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Report to the Chairman, Subcommittee on Transportation and Related Agencies, Committee on Appropriations, House of Representatives

August 1991

AIR TRAFFIC CONTROL

FAA Can Better Forecast and Prevent Equipment Failures

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Resources, Community, and
Economic Development Division

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August 2, 1991

The Honorable William Lehman
Chairman, Subcommittee on Transportation
and Related Agencies
Committee on Appropriations
House of Representatives

Dear Mr. Chairman:

The nation's air traffic control (ATC) system is critical to the safe control of air traffic, and deterioration of ATC equipment can have serious effects. In 1981 the Federal Aviation Administration (FAA) embarked on a long-term program to modernize the ATC system. However, this effort has been plagued with repeated delays. Consequently, FAA has had to use and maintain antiquated equipment, which is more prone to failure as it ages. Therefore, FAA has been faced with deciding if its equipment will last until new systems arrive or if it needs to purchase interim equipment in the meantime.

You expressed concern that FAA is not ensuring that the ATC system will continue to operate at a high level of performance until the new-generation systems and equipment arrive. Therefore, as requested, we evaluated how effectively FAA has identified and assessed equipment performance problems at FAA's en-route centers—those facilities that control traffic between airports. In addition, we explored ways in which FAA could better utilize its current maintenance data bases to manage the systems' maintenance effort.

FAA's en-route centers contain air traffic control systems that provide air traffic controllers with essential ATC services, such as radar data display, flight plan information, and radio communication. Each system is made up of a combination of interdependent equipment. For example, the Computer Display Channel, the system that provides the controllers with a radar data display, is made up of an array of lower level equipment, including computer memory units, data processors, display screens, and controls.

Results in Brief

FAA needs to take action to improve its measurement of en-route center performance by making use of available information on problems with equipment that supports critical ATC functions. Although FAA reports its en-route systems to be about 99 percent reliable, this does not take into

account the important fact that many of the aging equipment components within these systems have been experiencing problems. For example, while overall system outages are infrequent, en-route centers are logging hundreds of lower level equipment failures into the national computerized Maintenance Management System (MMS) every week. But FAA does not analyze these MMS data on equipment failures to measure equipment-level performance.

FAA could better forecast how long it will be able to sustain ATC systems at a high level of performance if it measured the reliability of its equipment. FAA's en-route ATC systems were designed with redundant equipment to prevent one equipment failure from causing a full system outage. This is a major reason why the systems have failed so infrequently. However, as all of FAA's equipment gets older and is more prone to failure, the margin of error provided by redundancy erodes, and the risk increases that both the primary and backup equipment will fail at the same time, causing system performance to deteriorate.

FAA can use computerized equipment maintenance data in the MMS to make management decisions based on a more thorough measurement of equipment performance. For example, analysis of these data can generate valuable information for deciding when to procure replacement equipment and for allocating technician staffing. In order to utilize these maintenance data to their fullest extent, however, FAA must address several MMS data base problems by refining data definitions and reporting guidelines.

Background

The Systems Maintenance Service at FAA headquarters is responsible for ensuring that ATC systems operate continuously at acceptable levels of performance and safety. The Systems Maintenance Service is responsible for collecting data to analyze ATC system performance, identifying problems, and directing efforts to resolve them. It provides policy and technical guidance to the field installations, such as en-route centers, that are responsible for the actual maintenance. The Logistics Center in Oklahoma City, Oklahoma, supports field maintenance operations by providing parts and doing repairs. Maintenance engineers and technicians in FAA's Airway Facilities field installations are responsible for the day-to-day maintenance of ATC system equipment. Some maintenance work for many newer systems is done on a contract basis.

The Systems Maintenance Service requires en-route center personnel to record all maintenance activities in MMS. This computer system consists

of several data bases, two of which contain data related to equipment performance. One is the National Airspace Performance Reporting System (NAPRS) data base, which contains data on ATC system outages and equipment failures that the Systems Maintenance Service defines as "major hardware elements." Another is the Corrective Maintenance data base, which contains data on all types of en-route center equipment failures, whether they are defined as major or not. The en-route centers retain the Corrective Maintenance data on-site and report only the NAPRS data to the Systems Maintenance Service. From the NAPRS data base, the Systems Maintenance Service compiles a national data base of ATC system outages.

FAA's Assessment of En-Route Center Equipment Performance Is Incomplete

FAA assessment of equipment performance at its en-route centers is incomplete since it analyzes only overall system performance data. The Systems Maintenance Service analyzes the portion of MMS data that records system outages to generate system performance indicators, such as reliability and operational availability.[1] These data show that overall ATC system outages are infrequent, and therefore FAA reports that system reliability and availability are high—about 99 percent. However, the Systems Maintenance Service does not use the remainder of its MMS data from either the NAPRS or the Corrective Maintenance data bases to generate similar performance indicators for the equipment that makes up the systems.

For example, performance analysis of the Computer Display Channel—the large computer system that processes radar and flight data and maps them out on a radar display screen for the air traffic controller—shows that overall system reliability is about 99 percent. However, air traffic controllers and field maintenance personnel have reported many problems with equipment components of this system, such as the controllers' radar displays. Despite numerous reported problems, the Systems Maintenance Service has not used available MMS data on this equipment to thoroughly analyze its performance record and measure how serious the problems are.

Yet, equipment components of the Computer Display Channel, such as the controllers' radar display screens, are critical to the safe control of air traffic, and their deterioration can have serious effects. For example,

[1]FAA defines reliability as the probability that a system will operate without failing during any 24-hour period. Availability is the percentage of time that a system is in service for a given period of time.

when a radar display screen recently failed at one en-route center, the center had to control traffic using one less radar display screen, even though the Computer Display Channel system as a whole continued to function. Another controller temporarily had to assume responsibility for the airspace served by the failed radar display in addition to his assigned airspace. The sudden increase in the volume and complexity of air traffic for this controller contributed to the controller's not maintaining the minimum required separation between aircraft—two aircraft got too close together, creating a potentially dangerous situation in the air.

The NAPRS data base that the Systems Maintenance Service reviews contained no record of the equipment failure involved in this incident because the Computer Display Channel system did not fail. On the other hand, FAA procedures require centers to record all such equipment failures in the MMS Corrective Maintenance data base.

Our analysis of MMS data illustrates the more complete nature of the Corrective Maintenance data base. For the 12 months from August 1989 through July 1990 at one center, our analysis showed 1,935 failures or malfunctions of Computer Display Channel equipment, such as controller radar displays and control panels. NAPRS reporting criteria required that only 170 of these equipment failures be reported to the Systems Maintenance Service. Further, during the same period, only three Computer Display Channel system outages occurred, which were included in the national outage data base FAA uses to generate availability and reliability statistics.

Equipment Performance Is Assessed Primarily Through Professional Judgment

To assess the performance of equipment, the Systems Maintenance Service has relied on information from field maintenance personnel, based on their professional experience with equipment problems. For several years, maintenance engineers and technicians have reported difficulty in maintaining old equipment. The Systems Maintenance Service conducted several special surveys to assess the extent of equipment problems raised by field personnel. From 1986 through 1990, FAA prepared 14 reports of en-route center problems based on input from field maintenance personnel to various studies, conferences, and surveys. These reports cite many of the same problems. For instance, problems with the power supply equipment for the Computer Display Channel appear in 7 of the 14 reports, and problems with the controllers' flight plan updating equipment appear in all reports that deal with that type

of equipment. In addition to compiling these reports, the Systems Maintenance Service periodically reviews NAPRS data from the field on major equipment failures to gain insight on equipment problems.

These methods of assessing equipment performance represent the collective judgment of maintenance officials both in the field and at FAA headquarters. They do not include thorough quantitative analyses to measure the size or severity of the problems. At the time of our review, FAA had not prioritized its en-route center equipment problems for resolution, and most remained unresolved.

Older Equipment Is More Likely to Fail, but FAA Does Not Measure Its Performance

A major reason that FAA's en-route systems have experienced so few overall outages is that they were designed with redundant equipment to prevent an individual equipment failure from causing a full system outage. However, as all of the equipment gets older and is more prone to failure, the margin of error provided by redundancy erodes, and the risk increases that both the primary and the backup equipment will fail at the same time, causing system outages. FAA's approach of measuring only system performance does not assess the risk that equipment problems will cause system performance to deteriorate in the future. In other words, FAA's statistics do not reflect an equipment problem until after it causes a system to fail. However, by that time, equipment problems have already breached the safety net of equipment redundancy.

The Systems Maintenance Service itself has recognized the value of analyzing more than just system performance. A September 1988 order by the Systems Maintenance Service states that identifying high system reliability alone can lead to a less than complete picture of performance if information is available that identifies equipment problems. The order further states that "All data must be considered and presented when performing analysis . . ." to ensure that results contain the complete picture of a system's performance.

In practice, however, the Systems Maintenance Service essentially confines analysis of computerized equipment performance data to a daily review of NAPRS data. Furthermore, at the time of our review, the Systems Maintenance Service had not disseminated any detailed analysis plans, instructions, or mandate to either en-route center or headquarters

officials to analyze equipment data. Consequently, the centers are maintaining extensive amounts of valuable data in the Corrective Maintenance data base as little more than a historical record of maintenance activities.

FAA Could Better Utilize MMS Data but Needs to Improve the Data's Consistency

The Corrective Maintenance data base was designed to keep a detailed maintenance history on all en-route center equipment. It has information about each equipment failure—when it occurred, its duration, and its cause. By utilizing Corrective Maintenance data, the Systems Maintenance Service can enhance its ATC performance analyses and more proactively manage the systems maintenance effort. FAA can use the Corrective Maintenance portion of MMS for the following purposes:

1. Quantify equipment problems and track performance trends that may adversely affect ATC system performance in the future.

2. Assess the trade-offs of replacing versus repairing equipment to keep the systems operating effectively.

3. Measure the effectiveness of new equipment or other corrective actions FAA has taken to sustain systems.

4. Update staffing allocations to maximize the effectiveness of the maintenance work force.

5. Justify its budget requests for any equipment replacement projects that may be needed.

First, when accumulated over several years, Corrective Maintenance data would enable FAA to quantify recurring equipment problems and monitor deteriorating performance trends before they result in system outages. Equipment failure projections would help FAA estimate the potential for system outages that occur when both primary and backup equipment components fail at the same time. This type of information will enable FAA to assess the effect of deteriorating equipment on the future availability of systems and to make timely, proactive procurement decisions.

Second, even when system availability is not in jeopardy, FAA can use Corrective Maintenance data to determine whether replacing old equipment would be more advantageous than continuing to maintain it. Trends can quantify the extent to which equipment deterioration is

reducing system capabilities and increasing the maintenance work load. For example, our analysis indicates that the controllers' radar display screens and controls malfunction frequently. One center experienced 964 failures or malfunctions of these components from August 1989 through July 1990. These incidents disrupt the flow of critical aircraft information from the Computer Display Channel to air traffic controllers and require significant time to repair. FAA can calculate the effects of these failures and malfunctions, both in terms of operational effectiveness and maintenance time, using data from the Corrective Maintenance data base.

Third, by analyzing Corrective Maintenance data, FAA also would be able to evaluate the effectiveness of new equipment, or other corrective action, by measuring performance trends before and after new equipment is installed or the action is taken. For example, FAA made a partial replacement of the old controller keyboards at each of its 20 en-route centers. Corrective Maintenance data before and after delivery of the new keyboards show that FAA replaced too few of the old keyboards to significantly reduce overall keyboard failures at the en-route centers. Such analyses are important for measuring the success of procurement projects and deciding whether the projects should be extended, discontinued, or re-oriented to meet their objectives. This will help ensure that scarce program funds are expended as effectively as possible.

Fourth, FAA would be able to update staffing allocations by measuring current needs in the field using Corrective Maintenance data and other types of maintenance data from MMS. FAA currently allocates staffing on the basis of staffing standards, which the Systems Maintenance Service formulates through a time-consuming, labor-intensive process that includes manually reviewing maintenance logs and interviewing technicians. FAA could automate a portion of this process by tapping into MMS logs to measure the maintenance effort required to keep equipment operational. With improved, up-to-date staffing allocations, FAA could distribute its limited technician work force so as to maximize its effectiveness for maintaining the old ATC systems.

Fifth, FAA would be able to use its Corrective Maintenance data base analysis to help justify any requests to the Congress, the Department of Transportation, or within FAA for funding that might be necessary to procure interim equipment replacements. Performance analysis and trends will help FAA demonstrate a need for and the appropriate timing of funding requests. For example, trends that show deteriorating equipment may point to a need for replacing equipment on an interim basis

until modernized systems arrive. Our 1990 report on the Interim Support Plan emphasized the need for FAA to obtain better data when justifying costly interim equipment programs.[2]

MMS Data Are Not Uniform and Consistent

Although the Corrective Maintenance data base can be a useful management tool, its data entries were not uniform and consistent at the time of our review. Technicians did not use uniform equipment names in their entries, and "time" data were often entered inconsistently. In some cases, technicians recorded the total amount of time that a piece of equipment was inoperable, sometimes a period of several weeks. In other cases, technicians recorded only the amount of time spent to make the repair, which was only a few hours or less. In still other cases, technicians simply disregarded the time fields. Separate data fields for the time the equipment was out of service and for the total maintenance time spent to repair could have eliminated this problem.

Our analysis of the data demonstrated the seriousness of these data problems when the data are used for analyzing performance. For example, because of the nonuniform use of equipment names, time-consuming review of the comments fields was necessary to count failures for certain equipment. Also, because of the inconsistent entry of time variables, we could not accurately calculate "Mean Time to Restore," an important equipment performance indicator.

FAA has allowed these data problems to develop primarily because the Corrective Maintenance data base is being maintained only as a historical record of maintenance activities. The data do not undergo any computerized analysis that would require uniformity and consistency. However, this practice hinders some of MMS' key objectives. FAA's system specification states that MMS will provide "uniform reporting" of system and equipment failures. The specification also states that this uniform reporting

> will provide FAA management with information needed to react to problems which are potential threats to the performance or effectiveness of the [National Airspace System]. This also aids in decision-making regarding maintenance policies and procedures or the replacement of equipment.

Unless FAA ensures uniformity and consistency in its Corrective Maintenance data, it cannot fully meet these objectives.

[2]Air Traffic Control: The Interim Support Plan Does Not Meet FAA's Needs (GAO/RCED-90-213, Sept. 11, 1990).

Conclusions

FAA has not performed a comprehensive assessment of the reliability of its ATC equipment at en-route centers. Consequently, FAA managers do not have the complete picture they need to adequately assess the gravity of problems that maintenance personnel and controllers are experiencing with ATC system equipment. Current indications of problems with antiquated ATC equipment may be a precursor to failures in critical systems. Therefore, FAA needs to analyze additional information to ensure that it corrects these problems in a timely and efficient way, through either more aggressive repair efforts or equipment replacement. FAA's current approach of measuring only overall system performance does not allow the agency to project equipment performance, a necessary input to maintenance decisions.

Provided FAA improves the quality of the data it contains, the MMS Corrective Maintenance data base holds the most promise for enabling FAA to take a more proactive approach to managing systems maintenance. FAA could more fully assess equipment performance, predict trends in performance, and project specific equipment needs. Accumulation of detailed maintenance data on new ATC modernization systems will allow FAA to routinely undertake performance analyses throughout each system's lifetime.

Recommendations

In order to strengthen FAA's equipment performance analyses, we recommend that the Secretary of Transportation direct the Administrator, FAA, to

- refine FAA's Corrective Maintenance data base to make the data uniform and consistent, and add precise information to permit complete equipment maintenance analysis;
- use FAA's Maintenance Management System data bases, including the Corrective Maintenance data base, to analyze and project equipment performance trends; and
- establish better management controls to ensure that technicians properly record information in maintenance data bases.

Agency Comments

As requested we did not obtain official agency comments. However, we did provide a draft of this report to FAA and Department of Transportation officials for their informal review. With regard to our conclusions and recommendations, these officials agreed that the agency could, and should, perform a more comprehensive assessment of equipment maintenance data. However, they said our characterization of FAA's current

equipment performance methods was unfair because we did not recognize all of their efforts. Specifically, they noted that the Systems Maintenance Service does examine some equipment-level data in NAPRS. We changed our report to better reflect that FAA does judgmentally examine some equipment-level data. However, given the criticality of ATC equipment and the continued slippages in delivery of new equipment, we believe that measurement and assessment of these data are necessary to help forecast whether or not antiquated equipment needs to be replaced.

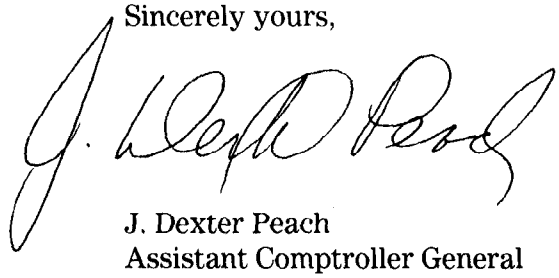
FAA officials also said the draft used inaccurate terms in some places. We incorporated their comments, where appropriate, in order to improve the precision of our terms and the technical accuracy of the report.

Details on our objectives, scope, and methodology are contained in appendix I.

Unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from the date of this letter. At that time we will send copies to interested congressional committees; the Secretary of Transportation; and the Administrator, FAA. We will also make copies available to other interested parties upon request.

This work was performed under the direction of Kenneth M. Mead, Director, Transportation Issues, who may be reached at (202) 275-1000. Major contributors to this report are listed in appendix II.

Sincerely yours,



J. Dexter Peach
Assistant Comptroller General

Objectives, Scope, and Methodology

In response to a May 1990 request from the Chairman of the Subcommittee on Transportation, House Committee on Appropriations, we evaluated how effectively FAA has identified and assessed equipment performance problems at en-route centers. In addition, we explored ways in which FAA could better utilize its current maintenance data bases to manage the systems maintenance effort.

To address our objectives we analyzed FAA's processes for evaluating equipment performance. We directed our work at en-route equipment support problems, since we recently reviewed FAA's Interim Support Plan for other major facilities on a separate assignment.[1] Our review included four centers: Atlanta, Chicago, Seattle, and Washington, D.C. We chose these locations because of their geographical dispersion and because they represent both very busy and moderately busy centers. We also performed work at FAA headquarters' Systems Maintenance Service, [National Airspace System's] Systems Engineering Service, and Automation Engineering Division in Washington, D.C.; the Southern Regional Office in Atlanta, Georgia; the FAA Logistics Center in Oklahoma City, Oklahoma; and the National Automation Engineering Field Support Division in Atlantic City, New Jersey.

To obtain information on equipment problems and to determine how FAA identifies and analyzes those problems, we interviewed technicians, engineers, and maintenance managers. We also interviewed maintenance managers at headquarters and FAA's Logistics Center and National Automation Engineering Field Support Division to determine what actions are being taken to alleviate equipment problems. In addition, we reviewed and analyzed pertinent documents on equipment performance and reported problems, including NAPRS, the results of special FAA surveys to identify problems, and National Maintenance Engineering Conference reports. These reports, surveys, and conferences generally covered the period from 1986 through 1990. Our analysis of the NAPRS reports showing equipment outages covered the 12-month period that ended July 31, 1990.

In addition, we evaluated the potential of the MMS Corrective Maintenance data base for equipment performance trend analysis using a dBase III Plus program we designed for this purpose. We analyzed data for the period from August 1, 1989, through July 31, 1990, collected from the Atlanta, Chicago, and Seattle en-route centers. Our analysis of

[1] Air Traffic Control: The Interim Support Plan Does Not Meet FAA's Needs (GAO/RCED-90-213, Sept. 11, 1990).

the Corrective Maintenance data base focused on equipment components that center engineers and technicians had reported in FAA surveys as being problems. We discussed MMS' capabilities with the headquarters program office responsible for that system and with MMS users at the en-route centers. We also discussed the potential uses for MMS with FAA's Systems Engineering and Integration contractor and reviewed the preliminary results of the contractor's analysis of FAA maintenance data bases.

We conducted our review between May 1990 and March 1991 in accordance with generally accepted government auditing standards.

Major Contributors to This Report

Resources, Community, and Economic Development Division, Washington, D.C.	Robert E. Levin, Assistant Director Robert D. Wurster, Assignment Manager Kathleen Johnson, Staff Evaluator
Atlanta Regional Office	Ray B. Bush, Evaluator-in-Charge Jerry K. Marvin, Site Senior James B. Michels, Staff Evaluator Cheri Y. White, Staff Evaluator

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