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BY THE COMPTROLLER GENERAL

**Report To The Chairman,
Committee On Government Operations
House Of Representatives**
OF THE UNITED STATES

**Examination Of The Federal Aviation
Administration's Plan For The National
Airspace System--Interim Report**

A plan for the National Airspace System, estimated by the Federal Aviation Administration (FAA) to cost about \$10 billion, has been developed. The aims of the plan are consolidation of facilities, standardization of computer hardware and software, and greater reliance on automation for improved safety, fuel efficiency, and productivity.

While the plan is a step in the right direction, it lacks the detail and justification usually needed for budgetary approval and implementation. Major issues involving computer acquisition, landing systems, collision avoidance, and communications systems must be resolved before transition and implementation.

The plan should be periodically updated to reflect changing user needs, air traffic forecasts, and budget adjustments.



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

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APR 20 1982

The Honorable Jack Brooks
Chairman, Committee on Government
Operations
House of Representatives

Dear Mr. Chairman:

In accordance with your Committee's June 11, 1981, request, we began a review of the Federal Aviation Administration's (FAA's) planning, management, and acquisition of automated systems for air traffic control and management purposes.

In response to your March 23, 1982, letter (see app. I) we have temporarily redirected our efforts to provide the Committee with an analysis of FAA's plan for upgrading its current computer and communications systems for air traffic control and for making extensive improvements to the National Airspace System (NAS).

Appendix II of this report provides responses to the specific questions in your request. With respect to your request for a thorough and comprehensive analysis of the NAS plan, we are providing the following observations on issues that we believe require some attention at this interim stage of our review.

NAS PLAN IS A STEP IN THE
RIGHT DIRECTION TOWARD OVERHAULING
THE AIR TRAFFIC CONTROL SYSTEM

FAA's NAS plan deals with facilities and equipment as well as with supporting research and development. According to FAA, the plan focuses on the current system and on the improvements that must be made in the immediate future to meet projected needs and demands of aviation and to ensure a system that operates safely.

FAA's plan is a step in the right direction toward overhauling the air traffic control (ATC) system. FAA's stated aims in the plan are (1) consolidation of facilities, (2) standardization of computer hardware and software, and (3) greater reliance on automation for improved safety, fuel efficiency, and productivity. Moreover, the plan projects through the year 2000, which should provide ample time for replacing the equipment that is obsolescent or is fast approaching obsolescence. The plan also introduces design innovations for the long haul.

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NAS PLAN SHOULD NOT BE VIEWED
AS BASIS FOR APPROVING BUDGETARY
AND IMPLEMENTATION ACTIONS

First, to determine if the objectives of the NAS plan are reasonable, achievable, and worth the cost, they should be quantified, linked to implementing systems and actions, and compared with their associated cost. This process should be essential for a development program estimated to cost \$10 billion, but in this case, it was not done.

Second, additional supporting detail is needed in the NAS plan to support the (1) increased future demands, (2) improved safety and services, (3) reduction of operating costs, and (4) replacement of aging facilities and equipment. In addition, these needs are not ranked in any order, and the potential impact--if they are not funded--is not assessed. Also, they are heavily skewed by a projection of rapid aviation growth that is open to question.

Third, the plan should include cost information on individual programs, projects, or systems. Such information is required to assess the cost effectiveness of various NAS components. Moreover, the plan presents only one approach, thus ruling out a determination that it is the most cost effective alternative. At the time this report was prepared, we had not received FAA's fiscal 1983 budget data, so we were unable to comment on that request. The Congress needs more detailed data on implementation costs, associated benefits of major projects, and the potential source of funds.

Clearly, more information is required on the benefits and savings claimed in the plan before the Congress and users will commit to its estimated price tag of \$10 billion. (See app. III.)

MAJOR ISSUES REQUIRE RESOLUTION BEFORE
TRANSITION PLANNING AND IMPLEMENTATION

Major technical issues should be resolved before transition planning can be completed and implementation started. These issues include computer acquisition, continued use of old software, and problems with landing, collision avoidance, and communication systems.

ATC computer acquisition issues

A major issue that has not been resolved is whether FAA will comply with Public Law 89-306 in procuring computers for the ATC system. FAA's plan calls for the replacement of the en route and terminal system computers as well as the procurement of computers for other uses such as weather systems, communications, and flight services data processing. On February 18, 1982, we sent a report

to the Secretary of Transportation ^{1/} recommending that FAA be directed to comply with Public Law 89-306 and the General Services Administration (GSA) implementing procedures for computer procurements. In testimony before the House Committee on Public Works and Transportation, Subcommittee on Aviation, on March 17, 1982, the FAA Administrator said that FAA does not intend to follow Public Law 89-306 and the GSA procedures. As of the date of this report we have not received an official reply from the Secretary of Transportation on this major issue.

Other major issues needing resolution are (1) continued use of the current software on the new computers and (2) transition planning.

FAA's decision to upgrade ATC computers and to continue using the current software will have both short and long term consequences. Initially, a risk will be run that the software will not be updated. The end consequence, under those conditions, would be that hardware capacity would be increasingly absorbed by obsolete software. It appears that less risky alternatives should be considered; otherwise, FAA may simply be deferring today's problem until tomorrow.

FAA's plan calls for an evolutionary approach for moving from its current computer system to the future system. Within the air traffic en route and terminal computer systems, more than 30 time-critical events are scheduled between 1981 and 2000. For an effort of this magnitude to be successful, careful and detailed transition planning must be done. According to FAA, because a number of difficult issues have to be resolved, a transition plan has not yet been developed. (See app. IV.)

ATC landing, collision avoidance,
and communications issues

Several other problems may arise in the implementation process without appropriate transition planning. (See app. V.)

- Certain ATC and landing systems may be procured prematurely because FAA plans to buy equipment before negotiations on international agreements on these matters are concluded.
- Certain planned collision avoidance equipment will not be employed in areas where most mid-air collisions occur.
- Future collision avoidance protection may be excessively dependent on a single data link system without adequate backup.

^{1/}"Applicability of Public Law 89-306 to the Federal Aviation Administration's (FAA's) Procurement of Computers for the Air Traffic Control System," AFMD-82-47, Feb. 18, 1982.

- Interim communications switches scheduled for acquisition may not be cost effective because they will be used for only a small portion of their life expectancy.
- The cost effectiveness of the trend analysis portion of remote maintenance monitoring must be verified. The Congress may not want FAA to expand the FAA-owned long haul communications network even though preliminary FAA estimates indicate it to be cost effective. Traditionally, the Government leases such services from commercial communications carriers.

PLANNING IS INADEQUATE FOR
PROCUREMENT OF COMPUTER SYSTEMS
FOR MANAGEMENT AND ADMINISTRATIVE PURPOSES

FAA has made serious omissions in its planning for procurement of computer systems for management and administrative purposes. These omissions result from not adhering to the principles of proven information resource management. As a result, FAA is procuring (1) a new computer for its Aeronautical Center when other less costly alternatives exist and (2) new computers for its regional offices that may not be needed.

FAA plans to award a contract in June 1982 for a new large mainframe computer to replace the three computers currently at the Aeronautical Center. The requested computer will nearly quadruple present processing capability and cost \$7.3 million over its 8-year life cycle. We did not find this procurement to be properly justified.

FAA's procurement of nine computer systems (plus an option for five more) for its regional offices, headquarters, and Aeronautical Center is also not justified. Estimated purchase costs are \$19 million. (See app. VI.)

FAA'S ABILITY TO MANAGE NAS PLAN
IMPLEMENTATION IS A MAJOR CONCERN

FAA must deal with a disparate group of interested parties--the Congress, the Aircraft Owners and Pilots Association, the Air Traffic Association, the Airline Pilots Association, the General Aviation Manufacturers Association, and the general public--all with different desires and interests. It is not surprising that almost any FAA decision will generally please some while antagonizing others.

It is within this context, however, that management must be exercised most prudently. FAA has experienced problems in developing less complex ATC automation and related projects, and past schedule slippages and cost overruns do not engender confidence in FAA's ability to successfully implement the NAS plan under current project management and organizational direction. (See app. VII.)

One positive point of the plan is the high degree of coordination that was necessary within FAA in developing this plan. To allay fears of both the Congress and the aviation community about its ability to execute the plan on schedule and within budget FAA intends to establish both a high level acquisition review committee and project managers for major projects.

The successful implementation of the NAS plan will depend on many factors, including the support of all parties involved. The continued active leadership by the Administrator, support from FAA officials, contributions and support of system users, talents of the FAA technical staff, and selection and close monitoring of contractors are all essential to ensure that the plan meets its objectives.

On the other hand, there are some elements which are beyond the Administrator's direct control. These include budget constraints, personnel pay caps and ceilings and inherent delays in hiring qualified employees.

The Administrator's ability to deal with both controllable and uncontrollable elements will be the major factor determining the success or failure of the plan.

UPDATED NAS PLAN AND SUPPLEMENTAL
EXECUTION PLANS SHOULD BE PREPARED
BEFORE 1984 BUDGET HEARINGS

As mentioned earlier, the NAS plan is a good first step, but because of major questions and issues discussed in this report and associated appendixes, the plan should be viewed as a general framework for defining costs, benefits, acquisition strategies, implementation planning, and human as well as dollar resources. To have a lasting use, the plan should be revised and updated annually to accommodate changes in needs, technology, funding, and test results.

At a minimum, the plan must address contingencies for variations in air traffic forecasts. Cost and funding issues should be clarified, with specific attention to user tax implications. Because much of the estimated \$10 billion will apparently be obligated between 1984 and 1987, the plan should be amplified, periodically updated, and provided to the Congress as an aid in preparing for fiscal 1984 budget deliberations.

CONCLUSIONS AND RECOMMENDATIONS

Until we have completed all field work, we are deferring our conclusions and recommendations in the air traffic control area. Regarding the NAS plan, we believe FAA has made a good start in its effort to plan for the future ATC system. However, the plan

needs more detail on (1) consideration of alternatives and needed funding, (2) adequate testing of systems to assure that operational problems have been resolved, and (3) better coordination and transition planning of related projects.

We do, however, have conclusions and recommendations with respect to the administrative and management computer systems. As described in appendix VI, FAA has not properly planned, justified, or managed its computer procurements for its regional offices and Aeronautical Center. In this effort, FAA has not followed proven information resource management methods. Information requirements have not been fully defined and alternatives were not considered.

We recommend that the Secretary of Transportation direct FAA to:

- Cancel its procurements for replacing the regional computer systems and the computer for the Aeronautical Center.
- Conduct a comprehensive information requirements analysis including the identification and ranking by priority of future software applications.
- Prepare a long range plan to obtain needed processing and telecommunication capabilities.

OBJECTIVES, SCOPE, AND METHODOLOGY

This assignment was performed in accordance with our current "Standards for Audit of Governmental Organizations, Programs, Activities, and Functions." Our work was conducted at the Department of Transportation, FAA headquarters in Washington, D.C.; the FAA Technical Center in Atlantic City, New Jersey; the FAA Aeronautical Center in Oklahoma City, Oklahoma; 8 of 10 FAA regional offices; 7 of 20 air route traffic control centers located in the continental United States; and about 10 of 150 terminal facilities. We interviewed FAA staff members involved in planning for the proposed computer replacement solution and those involved in operating and maintaining the National Airspace System. We also reviewed FAA documents relating to FAA's planning, management, and operation of the National Airspace System.

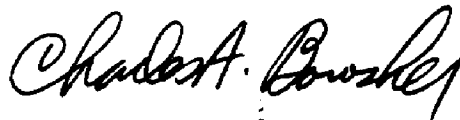
Our objectives were to (1) analyze FAA's NAS modernization plan, (2) assess FAA's plans to develop new management and administrative information systems in support of, and integrated with, the new NAS project, and (3) determine whether the ATC automation programs, radar, and communications portions of the NAS plan are technically sound, present feasible and cost effective solutions

to identified requirements, and are sufficiently integrated with the other segments of the plan to ensure a successful "total system project."

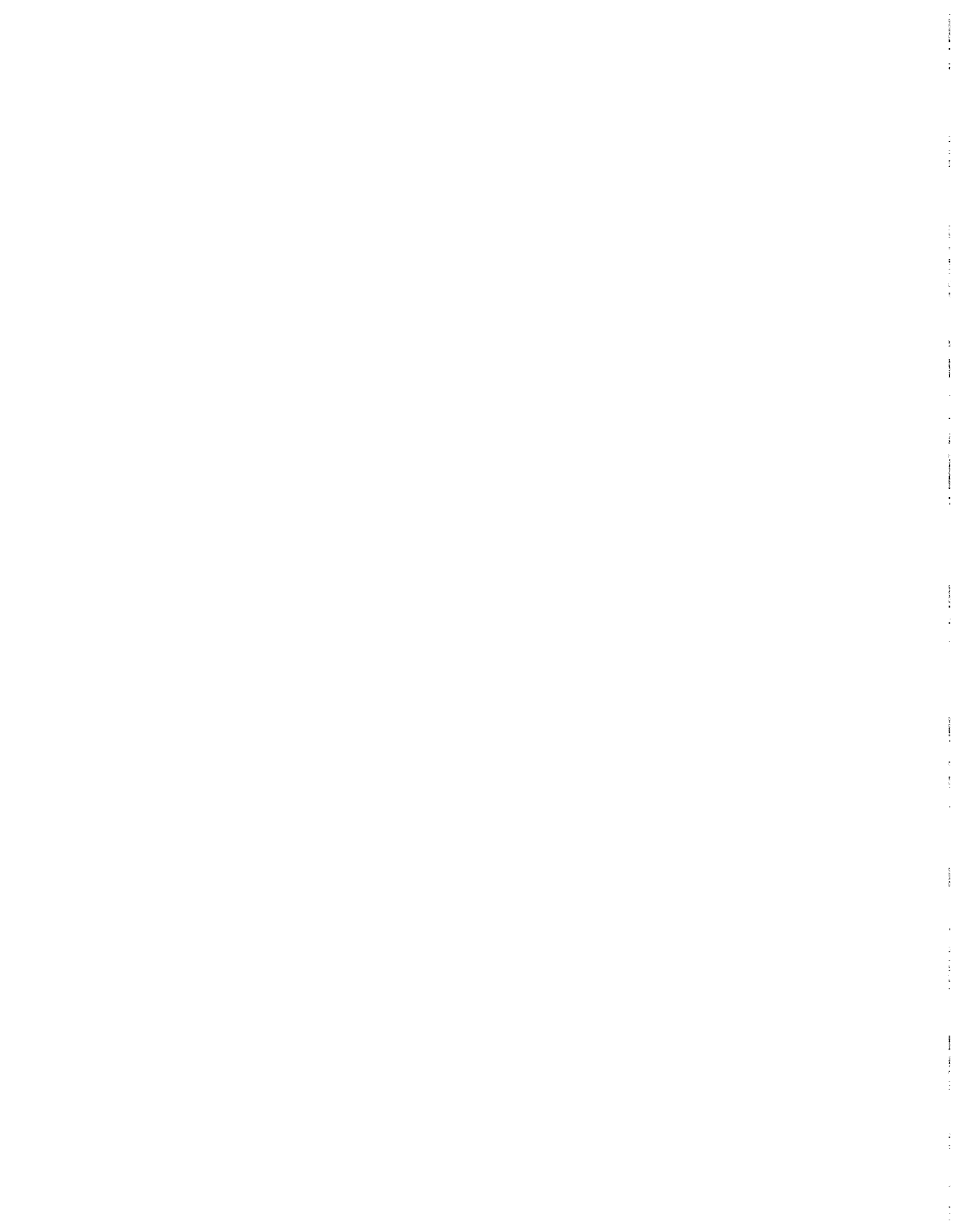
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As arranged with your office, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from its date. At that time we will send copies to the Secretary of Transportation and the Administrator of the Federal Aviation Administration, and will make copies available to other interested parties.

Sincerely yours,

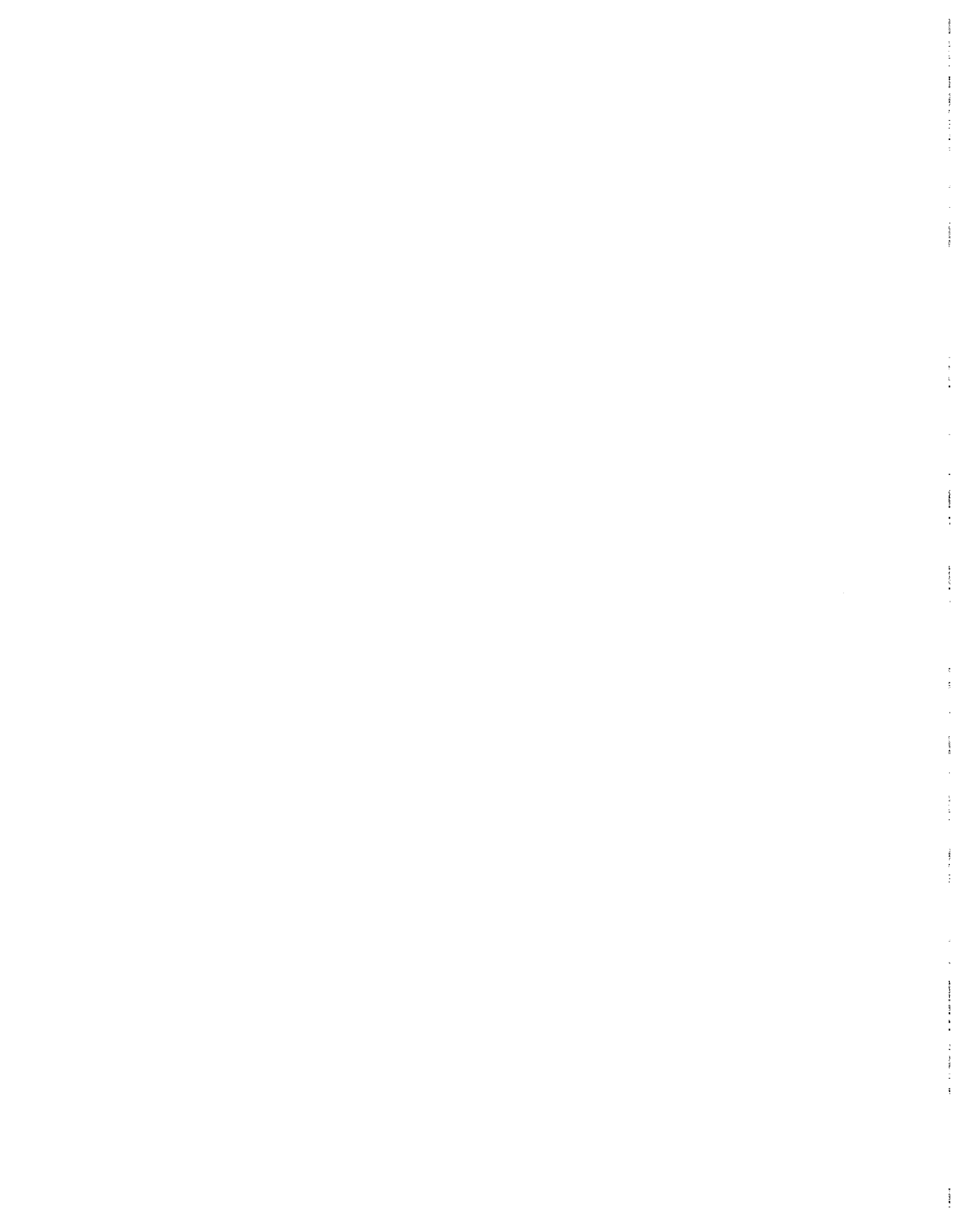


Comptroller General
of the United States



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NINETY-SEVENTH CONGRESS
Congress of the United States
House of Representatives

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 March 23, 1982

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The Honorable Charles A. Bowsher
 Comptroller General
 General Accounting Office
 441 G Street, N.W.
 Washington, D.C. 20548

Dear General:

Last June, the Committee requested that the GAO initiate a comprehensive investigation of the Federal Aviation Administration's planning, management, and acquisition of automated information systems for Air Traffic Control and FAA management purposes. The GAO was to complete its investigation and report its findings, conclusions and recommendations by October 1982 with interim reports delivered to this Committee on a quarterly basis. As a result of this request, GAO established a large multi-division task force to perform the review and report its findings to the Committee.

As you may know, the FAA is moving rapidly to upgrade its current obsolete computer and communications systems. The proposed multi-billion dollar modernization program is one of the largest, most complex computer projects ever attempted by a federal agency. Within the past few weeks, the Administrator has indicated that his agency's plan is complete and he wishes immediate Congressional approval. The Congress is painfully aware of past poorly conceived "hurry-up" ADP proposals that have cost the U.S. taxpayers billions and have ended as catastrophic failures. We can ill afford similar debacles in the 1980's, particularly in our critical Air Traffic Control System.

With immediate Congressional decisions imperative, the Committee must take advantage of GAO's past ten months' worth of investigation into FAA's current approach and plans. Therefore, I request that the GAO prepare an interim report to be delivered to the Committee by April 20, 1982. This effort should contain the current results of GAO's review, including recommendations, of FAA's Air Traffic Control and management system as well as an evaluation of FAA's modernization plan. Since there seems to be some uncertainty among the GAO multi-division task force as to the intended content of this report, I am enclosing a list of questions that are of particular concern to the Committee.

With best wishes, I am

Sincerely,



JACK BROOKS
 Chairman

Enclosure

Questions for GAO Interim Report

A. FAA has delivered to Congress its new plan for total replacement of the nation's air traffic control system. Administrator Helms has personally and forcefully mounted an aggressive campaign to seek immediate Congressional approval of this project. He has indicated to Members of Congress that the plan is complete and workable and that there is little room, if any, to make adjustments to accommodate the concerns of Congress. Please provide a thorough and comprehensive analysis of the FAA plan including the following:

1. Is the new "National Airspace Performance Reporting System" (NAPRS), reportedly effective January 1982, fully responsive to the corrective recommendations in both the Government Operations and Appropriations Committees reports regarding the reporting of ADP failures?
2. Do the "Responses to Congressional Recommendations Regarding the FAA's Enroute Air Traffic Control Computer System" (transmitted February 22, 1982) correspond or comport with the National Airspace System Plan" of December 1981? For instance:
 - Figure 2-1 at page 13 of the "Responses" document uses 23 enroute centers as a basis for cost comparisons, yet the NAS Plan calls for only 16 centers.
 - Item (3)(c) of the "Findings" section (at p. 10) of the "Responses" volume says, "Evolution of this system in the 1990's...may include...replacement of the host computer." What does this mean and is it reflected in the NAS Plan?
3. How much money was expended on the "ATARS" program prior to cancellation? Were any other air traffic control automation projects within FAA actually cancelled as a result of the evaluation leading to the NAS Plan?
4. What are the current total cost projections of the Flight Service Station Automation Program and exactly what studies have been done to determine consumer acceptance of the ultimate service/product? Are the studies adequate to substantiate the expenditure?
5. FAA has experienced considerable problems in the simple, straightforward upgrades of the ARTS II, ARTS III, and DARC. Does GAO believe that the FAA staff has sufficient technical expertise to manage the development and implementation of the highly complex NAS project?
6. Has FAA completed a review of its technical and functional requirements and, if not, what are the possible adverse consequences of failing to do so?
7. FAA has asserted that the new computer systems will be acquired on a fully competitive basis following the guidelines contained in OMB Circular A-109. Are these assertions true and, if not, what are the possible consequences of failing to do so?

8. According to the FAA, any new computer systems that will be acquired must be able to operate using FAA's old software and that sometime in the future new software will be developed. Won't this technical approach inhibit innovation and constrain new software to the capabilities of the previously installed hardware? If this should happen, what would be the impact of FAA's ability to meet its future mission requirements?
 9. Administrator Helms has stated that by the time of his departure in 36 months all critical decisions will have been made and that the transitions to the new systems will be smooth. Please provide an assessment of FAA's transition plan including an identification of any problems that may cause slippage in the program's implementation.
 10. FAA's computer plan appears to be driven by the need to replace hardware which is running out of capacity and all subsequent decisions and steps are constrained by this original decision. Are there other less risk approaches available to FAA which would allow the agency to accommodate immediate capacity shortfalls while concurrently developing a new system.
 11. Questions have been raised about ex parte communications between officials of the FAA and certain vendors concerning FAA's procurement plans. Has GAO identified any violations of procurement law and regulations during its review?
- B. What is GAO's assessment of FAA's plans to develop new management and administrative information systems in support of, and integrated with, the new NAS project? Are FAA's current computer plans justified in this area?
- C. Are the radar and communications portions of the FAA plan technically sound, represent state-of-the-art technology and sufficiently integrated with the other segments of the plan to ensure a successful "total systems" project?
- D. Congress is faced with the need to make some immediate decisions regarding front-end funding and procurement approval on segments of FAA's NAS and MIS plans. Recognizing that once the "seed money" is approved it will be difficult to re-direct the project, what additional recommendations can GAO make to assist Congress in the difficult decisions facing it in the weeks ahead?

GAO RESPONSE TO COMMITTEE QUESTIONSQuestion A.1

Is the new "National Airspace Performance Reporting System" (NAPRS), reportedly effective January 1982, fully responsive to the corrective recommendations in both the House Government Operations and Senate Appropriations Committees reports regarding the reporting of ADP failures?

GAO Response

NAPRS addresses many of the corrective recommendations made by the House Government Operations and Senate Appropriations Committees. It is not by itself, however, fully responsive to these recommendations. According to FAA, each recommendation is addressed either in NAPRS or in another existing or planned system.

The specific corrective recommendations made by each Committee are as follows.

House Committee on Government Operations

- "A. FAA should establish a single, verifiable failure (outage) reporting system for its air traffic control automated data processing (ADP).
1. Equipment or hardware failure reports should be recorded in a way that they can be cross-checked with reductions in parts inventory.
 2. All ADP failures which result in a controller receiving less than full support should, to the extent possible, be recorded and reported automatically by the machines themselves.
 - (a) This information should be collected irrespective of whether the failures (outages or interruptions) are 'scheduled' or 'unscheduled' according to the agency's current definitions.
 - (b) This information should be fully correlated with safety problems in air traffic control such as 'system errors' and near mid-air collision reports."

Senate Committee on Appropriations

"The reporting criteria of 1 minute or more for reporting an outage [should] be dropped and all outages of any duration be recorded so as to determine their impact on safety, service to user, and computer performance reliability.

FAA [should] revise its reporting system to eliminate the practice of reporting unscheduled maintenance outages as scheduled outages. Scheduled maintenance should cover only regular, periodic, routine preventive maintenance tasks. Reporting unscheduled outages as scheduled distorts recording of corrective maintenance actions and computer performance reporting."

To address these recommendations, FAA initiated several actions including the development of NAPRS. According to FAA, NAPRS consolidated the three previous systems into a single system which became operational on January 24, 1982. This statement by FAA, however, is misleading. NAPRS, as originally designed, is not fully implemented. Although the FAA order regarding NAPRS became effective in January 1982, the automation aspect of NAPRS has been delayed until October 1982 because of cost and design problems. Meanwhile, NAPRS is a manual system. Nevertheless, it addresses many of the committees' recommendations. NAPRS will provide the capability to report

- all interruptions, regardless of duration,
- any partial outage or degraded service, and
- ADP equipment failures.

In addition, under NAPRS, maintenance interruptions have been redefined to differentiate between scheduled and unscheduled corrective maintenance. Also, both types of maintenance are to be reported and used in evaluating system performance.

By consolidating the three previous systems into one, NAPRS also eliminates the problems of inconsistent definitions and varying reporting periods.

As stated previously, NAPRS alone is not fully responsive to all the committees' recommendations. Those not addressed by

NAPRS are handled by other existing or planned systems. Specifically, the recommendation concerning correlation of safety incidents with computer outages is being performed by the Air Traffic Evaluation staff through their Operational Error/Deviation Investigation and Reporting System which became operational in July 1981. Under this system, each safety incident is investigated and the role of any total or partial computer outage is identified.

According to FAA, the remaining two recommendations--that ADP failure reports should be cross-checked with reductions in parts inventory and that the recording and reporting of ADP failures should be automatic--are to be addressed by systems now under development. These systems, one of which will replace NAPRS, are the Maintenance Management System (MMS) and the Remote Maintenance Monitoring System (RMMS). Both are scheduled for operation in 1983. They will allow FAA headquarters to monitor parts usage at the depot in Oklahoma City and compare it to reported ADP failures. Under RMMS, ADP equipment will monitor its own health and report, to the parts level, any malfunction. This information will be fed automatically into the performance reporting system.

It appears to us, based on our limited review of NAPRS and the safety incident reporting system, that they satisfy many of the corrective recommendations made by the Committees. Whether or not the recommendations will be fully satisfied depends on FAA's commitment and ability to implement MMS and RMMS.

Question A.2

Do the "Responses to Congressional Recommendations Regarding the FAA's En Route Air Traffic Control Computer System" (transmitted Feb. 22, 1982) correspond or comport with the "National Airspace System Plan" of December 1981? For instance:

- Figure 2-1 on page 13 of the "Responses" document uses 23 en route centers as a basis for cost comparisons, yet the NAS Plan calls for only 16 centers.
- Item (3)(c) of the "Findings" section (at p. 10) of the "Responses" volume says, "Evolution of this system in the 1990's * * * may include * * * replacement of the host computer." What does this mean and is it reflected in the NAS Plan?

GAO Response

The documents entitled "Responses to Congressional Recommendations Regarding the FAA's En Route Air Traffic Control Computer System" and "National Airspace System Plan" (NAS) exhibit differences that are understandably reflective of their original purpose. However, even if such differences are acknowledged, we believe the responses document, which FAA considers the primary support document for its air traffic control (ATC) computer modernization program, does not respond to congressional concerns about comprehensive analysis and study. It does not provide the same level of analysis for FAA's chosen solution as it does for eight other options. A cost breakdown is not given for the proposed \$1.6 billion solution nor are such NAS decisions as to consolidate centers and facilities reflected.

FAA states that the purpose of the responses document is to summarize and document the results of FAA's supporting study and evaluation of alternative technical approaches for evolving to an advanced ATC system. Therefore, the document addresses only the en route computer systems, a subset of the National Airspace System. In contrast, the NAS plan delineates specific improvements to facilities and equipment and supporting research and development associated with the entire National Airspace System.

However, the documents were used to respond to a wider range of concerns than originally planned. For example, FAA provided the NAS plan as its response to both (1) the congressional recommendation for a "formal long-range plan to reflect agency strategy, goals, and objectives," ^{1/} and (2) House Resolution 202 which required FAA to submit a system plan by December 15, 1981. Even in the reduced scope of NAS, the plan does not address the congressional requirement for providing funding requirements. We believe the major deficiency in the responses document is the lack of indepth analysis of the ATC automation solution FAA proposed.

^{1/}Recommendation 3, which states "The FAA develop a comprehensive formal long-range plan to reflect agency strategies, goals and objectives and be reviewed and approved by top management. The plan should set forth milestones for measuring and controlling activities, funding requirements, achieving efficient and effective use of resources and committing top management to action."

Analysis is confined to eight options--apparently attributed incorrectly to the original Senate recommendations. The document states

"These options reflect the concerns identified in the congressional recommendations. As such, no single option includes the selected approach which is a composite of options and variation of options."

Thus, we feel that FAA did not present the analysis necessary to support its chosen option. Cost derivations in the responses were based on 23 en route sites for the four near term options (20 en route centers plus a training facility, a test facility, and a development facility) and 26 sites for the far term options. Consolidation of centers was not considered. In contrast, the NAS plan projects not only en route center consolidation, but terminal facility consolidation as well. The NAS plan is based on the assumption that 16 en route centers will remain in the continental United States by 1990. Two offshore sites are also scheduled by that year.

Another significant difference in the two documents is the definition of the final ATC automation step, namely the advanced computer system (ACS) needed in the early 1990s to implement the "AERA" concept. 1/ The AERA concept is predicated on future technological breakthroughs that will permit greater decisionmaking by the computer, thus alleviating the routine functions currently performed by the air traffic controller. The responses address the possibility of new hardware to accomplish AERA. FAA states that

1/AERA is a concept in which computers assume the primary control responsibility and perform most ATC functions autonomously. In an AERA scenario, computers would make all time-critical ATC decisions. Responsibility for conflict recognition and resolution, as well as for flow control, would be officially transferred from the human controller to the machine. AERA was historically an acronym for Automated En Route Air Traffic Control. However, FAA found AERA to be applicable to some portions of terminal airspace. Therefore, AERA is now used by FAA as a noun rather than an acronym.

this could be either total replacement (mainframe or distributed systems architecture) or augmentation (upgrade of rehost computer). ^{1/} Although a decision on this potential \$500 million acquisition is deferred in the responses, the possibility is not referred to at all in the NAS Plan.

Question A.3

How much money was spent on the "ATARS" [Automatic Traffic Advisory and Resolution Service] program before it was cancelled? Were any other air traffic control automation projects within FAA actually cancelled as a result of the evaluation leading to the NAS Plan?

GAO Response

FAA's total incurred costs from 1978 through 1981 for ATARS was \$14.7 million. This consists of \$10.6 million (72 percent) spent through contractors and \$4.1 million (28 percent) spent on FAA activities. Although ATARS was terminated, it resurfaced without the resolution feature as the Automatic Traffic Advisory Service (ATAS) in FAA's plan.

FAA's plan mentions the discontinuance of projects without identifying them. However, FAA's response to our inquiry disclosed that the requirements of the terminated projects have been incorporated into other projects in this plan. This appears consistent with information we have about situations in which FAA terminated projects by name, while continuing the same or a similar project under another name in the plan.

Prior to plan

Passive BCAS

Active BCAS

FAA's plan

TCAS I--Only the name changed

TCAS II--BCAS with a directional antenna

^{1/}A rehost computer is a current generation computer system that can process the existing IBM 9020 software. The IBM 9020 software would be adapted to run on this new "host" computer.

Question A.4

What are the current total cost projections of the Flight Service Station Automation Program [FSSAP] and exactly what studies have been done to determine consumer acceptance of the ultimate service/product? Are the studies adequate to substantiate the expenditure?

GAO Response

FAA's February 28, 1982, facilities and equipment cost estimate for the FSSAP was as follows:

<u>Fiscal year</u>	<u>Amount</u>
	(in millions)
1983	\$112.0
1984	219.3
1985	<u>146.1</u>
Total	<u>\$477.4</u>

This estimate approximates the \$495.3-million figure cited as the total fiscal 1977 through 1986 program costs in the fiscal 1982, Subcommittee on Transportation, House Committee on Appropriations, hearings.

At this point in our assignment, we have surveyed some of the projects (direction finder, tone equipment, and air/ground communications equipment) related to the FSSAP and other programs. However, because our review of FSSAP as a program has not been started, we have no information at this time about the program's performance or the adequacy of the studies on user acceptance.

Question A.5

FAA has experienced considerable problems in the simple, straightforward upgrades of the ARTS II, ARTS III, and DARC. Does GAO believe that the FAA staff has sufficient technical expertise to manage the development and implementation of the highly complex NAS project?

GAO Response

Recent analysis of the agency's engineering staffing has confirmed FAA top management's concern that the current organizational structure in the systems development area may preclude successful implementation of the NAS plan. Although we cannot state that FAA lacks the technical expertise to manage the highly complex NAS project, we believe its past performance in managing less complex ATC automation-related projects casts doubt on FAA's ability to develop and implement the NAS plan under current conditions.

Problems in project management

We believe that some difficulties in research and development stem from inadequate contract monitoring and project management. FAA has tried to alleviate staff shortages by heavily supplementing its own technical staff with contractor support. For example, over the past 3 years FAA has spent over \$19 million for various engineering analyses to be used in developing future ATC computer requirements. The level of FAA contract monitoring seems to have been inadequate in some cases since contract managers acknowledge difficulty in correlating the quality of work produced to invoice payments. Many documents have been issued but improvement in the agency's ability to accomplish its mission cannot be readily demonstrated. Inadequate project management had also led to poor use of the Department of Transportation's Transportation Systems Center (TSC) support. Of 13 TSC projects we reviewed, 9--costing over \$2.3 million of the \$3.6 million total--were either terminated or suspended. TSC officials say much of the work terminated is of little value because FAA did not require the Center to provide final documentation. As a result, products such as the TSC work on a computer model to predict air traffic volume have gone unused. That model is stored in a tape library at TSC because the absence of documentation precludes its use on FAA's technical center computers in Atlantic City, New Jersey.

Dispersion of technical expertise

We believe another area of concern is the dispersion of ATC automation expertise throughout the agency. Developmental projects are initiated not only in the agency's research and development area but in operational areas as well. But those operational areas must maintain their full-time organizational responsibilities at the same time they are developing a project. Not only is available time a problem, but the organization implementing the system is also one of the ultimate users. We believe that

inexperience in software development activities by the organization responsible for operational software maintenance is one cause of the current difficulties in implementing the conflict alert function on the New York TRACON system. Similar problems could recur with implementation of the NAS plan. FAA has assigned the organization responsible for hardware maintenance with the task of overseeing both hardware and software development activities related to enhancing the Direct Access Radar Channel (DARC) system. As the primary backup to the IBM 9020 enroute computers, the enhanced DARC should ease controller transition workloads by more closely replicating the information provided before a main computer system failure. Timely introduction of DARC enhancements will be made more critical by any schedule slippages in FAA's plan to acquire rehost computers.

FAA appears to be aware of the need to coordinate ATC automation activities. Its newly created Advanced Automation Program Office has been charged with coordinating and integrating some of the projects defined in the NAS plan. It is still not clear how day-to-day improvements made by the operational areas will be integrated with new development projects.

Technical complexities underestimated

We feel that underestimation of the complexities involved in two projects, including requirements definition, has contributed to lengthy delays in those projects. The Tampa/Sarasota Umbrella Project, which was initiated in 1974, was to provide remote digitized air traffic data to an airport and its satellite airports. Contract costs have risen from \$4.3 million to \$11.5 million, and the project is not yet complete. Current problems may cause what equipment has been installed to be replaced with a more standardized ARTS IIIA system.

Overruns and schedule delays have also been associated with the Electronic Tabular Display Subsystem (ETABS) project. ETABS is an engineering model designed to test improvements to controller productivity by disseminating automated flight information. Based on ETABS' history of problems, we are concerned that FAA may not be able to develop and integrate the ETABS-related sector suite 1/ program within the time and cost projected in the NAS plan.

1/The sector suite will be a controller workstation which will display information related to surveillance, weather, flight information, and traffic planning. Each sector suite will have redundant processors and displays will be functionally interchangeable.

Field implementation

The examples we have provided raise questions about FAA's technical ability to manage the planning, design, development, test, and evaluation phases of the NAS project. The implementation of operational systems will be mainly undertaken by FAA's field organization. Our interviews with FAA center and facility personnel indicate a strong dedication to the task at hand, although reduced morale due to furloughs and decreasing training opportunities may affect the field staff's ability to maintain day-to-day activities while implementing new systems.

Question A.6

Has FAA completed a review of its technical and functional requirements and, if not, what are the possible adverse consequences of failing to do so?

GAO Response

Following almost 3 years of requirements definition by a broad range of organizations, the FAA Administrator has approved the functional and operational requirements expected of the replacement ATC computer systems. These requirements are embodied in FAA Order 1812.4 entitled "System Requirements Statement for Air Traffic Control Computer Replacement." They are being translated into specifications suitable for competitive acquisition. However, the program manager of the Advanced Automation Program Office has not provided us with draft documents outlining key decisions behind FAA's computer replacement strategy. Our analysis is therefore limited to work accomplished before the redirection caused by the NAS plan.

Functional requirements

The portion of FAA's mission pertaining to ATC automation is to provide the ATC services that lead to safe and efficient use of the Nation's airspace.

FAA has identified four basic operational requirements that must be satisfied by the new ATC computer system. These requirements are as follows.

--Capacity. The ATC computer system must have the capacity to perform all operational functions for the aircraft being

controlled. FAA has estimated that long range improvements associated with the AERA concept will require almost six to ten times the compute power now available.

- Reliability and availability. Nearly 100 percent functional reliability and availability will be needed when operating duties are shifted from the human controllers to the computer system.
- Maintainability. The contribution of maintenance costs to overall life cycle costs requires that the new system be reliable enough to minimize hardware and software corrective work.
- Growth potential. The computer system must be flexible enough to accommodate changes in such areas as surveillance systems, communications, navigation aids, and avionics. It must also be capable of growing to support new functions and evolving with new technology.

Although we have not completed our analysis of FAA's supporting documentation, we are concerned about:

- The Administrator's liberal interpretation of the requirement "the architecture of the replacement automation system must be such as to ensure a functional reliability/availability approaching 100 percent." The Administrator appears to have extrapolated this functional requirement into a hardware-oriented, 100-percent computer system availability requirement (as he stated at the Feb. 23, 1982, hearings before the House Committee on Science and Technology). Although we do not dispute the need for increased reliability, we cannot find the FAA analysis supporting the Administrator's statement. The case for 100-percent functional reliability/availability appears to be directly related to the potential automated decision-making capability in the future ATC system of the mid 1990s.
- The apparent difference between the Systems Requirements Statement and the NAS plan. After a year of internal coordination, the statement was approved in December 1981, a month before formal issuance of the NAS plan. Yet, the statement does not reflect the Administrator's new direction, including the concept of center and facility consolidation. Also, the schedule and procurement strategy it

contains does not conform to that specified in the NAS plan. It is not clear why the Administrator signed the statement in its present form.

Technical requirements

FAA has devoted a large portion of both its in-house and contractor resources to defining, developing, and specifying requirements necessary to acquire the ATC computer system of the future. However, until January 1982 such efforts were focused on FAA's previous procurement strategy of one-step replacement. As a result of the NAS plan, therefore, FAA technical personnel have been directed to produce two procurement packages:

- (1) Request for Proposals (RFPs) for rehost computers that are software-compatible with current IBM 9020 en route computers. Issuance to industry by fall 1982 is planned with production award by 1985.
- (2) Request for Proposals for a system integrator responsible for designing, developing, fabricating, and integrating over 1,000 sector suites; redesigning the current host software; and integrating these new systems with the Government-furnished computers acquired in the other RFP. Issuance to industry is planned shortly after the computer replacement RFP. FAA predicts production award by 1986.

The director of the Advanced Automation Program Office considers current specifications incomplete and unsuitable for our review. Based on interviews and analysis of previous specifications, we surmise that some questions have yet to be answered. These include:

- Scope of the rehost RFP. Are display computers and peripheral adapter modules included?
- Sector suite and software redesign interrelationship. Should sector suites be installed with the old software if software redesign efforts are delayed? Should software redesign proceed separately if sector suite development takes longer than expected?
- Hardware and software commonality. Are the same computers expected at consolidated terminal hubs? What are the

criteria for capacity at these yet-to-be-determined hub facilities?

- 100-percent functional availability. How will this requirement be specified in the rehost system using the existing NAS software?
- Reliance on current ATC design concepts. Previous specifications do not appear to have permitted innovative concepts for ATC automation. How will the new specifications permit the system integrator to implement new techniques and to what extent?

AERA feasibility questioned

We are concerned about the controversy surrounding the future functions of AERA. The intent to increase the level of automated decisionmaking with the controller acting as a system monitor has yet to prove itself from a technical and practical standpoint. Although further analysis will be made, we believe the needs of working controllers and maintenance personnel have not been adequately solicited and incorporated in the design of future ATC functions. The key question that FAA should ask is not what technical innovation can be provided but what functions are really needed.

Question A.7

FAA has asserted that the new computer systems will be acquired on a fully competitive basis following the guidelines contained in OMB Circular A-109. Are these assertions true and, if not, what are the possible consequences of failing to do so?

GAO Response

In testimony, the Administrator has said that FAA will follow the OMB A-109 procedure to the extent necessary. He indicated he believes it is possible to reduce the time frames for some of the steps by reducing the number of competitive vendors in the "compute off." ^{1/} We believe these aspects of FAA's rehost procedure do not fully comply with the intent of the A-109 process. A-109

^{1/}Vendors build prototype systems so that competing concepts can be evaluated by the Government. This concept is included in OMB Circular No. A-109.

places particular emphasis on generating innovation and competition from industry. Also, A-109 stipulates that an agency's mission need is not to be expressed in terms of the solution, equipment, or other equivalently specific alternatives that might satisfy the need. Approval of the mission need statement by the agency head initiates a search for solutions by granting authority to explore alternative system design concepts. Contrary to this concept, FAA's rehost decision is proposing an equipment solution to satisfy a mission need.

In addition to OMB Circular No. A-109, FAA's ADP procurements are subject to the requirements of Public Law 89-306. During our review, however, we received indications that FAA does not intend to comply with these requirements.

On February 18, 1982, we sent a report to the Secretary of Transportation 1/ recommending that he direct FAA to comply fully with the provisions of Public Law 89-306 in procuring the replacement computers for the air traffic control system.

We asked the Transportation Secretary to reply by March 5, 1982. We received an interim reply on March 5, 1982, stating that a response would not be completed until March 24, 1982. In testimony before the House Committee on Public Works and Transportation, Subcommittee on Aviation, on March 17, 1982, the FAA Administrator said that FAA does not intend to follow Public Law 89-306 and the GSA procedures.

As of the date of this report, the Department of Transportation's position on Public Law 89-306 has not been received. We are concerned that these delays will have critical impact on FAA's planned two major procurements and thereby delay planned air traffic improvements.

Question A.8

According to the FAA, any new computer systems that will be acquired must be able to operate using FAA's old software and that some time in the future new software will be developed. Won't this technical approach inhibit innovation and constrain new software to the capabilities of the previously installed hardware? If this should happen, what would be the impact on FAA's ability to meet its future mission requirements?

1/"Applicability of Public Law 89-306 to the Federal Aviation Administration's (FAA's) Procurement of Computers for the Air Traffic Control System," AFMD-82-47, Feb. 18, 1982.

The technical approach associated with the decision to rehost may inhibit innovation and constrain new software to the capabilities of the previously installed hardware. However, at this point we do not have enough information to state whether this approach will keep FAA from meeting its projected requirements.

Technical feasibility

According to one FAA contractor's analysis of this approach, a rehost system would provide more than adequate system capacity for some time, thereby expanding FAA's ability to meet its future mission requirements. However, FAA predicts that the AERA concept will reduce this excess capacity. Preliminary FAA estimates are that AERA will require 6-10 times the current system resource usage to control the same traffic loads because of increased automated decisionmaking capability.

Another contractor's analysis of the rehost option concluded that, in spite of technical problems, the current NAS software can be modified to run successfully on the replacement machine. The current IBM 9020's execute about 15 special instructions that are not standard System/360 instructions and that could not be executed by the rehost machine. The contractor suggests this could be handled by trapping and emulating the instructions, by changing the operation code, or by doing nothing since the instruction would not be executed in the rehost system.

Lack of incentive to redesign current software

The risk in FAA's technical approach is that the computer capacity gained through rehosting will provide an opportunity to extend the use of the current software system with no incentive to follow through with the software redesign effort. This could further delay the implementation of urgently needed new software while the old system grows ever more cumbersome to maintain. It is conceivable that eventually hardware capacity would again become a major problem.

Problems in the NAS software

Past studies have demonstrated problems with the software in the NAS system. For example:

- In a 1975 study, a contractor recommended redesign and reprogramming of the NAS software because the original system was written before requirements were known. It was noted that much maintenance work was done without

using documentation and that a considerable amount of "documentation" was in the heads of selected individuals.

--A July 1981 FAA report stated that the technical procedures used to develop software are predominantly those used from 1965 to 1975.

--A 1981 report requested by FAA on the status of the NAS software stated that each new release results in 40 to 60 new program trouble reports after release--a situation considered to be a natural condition of a large software system used over a number of years without extensive restructuring. As further software modifications are made to reflect the changing role of NAS, the software is expected to become even more of a maintenance liability.

Current software maintenance procedures reflect the difficulties encountered by FAA in trying to maintain a patched-up system. An official of the organization responsible for software maintenance said that one of the current FAA orders on software modifications was "90 percent * * * out of date" and was unworkable. He agreed that contradictions and differences in the FAA orders made control over modifications increasingly more difficult. For example:

--One order sets a limit of five on the number of local "patches" while another order contains no such limit. It has been demonstrated that outages related to software have decreased when software changes were temporarily disallowed.

--One order requires certain baseline testing and provides guidance and criteria to be used in analyzing results. The other document includes no such guidance.

--There is no line authority over local facilities to direct the removal of local patches.

--No criteria exist by which to judge the worth of any proposed local changes. Thus, there is no uniformity in determining when to approve a proposed local modification.

This problem with current guidelines has been cited by several internal and external study groups. FAA is currently in the process of revising its ADP orders to address this problem.

We found numerous examples that FAA is having great difficulty managing the maintenance of NAS software, especially in implementing new versions. For example:

--All sites do not use the same version of the software.

--Seattle Center is using version 2.10 and is preparing to implement 2.12. They never received version 2.11 because other centers experienced problems with it.

--New York Center has continued to use version 2.10 because the controller job action necessitated moving programming staff into air traffic control work, and sufficient staff are not available to make the changes.

--Many of the fixes and improvements to existing versions are released to the field, but they are not always in operation at every facility.

--En route metering 1/ is not implemented at Atlanta Center because of system aborts experienced when the patch was used to provide flow control. The New York Center, which services one of the Nation's busiest airports, has also not implemented this feature.

--The en route minimum safe altitude warning (E-MSAW) patch 2/ could not be implemented at the Atlanta Center because it produced false alerts in center testing. This patch is also not implemented in the Boston or New York Centers due to staff shortages.

--Local facilities are allowed considerable leeway in implementing locally developed patches, which can only add to FAA's software maintenance burden.

Need to stabilize current NAS software environment

We believe FAA must develop stability in its current software environment so that old software operating on new software-compatible hardware can successfully evolve into redesigned and rewritten software on the same rehost equipment. We believe current versions could be stabilized by:

1/En route metering provides for improved fuel efficiency by feeding aircraft into airports in a preplanned orderly sequence.

2/The E-MSAW function is an automated aid which alerts the controller of situations when a tracked aircraft is below or predicted to be below a specified minimum safe altitude.

- Freezing all new development unless it is necessary to maintain air safety, smooth the transition of new equipment, or assist in the transition from old software to the redesigned software.
- Concentrating the efforts of automation groups on correcting all known errors or problems stemming from releases of NAS software.
- Reevaluating and possibly delaying for later implementation some of the recent innovations that have proved troublesome to implement.

Question A.9

Administrator Helms has stated that by the time of his departure in 36 months all critical decisions will have been made and that the transitions to the new systems will be smooth. Please provide an assessment of FAA's transition plan including an identification of any problems that may cause slippage in the program's implementation.

GAO Response

FAA's Advanced Automation Program Office has primary responsibility for ensuring a smooth and trouble-free transition to the new systems. The director of that office has indicated that FAA is still trying to resolve a number of difficult issues and doesn't know yet what its transition strategy will be.

According to the director, a critical element is the parallel operation of the old and new systems during the transition. This will ensure that a proven and reliable backup system is available should problems arise with the new system. A transition of this type requires careful consideration and planning. A study made for FAA indicates that the planning for this type of transition must address potential problems caused by (1) necessary remodeling of facilities, (2) interfaces of the two systems, and (3) the need for trained personnel to operate and maintain both systems. Inadequate consideration in any of these areas could delay implementation of FAA's program.

Another potential problem that could cause delay lies in the Advanced Automation Program Office itself. While this office has primary responsibility for planning and implementing FAA's new

automation program, the organizational makeup and staffing requirements for the office have not yet been finalized. Further, the director has expressed some concern about the ability to obtain staff--whether from inside or outside FAA--with the skills needed to manage the program. More than anything else, successful implementation of the new automation program depends on FAA's ability to resolve this problem. The director declined any further discussion of transition planning except to say that options are being evaluated and a plan will be finalized as soon as possible.

Since a transition plan has not been developed, we cannot assess the adequacy of FAA's transition planning. We believe, however, that the absence of a transition plan at this point, as well as the current organizational and staffing uncertainties within the Advanced Automation Program Office, could adversely affect FAA's ability to implement its new program on schedule.

Question A.10

FAA's computer plan appears to be driven by the need to replace hardware that is running out of capacity, and all subsequent decisions and steps are constrained by this original decision. Are other less risky approaches available to FAA which would allow the agency to accommodate immediate capacity shortfalls while developing a new system?

GAO Response

FAA has done insufficient analysis to predict that current en route computers will not reach saturation until the late 1980s. Some centers are exhibiting performance problems in spite of artificial constraints imposed by centralized flow control. From a contingency point of view, we believe FAA should be developing short term alternatives in case the rehost program is delayed.

Computer capacity saturation

FAA's rehost decision and its urgency to replace current en route air traffic control computers are based on the view that aircraft tracks are directly related to computer processor capacity and that operational delays will start occurring in the late 1980s. We believe that although such a relationship exists, processor utilization is not the sole determinant of when current systems will become overloaded. FAA based its IBM 9020 system capacity estimates on studies of processor use during 4- to 7-day periods at each en route center between June 1980 and January

1981. These periods did not necessarily cover the peak days of the year. Also, the studies did not address potential bottlenecks in other parts of the system, such as channel use. Other performance studies relied on a simulation package that has not been validated and on admittedly faulty data collected by the NAS software.

In the past year, FAA conducted or contracted for several studies to determine when computer saturation would occur at each en route center. The FAA's official position is that the en route centers will begin running out of capacity in the late 1980s. This position is based on a study conducted by the FAA Technical Center and sponsored by one of its research and development organizations. Another research and development group contracted for a similar study which used sophisticated modeling techniques. However, the results of this effort were inconclusive. A similar analytical analysis was contracted for by one of FAA's operational organizations. We believe this apparent duplication of effort stems from the fact that FAA still does not have an established computer performance management function. Such a function has been recommended by several study groups including the Senate Appropriations Committee in its 1980 report (S. Rep. 96-932) on FAA's En Route Air Traffic Control Computer System.

We believe that from its inadequate analysis, FAA cannot predict with any certainty when and where saturation will occur. Recent visits to seven en route centers indicated that FAA can affect computer capacity through operational modifications and local decisions on the implementation of certain functions. Capacity shortage was shown to be more critical in some centers, such as Houston. Based on these uncertainties and the possibility that the rehost computers will not be installed in time, we believe FAA should consider short term alternatives as a contingency solution.

Less risky alternatives

The solution chosen by FAA appears to have been driven by several factors, including:

- Perceived capacity shortfall in the late 1980s, especially at IBM 9020A centers.
- Use of the rehost computers as the foundation for the replacement system and potentially the advanced computer system.
- Compatibility with an accelerated schedule to integrate a new sector suite.

From a short term standpoint, other alternatives are technically less risky than FAA's proposed solution. These alternatives, or variations of these alternatives, have been studied by FAA.

As an initial step, FAA could expand its current en route airspace consolidation plans. Portions of airspace previously controlled by the New York and Indianapolis Centers are now being controlled by the Washington and Atlanta Centers, respectively. Consolidation and elimination of low volume centers and diversion of this hardware to IBM 9020A sites could be a short term solution to FAA's capacity problem. This action would provide FAA with additional time to adequately develop its requirements for the future system.

As another option, FAA could upgrade its IBM 9020A centers with IBM 9020D computers, thereby addressing the capacity problems of the late 1980s in some centers. Again, this would provide FAA with additional time to work on developing the advanced computer system. The advantages of this solution are:

- Minimal cost, scheduling, and technical risk since FAA has considerable experience in building IBM 9020D systems.
- Added time to develop comprehensive specifications for the future system.
- Design and development of replacement and advanced computer systems as a single integrated package.

The disadvantages are:

- Obsolescence of the IBM 9020D system design.
- Uncertainty that the option can be adequately supported until the IBM 9020 system is completely replaced. The risk is that, at some time in the future, equipment wearout and software maintenance will cause availability problems. This risk is somewhat minimized by the reported high confidence level in current DARC systems. Enhancements should make DARC usage even more acceptable.
- Delay in implementing software redesign until the installation of the replacement system.
- Delay in implementing the sector suite with its purported controller productivity increases until the 1990s.

Another alternative would be to acquire the rehost as contemplated, but immediately rewrite and redesign the software using an easier-to-maintain, higher level language. The sector suite program would be disassociated from this redesign effort. The advantages of this solution are:

- An accelerated software redesign timetable, allowing for improved maintenance and system reliability.
- Independence from the sector suite program, reducing the risk from potential sector suite development delays.
- Time to address capacity shortfalls.

The disadvantages are:

- Delayed implementation of the sector suite with its purported productivity gains.
- Potential throwaway of software redesign to accommodate host and sector suite workload separation requirements.
- Lengthened schedule causing higher cost than FAA's proposed solution.

The close interrelationship among the projects in the NAS plan increases the risk factor for all projects. FAA can attempt to minimize its risks by ranking its improvement needs by priority so it can project the minimum number of projects requiring commitment and support.

Question A.11

Questions have been raised about ex parte communications between FAA officials and certain vendors concerning FAA's procurement plans. Has GAO identified any violations of procurement law and regulations during its review?

GAO Response

While it is true that several vendors have been contacted by FAA concerning FAA's procurement plans, this is not by itself a violation of procurement law or regulation. In fact, the Comptroller General has in several decisions recognized the appropriateness of holding preprocurement discussions. Such discussions are often necessary to increase competition for the procurement. Because we lack specific knowledge of the nature

of the discussions with vendors, it is impossible for us to determine whether irregularities have occurred. In our limited work, however, we have identified no violations of procurement law or regulations.

According to the director of the Advanced Automation Program Office, FAA wants to promote as much competition as possible in its upcoming rehost and system procurements. Because of this, the director has personally met with the chief executives of 17 companies to discuss their companies' experience, expertise, and ability to meet FAA's requirements. He has sought to determine their interest in bidding on either the rehost contract or system contract or both. To date, the director has received clear indications that several vendors will bid on the rehost contract. He has also received indications that several of the vendors he contacted intend to bid on the system contract. If this level of interest holds true, concerns about restricted competition may no longer be valid.

Question B

What is GAO's assessment of FAA's plans to develop new management and administrative information systems in support of, and integrated with, the new NAS project? Are FAA's current computers plans justified in this area?

GAO Response:

FAA has no mid-range (3 to 5 years) or long-range (more than 5 years) plans for developing management and administrative software applications. FAA restricts its planning to individual software development projects. As a result, these efforts are highly fragmented. This fragmentation is due to the fact that FAA has not comprehensively analyzed its total information requirements for automation.

The only management software application identified in the NAS plan is the Maintenance Management System (MMS). The earliest effort we found on this current development project was a feasibility study conducted in 1973, more than 8 years before the NAS plan. The objective of the MMS is to identify failure-prone radar and other equipment components for redesign by compiling maintenance statistics. Under the planned NAS project, remote maintenance monitors would identify component failures through the use of microcomputers. This data would be relayed to a dedicated minicomputer or the new regional computers for

analysis. The MMS still has not progressed beyond the requirements analysis/feasibility study stage. Because FAA has not comprehensively defined its total information requirements, it has not fully considered the possibility that the requirements for this system could be satisfied through an improved logistics and inventory system which is also in the early stages of development. Failure rates could be computed based on the number of components replaced and the number in service.

The NAS project, if successful, should reduce FAA's total administrative and management information processing requirements. One goal of the NAS project is to reduce the number of personnel and facilities while improving equipment reliability with reduced scheduled maintenance. Simply put, there will be less to manage and therefore, reduced requirements for management and administrative information processing can be expected. The manner in which information can be collected and processed may change but unconstrained information requirements can be expected to stay the same or decrease. Because FAA has not compiled its comprehensive information requirements, it is not possible to determine the level of information processing capability FAA will need in the future or the software applications it should develop.

Our examination of FAA's application software development process, although not yet completed, shows that the software development cycle is frequently severely prolonged. Routine administrative applications such as the Uniform Payroll System have taken 10 years to complete. The Uniform Accounting System, initiated in 1974, is still under development. Obviously, protracted development cycles due to consistently missed milestones preclude timely responses to existing needs as well as to any different or modified ADP requirements from the NAS project. Under these circumstances, the proper quantification of future information processing requirements becomes little more than a guessing game.

Despite these facts, FAA plans to replace its large mainframe computers at the Aeronautical Center and its regional computers. These procurements are not adequately justified. Currently, FAA has two IBM 370/155 computers and a IBM 4341 computer at its Aeronautical Center. Regional offices are equipped with a Univac 70/35 batch computer or an IBM 1401 batch computer, Univac 9300 remote job entry station and Four Phase IV/90 data entry system. FAA intends to replace all regional ADP equipment with a single computer system at each region.

FAA plans to award a contract in June 1982 for a new large mainframe to replace the three current computers at the Aeronautical Center. The new computer will nearly quadruple present processing capability and cost \$7.3 million over its 8-year life cycle. We found this procurement was not properly justified because FAA:

- developed its stated processing requirements using incorrect data and an inappropriate methodology. This resulted in the workload being overstated.
- may be excluding less costly systems with equivalent capability to process its administrative workload because internal computer operating speed rather than the ability to process anticipated workloads (benchmark) was the sole criterion for acceptability, and
- did not examine alternatives such as shifting workload to the Transportation Computer Center which could save money.

FAA's procurement of 9 computer systems (plus an option for five more) for its regional offices, headquarters, and Aeronautical Center is also not adequately justified. FAA awarded a contract on April 5, 1982, to Small Business Systems for these computers. FAA estimates the purchase price of 12 systems, the likely number to be purchased, to be \$19 million. Our evaluation of this procurement showed that FAA

- did not specify a processing requirement in its Request for Proposals,
- had inadequate knowledge of current workloads to evaluate proposals, and
- did not consider alternatives such as shifting regional batch processing workload to the Aeronautical Center which could reduce costs.

Question C

Are the radar and communications portions of the FAA plan technically sound, represent state-of-the-art technology and sufficiently integrated with the other segments of the plan to ensure a successful "total systems" project?

GAO Response

Generally, the radar and communications portions of the FAA plan appear technically sound and, considering cost constraints, within the state-of-the-art technology. The same can be said regarding integration because radars and communications usually can be independently accomplished. However, at this point in our assignment, we are not able to provide a detailed evaluation. Rather, certain observations requiring future inquiry or monitoring have been made. These observations are as follows:

General-- The long term implementation period and operating period through year 2000 coupled with the general knowledge of the present technological revolution in electronics offers the potential for obsolescence before the year 2000.

Mode S 1/--1. The projected number of ground interrogations are reduced; however, the usage is increased by adding TCAS requirements and longer messages. Therefore, there is a potential for interference or need to establish a lower system capacity.

2. En route flights would be undetected if Mode S airborne equipment encounters outages because the backup en route radars are being eliminated.
3. The project does not and should not precede the IBM 9020 computer replacement due to the increased information processing requirements. Therefore, any slippage in computer replacement will necessitate the reprogramming of Mode S.

Consolidation of communications facilities--Proper selection of the radio frequencies at each location will be required to avoid harmonic interference.

There are some related projects where some delay or slippage would not affect the success of the overall plan. For example:

1/Mode S is an upgraded surveillance system. It will provide aircraft positions to ATC computers, an improved data link for transmitting information between the air and ground, and discrete addressing of aircraft to eliminate interference.

- The replacement of tube type with solid state type tone equipment at en route centers can be deferred to coincide with the installation of the Voice Switching and Control System (VSCS).
- The hub consolidation multiplexing project, which is intended to reduce leased circuit costs, could be deferred 2 years to coincide with the rest of the hub consolidation program.

Question D

Congress is faced with the need to make some immediate decisions regarding front-end funding and procurement approval on segments of FAA's NAS and MIS plans. Recognizing that once the "seed money" is approved it will be difficult to re-direct the project, what additional recommendations can GAO make to assist Congress in the difficult decisions facing it in the weeks ahead?

GAO Response

Until we have completed the field work, we are deferring our conclusions and recommendations in the air traffic control area. However, our responses to the questions include matters to be considered by the Congress. Our conclusions and recommendations with respect to the administrative and management computer systems are included in appendix VI of this report.

NATIONAL AIRSPACE SYSTEM PLANNING

After a 10-month review of the National Airspace System, (NAS) FAA has prepared a comprehensive plan for modernizing and improving air traffic control (ATC) and airway facilities services from now until the year 2000. This plan, which was released in February 1982, is widely publicized as a \$10-billion effort although FAA has not completed firm cost estimates. This was FAA's first comprehensive NAS plan. It contains a number of areas for improvement but in general is viewed as a positive effort headed in the right direction.

Today's air traffic control and air navigation system is a combination of equipment, techniques, procedures, and skills that have evolved over 40 years. As a result, today's NAS consists of equipment of various ages, technologies, and types. The need for modernization provided FAA an opportunity to assess its plans with respect to its goals and needs of the user community.

The following is our preliminary assessment of the reasonableness and thoroughness of FAA's NAS objectives, requirements, and analysis as stated in the plan.

OBJECTIVES COULD BE STRENGTHENED

The recurrent theme throughout the NAS plan is to promote safety, capacity, productivity, and economy through higher levels of automation, consolidations of facilities, and application of lower cost telecommunications technologies.

The NAS plan identifies seven objectives to be achieved by the year 2000. To determine if the objectives are reasonable, achievable, and worth the cost involved, they should be quantified in measurable terms, linked to the implementing systems and actions, and compared with their associated cost. This should be especially essential for a \$10-billion program such as the NAS plan. However, its objectives are not sufficiently quantifiable and supported, and we could not completely assess the NAS plan's cost effectiveness.

Four of the NAS plan objectives are quantified, the other three are not. The contrast is evident in the list below.

Measurable objectives

Developing techniques for more accurate classification and counting of system errors by 1983; reducing systems errors by 80 percent between 1983 and 1995.

Increasing air traffic controller and flight specialist productivity by a factor of at least two by the year 2000 compared with 1980 productivity levels.

Maintaining the overall cost of operations of the National Airspace System at the 1980 level, when adjusted for inflation, excluding the capital cost of modernization.

Reducing, by one-third by the year 2000, the technical staff required to maintain and operate the modernized and expanded system, compared with 1980 figures.

Nonmeasurable objectives

Having an operating National Airspace System in place that meets the national aviation demands.

Accommodating increasing demand so that airspace users can operate with a minimum of artificial constraints and with fuel efficiency.

Reducing risks of mid-air and surface traffic collision, landing and weather-related accidents, and collisions with the ground.

Even where objectives were quantified, the plan does not indicate why and how those particular objectives were selected. For example, the plan does not explain why the objective of 80 percent reduction in system errors was selected or how that level of improvement will be realized. In other words, we could not determine from the plan if the objectives are arbitrary, desired goals, or projected capabilities of the new integrated systems and techniques.

In examining the seven objectives, we noted that two deal with meeting future aviation demands, two with improving safety, and three with cost reduction. Although more objectives deal with cost than with any other subject, the plan contains virtually no cost information.

Considering that this is FAA's first total NAS plan, we consider it to be a constructive effort, moving in the proper direction. We believe, however, that the objectives can and should be improved upon as the plan evolves over the implementation period. We could not determine from examining the plan how reasonable and cost effective individual objectives are, but on the surface they appear to be desirable.

Completeness of requirements
and validity of assumptions

In general, FAA considers it necessary to expand the NAS system to meet anticipated future demands, provide improved safety and services, reduce operating costs, and modernize or replace aging facilities and equipment. But, the NAS plan does not include (1) the detail to support those broadly stated needs, (2) an assessment of the impact if the needs are not met, or (3) a priority ranking of needs. Also, the needs are based largely on projections of rapid aviation growth which could be questionable. In addition, the \$10 billion NAS program is being made to look more urgent by a current need to update and expand the capacity of certain air traffic control computers.

FAA expects air traffic to increase considerably over the next 10 to 20 years, and with it the demand for ATC services. Its plans for modernizing and expanding the NAS are predicated on accommodating continued rapid growth. Key assumptions in FAA's growth forecasts have been that future growth will not be constrained and new facilities and equipment will be deployed where and when needed to meet the demand.

The NAS plan is based on forecasts that demand for aviation services will more than double in the next two decades. For example, FAA's forecasts indicate that the number of air carrier aircraft will increase by 42 percent, commuter aircraft by 175 percent, and general aviation by 94 percent.

However, based on an Office of Technology Assessment (OTA) report on February 9, 1982, FAA past forecasts have consistently exceeded actual demand by as much as 50 percent. Some industry observers already see trends developing differently than FAA and consider FAA's forecasts of aviation growth too high. These observers cite as their differences of opinion: (1) the current economic plight of the aviation industry, (2) the number of air carrier aircraft remaining constant over the last decade, (3) increases in electronic mail with corresponding decreases in air transport of mail, (4) the saturation of large airports which

now limit additional growth, and (5) the impact of other limiting factors such as the controller's strike, fuel price increases, and lower population growth.

These concerns raise questions about the usefulness of FAA forecasts as a basis for long term planning and about how quickly FAA needs to proceed with capacity-related improvements in its 1982 NAS plan.

Further, FAA expects general aviation users to account for 75 percent of the increase in demand, but the importance of the NAS plan's benefits to private general aviation are not clear. The benefits will accrue to air carriers and business aviation and other aircraft flying in the heavy corridors and centers as well as general aviation aircraft carrying the Mode S communications link with traffic and weather data. However, most private owners of general aviation aircraft are not expected to invest in such equipment since it will not be mandatory.

FAA has promoted an early approval of the NAS plan as crucial for aviation safety and meeting growing demands. While it is generally recognized that certain computers in the air traffic control system need upgrading and expanding, the NAS plan gives little evidence indicating the entire \$10 billion program must be implemented as scheduled. Much of this investment will be made for equipment to reduce operation and maintenance cost rather than to correct poor performance. Therefore, the time frames for the installation of certain systems and equipment are candidates for reevaluation.

The NAS plan does not discuss the impact or consequences of changing systems implementation time frames or substituting alternative solutions. Neither does the plan explain the impact on changes in growth. Some industry observers believe that the aviation industry has matured and that past growth trends will not continue.

Finally, the full benefits of the NAS plan will not be realized until the late 1990s and benefits will be small until then. Therefore, the potential negative consequences of deferring portions of the plan for further examination by users and the Congress could be outweighed by the advantages of better selection of options and phase-in time frames.

NAS PLAN DOES NOT DETAIL ISSUES OF
COST EFFECTIVENESS

In developing the NAS plan, FAA estimated that if projected demand materializes, \$9 billion (in current year dollars) will be saved in personnel, rents, utilities, and communications costs in operating and maintaining the FAA system through 1990. Savings (in current year dollars) through the year 2000 could be \$43 billion. The cost of the plan through fiscal 1987 has been estimated at \$7.5 billion, with total costs estimated at about \$10 billion.

A substantial portion of the cost is to be raised through user taxes. The clearest benefits to users from the program are the fuel benefits available from direct routings and the optimal use of airspace. FAA estimates that

- the annual benefit for air carriers will be \$600 million by 1990;
- the annual benefit to piston engine general aviation aircraft will be \$90 million by 1990; and
- savings in system operation, as compared to the 1981 equivalent system will be \$6.7 billion by 1990 and \$17.8 billion from 1991 through the year 2000.

The additional expected major benefit, which has not been quantified, is reduced risk of collisions and of landing and weather-related accidents.

FAA appropriately characterizes today's system as

- vacuum-tube-type electronic equipment with associated high operating costs;
- different types of computers, software, consoles, and display equipment;
- overlapping coverage of navigation aids, communications sites, and surveillance facilities; and
- proliferated ATC facilities and leased communications with accompanying overhead costs.

We believe that FAA is also correct in stating that expanding today's system to meet the needs of the next two decades will only

amplify its current shortcomings. Beyond that, however, we have a number of concerns, including the following.

- The plan does not present cost information on individual programs, projects, or systems which is required to assess the cost effectiveness of various NAS components.
- The plan presents only one approach and we could not determine if that one is either the most cost effective overall or by individual components.
- The time frames for implementing certain individual components is suspect.
- Details are insufficient to verify the savings and benefits claimed.
- The plan does not differentiate between the decisions that must be made in fiscal 1983 and those that could be deferred.

At the time we prepared this report, we had not received FAA's fiscal 1983 budget data. Therefore, we are unable to comment on that request. However, in our opinion, the Congress needs more detailed information on implementation planning, cost and associated benefits of major components, and source of funds before deciding on NAS funding for fiscal 1983.

In summary, several questions are raised by the current NAS plan. Among them:

- Only one implementation schedule is presented. In the event actual demand does not match the forecast, no alternative position is discussed.
- Just how a 100-percent increase in aircraft operations and passenger enplanements will materialize between 1980 and 2000 and be handled at the airports that are already saturated is not clear.
- From an overall management viewpoint, the NAS plan is a good tool, but options will have to be reassessed and revisions made with each project due to changes in demand, funding availability, technology, and costs. Therefore, the plan should be a living document that is periodically updated

(about every 2 years) rather than a one-time snapshot of the situation with little flexibility for future changes.

- The forecasts of aviation growth presented in the plan are suspect.
- Supporting detail is largely absent in the NAS plan and there are few specifics for evaluating the reasonableness and cost effectiveness of the plan, especially in the areas of cost, benefits, and needs.
- Much of the \$10 billion investment will be made between fiscal 1984 and 1987. Therefore, a thorough congressional examination of the major programs and projects should be completed before the fiscal 1984 congressional budget hearings.

ATC COMPUTER ACQUISITION PROBLEMS

The successful implementation of the NAS plan will be highly dependent on FAA's ability to address short term ATC automation problems as well as planning for the future automated system. In this appendix, we have identified several issues of concern in the area of ATC computer acquisition.

FAA'S TRANSITION PLANNING
IS STILL NOT COMPLETE

FAA's National Airspace System Plan calls for a complex evolutionary approach for moving from its current automated air traffic control system to the future system. Within the automation area alone, over 30 time-sensitive events are scheduled between 1981 and 2000. For an effort of this magnitude to be successful, careful and detailed transition planning must be done. Without such planning, significant difficulties can be encountered which could cause unacceptable risks and serious constraints on air traffic. The FAA recognizes the need for and importance of transition planning; however, as of this report, a transition plan has not been developed. The project manager for the Advanced Automation Program is responsible for achieving a smooth and trouble-free transition to the new system and has indicated that a plan to accomplish this will be developed. In the interim, however, FAA is trying to resolve a number of difficult issues. At this time, FAA doesn't know what its transition strategy will be.

A critical element being discussed is the parallel operation of the old and new systems during the transition. This will ensure that a proven and reliable backup system is available should problems arise with the new system. A study made for FAA indicates that the planning for this type of transition must address several potential problems, such as the need to remodel facilities. Also, the interfaces of the two systems must be adequately defined. Finally, the availability of trained personnel to operate and maintain both systems must be assured. This particular area was a concern expressed at virtually every en route center, terminal, and FAA regional office we visited. Many of the people we spoke with believe a key element in determining FAA's success in making this transition will be their ability to obtain and train the people needed to operate and maintain the new systems. We believe that inadequate consideration of any of these areas could cause a slip-page in implementing FAA's program.

INTENT OF OMB CIRCULAR NO. A-109
HAS NOT BEEN FULLY COMPLIED WITH

In testimony, the Administrator has said that FAA will follow OMB Circular No. A-109 to the extent necessary. He indicated that he believes it is possible to reduce the time frames for some of the steps by reducing the number of competitive vendors in the "compute off." ^{1/} We believe these aspects of FAA's rehost procedure are inconsistent with the intent of the A-109 process. It should be noted that the A-109 process places particular emphasis on generating innovation and competition from industry. Also, A-109 stipulates that an agency's mission need is not to be expressed in terms of the solution, equipment, or other equivalently specific alternatives that might satisfy the need. Approval of the mission need statement by the agency head initiates a search for solutions by granting authority to explore alternative system design concepts. Contrary to this concept, FAA is proposing an equipment solution to satisfy a mission need.

PUBLIC LAW 89-306
HAS NOT BEEN COMPLIED WITH

On February 18, 1982, we sent a letter to the Secretary of Transportation recommending that he direct FAA to comply with the provisions of Public Law 89-306 in procuring the replacement computers for the air traffic control system.

We asked the Transportation Secretary to reply by March 5, 1982. We received an interim reply on March 5, 1982, stating that a response would not be completed until March 24, 1982. In testimony before the House Committee on Public Works and Transportation, Subcommittee on Aviation, on March 17, 1982, the FAA Administrator said that FAA does not intend to follow Public Law 89-306 and the GSA procedures.

As of the date of this report, the Department of Transportation's position on Public Law 89-306 had not been received. We are concerned that these delays will have a critical impact on FAA's planned two major procurements and thereby delay planned air traffic improvements.

^{1/}Vendors build prototype systems so that competing concepts can be evaluated by the Government. This concept is included in OMB Circular No. A-109.

FAA CANNOT BE CERTAIN WHEN AND WHERE
COMPUTER SATURATION WILL OCCUR

FAA's rehost decision and its urgency to replace current en route air traffic control computers are based on the view that aircraft tracks are directly related to computer processor capacity and that operational day delays will start occurring in the late 1980s. We believe that although such a relationship exists, processor utilization is not the sole determinant of when current systems will become overloaded. FAA based its IBM 9020 system capacity estimates on studies of processor utilization during 4- to 7-day periods at each en route center between June 1980 and January 1981. These periods did not necessarily cover the peak days of the year. Also, the studies did not address potential bottlenecks in other parts of the system, such as channel utilization. Other performance studies relied on a simulation package that had not been validated and on admittedly faulty data collected by the NAS software.

In the past year, FAA conducted or contracted for several studies to determine when computer saturation would occur at each en route center. FAA's official position is that the en route centers will begin running out of capacity in the late 1980s. This position is based on a study conducted by the FAA Technical Center and sponsored by one of its research and development organizations. Another research and development group contracted for a similar study which used sophisticated modeling techniques. However, the results of this effort were inconclusive. A similar analytical analysis was contracted for by one of FAA's operational organizations. We believe this apparent duplication of effort stems from the fact that FAA still does not have an established computer performance management function. Such a function has been recommended by several study groups including the Senate Appropriations Committee in their 1980 report (S. Rep. 96-932) on FAA's En Route Air Traffic Control Computer System.

We believe that from their inadequate analysis, FAA cannot predict with any certainty when and where saturation will occur. Recent visits to seven en route centers indicated that FAA can affect computer capacity through operational modifications and local decisions not to implement certain functions. Capacity shortage was shown to be more critical in some centers, such as Houston. Based on these uncertainties and the possibility that the rehost computers will not be installed in time, we believe FAA should consider short term alternatives as a contingency solution.

LESS RISKY ALTERNATIVES SHOULD
BE CONSIDERED

The solution chosen by FAA appears to have been driven by several factors, including:

- Perceived capacity shortfalls in the late 1980s, especially at IBM 9020A centers.
- Use of the rehost computers as the foundation for the replacement system and potentially the advanced computer system.
- Compatibility with an accelerated schedule to integrate a new sector suite.

From a short term standpoint, other alternatives or variations are technically less risky than FAA's proposed solution. These alternatives or variations of these alternatives have been studied by FAA.

As an initial step, FAA could expand its current en route airspace consolidation plans. Portions of airspace previously controlled by the New York and Indianapolis Centers are now being controlled by the Washington and Atlanta Centers, respectively. Consolidation and elimination of low volume centers and diversion of this hardware to IBM 9020A sites could be a short term solution to FAA's capacity problem. This action would provide FAA with additional time to adequately develop its requirements for the future system.

As another option, FAA could upgrade its IBM 9020A centers with IBM 9020D computers, thereby addressing the capacity problems of the late 1980s in some centers. Again, this would provide FAA with additional time to work on developing the advanced computer system.

Another alternative would be to acquire the rehost as contemplated, but immediately rewrite and redesign the software base using an easier-to-maintain, higher level language. The sector suite program would be disassociated from this redesign effort.

CAPACITY GAINS CAUSED BY REHOST HARDWARE
MAY REDUCE THE INCENTIVE TO REWRITE AND
REDESIGN CURRENT PROBLEM-PLAGUED NAS SOFTWARE

The decision to rehost may inhibit innovation and constrain new software to the capabilities of the previously installed hardware. However, at this point we do not have enough information to state whether this approach will keep FAA from meeting its projected requirements. FAA has stated that definition of standard interfaces and communications will enable the agency to acquire a modular expandable system.

The risk in the FAA's technical approach is that the computer capacity gained through rehosting will provide an opportunity to extend the use of the current software system with no incentive to follow through with the software redesign effort. This could further delay the implementation of urgently needed new software while the old system grows more cumbersome to maintain. Eventually, hardware capacity could again become a major problem.

Current software maintenance deficiencies

Current software maintenance procedures reflect the difficulties FAA encountered in trying to maintain a patched-up system. An official of the organization responsible for software maintenance told us that one of the current FAA orders on software modifications was "90 percent * * * out of date" and was unworkable. He agreed that contradictions and differences in the FAA orders made control over modifications increasingly more difficult. This particular problem has been cited by several internal and external study groups. FAA is currently in the process of revising its ADP orders to address this problem.

There are numerous examples of FAA having great difficulty in managing the maintenance of NAS software, especially in implementing new versions. For example:

--All sites do not use the same version of the software, Seattle Center is using version 2.10 and is preparing to implement 2.12. They never received version 2.11 because other centers experienced problems with that version.

--En route metering is not implemented at the Atlanta Center because of system aborts experienced when the patch was

used to provide flow control. The New York Center, which services one of the Nation's busiest airports, has also not implemented this feature.

--The en route minimum safe altitude warning patch could not be implemented at the Atlanta Center because it produced false alerts in center testing. This patch is also not implemented in the Boston or New York Centers due to staff shortages.

--Local facilities are allowed considerable leeway in implementing locally developed patches which can only add to FAA's software maintenance burden.

We believe FAA must develop stability in its current software environment so that old software operating on new software-compatible hardware can successfully evolve into completely redesigned and rewritten software on the same rehost equipment. We believe that current versions could be stabilized by:

--Freezing all new development unless it is necessary to maintain air safety, smooth the transition to new equipment, or assist in the transition from old software to the redesigned software.

--Concentrating the efforts of automation groups on correcting all known errors or problems stemming from releases of NAS software.

--Reevaluating and possibly delaying for later implementation some of the recent innovations that have proved troublesome to implement.

QUESTIONS ON APPROACHES AND
COST EFFECTIVENESS ASSOCIATED WITH ATC,
LANDING, COLLISION AVOIDANCE, AND
COMMUNICATIONS PROJECTS

We have made a limited examination of 42 ATC, landing, collision avoidance, and communications projects, categorizing them as follows:

<u>Category</u>	<u>Number of projects</u>
Collision avoidance	7
Communications	17
Major facilities	3
Navigation	8
Radars	<u>7</u>
TOTAL	<u>42</u>

Based on our limited examination, we have several concerns regarding cost effectiveness and implementation scheduling.

- Several key systems (i.e., the Mode S data link system, Threat Alert and Collision Avoidance System (TCAS), and Microwave Landing System with its associated Precision Distance Measuring Equipment) are scheduled for implementation before their international use is approved by the International Civil Aviation Organization, which could take several years. Such procurements could be premature and require subsequent equipment alterations if different versions are ultimately approved for international use. [FAA plans to award production contracts for Mode S and the Microwave Landing System during 1983.]
- Should the Mode S procurement be deferred until its international use is approved (or for any other reason) other projects that rely upon the Mode S communications capability should also be deferred to coincide with its implementation. These are TCAS, Automatic Traffic Advisory Service (ATAS), and various automated weather services.
- The backup TCAS and ATAS collision avoidance systems will rely on Mode S for data relay between the air and ground. The failure of the airborne Mode S transponder and the planned phase-out of long range primary radar by the year 2000 will leave large geographical areas without surveillance coverage.

- Most midair collisions occur below 6,000 feet and near small airports. Many airplanes operating in those areas will not be required to carry collision avoidance equipment and their owners are not likely to acquire it.
- Interim communications switches may not be cost effective. FAA plans to acquire 98 Integrated Communications Switching Systems (ICSSs) between 1982 and 1986 for its new towers and Terminal Radar Control (TRACON) and to replace some switches at existing facilities. Based on the NAS plan, these switches will likely become excess to FAA's needs when the nearly 200 TRACONS are consolidated into other facilities between 1988 and 1992. As a result, these interim switches, which have a 20-year life expectancy, may be used minimally.
- FAA plans to replace tube type with solid state radios at the existing Flight Service Stations (FSSs) between 1982 and 1985. The current plan is to consolidate those 315 FSSs into 61 automated FSSs between 1983 and 1988, thus making the solid state radios at the old FSSs excess.
- Some projects appear to be designed without consideration for the implementation schedule of related projects. First, the scheduled 1985-88 replacement of tube type with solid state type tone control equipment, which supports communication switches at en route centers, could be deferred to coincide with the installation of the new Voice Switching and Control System (VSCS) starting in 1988. Second, the Air Traffic Control (ATC) terminal hub consolidation communication multiplexing project, to be installed between 1986 and 1989, could be deferred 2 years to coincide with the rest of the hub consolidation program. FAA will possibly request 1983 funding for this tone equipment.
- The cost effectiveness of the trend analyses portion of Remote Maintenance Monitoring (RMM) needs to be established. This technique for predicting equipment failure works well with tube type equipment which degrades slowly, but it becomes of questionable value for collecting trend data on the newer solid state equipment which loses very little operating capability until sudden failure.
- Two planned projects, Mode S and TCAS, may have operational problems or limitations. Full testing is needed to determine whether these potential problems exist and if so, to assure

they are resolved. Otherwise implementation may be premature. First, Mode S is intended to reduce interference by reducing by up to 95 percent the number of data transmissions. This advantage may be largely offset by the heavy workload for Mode S in high density areas, thus leading to interference, because (1) the message length will be 4 to 8 times longer than with existing equipment, (2) communications support for TCAS II will be provided by Mode S, and (3) Mode S will provide communications support in the terminal areas for the proposed ATAS. Second, advanced TCAS systems will use existing barometric altimeters for altitude data. Altitude errors inherent in this equipment, which has not previously adversely affected FAA's radar surveillance activity, may produce false alarms or may not produce a warning when needed. Another potential TCAS problem is due to the large number of aircraft in terminal areas. This creates excessive false alarms which the less sophisticated TCAS I is not expected to handle. As a result, FAA plans to have pilots shut off TCAS I equipment in terminal areas and install directional antennas for TCAS II.

--The Congress may want FAA to rely on commercially available leased services, rather than install its own long-haul communications network. FAA claims that its own network would reduce its costs, which have been increased due to the recent demise of the bulk discount service (Telpak) for leased circuits. In the past, the Congress has generally required the Federal agencies to use leased telephone circuits in the continental United States rather than agency-owned communications networks. The Congress may want to reconsider its earlier decision on agency-owned communications networks and FAA's plan to establish an FAA owned communications system before FAA puts considerable time and money into these projects.

The above observations should be considered preliminary because our ongoing examination is at varying stages of development. We present them as potential areas of consideration for FAA and the Congress to focus their attention on, particularly during the fiscal 1983 budget deliberations.

Our observations notwithstanding, the 42 surveyed projects appear to have potential for reducing cost and improving safety. For example, by consolidating facilities and replacing tube type with solid state equipment, costs should be lowered; improved radar should benefit operations; and communications multiplexing should reduce the costs of leased circuits and increase capacity.

PLANNING IS INADEQUATE FOR PROCUREMENT OF
COMPUTER SYSTEMS FOR MANAGEMENT AND
ADMINISTRATIVE PURPOSES

FAA has made serious omissions in its planning for procurement of computer systems for management and administrative purposes. These omissions are due to FAA not adhering to the principles of information resource management. Information resource management is the art of taking complex, seemingly overwhelming problems of automation and records management and breaking them down into manageable components to be accomplished incrementally. As a result, FAA is in the process of procuring a new computer for the Aeronautical Center when other less costly alternatives exist. FAA has also procured new computer systems for its regional offices which may not be needed. At the heart of the problem is FAA's lack of a comprehensive information requirements definition. Without detailed knowledge of both current and future software applications, it is not possible to economically procure responsive hardware systems and meet the needs of users.

We evaluated FAA's procurement of computer systems for administrative and management purposes as part of a comprehensive review of automated information systems for management purposes. Our work was performed at the Department of Transportation (DOT) and Federal Aviation Administration (FAA) headquarters in Washington, D.C., the FAA Aeronautical Center in Oklahoma City, and three FAA regions: Southwest in Ft. Worth, Southern in Atlanta, and Central in Kansas City. We evaluated the justification for two Requests for Proposals (RFP) to (1) replace computers for the FAA Aeronautical Center and, (2) replace computers for FAA regional offices. We analyzed current and future computer processing workload statistics, related documents, and interviewed numerous agency officials.

Specifically, we found the following problems with FAA's procurements for the Aeronautical Center and its regional offices:

- Inaccurate workload projections were used to substantiate more powerful computers than actually required or no workload analysis was performed at all.
- Benchmarks, the use of which is widespread throughout Government and industry as a valuable tool in assessing computer system performance, are not being employed in either procurement. 1/

1/Benchmarks are a standard industry method used to assess whether proposed computer systems have sufficient capacity to meet user processing requirements.

--Alternatives, such as shifting workloads and using different distributions of processing resources which offer considerable potential savings, have not been considered.

FAA NEEDS TO DETERMINE ITS
TOTAL ADMINISTRATIVE INFORMATION
REQUIREMENTS BEFORE ACQUIRING COMPUTERS

FAA needs to determine its total information requirements to provide efficient and effective management and administrative ADP support for its current operations and the new National Airspace System (NAS) project. The products of FAA's current planning efforts are no more than an annual compilation of the administrative software applications presently being processed--such as payroll and personnel--and short descriptive narratives of ongoing software development projects--such as uniform accounting and logistics. This is not sufficient to determine future processing needs, particularly for the new NAS project. This project will generate requirements for new management application systems and modifications of existing software systems.

Identification of information requirements logically precedes system acquisition and provides a governing structure from which engineering and architectural decisions naturally flow. Because FAA's planning only lists current applications and current development projects, and does not fully identify information requirements, it is procuring systems that may be incapable of efficiently and effectively meeting those requirements. The Office of Management and Budget Circular A-109, "Major Systems Acquisitions" specifically directs that procurements be based on valid information requirements.

FAA's piecemeal approach to managing, planning, developing, and procuring administrative systems is unlikely to produce efficient and effective administrative computer support. By treating the large mainframe facility (Aeronautical Center) and distributed data entry and miniprocessor facilities (regions) separately, FAA does not consider viable alternative distributions of processing capability offering potential savings. These alternatives include both further decentralization of processing resources or fully centralizing all computer processing. Regardless, we found that even treated on an individual basis, neither procurement was justified as explained in the following sections.

REQUIREMENTS FOR AERONAUTICAL
CENTER PROCUREMENT CANNOT BE
SUPPORTED

During June 1982, FAA plans to award a contract to replace its computers at the Aeronautical Center. The requested replacement computer will nearly quadruple the present processing

capacity and cost \$7.3 million over the system's 8-year life cycle. In our opinion, FAA did not plan and manage this procurement in accordance with information resource management principles and it is likely to result in an underutilized and uneconomical computer system to support administrative and management functions. Specifically, FAA

- developed processing requirements based on inaccurate workload projections rather than a comprehensive requirements analysis.
- may be excluding less costly systems with equal capability to process its administrative workload because the benchmark process is not being used.
- did not examine viable alternatives such as shifting workload to DOT's computer center which could save significant resources.

Workload projections do not substantiate requested processing capability

Our analysis of FAA's Request for Proposals (RFP) for the Aeronautical Center computer shows FAA unrealistically projected future system workload. The RFP specifies a mandatory processing requirement of 10 to 13 million instructions per second (MIPS) to process workload during the 8-year life cycle. These MIPS requirements are overstated and do not adequately support computer processing requirements because FAA

- inaccurately projected a 10 percent annual growth in current applications workload,
- compounded this inaccurate projection over the 8 year life cycle, and
- overestimated processing requirements for future software applications.

FAA's projection of a 10 percent annual workload increase is flawed because it is based on a time period, 1977-1980, when four large software applications were developed and implemented. Without these new systems, annual processing growth was only 2.5 percent. In addition, the incorrect workload was then projected over the system life cycle using the 10 percent growth rate. Processing growth was compounded annually which vastly distorts processing

workload over an 8-year period. FAA's current plans do not call for this level of activity in the future. Only two large systems with similar processing requirements are planned for implementation during the next 4 years.

Projected MIPS requirements for these two software applications are also overstated. The Director of the Aeronautical Center told us he had directed his staff to "take the high road" in estimating processing requirements for these applications. Further, he stated that the total processing requirements in the RFP are overstated based on available data because the methodology used double counts some workload.

We believe a more realistic measurement of FAA's administrative processing requirements can best be accomplished through a comprehensive analysis of workload for current and future software applications.

Failure to benchmark can preclude
acquiring less costly systems that
can satisfy requirements

By excluding a benchmark from the procurement process FAA may be procuring a computer system which is not properly matched to its information processing requirements. Benchmarking is a standard industry method used to assess whether proposed systems have sufficient capacity to meet user processing requirements. Simply, a benchmark is a representative portion of a users processing workload. The time required to process this workload for any computer gives a relative sizing (benchmark) for that computer.

The Director of the Aeronautical Center computer facility told us that a benchmark was not used because he believes MIPS ratings are sufficient to select a computer. Numerous studies in industry publications have proved that MIPS ratings lack reliability because instead of measuring throughput (processing efficiency of a total system configuration) they merely measure the internal speed of the central processing unit (CPU). Thus, even if FAA's MIPS requirements were derived conscientiously, it is possible to order computers with higher ratings whose actual throughput could be noticeably lower--a fact not likely to be observed without a benchmark until after procurement and installation. Accordingly, most large mainframe manufacturers have excluded MIPS ratings from their literature.

The following table shows the cost of large-scale compatible hardware that might satisfy valid requirements.

Comparison of Costs and Internal
Processing Speeds of Compatible Computers

<u>Manufacturer</u>	<u>Model</u>	<u>MIPS rating</u> a/	<u>Purchase price</u> a/ <u>(millions)</u>
Amdahl	470V7A	4.6	\$3.0
	470V7	5.7	3.3
	470V8	6.8	3.5
	5860	13.6	4.5
National Advanced Systems	7000DPC	5.4	3.0
	9000N	7.7	3.1
	9000	9.6	4.2
	9000DPC	17.6	6.4
IBM	3033U	5.4	3.5
	3033AP-1	9.2	4.6
	3081	11.0	4.5

a/Source: Computer Decisions, November 1981.

The purchase price of these machines ranges from \$3.0 million to \$6.4 million with varying degrees of processing capability. FAA could save at least a million dollars if a benchmark demonstrated that several computers with lower MIPS ratings could process its expected workload.

Less costly alternatives
have not been considered

During our review we found little or no coordination and cooperation between DOT and FAA. In our opinion, this has contributed to lost opportunities to provide more efficient and economical use of information resources within FAA.

For example, FAA has not actively pursued using excess computer capacity available at DOT's Transportation Computer Center (TCC) in lieu of purchasing a new larger computer system. We found DOT's TCC is greatly underutilizing its two modern computers. Because the TCC and Aeronautical Center's computers are code compatible, it is technically feasible to transfer one or more of the Center's administrative applications to TCC without incurring significant conversion costs.

Although the Deputy Director of TCC told us DOT was actively seeking users throughout the Department, no DOT memorandums or orders addressing this subject have been issued. When approving FAA's procurement plan, DOT's Office of Information Systems and Telecommunication Policy did not consider the possible use of TCC in conjunction with a procurement. Other viable alternatives

such as moving one of TCC's computers to the Aeronautical Center or consolidating the centers were neither discussed nor studied by FAA or DOT. Greater cooperation and coordination between DOT and FAA is needed to insure efficient and economical use of information resources.

REQUIREMENTS FOR REGIONAL
COMPUTER PROCUREMENT DO
NOT EXIST

On April 5, 1982, FAA awarded a contract to Small Business Systems for nine computer systems (plus an option for five more) for its regional offices, headquarters, and Aeronautical Center. These computer systems will replace existing regional computers including:

<u>Make and model</u>	<u>Type of equipment</u>
UNIVAC Spectra 70/35	batch computer
UNIVAC 9300	remote job entry station
IBM 1401	batch computer
Four Phase IV/90	data entry system

With the exception of the Four Phase equipment, the existing equipment is antiquated and requires replacement. FAA estimates the purchase cost of 12 systems, the number it intends to acquire, to be \$19 million.

Serious deficiencies were evident in FAA's planning and management of this procurement. First, FAA did not specify a processing requirement in its RFP for these systems. Second, FAA is basing its selection of a new computer system on outdated workload statistics because regional workloads have decreased and will continue to do so. Third, FAA did not properly consider alternatives which might forestall a procurement or reduce its costs.

FAA did not specify
processing requirements

On October 28, 1980, FAA issued an RFP to acquire 10 (later amended to 9) administrative computer systems. These systems would functionally replace the previously identified ADP equipment. These ADP functions include data entry, remote job entry and batch processing. Given the Aeronautical Center's large mainframes, the only mandatory functions for any region are data entry and remote job entry. Batch processing could be accomplished through a local processor as done currently or at the Aeronautical Center by using a remote job entry station.

In the RFP, FAA detailed a number of different hardware specifications for the procurement. These specifications are detailed in configuration requirements setting out mandatory specifications for quantities of disk storage, tape drives, printers, card readers/punches, video terminals and terminal printers. For each piece of peripheral equipment, detailed hardware specifications were made mandatory requirements. For example, disk storage minimum capacity, minimum number of drives, minimum storage per drive, access rate, data transfer rate, and removable disk packs were all specified as mandatory requirements. Only the processing capability of the central processing unit (CPU) was not specified.

By specifying an operational capability demonstration in its RFP, FAA precluded the use of a benchmark in evaluating CPUs which vendors bid. Benchmarks are widely used in evaluating systems throughout Government and industry because the relative performance of two different systems will vary greatly depending upon the workload tested. In contrast to a benchmark process where a computer is timed while processing a specific representative workload of the user, an operational capability demonstration is merely an observation that the CPU can process the test installation's demonstration workload. Interpreting performance becomes a judgment call of the FAA. We asked the Chief of FAA's Data Systems Management Division why an operational capability demonstration was used instead of a benchmark. He told us that before a benchmark could be used it would be necessary to define the processing requirements. Since FAA did not define the processing requirements, a benchmark could not be used. Therefore, an operational capability demonstration, using subjective judgment, was employed in evaluating CPUs bid by vendors.

There are two basic flaws with this approach. First, since requirements have not been specified, vendors are proposing systems against an unknown standard. Second, FAA must evaluate the proposed systems without objective, relative performance data against a subjective standard. We believe that it would be unlikely to select the same computer under an operational capability demonstration as would be selected under the benchmark process.

Regional workloads are small
and decreasing with centralized
software applications

Before issuing the RFP, FAA surveyed regional processing activities and compiled statistics in a February 1979 "requirements analysis." These statistics were actually obtained from a contractor study delivered in October 1978. Therefore, more than 3 and 1/2-years have passed, making the statistics too old to adequately justify a procurement. We found that the average monthly

regional batch processing workloads at the three regions we visited had decreased substantially, or an average of 31 percent. Further, batch processing was expected to decrease even further with the introduction of the centralized Uniform Accounting System scheduled for implementation at the Aeronautical Center in June 1982.

The following table shows that monthly batch processing workloads reduced substantially between the requirements study of 1978 and fiscal year 1981 for the three regions we visited.

Regional Batch Processing Workload 1978 and 1981

<u>Region</u>	<u>1978 (hrs.)</u>	<u>1981 (hrs.)</u> b/	<u>Percentage reduction</u>
Central (total) a/	348	248	29
Payroll	125	6	95
Accounting	114	107	6
Southwest (total) a/	291	206	29
Payroll	73	36	51
Accounting	108	93	14
Southern (total) a/	299	195	35
Payroll	125	23	82
Accounting	73	63	14

a/Total includes other functions such as supply and inventory processing.

b/Compiled from regional records of system usage.

As can be seen, a significant reduction in regional batch processing workload has occurred. Most of the reduction has occurred due to reduced local payroll usage attributable to the introduction of the centralized Uniform Payroll System in April 1979.

Another significant purpose for regional batch processing has been accounting. The Chief of the Southern Region's Accounting Division expects to drop all local accounting systems with the introduction of the centralized Uniform Accounting System. The Chief of the Southwest Region's Accounting Division intends to keep local accounting systems responsible for only about one-fourth the current accounting batch processing workload. Therefore, further significant reductions will occur once the Uniform Accounting System is implemented early this summer. Because the FAA headquarters RFP identified the 1978 workload to vendors and has not monitored regional batch processing workloads since 1978, it is very likely that excess batch processing capability will be procured.

Alternative methods to meet requirements have not been considered

FAA has not considered alternatives to meet regional data entry and processing requirements. This condition is directly attributable to the lack of a comprehensive information requirements analysis. One viable alternative is to shift the regional batch processing workload to the Aeronautical Center and forestall the regional procurement. This would allow the regions to surplus the Spectra 70/35 and IBM 1401 computers after converting software to run at the Aeronautical Center facility. FAA expects considerable underutilization of its Aeronautical Center facility after that procurement is completed. In addition, the Four Phase IV/90 Data Entry System can be modified to perform remote job entry allowing the regions to surplus the Univac 9300 remote job entry station. FAA's Southern Region has already completed this effort and prepared a comprehensive guide for the other regional offices.

FAA, in its February 1979 requirements analysis, examined the feasibility of shifting regional batch processing to the large mainframe facility at the Aeronautical Center. This analysis was badly flawed for several reasons:

- Reductions in regional batch processing workloads were not considered.
- The study attributed a \$500 per hour cost for the large mainframe at the Aeronautical Center. The Director of this computer facility expects it will be vastly underutilized for several years after the replacement procurement. Therefore, shifting batch processing workload to the Aeronautical Center will not result in higher ADP costs.
- The study assumed a ratio of 40 to 1 for the relative processing power between the large mainframe and the current Spectra 70/35. A more realistic ratio would be 150 to 1 given FAA's RFP for replacement of the Aeronautical Center computers.
- The study attributed substantial additional telecommunication costs for dedicated lines to support remote job entry. However, needed telecommunications for remote batch processing can be provided during slack periods on current lines.
- The study did not consider additional personnel costs associated with local batch processing which would require a second shift of operators.

We believe a revised, rigorous analysis would show significant cost reductions possible through the use of the Aeronautical Center for remote batch processing.

CONCLUSIONS

FAA has not properly planned and managed its computer procurements for its regional offices and Aeronautical Center. By not following proven information resource management methods, FAA is prevented from achieving its stated goal to effectively and efficiently provide administrative and managerial support for the National Airspace System. The core of the problem is that FAA has not comprehensively defined its information requirements. A full set of information requirements, in addition to providing criteria for acquiring computer hardware, serves as a guide to software designers and programmers after the requirements are ranked by priority.

In addition to FAA's not comprehensively defining its information requirements, we found the existing justification for procurements to be weak, insufficient, or non-existent. If FAA continues its current methods, there is no assurance that excess capacity will not be acquired, the use of antiquated and inadequate computer hardware will not be perpetuated, or that user needs will be met.

Our evaluation of FAA's planning and management of the two procurements shows that viable alternatives were not considered. Alternatives which offer considerable potential savings, such as shifting workload, different distributions of processing capabilities, and consolidating computer centers were not considered, primarily because information requirements have not been comprehensively defined. Without detailed knowledge of current and future processing workloads, it is not possible to optimize the sizing and distribution of information processing resources.

RECOMMENDATIONS

We recommend that the Secretary of Transportation direct FAA to:

- Cancel its procurements for replacing the regional computer systems and the computer for the Aeronautical Center;
- Conduct a comprehensive information requirements analysis including the identification and prioritization of future software applications; and

- Prepare a long-range plan, in cooperation with DOT, to obtain needed processing and telecommunication capabilities considering all alternative distributions including, as a minimum, the following alternatives:
 - Shifting workload from the Aeronautical Center to the Transportation Computer Center;
 - Moving computers from the Transportation Computer Center to the Aeronautical Center;
 - Shifting regional processing workload to the Aeronautical Center; and
 - Consolidating the Transportation Computer Center and Aeronautical Center facility.

MANAGEMENT PROBLEMS
ASSOCIATED WITH ATC AUTOMATION
PROGRAMS AND ADMINISTRATIVE
ADP MANAGEMENT

ATC AUTOMATION PROGRAMS

Several deficiencies have been noted during our review concerning FAA's management of its ATC automation programs and administrative computing operations. FAA's failure to recognize and correct these deficiencies could adversely affect its ability to successfully implement the NAS plan as well as reduce its effectiveness in conducting day-to-day operations.

FAA'S project management
is inadequate

We believe some difficulties in the research and development area stem from inadequate contract monitoring and project management. FAA has tried to alleviate staff shortages by heavily supplementing its own technical staff with contractor support. For example, over the past 3 years FAA has spent over \$19 million for engineering analyses to be used in developing future ATC computer requirements. The level of FAA contract monitoring seems to have been inadequate in some cases, since contract managers acknowledge difficulty in correlating the quality of work produced to invoice payments. Many documents have been issued, but there is no evidence that the agency's ability to accomplish its mission has improved.

Inadequate project management has also led to poor use of the Department of Transportation's Transportation Systems Center (TSC). Of 13 TSC projects we reviewed, 9--costing over \$2.3 million of the \$3.6 million total--were either terminated or suspended. TSC officials say much of the work terminated is of little value because FAA did not require the Center to provide final documentation. As a result products such as the TSC work on a computer model to predict air traffic volume have gone unused. That model is currently stored in a tape library at TSC because the absence of documentation precludes its use on FAA's Technical Center computers in Atlantic City, New Jersey.

Technical expertise is dispersed

We believe that another area of concern is the dispersion of ATC automation expertise throughout the agency. Developmental projects are initiated not only in the agency's research and

development area but in operational areas as well. But, those operational areas must maintain their full-time organizational responsibility the same time they are developing a project. Not only is available time a problem, but the organization implementing the system is also one of the ultimate users. We believe that inexperience in software development activities by the organization responsible for operational software maintenance is one cause of the current difficulties in implementing the conflict alert function on the New York TRACON system. Similar problems could recur with implementation of the NAS Plan. FAA has assigned the organization responsible for hardware maintenance with the task of overseeing both hardware and software development activities related to enhancing the Direct Access Radar Channel (DARC) system. As the primary backup to the IBM 9020 en route computer, the enhanced DARC should ease controller transition workloads by more closely replicating the information provided before a main computer system failure. Timely introduction of DARC enhancements will be made more critical by any schedule slippages in FAA's plan to acquire rehost computers.

FAA appears to be aware of the need to coordinate the ATC automation activities. Its newly created Advanced Automation Program Office has been charged with coordinating and integrating some of the interrelated projects defined in the NAS Plan. It is still not clear how day-to-day improvements made by operational areas will be integrated with new development projects.

Technical complexities have been underestimated in the past

We feel that underestimation of the complexities involved, in two projects, including requirements definition, has contributed to lengthy delays in those projects. The Tampa/Sarasota Umbrella Project, which was initiated in 1974, was to provide remote digitized air traffic data to an airport and its satellite airports. Contract costs have risen from \$4.3 million to \$11.5 million, and the project is not yet complete. Current problems may cause what equipment has been installed to be replaced with a more standardized ARTS IIIA system.

Overruns and schedule delays have also been associated with the Electronic Tabular Display Subsystem (ETABS) project. ETABS is an engineering model designed to test controller productivity by disseminating automated flight information. Based

on ETABS' history of problems, we are concerned that FAA may not be able to develop and integrate the ETABS-related sector suite 1/ program within the time and cost projected in the NAS plan.

ADMINISTRATIVE ADP MANAGEMENT

FAA top level management has limited its attention on the framework for managing its administrative ADP. Top level management has not adequately monitored, supported and enforced this information management framework. While FAA has a steering committee of Associate Administrators to approve and monitor software development projects, inadequate commitment exists to meet the goal of these efforts--to provide efficient and effective administrative and managerial support. Without an effective steering committee (or other review mechanism), systemic problems have persisted throughout the information life cycle in spite of definitive DOT and FAA regulations.

We believe these problems are serious and directly impact FAA's ability to properly support the National Airspace System. Although our work is not yet completed, we have found the following problems:

- Management of individual software projects is highly fragmented.
- Cost/benefit studies are not always conducted and if completed, are frequently flawed.
- Alternatives to new system developments are not properly considered.
- Costly requirements analyses frequently must be redone.
- Software development resources are not properly targeted because funding and budgeting responsibilities are fragmented between the user divisions and the Office of Management Systems.

1/The sector suite will be a controller workstation which will provide display information related to surveillance, weather, flight information, and traffic planning. Each sector suite will have redundant processors and displays which will be functionally interchangeable.

Inadequate top management involvement
in steering committee

The lack of direct involvement of FAA's top managers in its steering committee for oversight and control of administrative information resources has had serious effects on its ability to manage these resources. The steering committee; entitled Information Systems Review Committee (ISRC), is composed of all Associate Administrators, and is chaired by the Associate Administrator for Administration. Its goal is to provide top management oversight and involvement in decisions relating to review and approval of hardware procurements and software development projects to insure efficient and effective administrative and management support. However, we found that due to the lack of involvement and commitment on the part of the Associate Administrators in the ISRC this goal cannot be met. For example, proposed major software systems development projects which come before the ISRC are frequently reviewed and approved without the attendance of many of the Associate Administrators. Usually attendance is limited to only those top managers whose systems are being reviewed while others send subordinates or are absent. In this situation it is highly unlikely that subordinates representing their Associate Administrators would ask the questions necessary to insure proper top management review.

We also found that the Chairman of the ISRC has delegated the authority to the Director of the Office of Management Systems to decide when and if the Chairman should attend meetings. Our review of the minutes of the ISRC meeting from 1975 thru 1981 indicated:

- Associate Administrators including the chairman are absent most of the time,
- ISRC reviews of approved development projects usually result in extension of development milestones and additional funding, and
- Inadequate and incomplete presentations of proposed new systems are rarely questioned.

Individual software projects
have fragmented management

Individual development projects generally have two or three managers instead of a single project manager. Typically, there is a user project manager from the user division and a data

processing manager from the Office of Management Systems. Occasionally, one person will serve in both roles. If the Aeronautical Center is providing substantial support, another manager will be assigned.

The obvious disadvantage to this system is that it is highly fragmented. To effectively manage projects under this structure requires a high degree of coordination from all parties throughout the entire project. This is very difficult to achieve and in practice, many project development problems have arisen because of disputes between the different project managers.

Low quality efforts throughout the information life cycle

We found problems in many phases of the information life cycle for the development projects. We are finding that the most pronounced problems are in the initial phases of project development--cost/benefit analyses, consideration of alternatives, requirements analyses and project funding including cost control. Because these projects have an inadequate basis for initiation, development cycles are unusually prolonged and developed systems are not fully effective or efficient.

We found cost/benefit analyses, specifically required by DOT and FAA regulations, were not conducted for the Enforcement Information System, Energy Management Information System and Operational Error/Deviation Information System. Even though a cost/benefit analysis was conducted for the Uniform Payroll System, its recommendation, not to initiate development, was not followed. In most other cases, we found the calculation of costs and benefits was either incomplete or flawed.

Although several alternatives are presented to the ISRC, the committee almost always authorizes a new development even though less costly options are available. For example, the ISRC approved an independent Energy Management Information System to collect cost and related data from utility bills which could have been incorporated in the Uniform Accounting System. An on-line interactive Air Traffic Controller Health Information System to collect statistical health data on controllers was approved when a one-time study could have met the goals for this effort.

Requirements analysis has been a major problem for several projects. FAA purchased the rights to an existing health data collection and analysis system for \$250,000 and

then discovered it was inadequate for their needs. Subsequently, FAA conducted a requirements analysis to better define information needs. For the Uniform Payroll System, FAA expended at least \$1.5 million over more than six years to rework its requirement analysis in three separate efforts.

Funding and budgeting for development projects has been split between the user divisions and the Office of Management Systems. As a result, systems have been funded by Management Systems that the user divisions would not fund themselves. Also, user divisions have funded systems that Management Systems believed were unsound or unworkable. Compounding this problem has been the almost complete absence of cost collection and control for all the projects we are evaluating.

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