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Report to the Chairman, Subcommittee on Transportation and Related Agencies, Committee on Appropriations, U.S. Senate

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AIR TRAFFIC CONTROL

Computer Capacity Shortfalls May Impair Flight Safety

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GAO

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Information Management and
Technology Division

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The Honorable Frank R. Lautenberg
Chairman, Subcommittee on Transportation
and Related Agencies
Committee on Appropriations
United States Senate

Dear Mr. Chairman:

In response to your request, we assessed the Federal Aviation Administration's actions to reduce near mid-air collisions. This report discusses the agency's management of air traffic control computer systems in terminal areas and whether computer capacity limitations could preclude effective implementation of planned safety enhancements intended to reduce near mid-air collisions. Under separate cover, in response to the same request, GAO has provided you with our report on the location and frequency of near mid-air collisions.

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 the Secretary of Transportation; the Administrator, Federal Aviation Administration; the Director, Office of Management and Budget; interested congressional committees; and other interested parties. Copies will be made available to others upon request.

This work was performed under the direction of Samuel W. Bowlin, Director, Defense and Security Information Systems. Other major contributors are listed in appendix I.

Sincerely yours,

Ralph V. Carlone

Ralph V. Carlone
Assistant Comptroller General

Executive Summary

Purpose

The Federal Aviation Administration (FAA) is responsible for the safe, orderly, and expeditious flow of civilian and military aircraft. FAA uses computer, radar, and communications systems to help accomplish this mission. Numerous reports of near mid-air collisions occur annually, especially in airspace near airports. The Chairman, Senate Committee on Appropriations, Subcommittee on Transportation and Related Agencies, has expressed concern about whether the capacity of FAA computer systems is sufficient to minimize the possibility of near mid-air collisions. He therefore asked GAO to evaluate these computer systems and determine whether they can accommodate planned safety enhancements.

Background

Air traffic controllers at FAA's Terminal Radar Approach Control (TRACON) facilities sequence and separate aircraft arriving at or departing from airports under their control. Controllers maintain safe distances between controlled aircraft using information processed by computers and displayed on video screens. Controlled aircraft must follow rules regarding where they may fly, file flight plans, communicate with controllers, and carry FAA-prescribed electronic equipment. Required equipment for controlled aircraft includes a Mode C transponder to transmit altitude and identity information. Uncontrolled aircraft are also required to follow rules regarding their flights, but are not required to file flight plans, communicate with controllers, or carry Mode C transponders except in specified airspace.

FAA plans to implement additional safety improvements to reduce near mid-air collisions. Among these are an expanded Mode C transponder rule that, beginning July 1, 1989, requires all aircraft to use Mode C transponders within a 30-mile radius of airports controlled by 23 high-density TRACONS. FAA expects about 44,000 additional aircraft to equip with Mode C transponders due to the rule. Effective December 30, 1990, aircraft at altitudes from 1,200 to 10,000 feet in airspace surrounding 116 additional airports will also be required to use Mode C transponders. To accommodate expected air traffic growth and to implement safety enhancements, FAA plans to award a contract by September 30, 1989, to acquire additional computer capacity.

Federal Information Resources Management Regulations require government agencies to conduct capacity management activities in planning for and acquiring computer resources. Such activities are important because they provide agencies with information about 1) the computer capacity current operations are using and 2) the additional computer capacity needed to support increased automation. Capacity management includes

activities such as collecting and analyzing detailed performance data on computer operations.

Results in Brief

Existing computer capacity shortfalls at some large, busy TRACONs are impairing controllers' ability to maintain safe separation of aircraft. Many TRACONs reported to GAO that they had experienced instances of aircraft position and identification information disappearing from controllers' displays, data flickering on the displays, and computer responses to controllers' attempts to update or request data being delayed.

Additional work load requirements resulting from the expanded Mode C requirement now threaten to exacerbate the capacity problems experienced by busy TRACONs. FAA plans to buy additional capacity to address existing shortfalls and meet future requirements. However, due to its lack of a computer capacity management program, FAA does not know if this action will remedy problems because it has not adequately analyzed current work loads or determined future requirements.

Principal Findings

Lack of Capacity Management Led to Computer Shortfalls

Computer capacity shortfalls at terminal area facilities are widespread. FAA did not recognize these capacity shortfalls until controllers began experiencing lost, flickering, or delayed data on their displays. These shortfalls occurred because FAA lacked a computer capacity and performance management program to monitor TRACON system performance and determine future requirements. Although GAO reported in 1983 that FAA should establish such a program, the agency concluded this was unnecessary because it believed that existing systems would meet requirements until replaced by an advanced system in the 1990s.

To temporarily alleviate current shortfalls at some locations, FAA has revised software, added features to reduce work loads, and postponed some less critical functions, such as training, until peak traffic loads have subsided. However, an effective computer capacity and performance management program is needed to identify current capacity problems and accurately predict future shortfalls.

Planned Safety Enhancements May Exacerbate Capacity Shortfalls

Current system overloads caused by heavy work loads may be increased by additional requirements resulting from the expanded Mode C requirement. This would further impair controllers' ability to maintain safe distances between airplanes. FAA recognizes it needs more capacity at its busiest TRACONs and therefore, plans to buy additional equipment. This equipment is scheduled to be delivered beginning in October 1990. However, because basic capacity management information is not available, it is unclear whether this additional equipment will meet FAA's needs.

Recommendations

GAO recommends that the Secretary of Transportation direct the FAA Administrator to take actions to ensure that critical air traffic control functions are not interrupted by capacity shortfalls. Initially, this involves gathering and reporting important capacity-related data, identifying quickly those TRACONs that have the most urgent problems, and, in concert with TRACON officials, identifying potential solutions to the problems. Identification of potential solutions should include considering approaches that have been successfully used at selected TRACONs, as well as other measures to reduce work loads. Once the optimal solutions have been determined, the FAA Administrator must take effective action to implement them.

In addition, GAO recommends that the Secretary direct the FAA Administrator to implement a computer capacity and performance management program for TRACON computer systems. This program should include analyzing trends in data processing work loads to determine when existing system capabilities will be saturated and conducting comprehensive analyses of the utilization, processing capacity, and input/output rates of present and projected work loads. Analyses of future work loads should include the full impact of the expanded Mode C rule.

GAO also makes other recommendations that are discussed in Chapter 4.

Views of Agency Officials

The views of FAA officials were obtained on the key facts, conclusions, and recommendations contained in this report. These officials generally concurred with the results of the review. Their views are incorporated throughout the report as appropriate. As requested, GAO did not obtain official written comments on a draft of this report.

Contents

Abbreviations

ARTS	Automated Radar Terminal System
FAA	Federal Aviation Administration
GAO	General Accounting Office
IMTEC	Information Management and Technology Division
TRACON	Terminal Radar Approach Control

Introduction

The Federal Aviation Administration (FAA) is responsible for the safe and efficient use of the nation's airspace. Although air travel is generally safe, numerous near mid-air collisions are reported annually, especially in areas near airports, or terminal airspace. FAA has implemented features in its air traffic control computer systems at terminal control facilities to promote safety and reduce the possibility of near mid-air collisions. Also, the agency plans to add other safety enhancements to diminish further the likelihood of near mid-air collisions.

Air Traffic Control

FAA's air traffic control mission is to promote the safe, orderly, and expeditious flow of civilian and military aircraft. To accomplish this mission, air traffic controllers communicate weather information, instructions, and clearances to pilots and other personnel; maintain safe distance between airplanes; and guide aircraft departures and approaches. Controllers maintain separation between aircraft using information processed by computers and displayed on video screens at their workstations. The information displayed on controllers' screens can include airplanes' identity, position, altitude, speed, and direction. This information is known as a data block. Additional information such as a flight's route, destination, and expected arrival time is provided to controllers on paper.

Controlled and Uncontrolled Aircraft

Aircraft supervised by controllers are known as controlled aircraft and operate under instrument flight rules. This means that each flight is followed from takeoff to touchdown by air traffic control to ensure that each flies in its own reserved block of airspace, safely separated from other traffic. Controlled aircraft must carry FAA-prescribed electronic equipment, including radios for communicating with controllers and a Mode C transponder, which provides aircraft altitude and identity to controllers. These aircraft must also file flight plans that detail the proposed journey, including arrival and departure airports and times, flight routes, and aircraft type. Commercial airlines are one example of controlled aircraft.

Uncontrolled aircraft are not controlled by the air traffic control system and generally operate under visual flight rules. This means they maintain their distance from other aircraft on a "see and avoid" basis. Although these aircraft are essentially outside the air traffic control system, they must follow well-established FAA rules governing where they can fly. Uncontrolled aircraft are not required to file flight plans

and, in certain airspace, are not required to communicate with controllers, carry radio equipment, or use Mode C transponders.

Near Mid-air Collisions

When two or more aircraft, either controlled or uncontrolled, come close to one another, pilots or other crew members may file a near mid-air collision report stating that a collision hazard existed. Because these reports are voluntary and reflect individual perceptions of the situation, they do not necessarily involve violations of separation requirements, air traffic controller errors, or even unsafe conditions. However, FAA considers these reports to be an indicator of the safety level of the air traffic control system.

FAA reviews every near mid-air collision report. These reviews, especially those involving air carriers, may include an analysis of computer-generated data if recorded at the controlling FAA facility. This type of data helps agency personnel assess the danger of the reported encounter.

Near mid-air collision reports have attracted increasing attention as the amount of aircraft in the skies has grown. With the deregulation of the airline industry, the number of commercial flights handled by air traffic control has grown significantly. For example, since 1982 the number of commercial flight operations has increased an estimated 48 percent and is expected to grow an additional 25 percent by the year 2000.

As discussed in our related report,[1] a total of 2,610 near mid-air collisions were reported to FAA for 1986 through 1988. The total number of reports in 1987 increased substantially from 1986 and then declined for 1988. The typical near mid-air collision involved one controlled and one uncontrolled aircraft; transpired between May and October; and happened most frequently in California, Texas, Florida, and Arizona. The majority of near mid-air collisions occurred in terminal airspace at altitudes below 5000 feet.

[1] Air Traffic Control: FAA's Interim Actions to Reduce Near Mid-air Collisions, (GAO/RCED-89-149, June 30, 1989).

Terminal Control Facilities: Automation and Safety Enhancements

To maintain a safe distance between aircraft in congested terminal airspace, FAA has established Terminal Radar Approach Control (TRACON) facilities.[2] At the 63 largest TRACONs, controllers sequence and separate aircraft arriving at or departing from the nation's busiest airports. Some of these facilities control traffic for more than one airport. Each of the 63 TRACONs is supported by a computer system known as an Automated Radar Terminal System (ARTS) IIIA.[3] These ARTS IIIA systems provide essential aircraft position and flight plan information to controllers. The system's computers receive input from radar, identify and track aircraft, associate the aircraft with flight plans, provide safety warnings, and display aircraft identification and position location to controllers.

To improve safety and reduce the incidence of near mid-air collisions, FAA has installed several safety enhancements in its computer systems at these TRACONs, including:

- Conflict alert, which aids controllers by detecting potentially hazardous situations where two controlled aircraft may come too close to each other within the next 40 seconds. In these instances, the system alerts controllers by sounding an alarm and flashing symbols on the display.
- Minimum safe altitude warning, which alerts controllers when an aircraft is flying too low.

Most of the large TRACON computer systems have been recently upgraded to provide other enhancements, such as displaying ground speed information for transponder-equipped uncontrolled aircraft. FAA plans to provide all ARTS IIIAs with this upgrade by Summer 1989.

Future Safety Enhancements

FAA plans to implement two additional automation-related enhancements that are expected to improve safety at TRACONs—Mode C Intruder beginning in 1993 and an expanded Mode C transponder rule, beginning in July 1989. Mode C Intruder is a warning designed to indicate when the distance between a controlled and an uncontrolled aircraft will become hazardous within the next 40 seconds. Mode C Intruder is similar to the conflict alert function in that it will alert the controller when two aircraft are dangerously close. Mode C Intruder differs from conflict alert

[2]FAA also maintains 22 Air Route Traffic Control Centers, which control air traffic that is enroute between airports, and 122 smaller Terminal Radar Approach Control facilities, which control traffic at less busy airports. Each of these facilities is supported by an automated system to help controllers maintain aircraft separation.

[3]The New York facility, the busiest of the 63 large TRACONs, is supported by a unique ARTS IIIA configuration that has enhanced capabilities beyond those provided by the other ARTS systems.

in that it will monitor one controlled and one uncontrolled Mode C-equipped aircraft, rather than two controlled aircraft.

The expanded Mode C transponder rule, beginning in July 1989, requires aircraft to carry an operating Mode C transponder when flying near designated high-volume airports and in other airspace above 10,000 feet. FAA issued the rule in June 1988, due to a congressional mandate[4] and an earlier National Transportation Safety Board recommendation. After investigating the August 1986 mid-air collision in Cerritos, California, between a controlled and an uncontrolled non Mode C-equipped aircraft, the Board recommended that FAA require all aircraft in terminal control areas to carry altitude-reporting Mode C transponders to provide controllers with altitude information.

FAA's expanded rule will be implemented in two phases. Phase I, effective July 1, 1989, requires a Mode C transponder for all aircraft operating at and above 10,000 feet; the transponder is already required at and above 12,500 feet. Aircraft are also required to carry an operating Mode C transponder at all altitudes within a 30-mile radius of airports in 23 high-density terminal control areas. Phase II, effective December 30, 1990, will require a Mode C transponder at altitudes from 1,200 to 10,000 feet in the airspace surrounding 116 other designated airports.

To accommodate the expanded Mode C rule and the Mode C Intruder function, and to provide adequate computer capacity to meet forecasted traffic increases, FAA will need to enhance TRACON computer systems. Therefore, FAA plans to award a contract by September 30, 1989, to sustain and enhance the existing systems until they are scheduled to be replaced by an advanced system in the mid-to-late 1990s.

Objectives, Scope, and Methodology

The Chairman, Senate Committee on Appropriations, Subcommittee on Transportation and Related Agencies, expressed concern about the capability of FAA's computer systems to minimize the possibility of near mid-air collisions. Therefore, as agreed with his office, our objectives were to (1) evaluate how FAA currently manages computer capacity in existing terminal systems, and (2) determine if FAA has assessed capacity limitations in terminal systems that could preclude effective implementation of planned safety enhancements.

[4]49 U.S.C.A. App. 1421(f)(3) (West Supp. 1989).

To evaluate how FAA manages computer capacity in existing terminal systems, we reviewed agency and contractor capacity studies, interviewed FAA and contractor officials to determine capacity management plans, sent surveys to 62 TRACONs to identify the extent of adverse effects resulting from site specific capacity shortfalls, and reviewed agency documents describing plans for eliminating capacity shortfalls. We did not send a survey to the New York TRACON because it has a unique system configuration that has enhanced capabilities beyond those provided by the other ARTS systems.

To determine if FAA has adequately assessed computer capacity limitations in terminal area control systems that could preclude effective implementation of enhancements, we reviewed FAA, National Transportation Safety Board, and Congressional Research Service documents describing the expanded Mode C transponder rule. We evaluated FAA and contractor studies estimating the capacity impact of the expanded Mode C rule and interviewed agency and contractor officials regarding existing shortfalls and potential overloads resulting from the rule. We also reviewed agency documents describing implementation of the Mode C Intruder enhancement and plans to sustain the terminal area control computer systems until the mid-to-late 1990s. We discussed FAA's acquisition plans with Department of Transportation and General Services Administration officials. We met with FAA and contractor officials to determine how existing systems could be expanded to accommodate the Mode C Intruder function. We also discussed the planned implementation of safety enhancements with staff at the FAA Technical Center, selected TRACONs, and Air Route Traffic Control Centers.

We performed our work at FAA headquarters in Washington, D.C.; the FAA Technical Center in Pomona, New Jersey; FAA regional offices in Jamaica, New York and Hawthorne, California; TRACON facilities in California, Minnesota, New York, Texas, and Washington, D.C.; Air Route Traffic Control Centers in Palmdale, California, and Ronkonkoma, New York; the Department of Transportation in Washington, D.C.; the General Services Administration in Washington, D.C.; the National Transportation Safety Board in Washington, D.C.; Martin Marietta Corporation in Washington, D.C.; UNISYS Corporation in St. Paul, Minnesota; and MITRE Corporation in McLean, Virginia.

Our review was performed from June 1988 to June 1989. We conducted our review in accordance with generally accepted government auditing standards. The views of FAA officials were obtained on the key facts,

conclusions, and recommendations contained in this report. These officials generally concurred with the results of our review. Their views are incorporated throughout the report as appropriate. As requested, we did not obtain official written comments on a draft of this report.

Existing Computer Capacity Shortfalls at TRACONs Are Significant

FAA recently recognized that computer capacity shortfalls existed when aircraft position and identification information began vanishing from controller displays, aircraft data flickered on displays, and system responses to controller changes or updates to flight information were delayed. These capacity problems occurred primarily because FAA has not had a capacity planning and management program for its TRACONs that would have predicted shortfalls before they occurred. FAA has taken actions at some TRACONs to temporarily alleviate current shortfalls. However, an effective computer capacity and performance management program is needed to identify and address fully both current and future problems.

Processing Shortfalls Affect Air Traffic Control

The computer system's most critical air traffic control function is calculating and displaying the position of aircraft to the controller. For each controlled aircraft, alpha-numeric information appears on the controller's display. This information includes identity, destination, altitude, speed, and direction. Similar data blocks for uncontrolled aircraft appear on the displays but may not contain information such as speed and destination. Aircraft are detected by radar and processed by the computer as they appear in a segment of the radar sweep known as a sector. All data for a sector should be processed before the computer begins to calculate aircraft positions in the next sector. However, if many aircraft are in one sector, the computer can eventually become overloaded resulting in the loss of information, known as sector loss. Sector loss affects the processing or displaying of aircraft information such as speed or altitude. According to a controllers' representative, the loss of altitude information in a high-density traffic area can be a critical problem. He added that "... the potential loss of the entire data block is a dangerous distraction under the best conditions and a disaster in the making under the worst of circumstances."

To identify whether TRACONs were experiencing computer overloads, we requested information from FAA headquarters regarding the frequency of the adverse effects of capacity shortfalls. However, headquarters officials were unable to provide this information because FAA does not require TRACONs to accumulate or report such data. Therefore, in order to obtain some information on whether computer overloads were occurring, we surveyed 62 TRACONs; 57 of them responded to our survey.

Twenty-seven of the surveyed TRACONs, or 47 percent, reported that their controllers had experienced sector loss due to processing shortfalls, resulting in the disappearance of aircraft information from

controllers' displays. A recent example involves a busy TRACON where on October 7, 1988, during the late Friday afternoon rush hour, aircraft position and identity information, including altitude, speed, and direction, disappeared from all controllers' screens for 16 consecutive minutes. According to the TRACON area manager, heavy traffic overloaded the computer, preventing it from keeping up with traffic demand. This caused severe concern to everyone on duty. To maintain safety, controllers reduced air traffic by holding departures on the ground and keeping arrivals outside of terminal airspace boundaries. They also maintained voice contact with aircraft already under their control.

At another very busy TRACON, an agency official said that several instances of sector loss had recently occurred for 15 to 20 minutes at a time. During these instances, position and identification information disappeared from controllers' displays, reappeared, and then disappeared again. At these times, the official said that other non-critical processing functions were halted to reduce the computer's work load, which then permitted the information to reappear on displays. The official emphasized that, even with the loss of data, controllers were able to maintain safe separation of aircraft through voice contact with pilots.

Twenty-eight TRACONs reported data blocks flickering on controllers' screens. Displays are designed to update data block information 30 times each second. When the processing load is such that updating information occurs less often, data blocks begin to flicker. This flickering can lead to confusing and obscured information being presented to controllers.

Another result of insufficient processing capability can be delayed keyboard responses when controllers attempt to input or request information. These delays can occur during heavy traffic, when the computer performs other functions before responding to keyboard entries.

Delayed keyboard responses were reported at 19 of the TRACONs responding to our survey. For example, TRACON officials reported that during busy periods, full data blocks often remained on the displays after controllers attempted to delete or transfer them to another controller. When controllers are busy, repeated attempts to delete or move the data block can distract them from their primary air traffic control duties.

No Capacity Management Program Existed

These data losses and other display problems have occurred mainly because FAA has lacked a capacity and performance management program for TRACON computer systems. Such a program is important to ensure maximum use of existing resources and adequate capacity for growth. Further, the Federal Information Resources Management Regulation Part 201-30 requires agencies to perform capacity management activities in planning, acquiring, and using computer resources.

An effective capacity management and performance monitoring program needs to address both performance management and capacity planning. Performance management involves analyzing the performance of computer systems to determine how resources are currently utilized and how such utilization can be improved. Capacity planning assists in forecasting computer resource requirements to ensure that enough capacity exists when needed.

In 1983,[1] we reported that FAA should implement a computer performance management function to measure terminal systems' efficiency and effectiveness because the capacities of these systems were not known and system behavior could not be adequately predicted. We also stated that delays in replacing existing equipment would require these systems to operate longer than anticipated and could result in decreased services due to capacity shortages. Our report recommended that FAA establish a comprehensive organization that could improve the agency's ability to (1) acquire and use computer resources effectively and efficiently, and (2) provide management with timely computer performance information. Although FAA established an Information Resources Management Office in 1984, this office does not address air traffic control computer systems, such as the ARTS IIIA systems at large TRACONS. Further, FAA did not establish a capacity management program for TRACONs because it believed that the ARTS IIIA systems could meet requirements until replaced by an advanced system in the 1990s.

[1] FAA's Plans to Improve The Air Traffic Control System: A Step In The Right Direction But Improvements And Better Coordination Are Needed, (GAO/AFMD-83-34, Feb. 16, 1983).

FAA's Attempts to Measure Computer Capacity Have Been Inadequate

Without a computer capacity and performance management program, FAA's assessments of computer capacity at large TRACONs have been limited. These assessments have focused primarily on measuring computer storage or track capacity.[2] While such measurements provide some useful information on available storage capacity, they do not give a complete picture of computer performance, primarily because computer utilization has not been adequately measured. Without utilization information, FAA cannot determine the system's ability to process data and display information to controllers in a timely manner.

FAA has begun to recognize the importance of monitoring system performance and computer utilization. For example, FAA recently tasked UNISYS Corporation to develop software to monitor system performance for ARTS IIIA systems. This performance monitor is intended to provide FAA with information on computer utilization at selected TRACONS. Although initial operational testing of the monitor began at two sites in June 1989, this testing has now been delayed to fix software problems with the monitor. As of June 1989, the agency anticipates that the monitor will become operational at all sites about November 1989.

Testing of New Software Has Been Inadequate

An effective capacity and performance management program requires planning and testing of enhancements to ensure that they will not overload systems. However, FAA has not always tested software enhancements in representative scenarios. The FAA Technical Center has the key role in testing enhanced software functions to ensure that they operate effectively and do not overload computer systems. When tests are successfully completed at the Center, the enhanced software is distributed nationally. However, the Center's system configuration and the simulated traffic loads used in testing software do not always represent the configuration or the traffic loads at the busiest operational TRACON sites.

Many TRACONS have more displays than the Center's test configuration and far more traffic than represented by the test scenario. Therefore, software that was successfully tested at the Center, when placed in an operational facility, does not always accommodate the traffic loads or operate efficiently at all locations. For example, when one TRACON attempted to use an updated version of software that had been successfully tested, controllers regularly experienced sector loss. This occurred

[2]A track occupies a portion of memory in the air traffic control computer. A track can hold data on controlled aircraft, uncontrolled aircraft, false target radar reports, aircraft detected by radar but not yet associated with a flight plan, and flight plans for aircraft not yet detected by radar.

because this TRACON's computers had a greater work load than many other sites. Specifically, the TRACON controlled many airports, had more displays, and had heavier traffic than many other locations.

FAA's Interim Attempts to Alleviate Capacity Shortfalls

To alleviate immediate capacity shortfalls that existed at some TRACONs, FAA has provided more efficient software and implemented a software feature that may be used to decrease system work load. Some TRACONs also postponed less important functions during periods of peak traffic.

FAA addressed capacity problems at one TRACON by improving some software features to improve efficiency. Therefore, according to FAA, additional information could be processed and sector loss has not occurred recently. However, according to FAA, software improvement, by itself, will not be enough to guarantee that increasing traffic loads can be handled. Further, these modifications have not been implemented at all TRACONs with capacity shortfalls.

FAA has also begun implementing a software feature called range/azimuth gating, which is currently operational at selected TRACONs and is scheduled for implementation at the remaining locations in November 1989. Intended to be used only during heavy traffic, this feature limits the display of aircraft to only that airspace that the TRACON is currently controlling, thereby reducing the computer work load.

Other procedures have also been used to alleviate capacity shortfalls. For example, controller training has been postponed at some TRACONs during periods of heavy traffic. Because site specific controller training is conducted on the same system at the same time that traffic is being controlled, system resources are shared between training and air traffic control. Therefore, eliminating training during busy periods provides some relief from capacity shortfalls. In addition, during periods of heavy traffic, some TRACONs delay accepting and storing flight plans until just before an aircraft enters the facility's airspace. This helps alleviate track storage problems, but does not affect processing capacity shortfalls.

In June 1989, FAA headquarters officials also stated that they plan to inform appropriate field personnel about potential capacity shortfalls and advise them about using the range/azimuth gating feature to reduce

work loads. Officials believe this will help alleviate capacity shortfalls. However, an effective computer capacity and performance management program is needed to identify current problems and accurately predict future requirements.

Planned Safety Enhancements May Exacerbate Capacity Shortfalls

FAA has not adequately determined the impact of future work load requirements, such as the expanded Mode C requirement, on its already overburdened TRACON computer systems. As a result, computer overload may be exacerbated by the increased work loads resulting from these additional requirements, which would further impair controllers' ability to control airplanes safely. Recognizing this dilemma, FAA plans to buy more equipment to provide additional capacity, in order to address current TRACON shortfalls and meet future work load requirements. However, the planned expansion may not provide enough capacity at all TRACONS because FAA does not know the current and future work load requirements.

FAA Has Not Adequately Determined Future Requirements

Because FAA does not have a capacity management program, there is insufficient data on current utilization to serve as a baseline for determining future requirements. Further, FAA's assessments of the impact of future safety enhancements, such as Mode C Intruder and the expanded Mode C rule, have also been inadequate.

In May 1988, FAA tasked a contractor to analyze future ARTS IIIA requirements, including the Mode C Intruder function. The contractor concluded that at least one additional processor was needed at each location to implement Mode C Intruder. However, the contractor's analyses were based on two sites that were not among the sites with the heaviest work loads. Therefore, the contractor did not estimate the impact of using Mode C Intruder software at those sites that have experienced capacity shortfalls.

Expanded Mode C Requirement Will Increase Computer Work Loads

Effective July 1, 1989, Mode C transponders are required on all aircraft within a 30-mile radius of 23 terminal control areas, from the surface to 10,000 feet. FAA anticipates that about 44,000 additional general aviation aircraft will equip with Mode C transponders due to the requirement. Since ARTS IIIA systems track all transponder-equipped aircraft, the problem of inadequate computer capacity at these TRACONS may be exacerbated by this requirement. However, as noted, FAA does not yet adequately know how this increase will affect TRACONS' processing capability. In developing the transponder requirement, FAA concluded that the resulting work load could be handled by its ARTS IIIA systems. This conclusion was based on a June 1988 study conducted to address the Associate Administrator for Air Traffic's concerns that Mode C requirements could adversely affect computer capacity. The June 1988 study

concluded that expanded Mode C requirements would cause no immediate impact on system capacity. However, it also indicated that as traffic increases, the system may incur data loss and display flicker earlier than previously predicted.

The June 1988 study's conclusions raised concern among air traffic officials. In December 1988, these officials issued a memorandum recommending that FAA delay the mandatory Mode C requirement until capacity was expanded. The memorandum stated that previous studies supporting the June 1988 study were based on faulty logic and incomplete analysis. For example, the study did not reflect the current situation, where some sites need more capacity just to meet current work loads.

Senior FAA officials said that they believe that all general aviation aircraft flying in terminal airspace affected by the requirement may not equip with transponders by July 1, 1989. Further, according to FAA officials, it is possible for pilots to request waivers from the rule, by meeting specific operating or aircraft conditions. FAA expects that these waivers and pilot delays in responding to the rule will mitigate additional capacity shortfalls.

Recognizing the potential impact of the rule, FAA has recently initiated studies of the work loads that could result. However, these studies are still in process and have generated very limited data to date. Nevertheless, FAA plans to proceed with implementation of the requirement, irrespective of current capacity deficiencies.

Plans for Capacity Expansion

FAA recognizes that more capacity is needed at TRACONS to address current shortfalls and to meet future work load requirements. Therefore, it plans to award a sole-source contract to UNISYS Corporation by September 30, 1989, at a cost of up to several hundred million dollars. The contract is expected to include refurbishing computer equipment, replacing existing memories with high-speed solid state memories, providing about 140 displays, acquiring up to 300 ARTS computers, and providing Mode C Intruder software. FAA anticipates that solid state memories will be delivered beginning in October 1990 and processors and displays beginning in April 1991.

In deciding to award a sole-source contract to UNISYS, FAA concluded that developing and acquiring a new system at this time would take too much time and be too costly, in view of plans for an advanced system to

replace terminal computer systems in the mid-to-late 1990s. In particular, FAA concluded that rewriting new software in order to buy processors currently marketed would be too time-consuming and costly. Therefore, FAA is planning, through the UNISYS contract, to expand current system configurations to their maximum design limit. This expansion will require FAA to buy older processors similar to the existing TRACON processors because the system software can only operate on the current hardware. To supply the outdated processors, UNISYS will have to restart a production line because these computers, developed in the late 1960s, have not been manufactured since the mid-1970s.

Conclusions and Recommendations

Conclusions

Computer capacity shortfalls at TRACONs have led to aircraft information vanishing from controllers' screens, flickering displays, and slow system responses. Almost 70 percent of the TRACONs responding to our survey indicated that controllers have experienced one or more of these problems. The depth of this problem is alarming in view of the critical nature of air traffic control.

Because it has not developed a computer capacity management program, FAA did not recognize these capacity shortfalls until controllers began experiencing problems. FAA has not been measuring computer utilization and as a result, cannot predict when and where capacity shortfalls will occur. Further, the agency has not tested software enhancements in scenarios that represent conditions and traffic at TRACONs with the heaviest work loads. FAA has attempted to alleviate current capacity shortfalls at some TRACONs by improving software and postponing functions such as training.

FAA has also not adequately assessed what resources are necessary to accommodate future traffic growth, the Mode C Intruder function, and additional Mode C-equipped aircraft. Although some studies were performed to determine future requirements, these do not provide sufficient information to identify future needs because they did not analyze or project needs for the busiest facilities.

FAA's expanded Mode C requirement in terminal areas may exacerbate computer capacity problems at some TRACONs because having more aircraft equipped with Mode C transponders will place a greater work load on these systems. Although FAA believes that existing systems can accommodate the additional work load, current shortfalls suggest that the busiest TRACONs will experience additional problems. Rather than fully assessing how the expanded Mode C rule will affect TRACON computer capacity, FAA is expecting uncontrolled aircraft to request exemptions from the rule. This expectation does not provide adequate assurance that problems will not become more severe after July 1, 1989, especially at sites with current shortfalls.

FAA now finds itself in a difficult situation. To increase computer capacity, it is committed to a sole-source contract, which includes the purchase of equipment that is no longer manufactured. This procurement is not an ideal solution. However, under the circumstances, where there is a critical need to increase capacity, a full analysis of other alternatives to meet this immediate need and the resulting potential development of new systems may not be practical. However, to meet the requirements of

the TRACONs through the 1990s and possibly beyond, an analysis of other viable alternatives is needed to ensure that future capacity will be adequate to support anticipated work loads.

Recommendations

Because of the importance of air traffic control, the Secretary of Transportation and the FAA Administrator need to act quickly to remedy computer capacity shortfalls. To address existing shortfalls that currently threaten the ability of controllers to maintain separation of aircraft, we recommend that the Secretary direct the FAA Administrator to take necessary actions to ensure that critical air traffic control functions are not interrupted by capacity shortfalls. Initially, this involves gathering and reporting important capacity-related data, identifying quickly those TRACONs that have the most urgent problems, and, in concert with TRACON officials, identifying potential solutions to the problems. Identification of potential solutions should include considering those temporary measures that have been successfully used at selected TRACONs, as well as other approaches to reduce work loads. Once optimal solutions have been determined, the FAA Administrator must take effective action to implement them.

Subsequent to the above immediate actions, we recommend that the Secretary direct the FAA Administrator to implement a computer capacity and performance management program for TRACON computer systems. This program should include

- analyzing trends in data processing work loads to determine when existing system capabilities will be saturated, and
- conducting comprehensive analyses of the utilization, processing capacity, and input/output rates of present and projected work loads. Analyses of future work loads should include the full impact of the expanded Mode C rule.

In addition, as part of this program, the FAA Administrator needs to ensure that the FAA Technical Center test facility uses configurations that more accurately replicate the processors, displays, and traffic at the busiest operational sites to ensure that approved software functions will work.

After implementing the above program and identifying the work load requirements for TRACONs, we recommend that the Secretary direct the FAA Administrator to ensure that all future procurements of hardware and software are determined by these requirements.

Because a new advanced system is not scheduled to replace existing TRACON systems until the mid-to-late 1990s, we also recommend that the Secretary direct the FAA Administrator to perform a complete analysis of all available alternatives for meeting the larger TRACONs' air traffic requirements for at least the next 10 years. Recognizing that the existing ARTS IIIA system design is over 15 years old, this analysis should seek to identify the most cost-effective solution for meeting FAA's requirements.

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