7
1970	23.1	11.7	185.3	30.9	74.9	17.2
1971	---	-8.0	---	43.3	---	7.6
1972	---	-5.5	---	43.5	---	10.2
1973	---	-5.8	---	15.4	---	1.3
1974	---	3.1	---	-9.1	---	-1.2
1975	---	4.2	---	-11.2	---	-1.2
1976	---	7.6	---	11.2	---	8.5
1977	---	11.3	---	50.1	---	23.8

SOURCE: CBO from FAA data.

NOTE: Minus sign denotes percentage underestimate; blanks indicate that forecast period is not yet complete.

a. Includes air taxi.

b. The 1966 forecast of air carrier aircraft to be handled 12 years later (1978) turned out to be 21.9 percent too high.

TABLE C-3. ACCURACY OF FAA FORECASTS OF INSTRUMENT OPERATIONS AT AIRPORTS WITH FAA TRAFFIC CONTROL TOWERS (Twelve-year and five-year errors, in percents)

Fiscal Year in Which Forecast Was Made	Air Carrier		General Aviation		All Aircraft	
	12 Years	5 Years	12 Years	5 Years	12 Years	5 Years
1966	N/A	N/A	N/A	N/A	-17.5	0.0
1967	N/A	N/A	N/A	N/A	15.2	22.7
1968	N/A	N/A	N/A	N/A	32.5	15.6
1969	N/A	N/A	N/A	N/A	14.8	-2.1
1970	N/A	N/A	N/A	N/A	20.6	-15.3
1971	---	N/A	---	N/A	---	-16.4
1972	---	-15.7	---	-30.9	---	-20.0
1973	---	-15.6	---	2.5	---	-3.6
1974	---	-5.6	---	-1.7	---	-2.2
1975	---	-6.1	---	-7.8	---	-7.1
1976	---	-6.8	---	16.8	---	4.6
1977	---	9.2	---	43.2	---	22.8

SOURCE: CBO from FAA data.

NOTES: N/A = Not available. Minus sign denotes percentage underestimate; blanks indicate that forecast period is not yet complete.

TABLE C-4. ACCURACY OF FAA FORECASTS OF AVIATION FUEL CONSUMPTION (Twelve-year and five-year errors, in percents)

Fiscal Year in Which Forecast Was Made	Air Carrier		General Aviation						Total Fuel	
			Gasoline		Jet Fuel		All Fuel			
	12 Years	5 Years	12 Years	5 Years	12 Years	5 Years	12 Years	5 Years	12 Years	5 Years
1966	54.3	-6.3	28.3	13.8	-26.0	17.5	-4.7	22.5	47.2	-4.9
1967	77.4	7.7	45.8	35.6	-44.1	-17.9	-7.7	13.5	66.8	8.2
1968	73.0	23.8	60.1	37.5	-43.9	-17.8	-4.8	14.0	63.0	23.0
1969	91.3	32.5	86.0	50.1	-50.0	-27.2	-1.1	15.6	78.3	31.0
1970	129.0	43.5	119.6	68.7	-62.1	-57.8	+0.4	-2.6	109.1	38.6
1971	---	35.2	---	56.3	---	-57.8	---	-9.2	---	30.2
1972	---	34.5	---	43.6	---	-48.8	---	-12.4	---	28.8
1973	---	25.6	---	5.3	---	-35.1	---	-19.5	---	20.0
1974	---	14.3	---	-0.6	---	-31.9	---	-19.2	---	10.2
1975	---	0.6	---	13.2	---	-27.6	---	-12.4	---	-1.1
1976	---	6.7	---	34.2	---	-5.9	---	8.5	---	7.0
1977	---	17.0	---	17.9	---	12.5	---	7.9	---	11.2

SOURCE: CBO from FAA data.

NOTE: Minus sign denotes percentage underestimate; blanks indicate that forecast period is not yet complete.

FAA METHODOLOGY

To help understand the relationship between aviation activity and economic conditions, FAA analysts have developed econometric models of past trends. Such a model is simply a mathematical representation of air traffic and its relationship to those economic variables thought to influence traffic growth. Econometrics is the statistical technique used to quantify the relationships. The most recent published relationships are summarized in Table C-5 and discussed below. Current FAA forecasts are shown in Tables C-6, C-7, and C-8.

ALTERNATIVE EXPLANATIONS OF PAST TRENDS

The plausibility of different assumptions about the relationship between air traffic and economic growth may be tested by simply using models with a different mathematical form.

A Maturity Scenario

One alternative assumption, discussed in Chapter III, is that the influence of rising income on air traffic, rather than remaining constant, is declining over time, as the travel market matures and approaches a saturation point, or plateau. In quantifying such a model, the CBO's statistical analysis finds that it explains past trends quite well--in fact, about as well as the FAA models. 1/ This means that neither the FAA assumptions nor the "maturity scenario" tested here emerges as a better explanation of past trends.

This difficulty in explaining past trends is unfortunate, since alternative models result in very different forecasts of future trends. For example, the maturity models yield a 9 percent smaller workload at air route traffic control centers in 1987 than the FAA models; this difference increases to 14 percent by 1993, and to 29 percent by the turn of the next century (see

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1. In econometric jargon, CBO estimated logistic (s-shaped) and semi-logarithmic (declining elasticity) models for passenger miles and general aviation aircraft fleet data over the period 1959-1980. CBO also estimated log-linear models as a basis for comparison. R^2 values for all three models were roughly equal (about 0.95). This equality arises in part because all three models reflect smooth time trends in the data, making it impossible to distinguish among them on statistical grounds.

TABLE C-5. SUMMARY OF RECENT FAA FORECASTING MODELS, BY AVIATION ACTIVITY a/

Activity	Model Form	Causal Variables	Elasticity (At mean) a/
Air Carrier Operations			
Revenue passenger miles (RPMs)	Linear	Revenue per passenger mile	-0.64
		Disposable income	1.80
		Investment in transportation	0.26
Total domestic operations	$\frac{\text{RPM} \times 2}{\text{Load factor} \times \text{Average seating capacity} \times \text{Average stage length}}$	N/A	N/A
General Aviation			
Tower workload			
Change in fleet size	Semi Log-linear in differences	GNP	17.00
		Aircraft price	-4.00
		Interest rates	-2.00
		Sales	3.00
		Time	Negative
Itinerate operations	Linear	Fleet size	1.07
		Fuel price	-0.23

(Continued)

TABLE C-5. (Continued)

Activity	Model Form	Causal Variables	Elasticity (At mean) a/
General Aviation			
Tower workload (continued)			
Local operations	Linear	Fleet size	0.21
		Students	1.00
Instrument operations	Linear	Fleet size	1.50
Flight service station workload			
Aircraft contacted	Linear	Itinerant operations	1.10
Pilot briefs	Linear	Fleet size	1.60
		Fuel price	-0.30
VFR flight plans	Linear	Fleet size	0.60
		Fuel price	-0.27
IFR flight plans	Linear	Fleet size	1.60
		Fuel price	-0.21

SOURCE: Congressional Budget Office from FAA Aviation Forecasts (September 1978) and Transportation Research Board, Circular No. 230 (August 1981).

NOTES: Minus sign denotes an inverse relationship between activity and the causal variable. Information reported in this table draws on the most recently published description of FAA models. Details change continuously as the FAA updates its methodology and data analysis.

a. Elasticity is the estimated percentage change in aviation activity that corresponds to each 1 percent change in a causal variable.

TABLE C-6. RECENT FAA FORECASTS OF AIRCRAFT HANDLED BY AIR ROUTE CENTERS
(In millions of dollars)

	Total Aircraft a/			General Aviation			Air Carrier (Including air taxi)		
	1987	1993	2005	1987	1993	2005	1987	1993	2005
FAA Forecast February 1982	34.7	43.4	57.8 b/	12.1	17.1	25.5 b/	18.0	21.7	27.7 b/
FAA Forecast February 1983 c/	34.0 (-2.0)	40.5 (-6.7)	51.5 b/ (-10.9)	11.1 (-8.3)	14.8 (-13.5)	20.9 b/ (-18.0)	18.3 (1.7)	21.1 (-2.8)	26.0 b/ (-6.1)

SOURCE: CBO from FAA data.

NOTE: Actual handles for 1982 were:

Total aircraft = 27.8 million
General aviation = 7.5 million
Air carrier = 16.0 million

a. The difference between total aircraft and the same of general aviation and air carrier reflects military aircraft.

b. Extrapolated by Congressional Budget Office.

c. Numbers in parentheses are the percent changes from the 1982 FAA forecast.

TABLE C-7. RECENT FAA FORECASTS OF INSTRUMENT OPERATIONS AT AIRPORTS WITH FAA TRAFFIC CONTROL SERVICE (In millions)

	Total Aircraft		
	1987	1993	2005
FAA 1982 Forecast	46.2	55.4	74.8
FAA 1983 Forecast a/	44.3 (-4.1)	52.9 (-4.5)	66.6 (-11.0)

SOURCE: CBO from FAA data.

NOTE: Actual operations for 1982 were 31.6 million.

a. Numbers in parentheses are the percent deviation of actual experience from the 1982 FAA forecast.

TABLE C-8. RECENT FAA FORECASTS OF AVIATION FUEL CONSUMPTION (In billions of gallons)

	Air Carrier			General Aviation			Total Aircraft		
	1987	1993	2005	1987	1993	2005	1987	1993	2005
FAA 1982 Forecast	10.0	11.8	15.4 a/	1.9	2.8	4.1 a/	12.0	14.6	19.5 a/
FAA 1983 Forecast b/	9.4 (-6.0)	11.1 (-5.9)	14.2 a/ (-7.8)	1.9 (--)	2.6 (-7.1)	4.0 a/ (-2.4)	11.3 (-5.8)	13.7 (-6.2)	18.0 a/ (-7.7)

SOURCE: CBO from FAA data.

NOTES: Details may not add to totals because of rounding. Actual handles for 1982 were

Total aircraft = 9.8 million
General aviation = 1.5 million
Air carrier = 8.3 million

a. Extrapolated by Congressional Budget Office.

b. Numbers in parentheses are the percent changes from the 1982 FAA forecast.

Tables C-9, C-10, and C-11). Since there is no reasonable basis on which to elect one forecast over the other, it is essential to subject potential aviation system investments and financing plans to a wide range of sensitivities in underlying traffic assumptions. This analysis is performed for the National Airspace System Plan in Chapters III and IV.

TABLE C-9. ALTERNATIVE FORECASTS OF AIRCRAFT HANDLED AT AIR ROUTE TRAFFIC CONTROL CENTERS (In millions) a/

	Air Carrier (Including air taxi)			General Aviation			Total Aircraft b/		
	1987	1993	2005	1987	1993	2005	1987	1993	2005
FAA Forecast February 1982 (Basis for FAA plan)	18.0	21.7	27.7 c/	12.1	17.1	25.5 c/	34.7	43.4	57.8 c/
FAA Forecast February 1983	18.3 (1.7)	21.1 (-2.8)	26.0 c/ (-6.1)	11.1 (-8.3)	14.8 (-13.5)	20.9 c/ (-18.0)	34.0 (-2.0)	40.5 (-6.7)	51.5 c/ (-10.9)
Forecast Based on Maturity Scenario	17.4 (-3.3)	19.0 (-12.4)	21.4 (-22.7)	9.3 (-23.1)	11.5 (-32.7)	15.1 (-40.8)	31.0 (-10.7)	34.9 (-19.6)	40.9 (-29.2)

SOURCE: CBO from FAA data.

NOTE: The actual numbers of aircraft handled in 1982 was:

Total aircraft = 27.8 million
General aviation = 7.5 million
Air carrier = 16.0 million

a. Numbers in parentheses are the percent changes from the 1982 FAA forecast.
b. The difference between total aircraft and the totals of general aviation and air carrier aircraft represents military aircraft.
c. Extrapolated by Congressional Budget Office.

TABLE C-10. ALTERNATIVE FORECASTS OF INSTRUMENT OPERATIONS AT AIRPORTS WITH FAA TRAFFIC CONTROL SERVICE (In millions) a/

	Total Aircraft		
	1987	1993	2005
FAA 1982 Forecast (Basis for FAA plan)	46.2	55.4	74.8
FAA 1983 Forecast	44.3 (-4.1)	52.9 (-4.5)	66.6 (-11.0)
Forecast Based on Maturity Scenario	40.4 (-12.6)	45.6 (-17.7)	52.9 (-29.3)

SOURCE: CBO from FAA data.

NOTE: Actual operations for 1982 were 31.6 millions.

a. Numbers in parentheses are the percent differences from the 1982 FAA forecast.

TABLE C-11. ALTERNATIVE FORECASTS OF AVIATION FUEL CONSUMPTION (In billions of gallons) a/

	Air Carrier			General Aviation			Total Aircraft a/		
	1987	1993	2005	1987	1993	2005	1987	1993	2005
FAA 1982 Forecast (Basis for FAA plan)	10.0	11.8	15.4 b/	1.9	2.8	4.1 b/	12.0	14.6	19.5 b/
FAA 1983 Forecast	9.4	11.1	14.2 b/	1.9	2.6	4.0 b/	11.3	13.7	18.0 b/
	(-6.0)	(-5.9)	(-7.8)	(---)	(-7.1)	(-2.4)	(-5.8)	(-6.2)	(-7.7)
Forecast Based on Maturity	9.1	10.0	11.5	1.7	1.9	2.1	10.7	11.8	13.6
	(-9.0)	(-15.3)	(-25.3)	(-10.5)	(-32.1)	(-48.8)	(-10.8)	(-19.2	(-30.3)

SOURCE: CBO from FAA data.

NOTES: Details may not add to totals because of rounding. Actual fuel consumption in 1982 was:

Total aircraft = 9.8 million
General aviation = 1.5 million
Air carrier = 8.3 million

a. Numbers in parentheses are the percent changes from the 1982 FAA forecast.
b. Extrapolated by Congressional Budget Office.

APPENDIX D. BACKGROUND ISSUES AND COMPUTATIONAL METHODS IN INVESTMENT APPRAISAL

BACKGROUND ISSUES

For long-lived capital investments, the simple rule that justifies adoption of a project--that benefits exceed costs--must be modified, since future benefits and costs are worth less than present ones. Indeed, the very existence of interest rates means that people do discount--attach less value--to future expenditures. Essentially, then, an investment is worthwhile if the sum of discounted benefits--their present value--exceeds the present value of its costs. 1/

Choice of Criteria

To compute the present values, an interest (or discount) rate must be selected. One approach would result in a rate (after inflation) of about 9 percent, representing the opportunity cost of capital in the private sector (on the basis of the observed real-dollar yield of 7 percent for corporate bonds, grossed up by approximately 30 percent to allow for the effective corporate profits tax). Others use a rate of about 5 percent to represent the real-dollar cost of federal government borrowing. Over the last few years, the Office of Management and Budget (OMB) has required the use of a 10 percent discount rate (after inflation) in federal investment appraisals. In other words, OMB would prefer to budget for only those capital projects that are likely to achieve a rate of return of 10 percent or more. Although this is a somewhat arbitrary policy, 2/ 10 percent happens to approximate fairly closely the estimated opportunity cost of capital in the private sector, although at present, it appears somewhat higher. Use of 10 percent as a test (or passmark) rate should thus guarantee that public investments do not supplant better investments that could be made by private firms.

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1. See Ajit K. Dasgupta and D.W. Pearce, Cost-Benefit Analysis: Theory and Practice (MacMillan, 1972).

2. The fact that the OMB discount rate has remained unchanged since 1973 means that it is not geared to any particular market rate.

A way around the problem of estimating present values is to compute the FAA plan's internal rate of return directly, and then to compare this rate with a range of possible standards for federal investment (for example, 10 percent). As with the use of present values, it remains essential to choose some acceptable standard as the basis for comparison. The only advantage in computing the rates of return directly is that it conveys more precise information as to how close a project actually comes to the predetermined standard, and thus how risky the project is. 3/

COMPUTATIONAL METHODS

Chapter III presents four measures of cost-effectiveness of the FAA plan:

- Internal rate of return;
- Net present value;
- Benefit-to-Cost ratio;
- First-year benefit; and
- Risk analysis on the rate of return.

Rate of Return

The computational procedure to calculate the internal rate of return is based on the following definition:

> The internal rate of return is the discount rate that makes the net present value of a project equal to zero.

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3. See David F. Bradford, "Constraints on Government Investment Opportunities and the Choice of Discount Rate," American Economic Review (December 1975).

This implies solving for the discount rate R the equation

$$\sum_{i=1}^{N} \frac{\sum_{j=1}^{NBS} B_{i,j} - \sum_{j=1}^{NCS} C_{i,j}}{(1 + 0.01R)^{i-1}} = 0$$

in which: NBS is the number of benefit streams
NCS is the number of cost streams
R is the discount rate expressed as a percentage
N is the life of the project (since the beginning of construction)
$C_{i,j}$ is the i^{th} item, in the j^{th} cost stream
$B_{i,j}$ is the i^{th} item, in the j^{th} benefit stream.

The above equation (a polynominal of $(N - 1)^{th}$ degree) is solved by successive approximations for the range -20 percent to 100 percent.[4] The approach assumes the following:

(i) The net present value is a monotonic function of the discount rate; and

(ii) A federal project that merits appraisal will have an internal rate of return which will be in the range -20 percent to 100 percent.

Present Value

The present value is a discounting procedure performed over the set of current streams. The formula used is the following:

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4. See The World Bank Group, Cost Benefit Package Users Manual (August 1979).

$$PV = \sum_{i=1}^{N} \frac{\sum_{j=1}^{NBS} Bi,j - \sum_{j=1}^{NCS} Ci,j}{(1 + 0.01R)^{i-1}}$$

in which R is the OMB test rate of discount.

Benefit-to-Cost Ratio

The benefit-to-cost ratio is defined as the ratio, expressed as a decimal fraction, between the present value of total benefits and the present value of total costs of a project. The computational procedure uses all current streams (benefits and costs) and computes the following:

$$BCR = \frac{\sum_{i=1}^{N} \frac{\sum_{j=1}^{NBS} Bi,j}{(1 + 0.01R)^{i-1}}}{\sum_{i=1}^{N} \frac{\sum_{j=1}^{NCS} Ci,j}{(1 + 0.01R)^{i-1}}}$$

in which R is the OMB test rate of discount.

First-Year Benefit

The First-Year Benefit--often used as a test of the timing of a project--is the ratio, expressed as a percentage, between total benefits realized the first year after construction is completed, and total project costs. Interest on capital outlays during the construction period is computed and added to the total project cost; the equation used is the following:

$$FYB = \frac{\sum_{j=1}^{NBS} B_{kj}}{\sum_{i=1}^{k-1} \sum_{j \in Jcc} Cij(1+0.01R)^{k-i-1}} * 100$$

in which **R** is the OMB test rate of discount.

Risk Analysis

A risk analysis amounts to repeated computations of the internal rate of return using, in each case, cost and benefit data that are modified by random variations expressed as a percentage of original values prior to each computation. The number of times the rate of return is computed determines the sample size. The sample generated is an artificial sample made on the basis of random patterns of variations (probability distributions) that, in CBO's judgment, reflect the real uncertainty of the cost and benefit estimates. The analysis also takes account of the dependency that might exist among uncertain streams.

All cost and benefit estimates are assumed to vary according to a normal probability distribution given by:

$$f(u_o) = \frac{1}{\sqrt{2\Pi}} e^{-(1/2)\, u_o^2} \quad \text{for } -\infty < u_o < \infty$$

where:

$$E(u) = 0 \; ; \; \sigma_u^2 = 1$$

$$u = \frac{x_o - E(x)}{\sigma_x}$$

and

$$x_o = u_o \sigma_x + E(x)$$

APPENDIX E. TIME--VALUING AN INTANGIBLE

The dollar value of time to be saved by installation of the microwave landing system at the nation's airports is one of the least certain elements in any assessment of the FAA plan, including that in Chapter III. In essence, the problem boils down to: What would air travelers do with the time saved? Would they spend it on productive activity? Would that activity be recompensed and hence an economic factor? Or would people simply enjoy the relief from the irritation of wasting time? Related to these questions is the distinction--often not a clear one when travel is involved--between working time and leisure time.

Using empirical studies that indicate the value of time apparently used by air travelers, the FAA has placed the value of time savings at 100 percent of the average hourly earnings of all aviation users.[1] Thus implicitly, the FAA regards time spent in transit as generally unproductive. Other analysts would take issue with this general approach, however. They would note, for example, that although roughly half of all air travel is done for business, many of those passengers spend a significant portion of their travel time engaged in work, often even in the same work that occasions the travel. In budgeting their workloads, many passengers actually count on airborne time as essential. Thus, time spent in transit may be far from wasted, and time absorbed by delays also not lost or wasted. According to this logic, then, the time savings attributable to the MLS could reasonably be valued at some fraction, but not the total rate, of passengers' earnings.

Another problem in arriving at a dollar value for time is the size of units of time saved. A span of ten minutes can quite easily be put to productive use, but ten one-minute savings are difficult to use. The time to be saved by the MLS is estimated roughly in the range of a few minutes per passenger per trip, and its economic value is therefore questionable.

A compromise approach would regard time spent in transit as not totally wasted and time saved as not totally productive in an economic sense. Analysts at the World Bank, for instance, have informally valued working time saved at about 50 percent of the average wage rate of all passengers, and nonworking time saved at about 25 percent of that rate.

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1. House Committee on Appropriations, Hearings--Department of Transportation and Related Agencies Appropriations For 1984, 98:1 (1983).

What the World Bank uses for analytic purposes is an average of about 30 percent, weighted to reflect the proportions of work and leisure travel. This compromise assumption was used in the CBO's analysis.