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Report to the Congress; by Elmer B. Staats, Comptroller General.

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Organization Concerned: Federal Aviation Administration.
Congressional Relevance: House Committee on Appropriations: Defense Subcommittee; House Committee on Public Works and Transportation; Senate Committee on Commerce; Congress.

The FAA's engineering and development program management was examined with an emphasis on the Upgraded Third Generation System, a computer-based semiautomated system intended for en route control centers and airport terminals. Findings/Conclusions: By the end of 1975, over $149 million had been spent on the Upgraded Third Generation System and $564 million more was planned for the next decade. Detailed studies and analyses which would provide information to assess the program's potential have not been completed. Among the unresolved issues are: whether programs to develop the system are designed in response to accident conditions and causes, whether programs to develop the system are cost effective, and whether the Government should go forward with the Third Generation program. FAA's development plans are often not timely; they lack information needed for program appraisal; they do not use savings techniques such as life-cycle-costing and design-to-cost goals; and they do not adequately describe integration of the various components into the existing system. The Administration does not have effective management control throughout development. Recommendations: A formal process to formulate long-range requirements and incorporate criteria for cost, schedule, and performance in these development plans should be established. Systems analysis should be strengthened and an implementation strategy should be developed early. (RRS)

REPORT TO THE CONGRESS

BY THE COMPTROLLER GENERAL OF THE UNITED STATES

Issues And Management Problems In Developing An Improved Air-Traffic-Control System

Department of Transportation
Federal Aviation Administration

Through 1985 about $25.5 billion will be needed for the Nation's air transportation system--$18.8 billion to operate, maintain, and administer the system and $6.7 billion to improve airports and equipment and for research and development.

As a part of this, a $713 million program is underway to develop a better air traffic control system for the 1980s and 1990s to improve safety, hold down costs, and increase capacity. The degree of its success will have a long-range effect on the amount of future spending needed to improve, operate, and maintain the air transportation system and the resulting benefits.

However, there are unresolved issues and associated weaknesses in the Federal Aviation Administration's planning and appraisal of its development program.

PSAD-77-13

DEC. 15, 1976

ERRATA

To the recipients of the Comptroller General's report to the Congress entitled "Issues and Management Problems in Developing an Improved Air-Traffic-Control System" (PSAD-77-13):

On the first page of the digest, the last sentence of paragraph 2 should read, "The improvement of the third phase is the subject of this report."

COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

B-164497(1)

To the President of the Senate and the
Speaker of the House of Representatives

This report assesses the Federal Aviation Administration's engineering and development program management and suggests ways the agency can improve its developmental efforts.

We made our review pursuant to the Budget and Accounting Act, 1921 (31 U.S.C. 53), and the Accounting and Auditing Act of 1950 (31 U.S.C. 67).

Copies of this report are being sent to the Director, Office of Management and Budget and the Secretary of Transportation.

Comptroller General
of the United States

Contents

ABBREVIATIONS

FAA	Federal Aviation Administration
GAO	General Accounting Office

COMPTROLLER GENERAL'S
REPORT TO THE CONGRESS

ISSUES AND MANAGEMENT PROBLEMS IN DEVELOPING AN IMPROVED AIR-TRAFFIC-CONTROL SYSTEM
Department of Transportation
Federal Aviation Administration

D I G E S T

The Federal Aviation Administration estimates that $25.5 billion will be needed for the Nation's air transportation system through 1985. This includes:

--$18.8 billion for air traffic controllers, flight specialists, and others who operate, maintain, and manage various aspects of the system; and

--$6.7 billion for improvement of airports, air traffic control facilities, such as radar, navigation, and weather prediction, and for research and development.

The Nation's air-traffic-control system has developed through three phases, the first from 1936 to 1960; the second, from 1960 to 1970; and the third, from 1970 to 1978. The current or third phase is the subject of this report.

The program underway, called the Upgraded Third Generation Air Traffic Control system, is designed to improve safety, hold down costs, and increase capacity of the air traffic system in the 1980s and 1990s.

The system includes major acquisitions and constitutes about 60 percent of the Federal Aviation Administration's research and development work.

Development of the Upgraded Third Generation System was started in the early 1970s based on an advisory committee's recommendations. Since then, changes have affected the growth and needs of aviation and, in turn, affected the priority of objectives of the "third generation" program.

PSAD-77-13

Safety remains the main objective. But reducing the cost to operate and use the air-traffic-control system is considered more important than increasing its capacity. (See p. 3.)

By the end of fiscal year 1975, the Administration had spent over $149 million on engineering and developing the Upgraded Third Generation System. It plans to spend $564 million more over the next decade.

The reordering of the program's priorities challenges the Administration's management to select the proper approach for improving the air-traffic-control system. (See pp. 3 and 5.)

Production decisions will be made soon, but because information is lacking, important issues on the program's potential for accomplishing safety, cost, and capacity objectives remain unresolved. These issues are:

--Whether programs to develop the Upgraded Third Generation System are designed in response to accident conditions and causes and are alined with the safety objective. (See pp. 5 and 6.)

--Whether programs to develop the system are cost effective; what their potential is for reducing operating costs and developing products users of the system can afford. (See pp. 5 and 8.)

--Whether the Government should go forward with the planned pace and content of the Upgraded Third Generation programs in view of (1) the prospect that the rate of increase of air traffic will be lower than originally expected, (2) the availability of underused satellite airports at major hubs, and (3) the increasing inability of surface transportation to provide access to airports. (See pp. 5 and 11.)

These and related questions remain unresolved because of weaknesses in the planning and

appraisal of the Administration's engineering and development programs. (See pp. 16 and 17.)

In program planning, the Administration's development plans are not as useful as they should be. For example

--plans often are not timely,

--they lack information needed for program appraisal,

--they do not use savings techniques such as life-cycle-costing and design-to-cost goals, and

--they do not consider timely implementation or adequately describe integration of the various components into the air-traffic-control system. (See pp. 17, 18, 21, and 23.)

In program appraisal the Administration did not have effective management control throughout development. For example:

--Key decision papers were submitted late in the development process, lacked information needed, or covered only portions of programs. (See pp. 25 and 26.)

--Cost-benefit analyses were not done to anticipate the needs of decisionmakers but as a result of Department of Transportation review. (See p. 27.)

--The Administration lacked a test and evaluation organization independent of the development organization.

--A master plan has not been completed to define the scope, timing, and responsibilities for program testing. (See p. 29.)

Decisions to advance Upgraded Third Generation programs further in development should be made only after the Administration has completed detailed studies and analyses to determine each program's value and alinement with program objectives.

These decisions should also require the Administration to reconfirm program needs, evaluate technical and nontechnical alternatives, and consider the effects of other transportation modes on air-traffic-control system needs. (See p. 15.)

The Federal Aviation Administration should improve its engineering and development program management by:

--Establishing a formal process to formulate long-range requirements.

--Incorporating criteria for cost, schedule, and performance in development plans and decision papers and use these for measuring progress.

--Strengthening systems analysis and incorporating cost-benefit analyses in development planning and appraisal.

--Developing implementation strategy early in development and coordinating this with the operating services.

--Defining "test and evaluation responsibility" and taking action to establish an operational testing capability independent of the development function. (See p. 31.)

The Department of Transportation generally agrees with GAO's recommendations.

However, Transportation is concerned with the uncertainties normally associated with the research and development process and the effect of these uncertainties on development and implementation planning. GAO believes that sound program control, through planning and appraisal, is the best method of dealing with these problems.

Transportation also says that prototype testing and field evaluations increasingly are used to provide information for implementation decisions. GAO points out that this testing is under control of the development organization and that there is no independent test function in the Administration. Transportation and

the Federal Aviation Administration should establish procedures and make other changes necessary to provide an independent testing and evaluation capability.

MATTERS FOR CONSIDERATION BY THE CONGRESS

During oversight and authorization hearings the Congress should make sure that Transportation and the Federal Aviation Administration are implementing the acquisition policies prescribed by the Office of Management and Budget and the Office of Federal Procurement Policy concerning

--analysis of agency missions and needs,

--setting program objectives and system requirements,

--program planning and control, and

--test and evaluation.

CHAPTER 1

INTRODUCTION

The Federal Aviation Administration (FAA) plans to spend about $25.5 billion through fiscal year 1985 to develop, procure, maintain, and operate the air-traffic-control system and to develop an adequate system of airports. This plan's success will be affected by how well FAA manages its 21 technical and complex engineering and development programs, such as radar, navigation, weather prediction, and data processing. FAA plans to spend $890 million through fiscal year 1985 on research and development for these programs. About $564 million is for the Upgraded Third Generation Air Traffic Control System. Included are major acquisitions intended to improve the air-traffic-control safety, cost, and capacity in the 1980s and 1990s.

Our study assessed FAA's engineering and development program management. We reviewed several development programs but focused on the Upgraded Third Generation System because (1) a significant portion of FAA's engineering and development plan concerns it; (2) decisions are being made which will lead to major investments in production equipment; and (3) in 1974 the Department of Transportation identified several program and planning weaknesses related to the Upgraded Third Generation System program. We did not evaluate the technical aspects of the program but did evaluate whether FAA had the necessary management information to properly guide the engineering and development programs.

SYSTEM EVOLUTION

The present air-traffic-control system has evolved through three phases, each characterized by improved equipment and techniques. Key features of each follow.

--First Generation (1936-60). An air navigation network which was completely manual, relied on radio communications, had no capability for direct aircraft surveillance (except visual), and relied on low-frequency navigation signals.

--Second Generation (1960-70). Used radar systems for aircraft surveillance. The primary system relied on radar reflections to track aircraft. A secondary system, the Air Traffic Control Radar

Beacon System, relied on airborne equipment to provide a coded signal which identified the aircraft.

--Third Generation (1970-78). A computer-based, semi-automated system intended for en route control centers and airport terminals. This system relies heavily on the radar beacon. One new set of equipment in major terminals, the Automated Radar Terminal System, automatically uses information from the radar beacon system to provide air traffic controllers with the identity, position, and altitude of the beacon-equipped aircraft being tracked.

The Upgraded Third Generation System will rely on automation and beacon surveillance for high density traffic control. Major planned improvements center around the additional use of computers to reduce the controller's workload and to increase his or her efficiency. Principal components include the following programs.

--Discrete Address Beacon System.

--Airborne Separation Assurance.

--Flight Service Station Program.

--Upgraded Air Traffic Control Automation--Terminal and En Route.

--Airport Surface Traffic Control.

--Wake Vortex Avoidance System.

--Wind Shear.

--Area Navigation.

--Microwave Landing System.

--Aeronautical Satellite Program.

These components are described in appendix I.

CHAPTER 2

THE DEVELOPMENT PROGRAM--A NEED TO RESOLVE ACQUISITION ISSUES

The program to develop the Upgraded Third Generation Air Traffic Control System began in the early 1970s based on the Department of Transportation's Air Traffic Control Advisory Committee recommendations. Since then, changes have affected the growth and needs of aviation and, in turn, affected the priority of program objectives. Although safety remains the main objective, priorities associated with the cost and capacity objectives have been reversed since the program began. Today, Transportation considers minimizing the costs to operate the system and using it more important than increasing air-traffic-control capacity.

The Federal Aviation Administration had spent over $149 million on engineering and developing the Upgraded Third Generation System by the end of fiscal year 1975 and plans to spend $564 million more during the next decade. This complex effort and the reordering of program objectives challenge FAA management to select the proper approach for upgrading the system. However, detailed studies and analyses which would provide information to assess the potential of the program have not been completed.

DEVELOPMENT PROGRAM ORIGIN AND LATER EFFECTS DUE TO CHANGED ECONOMIC CONDITIONS

The Air Traffic Control Advisory Committee, formed to recommend a system for the 1980s and beyond, concluded that air traffic was already in a crisis. Airlines complained of delays and stress was being placed on traffic control. The Committee attributed this to the failure of airports and the air-traffic-control system to keep pace with the growth of the aviation industry. It projected that by 1980 aviation activity would at least double and would double again by 1995 and that demand for traffic control service would triple by 1980 and triple again by 1995. The Committee saw that the Third Generation System, as planned, would not be adequate.

In formulating a system to satisfy predicted demands, the Committee considered various air-traffic-control systems and technologies. Two philosophies were compared. One

emphasized improving ground-based, centralized management, while the other emphasized placing most air-traffic-control functions in the cockpit. The Committee chose to "upgrade" centralized management because of advantages in performance and cost and because of ease of implementation. Emphasis was placed on the most traveled airspace and on the need for efficient use of runways and terminal airspace. It cautioned that any recommended improvements would "not be significant" unless runway capacity problems were also resolved.

FAA has used the Committee report as a guide for designing and upgrading the air-traffic-control system. The Upgraded Third Generation System incorporates basic features the Committee recommended, as well as others added in the past few years.

Since the report, the Aviation Advisory Commission was established under the Aircraft and Airway Development Act of 1970, Public Law 91-258, to recommend long-range aviation needs for consideration of the Congress and the President. Their 1973 report questioned the Committee's recommendations for upgrading the air-traffic-control system.

The Advisory Commission had a different view on the future growth of aviation than did the Air Traffic Control Advisory Committee. The Commission had reservations about the future growth of aviation. Forecasts available to the Commission assumed that growth would not be constrained and that future costs of passenger air travel would remain about the same, relative to the cost of other goods and services. Predicted growth and resources required to meet future demands were so large that the Commission doubted their validity, especially for air carrier passenger demand beyond 1985. In addition, the Commission favored the philosophy rejected earlier by the Committee and claimed that preliminary studies showed that placing certain air-traffic-control functions in the cockpit might be more cost effective.

In 1974, Transportation reviewed the entire Upgraded Third Generation developmental program. The report from this review showed that changes had taken place since the Committee's recommendations in 1969. The anticipated air carrier growth had not materialized and, due to the energy crisis and the depressed economy, forecasts of aviation growth were much less than originally anticipated. The report concluded that the prime program objective should continue to be safety and that increased emphasis should

be placed on reducing costs to operate and use the system. As such, the priority to increase capacity was reduced.

PROGRAM OBJECTIVES AND RELATED UNRESOLVED ISSUES

The safety, cost, and capacity goals of the Upgraded Third Generation System are interrelated; one cannot be accomplished without affecting others. For example, capacity cannot be increased without some reduction in safety, unless changes are made in the air-traffic-control system. When airport capacity is increased, spacing between aircraft will be reduced, increasing the chance of collision. Because of such interrelationships, the size of the Upgraded Third Generation development effort, and the recent reordering of program objectives, FAA needs information to assess the potential accomplishments of the program. This information is not yet available, but FAA has studies underway.

The August 1974 Transportation report identified several weaknesses in program planning and appraisal which warranted corrective action in engineering and development. FAA's plans did not include information needed to assess program objectives. Transportation found that more detailed analyses, both for the overall and individual Upgraded Third Generation programs, were required and that an aviation scenario was needed. Transportation required that a scenario be developed for evaluating the costs and benefits of the proposed system features and alternatives. FAA is responding to Transportation's recommendations regarding these weaknesses. Individual results are expected through 1977.

In its report, Transportation noted that a series of major decisions were to be made, beginning during 1975 and 1976, to produce equipment and implement portions of the Upgraded Third Generation System. Other elements of the system are in, or nearing decisions to start full-scale development. (See app. II.) Because information is lacking, important issues on the program's potential for accomplishing safety, cost, and capacity objectives remain unresolved. These issues are:

--Whether programs to develop the Upgraded Third Generation System are designed in response to accident conditions and causes and are alined with the safety objective.

--Whether programs to develop the Upgraded Third Generation System are cost-effective and what their potential is for minimizing operating costs through automation and developing products users can afford.

--Whether the government should go forward with the planned pace and content of the programs in view of reduced growth forecasts, available underutilized satellite airports for major hubs, and limited growth posed by surface transportation congestion.

Safety objective

Transportation recognizes that aviation has a good safety record; however, both Transportation and FAA desire better safety. In 1974, Transportation emphasized the need to maintain and improve safety because of the ever-present risk of midair collisions. This problem has been accentuated by the introduction of wide-bodied jets which risk more loss of life in a single accident and create air turbulence which threatens other aircraft during landing.

FAA plans include several Upgraded Third Generation programs that are considered major contributors to safety. However, the information below raises questions about how safety-related engineering and development funding is allocated to various categories of accident prevention. Detailed analysis is needed to answer the questions and to determine whether programs are designed in response to accident conditions and causes and alined with the safety objective.

The following table, based on FAA information, contrasts the accident fatalities from 1964 through 1972 with safety-related engineering and development funding for the 4 years ended June 30, 1975.

Accident category	Fatalities		Funding	
	Number	Percent	Millions	Percent
Approach and landing	1,616	20	$42.6	56
En route	a/5,210	64	3.4	5
Midair collisions	600	7	26.4	35
Takeoff	607	8	-	-
Ground operations	51	1	3.2	4
Total	8,084	100	b/$75.6	100

a/ Seven hundred and five fatalities were related to aircraft using the provisions of an instrument flight rule plan, which implies continuous surveillance by the air-traffic-control system. Four thousand five hundred and five fatalities were related to aircraft using visual flight rule plans or no plans.

b/ Excludes $27.7 million of safety-related engineering and development funds not attributed to accident categories.

Information on accident causes is available to FAA from records of the National Transportation Safety Board. FAA has compiled statistics on aircraft accidents and fatalities but has analyzed only midair collisions in relation to their engineering and development program. The need to reduce accidents in other phases of flight, especially en route and landing, is recognized. Except for the completed midair collision study and a study being made of landing accidents, FAA analyses done so far provide only a "gross understanding" of where engineering and development efforts are likely to be productive. FAA records show that more detailed analysis is necessary to understand the relative importance of engineering and development programs and their contribution toward reducing accidents and fatalities.

In its July 16, 1970, report (H.R. 91-1308), the Committee on Government Operations advised FAA that

> "all too often * * * progress has been the result of tragedy. The committee, desperately hopes that the FAA will * * * more earnestly seek to avert rather than respond to air tragedies in the 1970s."

We believe this has been partly due to FAA's failure to correlate, through detailed analyses, accident conditions and causes, with the programs being developed and with the need to start new programs. FAA's wind shear program illustrates the situation.

Wind shear

For several years, wind shear has been recognized by various authorities as a probable contributing factor, if not the direct cause, of numerous aviation landing accidents. However, after investigation, the cause was usually attributed to pilot misjudgment. Since the early 1960s, the Air Line Pilots Association has been asking FAA to allocate engineering and development resources to study wind shear. After a 1971 wind shear accident at New York's La Guardia Airport, FAA initiated a development program funded at about $200,000 a year. The Air Line Pilots Association continued to warn that wind shear remained a critical safety hazard. After a June 1975 crash at New York's Kennedy Airport, which killed 112 people, the program was accelerated, funded at $1.3 million for fiscal year 1976, and listed among FAA's top 10 priority programs. Now FAA is planning to assemble and analyze data, including those related to accidents, so that it can characterize the wind shear problem and pursue development efforts.

Cost Objective

In its 1974 report Transportation told FAA to place a higher priority on reducing air-traffic-control operating costs and minimizing user investment in the Upgraded Third Generation System. Cost had a lower priority in 1969. FAA estimates that from 1976 through 1985 operating costs will be over $18 billion.

Because the system is so expensive to run, analyses--covering the entire acquisition life-cycle from development through implementation and operations--are useful in determining whether expected improvements from engineering and development programs will be cost effective. Although FAA has made certain cost-benefit analyses, Transportation concluded that their scope and/or depth was limited and that FAA still needed to justify the high investment proposed for program improvements. Transportation emphasized that comprehensive evaluation was needed for each program and its alternatives before implementation. Since FAA is in

the process of responding to Transportation's requests, the cost effectiveness of the Upgraded Third Generation programs remains undetermined. The importance of cost-benefit analyses is illustrated below.

Area navigation

Area navigation is designed to permit navigation on direct routes to any destination or intermediate point. This simpler means of navigation should save flight time and cost, reduce pilot and controller workloads, and reduce the amount of needed radio communication. In spite of these claimed advantages, users and controllers of the air-traffic-control system are reluctant to accept this new approach to navigation. Shorter route advantages now seem considerably less than expected, and users state that FAA must prove benefits exist before area navigation will be accepted. Controllers found that the combination of aircraft equipped and not equipped with area navigation seriously complicated terminal area control. Although the program is ready to be implemented, FAA is studying issues such as potential user and Government costs and benefits, which should have been resolved during development. The current objective is to enable FAA and users to weigh the pros and cons of area navigation; determine the effect of implementation on operations; and, if necessary, to modify the degree and timing of implementation.

Constraining operating costs

Transportation advised FAA that the high cost of operating the air-traffic-control system needs to be constrained. These costs increased faster than the Air Traffic Control Advisory Committee forecast, roughly doubling since 1968. As a result, the Transportation report said the need to focus on cost was "much more critical" than originally perceived.

FAA plans to minimize operating costs by using automation programs aimed at increasing air-traffic-controller productivity. Transportation's 1974 report pointed out that a major unresolved issue in constraining operating costs was whether the Upgraded Third Generation automation program will result in a projected 5-percent increase in productivity. The results of ongoing tests, expected to continue through fiscal year 1977, are needed before the issue can be resolved. Transportation pointed out that, even if these experiments were successful, it would still be unclear whether implementing the new automation features would produce the

projected productivity increase or how long an increase would be sustained. Transportation's report noted that the projected increase was based on a 1971 study and that no other work had been done to relate the products of development programs to the number of control personnel required. Further, new automation programs will require extensive air traffic controller training and acceptance if they are to be successful.

Although FAA has estimated possible benefits from closer aircraft spacing, it reported that it has not yet been able to reliably estimate payoffs from most other planned automation improvements. For example, one series of simulation experiments, based on the Automated Radar Terminal System, failed to identify productivity increases. However, FAA believes that more traffic can be handled with the system.

Minimizing user costs

Affordability is important to the general aviation user of the air-traffic-control system. Transportation has recognized the need to minimize user investments in the Upgraded Third Generation System and FAA believes its programs are directed to this objective.

Today, avionics 1/ costs the general aviation aircraft owner about $4,000. How much more will the avionics associated with the Upgraded Third Generation System cost an aircraft owner? FAA has no firm estimate. A manufacturer of general aviation equipment said, however, such costs roughly would be an additional $6,000 per aircraft, for a total of $10,000--an increase of 150 percent. These figures do not include backup equipment, which many pilots desire.

We believe that such large cost increases require a systematic approach during engineering and development to help assure affordability of the eventual products. Will Upgraded Third Generation avionics be affordable? In recent years, a cost-limiting technique known as "design to cost" has been developed. When designing a product according to this technique, unit production cost is the main constraint. Performance and schedule are then designed to produce the

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1/ Electronic equipment used in aircraft.

maximum value for that given cost. The Upgraded Third Generation programs, however, lack the design-to-cost technique. The consequence, according to the Aircraft Owners and Pilots Association, has been

> "that * * * attention is devoted to ideas and projects of such sophistication that neither the taxpayer can afford them, nor the pilot cope with them * * *."

The design-to-cost technique requires that cost goals be set as early as possible during development. However, FAA has yet to do this in developing Upgraded Third Generation equipment.

For example, National Transportation Safety Board statistics show that midair collisions usually involve general aviation aircraft. FAA must develop equipment that general aviation owners can afford before it can solve the midair collision problem. FAA could productively use the design-to-cost technique in its collision avoidance programs since thousands of airborne units, of one type or another, will be needed. However, FAA has not used design-to-cost in this program or for alternative solutions to the midair collision problem.

Capacity objective

The size of the program recommended by the Air Traffic Control Advisory Committee was based on an assumed rate of economic activity with no growth constraints. Forecasts available in 1969 did not anticipate the downturn in economic activity or energy crisis soon to come. FAA's 1976 forecast shows only continued moderate growth in commercial air travel and it does not anticipate the extent of growth predicted in 1969.

The following table compares the growth expected by 1980 over 1969 levels of aviation activity, based on forecasts available in 1969 and 1976.

	Growth forecast	
	1969	1976
	(Percent)	
Aircraft handled by centers	100	40
Terminal instrument operations	200	120

After its comprehensive review of the Upgraded Third Generation program, Transportation assigned a lower priority to system capacity. FAA realizes that the capacity objective has been reordered and that factors affecting the aviation growth rate are long term. Although all Upgraded Third Generation programs contribute to multiple objectives, six of them, involving about 77 percent of planned development costs are still largely directed toward increasing capacity.

Transportation's Assistant Secretary for Administration in commenting on this report (see app. III), said that increases in the capacity of the system still appeared necessary. FAA continues to believe that it is desirable to complete Upgraded Third Generation development programs as planned.

The Office of Management and Budget and the Commission on Government Procurement state that all major system acquisition programs should be based on an analysis of an agency's mission and a determination of needs and goals reconciled with overall capabilities, priorities, and resources. Upgraded Third Generation programs aimed primarily at the capacity objective should be reevaluated in this light. In addition to the above issues other factors, such as increasing the aircraft occupancy rates and surface traffic congestion, must be considered in reevaluating needs for additional capacity.

Nontechnical alternatives and airport surface traffic congestion

As a result of its review of Upgraded Third Generation programs, Transportation asked FAA to evaluate nontechnical alternatives for achieving aviation goals. For example, Transportation's report said that the Air Traffic Control Advisory Committee had only cursorily considered the possibility that needs for increased system capacity could be met by existing underutilized satellite airports for major hubs. Other nontechnical alternatives included increasing the aircraft occupancy rate or restricting terminal airspace; each could help alleviate capacity problems at many airports. FAA recognizes that additional information on nontechnical alternatives is necessary to assess the need and value of Upgraded Third Generation technical programs and the magnitude of implementation programs.

Capacity can be limited by surface congestion in and around an airport. This involves (1) the facilities for moving passengers and cargo within the airport boundaries and (2) ground transportation (such as highways and railroads) connecting the airport to the urban community. The Air Traffic Control Advisory Committee did not consider the effects of this problem on air-traffic-control capacity.

Currently, FAA considers landside 1/ congestion, at 15 of the top 20 airports which handle about 56 percent of all airline passengers as a serious problem. A Transportation official stated that

> "* * * landside congestion (particularly airport access and egress) is rapidly becoming a limiting factor to continued increased airport capacity. To solve the problems of air/ground interface, the airport must be considered a part of the total regional transportation plan."

Neither FAA nor Transportation has direct responsibility for landside and other airport congestion. Airport planning and its relationship with ground transportation are the responsibility of local and State governments. The Federal role has been to guide and assist in improving the relationship. FAA has done little to eliminate airport landside problems, although it did initiate a development program in 1975 to investigate them.

Impact of general aviation

Forecasts of general aviation activity are used to measure future system demands. Since the 1960s, the size of the general aviation fleet has grown greatly. This, coupled with a recent trend toward larger aircraft, has led to increased use of the National Aviation System by the general aviation community.

FAA forecasts that by 1987 general aviation will account for 82 percent of all aircraft operations. (See fig. 1.) However, the Administration does not know how or where this growth will affect operations. Until FAA can assess

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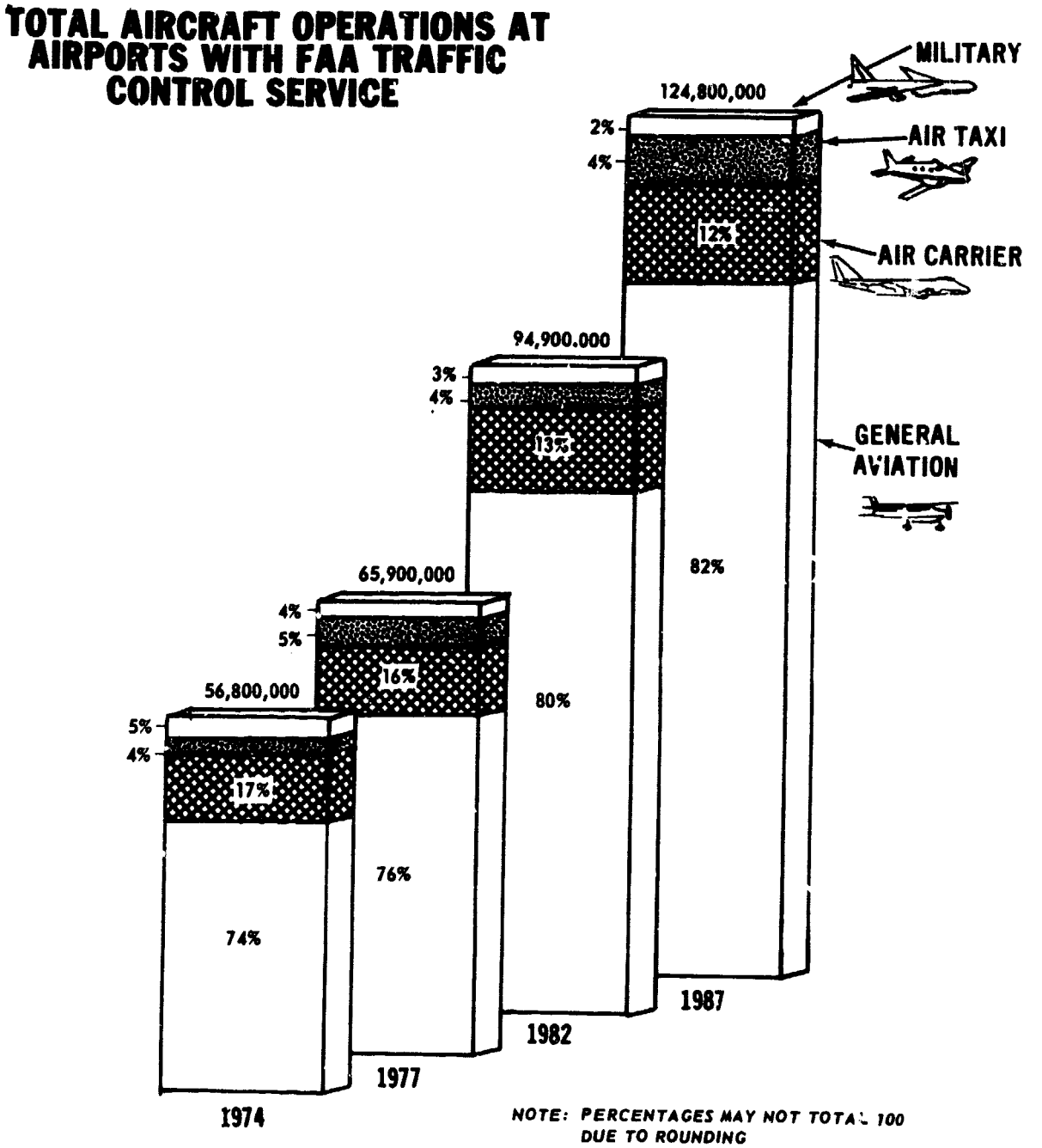
1/ Areas from the airport boundary to the aircraft loading ramp. It includes airport roads, rapid transit, parking, walkways, and all terminal facilities.

the impact of general aviation on engineering and development, these programs may not be properly alined with future needs.

FIGURE I.



SOURCE: AVIATION FORECASTS FISCAL YEARS 1976–1987, DOT/FAA, OFFICE OF AVIATION POLICY, SEPTEMBER 1975.

RECOMMENDATIONS TO THE SECRETARY OF TRANSPORTATION

The Secretary should assure that future decisions to further advance Upgraded Third Generation programs in development be made only after FAA has completed detailed studies and analyses upon which sound decisions can be based. Also, the Secretary should require FAA to reconfirm program needs, evaluate technical and nontechnical alternatives, and consider the effects of other transportation modes on air-traffic-control system needs.

AGENCY COMMENTS AND OUR EVALUATION

Transportation's Assistant Secretary for Administration, in commenting on this report (see app. III), said that future acquisition decisions would be made in accordance with our recommendations and issues pertaining to the Upgraded Third Generation programs are in the process of being resolved.

We believe Transportation's affirmative action can result in sound acquisition decisions if management control is exercised based on improved development program planning and appraisal. This matter is discussed in the following chapter.

CHAPTER 3

THE MANAGEMENT--A NEED TO IMPROVE PLANNING AND APPRAISAL

The Government acquires major systems--an important and expensive activity which affects technology, the Nation's economy, and accomplishment of agency missions. Acquisition management includes:

--Analysis of agency mission.

--Determination of mission needs and goals.

--Determination of system requirements.

--Program planning and control.

--Research, engineering, development, testing, and evaluation.

--Contracting, producing, and introducing the system into use.

--Budgeting and funding.

Good acquisition management requires effective planning and appraisal. Weaknesses in these management functions can cause poor allocation and use of limited resources available for development and can ultimately limit the usefulness of resulting products due to high price, poor timing, or poor performance. Issues discussed in chapter 2 remain unresolved because FAA's planning and appraisal of its engineering and development programs are weak.

The Federal Aviation Administration's acquisition management has been criticized in various studies and congressional reviews over the past several years. They concluded that improvements were needed in the Administration's program planning and appraisal. We agree. A continuing need for improvements exists in

--determining the needs for development,

--planning for development and eventual implementation, and

--evaluating the progress and value of development programs at key decision points, particularly during early development.

PROGRAM PLANNING AND APPRAISAL

Planning for development begins with a statement of the operational need for a system reconciled with the agency's mission, which is defined in terms of purpose, capability, and cost and schedule goals. This and a responding development plan which identifies alternatives for development and anticipated costs and results provide a basis for program planning and helps establish criteria for cost, schedule, and performance. When planning a system's relationship with its anticipated environment, its eventual implementation should be considered. This is needed to analyze the impact of decisions to defer acquisition of a system or to estimate investment costs for alternative development approaches.

Development plans are normally revised, updated and used for program appraisal at a few key decision points in the acquisition process. These points occur when a development program is initiated and alternative system concepts are explored; later, when a decision is reached on a preferred alternative which warrants costly full-scale development; and, finally, when the decision to produce and implement a program is reached.

Appraisal, which relies on the results of systems analysis and testing as an information base, is concerned with the

--relationship between development programs and agency mission,

--relative need and value of development programs and alternatives to them,

--status and progress of programs, and

--suitability of the results of development.

IMPROVEMENTS NEEDED IN PROGRAM PLANNING

Improvements are needed in planning for its engineering and development programs. FAA lacks a process to formulate requirements for new system needs. The Administration's development plans are not fully useful as management documents. They are often not timely, lack information needed for program appraisal, do not use cost-minimization techniques, do not consider prompt implementation of the system, or do not adequately describe the interfaces among system components and how they would be integrated into the air-traffic-control system.

Process to formulate requirements needed

In 1970, shortly after release of the Air Traffic Control Advisory Committee report, the House Committee on Government Operations recommended that the report be treated as "advisory" and that future planning of air-traffic-control system requirements be FAA's responsiblity. The Committee was concerned that the Administration accepted recommendations of outside expert groups "whose backgrounds did not include in-depth knowledge of complex air traffic control procedures and problems", and whose responsibilities did not include implementing the systems they designed. The Committee on Government Operations concluded that FAA had not been able to develop an effective design capability.

Four years later, an FAA management consulting contractor reported a similar weakness in the Administration's efforts to formulate requirements. The report associated a lack of in-house guidance with problems such as

--systems based on "external initiative" with little forethought on future needs and cost-berefit tradeoffs,

--acquisitions based on partial or isolated requirements, and

--poorly defined and coordinated statements of system requirements.

While FAA agreed with many acquisition management problems, identified by the contractor, Administration officials informed us they have not implemented associated recommendations

because some, dealing with organizational changes, are questionable and will not be adopted. Others, dealing with various management problems, are being considered.

Requirements should be formulated after meaningful dialogue between user and developer on what is needed and why. FAA's efforts to formulate requirements are complicated by the many types and diverse needs of air-traffic-control system users, such as general aircraft pilots and owners, airport operators, and controllers. The priorities which each assigns to performance and economics are not always compatible. The air-traffic-control system, itself a complex interrelationship of people and machines, further complicates FAA's task.

Representatives of various user groups said they are dissatisfied with the recognition FAA gave their ideas and with the information they get from the Administration on development programs. FAA does, though, provide numerous opportunities for users to become familiar with its engineering and development programs. According to a representative of the General Aviation Manufacturers Association, the real problem is the difficulty in analyzing the diverse information received from users in a way that will help the Administration make proper decisions regarding program direction. FAA's Associate Administrator for Engineering and Development confirmed the complexity of the situation and acknowledged that it had difficulty formulating requirements.

FAA has established procedures for documenting short- and long-term engineering and development requirements. Procedures for short-term requirements apply mostly to in-service engineering improvements which can be made within 2 years. These procedures do not lend themselves to longer range programs like the Upgraded Third Generation System.

On the other hand, the procedures for long-range requirements, called Federal Aviation Administration Requirements, have, according to FAA officials, "fallen into disuse" and people simply do not follow the procedures. Further, it seems to us that the procedures are aimed more at establishing a register of approved requirements than at defining what is necessary to form a valid requirement, including the responsibilities for developing and coordinating needed information. As such, FAA has no formal in-house process to identify the needs for a system.

In this environment, FAA has experienced difficulty in dealing with the diverse needs of its many users and with constantly changing requirements for program development. In its study of FAA's acquisition management, the consulting contractor's September 1974 report showed that 8 of 13 programs reviewed lacked firm requirements and as a result some programs were delayed and millions of dollars in additional costs were incurred. The Electronic Voice Switching program 1/ is a case in which losses may have been avoided if a firm requirement had been established.

Electronic voice switching program

FAA started work on the program in 1961 and in 1973 awarded a $13 million contract for testing, evaluating, and constructing a prototype unit, with the option to buy 21 production units for $65 million. The contract award was clouded by disagreements over technical and economic feasibility. Three months after the award, FAA proposed 36 changes (later reduced to 18) which increased the projected contract cost by $17 million. In August 1974 the contract was canceled because (1) no immediate or firm operational requirement existed, (2) technical problems lingered, (3) costs escalated and (4) economic benefits were uncertain. About a week after the contract was terminated, the FAA Administrator testified before the House Government Activities Subcommittee that the decision to cancel the contract was not easily made, especially since $13 million had already been spent. However, the Administrator stated that

> "* * * the prospect of an additional expenditure of a like or greater amount of money * * * without a better guarantee or assurance of real benefit, was much less attractive."

An FAA study of its acquisition process, initiated in 1974, also identified the need for a more effective system of determining National Airspace System requirements. As of January 1976, a requirements system had not been established.

1/ A communications network designed to provide speedier voice communication among air-route control towers, flight service stations, control towers, remote controlled air-ground facilities, and military bases.

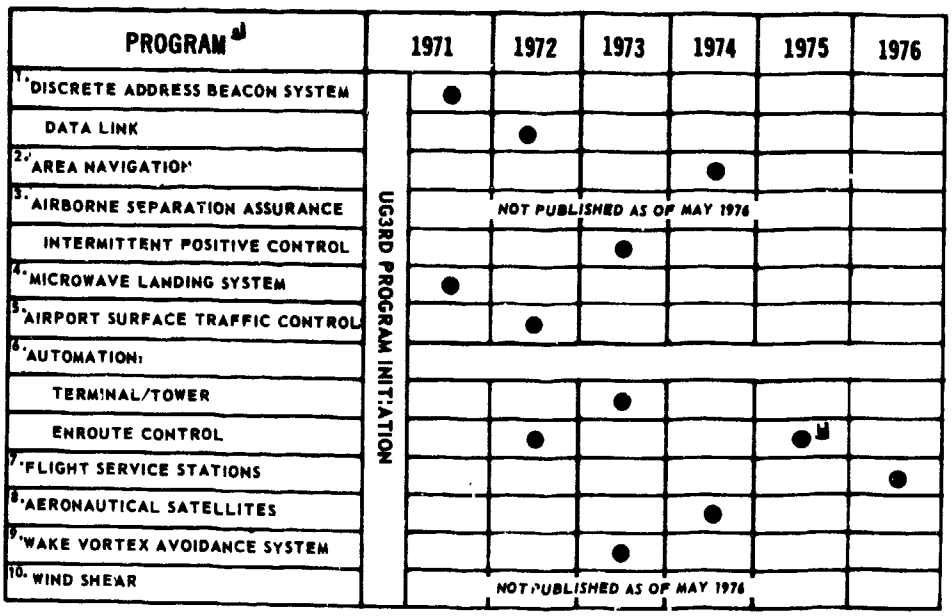
Program plans should be more timely and informative

FAA has established procedures for program plans to provide documents to help management make certain decisions. In practice, the plans are not fully useful because they (1) often are not prepared promptly and are not updated for decisionmaking, (2) lack key information needed for program appraisal, and (3) do not use cost-minimization techniques.

Preparing and revising program plans

Although the Upgraded Third Generation development program started before mid-1971, plans for the program components were often not published until several years later. Two such plans remained unpublished as of May 1976. Only one plan prepared for the components had been revised by January 1976. (See chart below.) None of the remaining plans were updated for major program milestones scheduled through the end of 1975. FAA officials said they do not have the resources to update plans already prepared. For example, the program plan published by FAA in 1971 for the Discrete Address Beacon system had not been updated in 1974. Later the Department of Transportation found that FAA's plan did not include information on cost, technical, and operational feasibility of the system and alternatives to it. This kind of decision information is needed to evaluate all options with equal confidence. The plan was still not updated in October 1976.

YEAR DEVELOPMENT PLAN PUBLISHED



[a] SEE APPENDIX I FOR A DESCRIPTION OF PROGRAMS.
[b] REVISED

Content of program plans

Without good development plans, programs can run into trouble. The previously mentioned consulting contractor's report showed that plans had not been consistently required, reviewed, or used to address technical, cost, and schedule matters for the 13 major system and equipment acquisitions they reviewed. The report concluded that the planning deficiencies adversely affected that part of FAA management's control process where progress should be measured against the plan. The contractor believed that if proper control had been exercised, delay and cost growth associated with the projects might have been avoided.

The program plans we reviewed also lacked fundamental information needed for program appraisal. For example, FAA could not provide us with initial estimates of cost and schedule for Upgraded Third Generation components. Further, our review of five randomly selected program plans showed that information required by FAA guidelines was not adequate. (See chart below.)

CONFORMITY OF PROGRAM PLANS TO REQUIREMENTS IN FAA GUIDELINES

Selected Topics Required By Guidelines

PROGRAM PLANS	PROGRAM GOALS AND OBJECTIVES	BENEFITS AND SAVINGS	ALTERNATIVE APPROACHES	RESOURCE REQUIREMENTS	INTERFACE AND COORDINATION WITH PROGRAMS	OPERATIONAL IMPLEMENTATION
AERONAUTICAL SATELLITE	YES	NO	YES	NO	YES	DETAIL LACKING
FLIGHT SERVICE STATIONS	YES	YES	YES	YES	YES	YES
WAKE VORTEX AVOIDANCE SYSTEM	YES	NO	YES	NO	NO	NO
INTERMITTENT POSITIVE CONTROL	YES	NO	YES	DETAIL LACKING	NO	NO
AREA NAVIGATION	YES	YES	NO	DETAIL LACKING	YES	DETAIL LACKING

Aside from the individual program plans, FAA, with assistance from The MITRE Corporation, prepared an overview of plans for the Upgraded Third Generation System in March 1975. This overview, published several years after the program began, was not prepared as a normal part of FAA's engineering and development planning. It was prepared in response to Transportation's August 1974 critique of the program and its requirement for appraisal information. Further, the document was not meant as a plan for those involved in development but as an overview for top level Transportation and FAA management.

Improvement is needed in several areas essential to sound program planning. The overview document and FAA program plans generally did not cover

--cost-benefit analysis,

--design-to-cost criteria and applications,

--life-cycle-costing plans and information, and

--program priority.

These management techniques are useful when assessing the relative value of programs and alternatives to them and when setting design goals to minimize user costs.

Integration and implementation planning needed during development

FAA recognizes that integrating the various Upgraded Third Generation System components into the air-traffic-control system and planning for implementation can affect the overall program in schedule and/or performance.

FAA officials said that so far they have not adequately described the interfaces among system components and their integration (technical and procedural) with the air-traffic-control system.

Although work is being done in the area, a major integration factor, communications, has been excluded from Upgraded Third Generation development plans. Upgrading the present air-traffic-control system will require communications expansion, a demand the current system may not be able to handle by 1985. If development of a new communication system is not properly timed, implementation of the Upgraded

Third Generation System and its anticipated benefits will be adversely affected. Present plans for a new communications system have not received priority status.

Planning for implementation involves making decisions on how, when, and where a product will be used. It requires coordination between FAA's development branch and those branches responsible for operating the air-traffic-control system. In cases like the Upgraded Third Generation System, where engineering and development are done to produce a product, planning for implementation should begin early in the development process. In FAA, coordinated planning for implementation is not done until just before engineering and development is finished. At that time, the Administration's operating branches (such as Flight Standards Service and Airway Facilities Service) are responsible for either accepting or rejecting the development branch's product and for preparing plans for implementation.

For example, early coordination was needed in June 1972 when FAA's development branch was authorized to evaluate a new communication switching technique called Frequency Division Multiplexing. The development branch interested the Administration's Southwest Regional Office in the system for the Dallas/Fort Worth Airport. Therefore, the development branch worked with the interested region, independent of the operating branch. The system was developed and installed for $1.9 million. Later, the operating branch believed the system too expensive for current needs. Hence, they do not plan to install it at other airports. Earlier planning between the development and operating branches may have produced a system acceptable to all. As it is, FAA may have to spend more money to develop a switching system to meet future needs at other airports.

Recently established "transition planning" groups will deal with implementation issues during development. At the time of our review, FAA had not established procedures or completed any transition plans, so it was too early to evaluate improvements which may result.

IMPROVEMENTS NEEDED IN PROGRAM APPRAISAL

In April 1974 hearings before a subcommittee of the House Committee on Appropriations, the FAA Administrator testified that the Administration had problems with acquisition management. He felt it best to have an outside group study FAA's acquisition process from identifying operational

requirements, through development, to procurement of equipment. Later, FAA's consulting contractor recommended that the Administration establish an acquisition management process which would identify major efforts and key events.

Further, the contractor recommended that FAA provide for management appraisal at major decision points, such as the transition from program initiation to development or when cost, schedule, and performance thresholds might not be met. Specifically, decisions for proceeding to the next development phase should be based on criteria concerning program importance, progress, and suitability.

At the time of our review, FAA had not implemented the consulting contractor's recommendations, even though six Upgraded Third Generation programs were in full-scale development. (See app. II.) We found there was a continuing need for improvement in program appraisal to provide effective managment control throughout development. For example,

--key decision papers prepared by FAA for program appraisal by Transportation's acquisition review council were submitted late in the development process, lacked information needed for appraisal, or only covered portions of a program;

--cost-benefit analyses required to provide insight on the need and value of development programs and alternatives to them were not done to anticipate the needs of decisionmakers but as a reaction to Transportation's review;

--FAA lacks a test and evaluation organization independent of the development activity and a master plan has not been established to define the scope, timing, and responsibilities for Upgraded Third Generation testing.

Decision papers should be more timely and informative

Policy requiring Secretary of Transportation approval of decisions on acquiring major systems 1/ is to insure that each program is properly considered at major milestones in the acquisition process. This approval is to be based on information from a top level acquisition review council and on decision coordinating documents called acquisition papers.

FAA officials said that they have done much work in preparing acquisition papers; however, Transportation's policy has not consistently resulted in appraisal of each major phase of development in FAA's Upgraded Third Generation programs. Some acquisition papers were not prepared until after major milestones for initiating a program and/or moving it into advanced phases of development had passed. Also, an alternative program for midair collision avoidance, Intermittent Positive Control, will be ready for implementation before Transportation is asked to review the first acquisition paper, in 1978. At that time, the program will have been in development over 6 years with cumulative costs over $6 million. Major milestones for program initiation and transition into full-scale development will have passed.

The acquisition papers prepared by FAA lacked information on one or more of the following, needed to evaluate a program.

--A comparison of costs incurred, schedule milestones attained, and technical performance accomplished with criteria that was planned to satisfy development objectives.

--Cost-benefit analyses to show program merits and relative worth compared to alternatives.

--Provisions for the timing and amount of investment planned for implementation and the expected impact on the air-traffic-control system.

1/ Defined by the Secretary as those systems sponsored or acquired by Transportation where total cost is estimated to exceed $10 million or where research, development, and demonstration cost is estimated to exceed $1 million.

--Planned interfaces which include system component needs and an explanation of how and when the systems will fit with others.

FAA has complicated the appraisal process by submitting piecemeal acquisition papers for some programs. This requires FAA to prepare and process acquisition papers for each part of a program and to explain how the various papers relate to one another. It further puts Transportation in the position of separately reviewing each paper and approving parts of a program before appraising the total.

This happened with the Upgraded Third Generation System Flight Service Station program.

Flight Service Station Program

The initial acquisition paper for a test model portion of the program was submitted in November 1972 and revised and resubmitted to Transportation in September 1973. In October 1973, a second acquisition paper for another part of the program was submitted. Action on the second paper was deferred. By January 1975, FAA found that a computer processing function was more important and costly than other development effort within the program. FAA asked for Transportation agreement to combine this function in the test model to eliminate integration problems. FAA stated it would submit an acquisition paper by March 1975 on the total Flight Service Station program. In July 1975, FAA asked Transportation to allow a procurement, without acquisition review, so that a portion of the program dealing with weather information and air-traffic-control notices could be tested early. FAA again agreed to submit an acquisition paper for the total program. The overall paper, first promised by March 1975, was submitted in September 1976.

Cost-benefit analyses needed during development

Cost-benefit analyses can help managers and decisionmakers (1) evaluate changes as a program proceeds, (2) compare the merits of alternatives for a requirement, and (3) make continuing tradeoffs, as needed, between costs and performance. These analyses should be done early in development to help set broad program direction and to help assure correlation between programs and agency missions or objectives. Later, as more complete and accurate data becomes

available, the analyses should be updated and refined in anticipation of decisions on preferred alternatives for full-scale development.

FAA should be doing a better job in using cost-benefit analyses for appraising its development programs. Analysis of the Upgraded Third Generation System and some of its components is now being done after Transportation noted the need for appraisal information in August 197' Transportation's study of the program pointed out that plans for additions and improvements to the air-traffic-control system had to be based on a scenario which included assumptions about future needs and on interpretations of Transportation-FAA goals and objectives. This scenario was needed as a framework for conducting cost-benefit analyses. This information was not included in FAA plans at that time and Transportation considered previous analyses done by FAA inadequate for upcoming decisions on implementation. According to FAA, the information requested by Transportation will be available at various times through 1977.

After Transportation's study, FAA's consulting contractor completed its report on the Administration's acquisition management. In relation to FAA's use of cost-benefit analyses, the contractor concluded that:

--FAA does not consistently conduct cost-benefit and related studies to determine the relative merits of proposed requirements and alternative concepts, and incorporate the results into planning.

--Management decisions are made without the full benefit of cost, benefit, performance, and risk information.

The report also pointed out that much of the Administration's analytical planning and design work is put off until late in development, and it concluded that this contributed to FAA's inability to do long-range planning and analysis. The following illustrates this problem.

Collision avoidance program

FAA has been studying the midair collision problem for over two decades, and the problem persists today despite improvements in the air-traffic-control system. Numerous

alternatives, which fall into two basic categories of systems (ground controlled and airborne), have been under development for years. In a report to the Congress 1/, we pointed out that development had been hindered by several factors including the need for comprehensive analysis. FAA agreed with our recommendations for technical and economic analyses of alternative solutions, with later development of the one most economically feasible.

Requirements and responsibilities for test and evaluation must be defined

Test and evaluation should help management control development. It can provide a basis for measuring progress in achieving mission-related performance and technical goals, can expose weaknesses, and can help define needed improvements. Properly planned, performed, and reported it can highlight areas requiring more, or less, resources.

FAA needs to develop a test and evaluation master plan which will define the scope, responsibilities, timing, and interaction of components with the Upgraded Third Generation System. The National Aviation Facilities Experimental Center is responsible for technical and operational testing. Upgraded Third Generation System work constitutes about 40 percent of the Center's estimated $27 million effort for fiscal year 1976. Center officials said this work will become increasingly important over the next several years. They estimate that 70 percent of their facilities will be used in varying degrees to test and evaluate the system.

The Center is planning to acquire new facilities to enhance its test capability and efficiency; however, specific cost and schedule effects (assuming either approval or disapproval of the new facilities program) on the Upgraded Third Generation System have yet to be defined, since specific responsibilities and schedules have not been set to define its test effort and the timing of that effort. Planning has recently started on this.

Test independence and responsibility

A recognized principle of testing is that commitments for full production be withheld until need is reconfirmed

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1/ Aircraft Midair Collision: A Continuing Problem (B-164497(1), Oct. 23, 1974).

and system performance is established through test and evaluation done independently of the developer. FAA's test Center reports to the Associate Administrator for Engineering and Development. As such, the Center is responsible to FAA's "developer", not independent of it.

Issues involving responsibility and authority affect the Center's mission and accomplishment. From a review of over 25 percent of the Center's most important technical program work during fiscal years 1975 and 1976 we found two problems.

1. While the work was directly related to its mission, the Center's actual responsibility was sometimes less than would be inferred by its assigned role as the Nation's civil aviation test center. Actual responsibilities sometimes excluded test planning, performance, or reporting--these were done in part by other agencies or contractors on a case-by-case basis. FAA officials agreed that the Center's testing responsibilities needed to be broadened and said they are taking action to do this.

2. Scheduled planning, performance, or reporting goals were, or were expected to be, missed in 138 of 192 (72 percent) instances. Center officials recognize problems with meeting schedules but believe some of them, such as report processing delays and personnel reassignments, are controllable, and they have begun to correct them. However, other schedule delays involving the Center's interaction with FAA headquarters (such as defining test methods and objectives, funding, and contractual approval) are more difficult to control.

SYSTEMS ACQUISITION

The executive branch is taking action on 149 recommendations made by the Commission on Government Procurement in early 1973 to improve Government procurement.1/ Twelve, which deal with acquiring major systems, were designed to work together and control the whole acquisition process. On April 6, 1976, the Office of Management and Budget issued a new policy on major system acquisitions:

1/ Executive Branch Actions on Recommendations of the Commission on Government Procurement (PSAD-76-39, Dec. 19, 1975).

--Top level management attention is to determine agency mission needs and goals.

--Earlier direction is to be given to research and development.

--Premature commitments to full-scale development and production are to be avoided.

--Decisions to produce are to be based on reaffirmation of needs and objectives and on system performance demonstrated by independent testing.

If FAA is to conform to the Office of Management and Budget policy, the Administration's program planning and appraisal must be improved.

RECOMMENDATIONS TO THE SECRETARY OF TRANSPORTATION

We recommend that the Secretary require FAA to take the following actions to improve its engineering and development program management:

--Establish a formal process to formulate long-range operational requirements.

--Incorporate criteria for cost, schedule, and performance estimates in development plans and decision papers and use these for measuring progress.

--Strengthen systems analysis and incorporate cost-benefit analyses in planning and appraisal of development.

--Develop system implementation strategy early in the development cycle, and coordinate this with the operating services.

--Define "test and evaluation responsibility" and take action to establish an operational testing capability independent of the development function.

AGENCY COMMENTS AND OUR EVALUATION

Transportation's Assistant Secretary for Administration, in commenting on this report (see app. III), said that actions are underway which relate to our recommendation for a process to establish requirements and which would result in necessary improvements. So far, FAA has (1) specified a format for requirement analyses, (2) developed a prototype requirement statement, and (3) started to set priorities for requirement analyses to be conducted.

Transportation did not fully agree with our recommendations on development and implementation planning and on test independence.

Development and implementation planning

Transportation cites concern about the uncertainties surrounding development and implementation planning. It states that development programs and decisions cannot be coupled with implementation planning due to changing costs, priorities, and schedules.

We realize that priorities, schedules, costs and other factors can change during research and development. Sound program control, through planning and appraisal, provides the best method of dealing with such problems. Development planning should consider and foster an implementation strategy which is adjusted and refined over time as technical, financial, and other uncertainties are resolved. While we agree that a final implementation plan must follow development, earlier assumptions and planning are needed to get an understanding of resource needs and to provide a framework for conducting cost-benefit studies. It was because of the absence of this kind of forward planning that

- --Transportation found weaknesses in FAA's analysis effort and
- --the FAA's consulting contractor reported that systems were developed with little forethought of future needs or cost-benefit trade-offs and that planning was "driven by (as opposed to driving) the Federal budget process."

Test independence

Transportation commented that the National Aviation Facilities Experimental Center is a necessary adjunct to the research and development program and should remain under control of FAA's development organization. It stated that implementation decisions are not based only on the test results as interpreted by the development organization. Increasingly, preproduction prototypes are deployed to operating sites for field evaluation by operating personnel. Implementation decisions are then made by field experienced personnel who have no stake in or association with the development programs.

We continue to believe that preproduction testing should be independent of the developer. Independent assessment by field organizations is also important; however, prototype testing and field evaluations are also under control of FAA's development organization since it

--sets test objectives and evaluation criteria,

--controls test funding,

--is responsible for leadership in conducting tests,

--modifies test plans and specifications, and

--reviews and approves test reports.

Office of Management and Budget policy on major systems acquisition states that production may be approved when the agency's needs and program objectives have been reaffirmed and when

> "* * * system performance has been satisfactorily tested, independent of the agency development and user organizations * * *"

This policy responds to recommendations made by the Commission on Government Procurement following years of dissatisfaction with the test and evaluation function and with the unacceptable performance of many newly produced systems.

The need for test and evaluation information will become increasingly important to Transportation and FAA

as portions of the Upgraded Third Generation System approach production decisions. Therefore Transportation and FAA should establish the procedures and changes needed to comply with major systems acquisition policy.

MATTERS FOR CONSIDERATION BY THE CONGRESS

During oversight and authorization hearings the Congress should make sure that Transportation and the Federal Aviation Administration are implementing the acquisition policies prescribed by the Office of Management and Budget and the Office of Federal Procurement Policy concerning

--analysis of agency missions and needs,

--setting program objectives and system requirements,

--program planning and control, and

--test and evaluation.

CHAPTER 4

SCOPE OF REVIEW

We interviewed officials at Department of Transportation and Federal Aviation Administration headquarters and reviewed records pertinent to policy and procedures for planning, appraising, managing, acquiring, and implementing engineering and development programs. We considered the impact of ground transportation and aviation forecasting upon FAA's engineering and development programs.

We conducted interviews and reviewed records related to system test and evaluation at FAA's National Aviation Facilities Experimental Center. We also visited various user groups to discuss their participation in FAA's current and planned engineering and development programs.

The review was made at the:

--Department of Transportation:

  --Office of the Secretary of Tra sportation, Washington, D. C.

  --Deputy Undersecretary of Transportation, Intermodal Planning Group, Philadelphia, Pennsylvania.

  --Federal Aviation Administration headquarters, Washington, D. C.

  --National Aviation Facilities Experimental Center, Atlantic City, New Jersey.

  --Flight Service Station, Philadelphia, Pennsylvania.

--Contractor:

  --Narco Scientific Industries, Fort Washington, Pennsylvania.

--Other organizations:

  --Aircraft Owners and Pilots Association, Washington, D. C.

--Air Line Pilots Association, Washington, D.C.

--Airport Operators Council International, Washington, D. C.

--Air Transport Association of America, Washington, D. C.

--General Aviation Manufacturers Association, Washington, D. C.

--National Air Transportation Associations, Inc. Washington, D.C.

--National Pilots Association, Washington, D.C.

--Professional Air Traffic Controllers Organization, Washington, D.C.

PRINCIPAL ELEMENTS OF THE UPGRADED THIRD GENERATION AIR TRAFFIC CONTROL SYSTEM

The Upgraded Third Generation Air Traffic Control System is planned for the 1980s and 1990s. The system is made up of the following separate, yet related elements.

DISCRETE ADDRESS BEACON SYSTEM

This system is meant to survey airspace with greater accuracy and reliability and to better detect aircraft flying near each other. It provides a two-way, electronic data link between aircraft and ground stations. Many other Upgraded Third Generation System elements cannot be successfully implemented without some type of data link.

AIRBORNE SEPARATION ASSURANCE

Midair collisions are a continuing problem and solutions being considered are:

--Intermittent Positive Control. This element is intended to improve flight safety and reduce potential midair collisions. It is designed so that pilot warnings and commands will be sent by data link from the ground to aircraft equipped with the Discrete Address Beacon. Ground control will intervene only when necessary.

--Airborne Collision Avoidance. Several airborne systems are being developed. The common basis for all these systems is the need for a device that can detect and warn pilots of other aircraft in the vicinity.

Our 1974 report (B-164497(1)) on midair collisions describes most systems; however, FAA recently added another system, Beacon Collision Avoidance. It functions similiarly to the Intermittent Positive Control System except that interrogations are made from aircraft to aircraft. Thus, the pilot has all the needed information in the cockpit to make decisions.

FLIGHT SERVICE STATION PROGRAM

Flight service stations are facilities where pilot flight plans are filed and briefings are provided on weather

and on the operational conditions of aviation facilities. The present program has not been improved in approximately 35 years and can no longer handle modern demands efficiently To correct the current problems and provide for future demands, a three-phase modernization program is planned.

--The Near Term Phase will immediately improve, independently of automated equipment, flight services' productivity and the dissemination of weather information.

--The Intermediate Phase, called the baseline system, will automate the station to aid the flight service station specialist and allow the user direct access to the system.

--The Long Term Phase will add to the baseline system. The two subsystems at the center of these phases--computer-generated voice response and a family of direct user access devices--are to provide automatic weather briefings, specialist support, and self-briefing to users who own terminals. The expected benefits are increased productivity and consolidation to achieve better operations.

UPGRADED AIR-TRAFFIC-CONTROL AUTOMATION--TERMINAL AND EN ROUTE

Automated functions will be upgraded by changing the computer programs that now control the data processing and the displays throughout the air-traffic-control system. Specific functions to be developed include aircraft metering and spacing and conflict predictions. Some new functions will rely heavily on the Discrete Address Beacon System data link for message exchange with aircraft and will have to integrate and make use of other Upgraded Third Generation elements. Expected benefits are reduced unit cost of controller services; more aircraft allowed in less, or the same airspace; and reduced delay.

AIRPORT SURFACE TRAFFIC CONTROL

This system is intended to allow safe, efficient aircraft movement on the airport surface. Early development is intended to improve radar surveillance and simple stop and go visual signals.

Future plans include some automated control functions and improved tower displays and facilities. The expected benefits are increasing airport capacity, reducing delays, and avoiding collisions between taxiing aircraft and vehicles.

WAKE VORTEX AVOIDANCE SYSTEM

This system is to provide the basis for increased airport capacity and improved safety by detecting and/or predicting the presence of high-energy wake vortices. A vortex is turbulent air created by large heavy aircraft during low speed final approach or departure. Today's safety separation standards are based on not knowing when and where vortexes exist. Reduced separation between aircraft is expected, as a result of knowing when wake turbulence will occur on final approach.

WIND SHEAR

Wind shear is a change in wind direction and/or speed over a very short distance in the atmosphere. Such conditions can have devastating effects on aircrafts. This program, recently added to the Upgraded Third Generation System and expedited because of wind shear's link to several disastrous air carrier accidents, is supposed to solve the problem of these potentially hazardous conditions at airports. To do this, the program will explore ground-based equipment, airborne equipment, and improved wind shear forecasting techniques. The final solution possibly will include elements of each.

AREA NAVIGATION

This system permits direct routes between pre-selected fixed points rather than the more indirect routes provided by the present navigation system. Ground control radar instructions are not needed. This should improve services to the user and may reduce operating costs. Further benefits expected are increased traffic-control efficiency in terminal areas and reduced controller workload.

MICROWAVE LANDING SYSTEM

This system is intended to increase landing system performance for civilian and military aviation. Various ground and airborne landing systems are being developed. The model best suited for particular needs at the best cost

can then be selected. Expected benefits are lower installation costs and installation at sites where the present instrument landing system will not work. Improved performance is expected by providing curved and multiple path approaches which would reduce noise in areas surrounding airports. Noise reduction may permit the reopening of runways closed due to noise.

AERONAUTICAL SATELLITE

This international program will explore the use of satellites to improve oceanic communications and provide surveillance information to the air-traffic-control system. The aim is to reduce the distance between aircraft flying over the ocean and improve oceanic air-traffic management.

The program should lead to the design of a system and an international agreement on a set of standard procedures to run such a system. The ultimate aim, beyond the scope of this program, is to achieve a working system in time to satisfy demands which cannot be met by current communication methods. The potential is seen for reduced costs over the long term by consolidating the oceanic traffic center and for greater air traffic efficiency by changing separation standards.

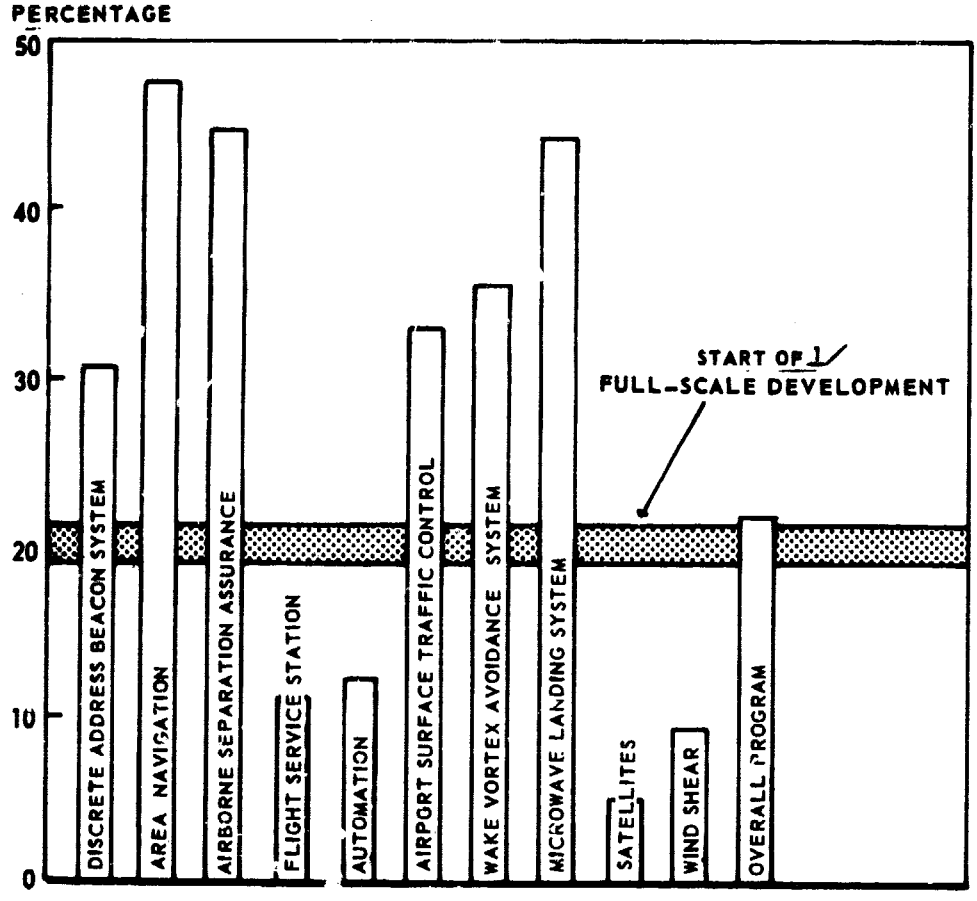
APPENDIX II

UPGRADED THIRD GENERATION

AIR-TRAFFIC-CONTROL SYSTEM PROGRAM STATUS

Entering full-scale development is a key point in the development of a major system, because alternative developments are reduced and more funds are committed. Before this decision, the agency's mission needs and goals should be reaffirmed and competitive demonstration should verify that the chosen concept is sound. The following chart shows the Upgraded Third Generation program status as of June 30, 1975, in relation to full-scale development.

PROGRAM STATUS BASED ON THE PORTION OF PLANNED DEVELOPMENT FUNDS OBLIGATED



[1] *CRITERIA USED TO IDENTIFY THE START OF FULL-SCALE DEVELOPMENT IS BASED ON DEPARTMENT OF DEFENSE EXPERIENCE IN MANAGING RESEARCH AND DEVELOPMENT AND SYSTEMS ACQUISITION.*

APPENDIX III

OFFICE OF THE SECRETARY OF TRANSPORTATION
WASHINGTON, D.C. 20590

ASSISTANT SECRETARY
FOR ADMINISTRATION

October 6, 1976

Mr. Henry Eschwege
Director
Community and Economic Development Division
U. S. General Accounting Office
Washington, D. C. 20548

Dear Mr. Eschwege:

This is in response to your letter of August 11, 1976, requesting comments from the Department of Transportation on the General Accounting Office draft report entitled, "FAA's Engineering and Development Programs: A Need to Resolve Issues and Improve Program Management." We have reviewed the report in detail and prepared a Department of Transportation reply.

Two copies of the reply are enclosed.

Sincerely,

for William S. Heffelfinger

Enclosures

APPENDIX III

DEPARTMENT OF TRANSPORTATION REPLY TO GAO DRAFT REPORT OF AUGUST 11, 1976 ON FAA'S ENGINEERING AND DEVELOPMENT PROGRAMS: A NEED TO RESOLVE ISSUES AND IMPROVE PROGRAM MANAGEMENT

SUMMARY OF GAO FINDINGS AND RECOMMENDATIONS

The General Accounting Office (GAO) concludes that improvement is needed in the Federal Aviation Administration's (FAA) policies, procedures, and practices used in managing the development and acquisition of air traffic control (ATC) systems. The GAO found that, because needed assessment information is lacking, important issues on the Upgraded Third Generation (UG3RD) development program's potential for accomplishing safety, cost and capacity objectives remain unresolved. The GAO states that the FAA needs to know whether (1) the UG3RD individual programs are properly correlated with accident conditions and causes and aligned with the safety objectives, (2) the UG3RD programs are cost effective, and (3) the Government should go forward with the planned pace and content of the UG3RD program. The GAO believes that these issues remain unresolved because of weaknesses in the planning and appraisal of FAA's engineering and development programs. Regarding program planning, the GAO states that a requirement formulation process is needed, program plans should be more timely and informative, and integration and implementation planning is needed during development. Concerning program appraisal, the GAO states that decision papers should be more timely and informative, cost benefit analyses are needed during development, and requirements and responsibilities for test and evaluation must be defined.

The GAO recommends that the Secretary assure that future acquisition decisions to advance UG3RD programs be made only after the FAA has completed detailed studies and analyses upon which sound decisions can be based. Further, that the FAA be required to reconfirm program needs, evaluate technical and nontechnical alternatives, and consider the effects of other transportation modes on ATC system needs. The GAO also recommends that the FAA take the following actions to improve its engineering and development program management: (1) establish a formal process to formulate long-range operational requirements, (2) incorporate cost, schedule, and performance baselines in development plans and decision papers and use these for measuring progress, (3) strengthen the systems analysis function and incorporate cost benefit analysis in development planning and appraisal, (4) develop system implementation strategy early in the development process, and coordinate these plans with the operating services, and (5) define test

and evaluation responsibility, and take action necessary to establish an operational testing capability independent of the development function. The GAO further recommends that the Congress consider requiring the FAA to provide assurance that the acquisition policies prescribed by the Office of Management and Budget and the recently established Office of Federal Procurement Policy are being implemented and adhered to.

SUMMARY OF DEPARTMENT OF TRANSPORTATION POSITION

The GAO report, in our opinion, does not properly reflect several important FAA actions which have been or are underway related to (1) the identification and resolution of the UG3RD program issues, and (2) improved management of FAA's development program planning and appraisal. We will, however, assure that future acquisition decisions to advance UG3RD programs further in development will be made only after FAA has completed necessary studies and analyses upon which sound decisions can be made. With regard to formulating long-range operational requirements, we are in the process of establishing a revised and revitalized requirements system which should result in necessary improvements. We are not fully in accord with the recommendations concerning development plans, systems analysis, cost benefit studies and test independence for the reasons set forth below.

POSITION STATEMENT

Regarding the three unresolved issues determined by the GAO, both the FAA and the Department of Transportation (DOT) recognized these issues even before DOT conducted its comprehensive technical review of the entire UG3RD development program in 1974. Analyses initiated by the FAA as long as two years ago to provide answers to the issues are now becoming available. In light of this, it would be more accurate to characterize the issues as questions which are in the "process of resolution" rather than issues "remaining unresolved." To illustrate, several documented analyses concerned with the cost effectiveness issue have been completed on the impact of automation on FAA costs and staff requirements. Further, additional estimates of the UG3RD impact on FAA productivity and costs were made in conjunction with a UG3RD system cost benefit analysis and are presently in the review stage.

Analyses concerning the desirability of continued UG3RD development in light of revised aviation growth forecasts and the possible use of satellite airports to increase airport capacity (pace and content issue) are also under review. These studies were performed in conjunction with an UG3RD system cost benefit analysis and analyses of UG3RD complementary policy strategies.

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The GAO suggests that the FAA consider further reduction of those UG3RD programs which are designed primarily to increase the capacity of the system, in view of activity forecasts which are much lower than the 1969 projections. The 1969 forecasts indicated that aircraft handled by centers would more than double by 1980 (over the 1969 level) and that terminal instrument operations would more than triple. Those forecasts did not anticipate the downturn in economic activity or the energy crisis.

Nevertheless, current forecasts (1976) project aircraft handled to be 40% above 1969 levels by 1980 and 90% higher by 1988. Terminal instrument operations are projected to be 120% higher in 1980 and 197% higher by 1988. Aircraft handled and terminal instrument operations are the two major indicators of capacity requirements. Given the magnitude of the projected increases, it appears essential to provide significant increases in the capacity of the system.

We will, however, assure that future acquisition decisions to advance UG3RD programs further in development will be made only after FAA has completed necessary studies and analyses upon which sound decisions can be made. We will also reconfirm program needs, evaluate technical and nontechnical alternatives, and consider the effects of other transportation modes on ATC system needs. The following comments are offered on the remaining recommendations.

Regarding the management of development program planning and appraisal, substantial efforts have been underway for some time within FAA to improve the procedure for long-range requirements. As of the present time, the FAA has specified a format for requirement analysis, developed a prototype requirement statement, and tentatively established a list of ten top priority requirement analyses to be conducted.

We do not believe the GAO fully appreciates two aspects of development plans. First, they relate to research and development (R&D) and not implementation. Not all R&D will be successful. Implementation planning requires the output of R&D efforts. Thus, it is not surprising that development plans lack some of the information regarding implementation costs and benefits. Second, the largest unknown in FAA development programs, outside of ultimate success, is the financial aspects. Congress appropriates year-by-year; development plans cover several years. Contract costs vary. Program priorities and schedules shift. Thus, development plans are nearly always being changed. They cannot be updated monthly. The FAA agrees that more frequent updating -- possibly annually -- is desirable, but the effort involved is significant. This is not to say that much documentation -- in the form of letters, memos, procurement plans, and acquisition papers -- is not available.

Concerning the systems analysis and cost-benefit studies, such efforts are necessary and cannot be underestimated. However, R&D decisions and programs are not and cannot be coupled with implementation planning as

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GAO suggests. One must precede the other. The existence of any R&D program is a presumption of implementation, but not a guarantee. After R&D, the cost and benefit picture may change.

With respect to establishing an operational testing capability independent of the development function, it should be recognized that the FAA's National Aviation Facilities Experimental Center (NAFEC) is a test and evaluation center for development programs. Implementation decisions are not predicated only on those results as interpreted by R&D sponsors of the programs. Increasingly, preproduction prototypes are deployed for field evaluation at operating sites by operating personnel before implementation decisions are made. The FAA is primarily an operating agency, and implementation decisions are made by practical field-experienced operating personnel with no stake or association with the R&D programs. We believe that the GAO has misinterpreted the role and influence of NAFEC on implementation decisions. In our opinion, NAFEC is a necessary adjunct to the R&D programs and should be under R&D control.

[See GAO note]

Acting Administrator

GAO note: A portion of this letter has been deleted because it is no longer relevant to the matters discussed in this report.

PRINCIPAL OFFICIALS

RESPONSIBLE FOR ADMINISTERING ACTIVITIES

DISCUSSED IN THIS REPORT

	Tenure of Office	
	From	To
DEPARTMENT OF TRANSPORTATION		
SECRETARY OF TRANSPORTATION:		
William T. Coleman, Jr.	Mar. 1975	Present
John T. Barnum (acting)	Feb. 1975	Mar. 1975
Claude S. Brinegar	Feb. 1973	Feb. 1975
John A. Volpe	Jan. 1969	Feb. 1973
FEDERAL AVIATION ADMINISTRATION		
ADMINISTRATOR:		
John L. McLucas	Nov. 1975	Present
James E. Dow (acting)	Apr. 1975	Nov. 1975
Alexander P. Butterfield	Mar. 1973	Mar. 1975
John H. Shaffer	Mar. 1969	Mar. 1973