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*Office of Inspector General*

***Audit Report***

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*Status Review of the Host and Oceanic  
Computer System Replacement Program*

*Federal Aviation Administration*

*Report Number: AV-2000-042*

*Date Issued: February 4, 2000*





U.S. Department of  
Transportation  
Office of the Secretary  
of Transportation  
Office of Inspector General

# Memorandum

Subject: **ACTION:** Status Review of the Host and  
Oceanic Computer System Replacement Program  
Report No. AV-2000-042

Date: February 4, 2000

From: Alexis M. Stefani  
Assistant Inspector General for Auditing

Reply To

Attn Of: JA-10:366-0500

To: Federal Aviation Administrator

This report presents the results of our review of the status of the Host and Oceanic Computer System Replacement Program (the Replacement Program). These computers receive, process, and track aircraft movement throughout the domestic and oceanic airspace. We are providing this report for your information and. In preparing this report, we provided periodic briefings to your staff and considered their comments.

The Federal Aviation Administration (FAA) structured the Replacement Program into four phases to reduce schedule risk, potential Year-2000 concerns, and end-of-service-life supportability issues. Phase 1 replaced the computer processors at 20 domestic en route centers and 3 oceanic and offshore sites<sup>1</sup> before the Year 2000. Phase 2 upgrades the system software, and Phases 3 and 4 replace aging computer peripherals such as printers and tape drives and modify the associated software.

In May 1998, FAA's Joint Resources Council approved program lifecycle costs of \$607.3 million through Fiscal Year (FY) 2008. This includes \$424.1 million<sup>2</sup> in program costs from the Facilities and Equipment appropriation. Program costs are not broken out by phase. Instead, FAA developed the cost estimate by functional areas such as software, hardware, deployment, program management, overtime, and travel. In April 1999, FAA definitized a contract modification for the Replacement Program with Lockheed Martin Corporation. The contract modification included the work effort needed to complete Phases 1 and 2. Congress appropriated \$213.2 million through FY 2000 for the Replacement Program

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<sup>1</sup> The three oceanic and offshore sites are New York, Oakland, and Honolulu.

<sup>2</sup> The remaining \$183.2 million is for operations and maintenance, travel, and overtime.

## ***Objective and Scope***

The objective of our review was to monitor the status of the Replacement Program. We interviewed FAA program officials, reviewed the monthly program risk management database, monitored the status of completing Phase 1 before the Year 2000, and assessed program risks for completing Phases 2 through 4. We collected summary data on maintenance calls on Host peripherals for January 1998 through June 1999. In addition, we collected and analyzed data on unscheduled outages of the new computers after they were fully operational at each site. This review was conducted in accordance with the Government Auditing Standards prescribed by the Comptroller General of the United States.

## ***Results in Brief***

FAA completed Phase 1 of the Replacement Program on schedule, before the Year 2000. Air traffic controllers at 20 domestic en route centers and 3 oceanic and offshore sites are now using new computers. FAA met the challenge within an extremely tight timeframe. While there have been 28 Host outages since the new computers were operational, none of these outages were caused by new computer hardware or software.

FAA still needs to complete Phases 2 through 4 of the Replacement Program. Phase 2 upgrades the software to improve the operational efficiency of the new computer processors. Phase 2 software development is nearly complete. FAA still needs to finish testing and install the upgraded software at the en route and oceanic sites. Phases 3 and 4 will replace aging peripheral equipment, such as printers, storage devices, and tape drives. FAA faces program delays and software development risk in replacing aging peripheral equipment.

### ***Recent Host Outages Were Not Caused by New Computer Hardware or Software.***

Since February 1999, when the first en route center began using the new Host computers, FAA reported 28 unscheduled Host outages. None of the outages were traced to the new computer hardware or software. For example, on January 6, 2000, the Washington en route center experienced an outage after a routine daily system certification of the Host system. The error occurred in existing Host software that is used to perform daily system certification operations, not in the software developed for Phase 1. FAA is developing a correction for this problem and is monitoring the Host system to prevent similar outages from occurring. The 28 outages since February 1999 were caused by 12 system operator errors, 7 errors in existing software, and 5 peripheral equipment failures. FAA was unable to identify the cause for four outages, but restarting the computer corrected the errors without additional problems.

FAA is taking action to reduce future Host outages. These actions include providing refresher training classes for all system operators, correcting software errors that caused the Host outages, and replacing aging peripheral equipment. Despite these unscheduled outages and associated inconveniences to the traveling public, nationwide Host system availability<sup>3</sup> was over 99.9 percent.

***Phase 2 Software Development Is Nearly Complete.*** Phase 2 upgrades the system operating instructions to improve the operational efficiency of the new computer processors. FAA completed Phase 2 software development for its en route centers and over 90 percent of the software development for the oceanic and offshore sites. Phase 2 involved more software development than Phase 1. Phase 1 required only 1,500 new source lines of code<sup>4</sup> for the en route sites and 3,885 source lines of code for the oceanic sites. Phase 2 software included about 33,370 source lines of code for the en route sites and 38,995 source lines of code for the oceanic sites. While FAA has nearly completed Phase 2 software development, it still needs to complete testing and install the upgraded software at the en route and oceanic sites.

***FAA Faces Program Delays and Software Development Risk in Replacing Aging Peripheral Equipment.*** FAA's plan to replace aging computer peripherals in Phases 3 and 4 by August 2001 will not be completed on schedule. FAA reduced program funding in FYs 2000 and 2001 from \$144.9 million to \$81.7 million, a 44 percent reduction. Funding was reduced to support higher priority programs within FAA, such as Free Flight Phase 1 and the Standard Terminal Automation Replacement System. Subsequent to making this funding decision, FAA completed an analysis of Host peripheral equipment on December 3, 1999, that determined how long each peripheral could be sustained, the best sustainment approach, and the corresponding risk of not replacing each peripheral. Using this analysis, FAA must now assign priorities to replace peripheral equipment and define its future funding needs to complete Phases 3 and 4. The revised priorities may change FAA's funding needs for Phases 3 and 4 or the time frame in which the funds will be needed.

*Replacing aging peripherals is important because Host peripherals are requiring more maintenance and can cause an unscheduled system outage if a peripheral item fails.* For example, on November 10, 1999, a Host peripheral, called a Keyboard Video Display Terminal, failed and eventually caused an 89-minute outage of the Host system at the Memphis center. FAA attributed 332 flight delays to this outage, which was 31 percent of the total flight delays nationwide for that day.

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<sup>3</sup> System availability is the percentage of hours that the system was available for operations compared to total facility operating hours. Our analysis considered only system availability due to unscheduled outages.

<sup>4</sup> "Source lines of code" is used to measure software size.

*FAA faces additional risk in Phases 3 and 4 because these phases require software development, which has historically been problematic to FAA. Software development is needed in Phases 3 and 4 to enable new hardware peripherals such as tape drives, printers, and storage devices to communicate with the Host and Oceanic computers. Since FAA has not yet updated plans for Phases 3 or 4 or selected the replacement peripherals, it does not know the extent of software development required for these phases. Therefore, FAA does not have an estimate of the source lines of code or know the associated risks.*

FAA plans to award a contract modification for Phases 3 and 4 to the existing Replacement Program contract with Lockheed Martin Corporation. This contract includes controls, such as earned value management<sup>5</sup>, to monitor the contractor's cost and schedule performance. In our December 21, 1999 report on Free Flight Phase 1<sup>6</sup>, we recommended that FAA negotiate provisions for earned value management in all future software development contracts and withhold payments if the contractor's use of earned value management is not adequate or progress is not commensurate with costs billed. Following these same principles, *FAA should include controls in the contract modification for Phases 3 and 4 to withhold payments if the earned value management techniques by the contractor are not adequate or progress is not commensurate with costs billed.*

### ***Recommendations***

FAA, using the results of the December 1999 analysis of Host peripherals, should assign priorities for replacing peripheral equipment and estimate future funding requirements for Phases 3 and 4. FAA should also include controls in the Phases 3 and 4 contract modification for withholding payments if the earned value management techniques by the contractor are not adequate or progress is not commensurate with costs billed.

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<sup>5</sup> Earned value management is a program management tool for measuring technical progress of a program, comparing that data to planned costs, and estimating how much the program will cost and when it will be delivered.

<sup>6</sup> Report on Management of Software Intensive Acquisitions for Free Flight Phase 1, FAA, Report Number AV-2000-028.

## *Observations*

***FAA Has Met the Challenge of Replacing Computer Processors on Schedule.*** In our March 1998 testimony<sup>7</sup>, we reported that FAA faced a significant challenge to replace computers at 20 domestic en route centers and 3 oceanic and offshore sites in less than 2 years, concurrently with repairing microcode on the existing processors. To its credit, FAA successfully delivered and installed new computers at 23 sites on schedule, and controllers are now using these new computers to control air traffic on a full-time basis. The hardware deliveries were completed in less than 13 months, and all 23 sites were fully operational by the end of September 1999, 18 months after FAA approved the program.

Since February 1999, when the first en route center began using the new Host computers, FAA reported 28 unscheduled Host outages. These 28 outages were caused by 12 system operator errors, 7 software related errors, and 5 peripheral failures. FAA was unable to identify the cause for four outages, but restarting the computer corrected the errors without additional problems. None of the outages were traced to the new computer hardware or software.

The most recent Host outage occurred on January 6, 2000, at the Washington en route center. This outage occurred because the Host computer system and a flight strip printer did not communicate as intended, after a routine daily system certification of the Host system. This caused the Host system to build up a backlog of flight plan print messages and led to the Host outage. The error occurred in existing Host software that is used to perform daily system certification operations, not in the software developed for Phase 1. FAA attributed 403 delays to this software error. Also, the Air Transport Association attributed 100 flight cancellations to this outage. FAA is developing a software update to prevent this error from occurring at other en route centers.

FAA is taking action to reduce Host outages. First, FAA is developing a refresher training class for all system operators. FAA officials stated that this refresher training would include training on operator errors that had previously caused Host outages. Second, FAA developed or is developing software updates for the existing software to prevent errors that caused Host outages from recurring. Software development for Phases 2 through 4 would not have prevented the seven software errors that caused Host outages. Third, FAA plans to replace aging peripheral

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<sup>7</sup> Air Traffic Control Modernization, testimony before the Subcommittee on Aviation, Committee on Transportation and Infrastructure, U.S. House of Representatives, on March 5, 1998 (Report No. AV-1998-089).

equipment and help reduce errors caused by peripheral failures. Despite these unscheduled outages and associated inconveniences to the traveling public, nationwide Host system availability<sup>8</sup> was over 99.9 percent..

***Software Development for Phase 2 Is Nearly Complete.*** Phase 2 upgrades the system operating instructions to improve the operational efficiency of the new processors. Phase 1 required only 1,500 new source lines of code for the en route sites and 3,885 source lines of code for the oceanic sites. Phase 2 software upgrades include about 33,370 source lines of code for the en route sites and 38,995 source lines of code for the oceanic sites.

All Phase 2 software development for *en route sites* was completed in February 1999. FAA completed key site testing at Salt Lake City in October 1999 and delivered the software upgrade to 20 en route sites on December 1, 1999. All en route sites are scheduled to be fully operational with the Phase 2 software upgrade by June 2000.

As of December 8, 1999, FAA completed software development for 36,364 of the 38,995 source lines of code (93 percent) for the *oceanic sites*. FAA plans to conduct Phase 2 oceanic software testing in July 2000, and the three oceanic and offshore sites are scheduled to be fully operational with the Phase 2 software upgrade by October 2000. However, FAA officials stated that they will delay installing software at the Honolulu site until FAA moves oceanic hardware to a new facility in January 2001. We plan to monitor FAA's efforts to complete the installation of Phase 2 en route software and the testing and installation of Phase 2 oceanic software.

***FAA Faces Challenges in Completing Phases 3 and 4.*** FAA's plan to replace aging peripherals in Phases 3 and 4 by August 2001 will not be completed on schedule. In addition, these phases involve software development, which has historically been problematic to FAA.

Replace Aging Peripherals. Phases 3 and 4 replace selected computer peripherals, such as printers and storage devices, and modify the National Airspace System software to operate with the peripherals. FAA had planned to replace a total of 13 peripherals at each of the 20 domestic en route sites and 3 oceanic and offshore sites by August 2001.

Replacing aging peripherals is important because a peripheral item failure can cause a system outage. Peripheral failures caused 5 of the 28 Host outages since the new computers were fully operational. For example, on November 10, 1999, a Host peripheral called a Keyboard Video Display Terminal failed and eventually caused

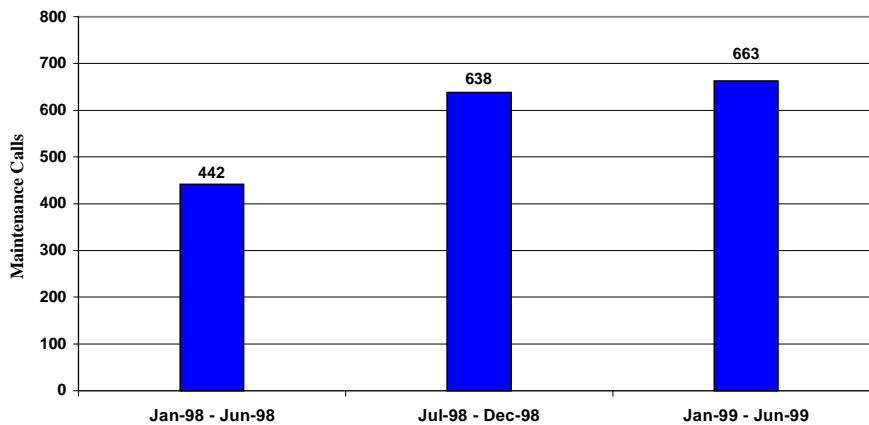
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<sup>8</sup> System availability is the percentage of hours that the system was available for operations compared to total facility operating hours. Our analysis considered only system availability due to unscheduled outages.

an 89-minute outage of the Host system at the Memphis center. According to the FAA report from the Memphis center, this outage led to 332 flight delays, which was 31 percent of the total flight delays nationwide for that day.

Computer peripherals that will be replaced during Phases 3 and 4 are requiring more maintenance and can cause similar outages if they fail. The following chart illustrates that computer peripherals are requiring increased maintenance attention.

### Host Peripherals Are Experiencing More Frequent Maintenance Calls



FAA’s data show that the number of maintenance calls, measured semiannually, increased from 442 during the 6-month period ended June 1998 to 663 during the 6-month period ended June 1999.

FAA had planned to replace the aging peripherals by August 2001 as shown on the following chart. However, FAA will not meet this time frame.

### Host and Oceanic Computer System Replacement Schedule Phases 2 through 4

Phase	Event	Event Date
Phase 2 (Software Upgrades)	Begin Software Development	March 1998
	Complete Software Installation at En route Sites	June 2000
	Complete Software Installation at Oceanic and Offshore Sites	September 2000
<b>Phases 3 and 4 (Peripheral Replacement)</b>	<b>First Site Operational (all peripheral equipment)</b>	<b>November 2000</b>
	<b>Last Site Operational (all peripheral equipment)</b>	<b>August 2001</b>
	Complete Sustainment and Technology Refresh	September 2008



FAA reduced funding for the Replacement Program by \$30.4 million in FY 2000 and \$32.8 million for FY 2001. According to the Deputy Program Director, FAA Requirements Development Directorate, program funding was reduced to support higher priority programs within FAA, such as Free Flight Phase 1 and the Standard Terminal Automation Replacement System.

The chart below compares the program baseline established in May 1998 to the current program budget and shows that FAA reduced program funding in FYs 2000 and 2001 from \$144.9 million to \$81.7 million, a 44 percent reduction. This reduction will have no impact on Phase 2 software upgrades, which were previously funded.

**Comparison of Program Funding**  
(Facilities and Equipment funding in millions)

<b>Funding</b>	<b>FYs 97-99</b>	<b>FY 00</b>	<b>FY 01</b>	<b>FY 02</b>	<b>FYs 03-08</b>	<b>Total</b>
May 1998 Baseline	\$158.5	\$85.2	\$59.7	\$23.0	\$97.8	\$424.1*
October 1999	158.4	54.8	26.9	\$23.0	130.9	394.0
<b>Difference</b>	<b>(0.1)</b>	<b>(30.4)</b>	<b>(32.8)</b>	<b>0.0</b>	<b>33.1</b>	<b>(30.1)</b>

\* May 1998 baseline total funding does not equal the sum of the yearly funding due to rounding.

Regardless of the funding reductions, FAA needed to assess options for sustaining Host equipment and better define their plans to replace aging peripherals. On December 3, 1999, FAA program officials completed an equipment analysis that determined how long each peripheral could be sustained, the best sustainment approach, and the corresponding risk of not replacing each peripheral. Using the results of their analysis, FAA must now assign priorities to replace peripheral equipment and define its future funding needs to complete Phases 3 and 4. The revised priorities may change FAA's funding needs for Phases 3 and 4 or the time frame in which the funds will be needed.

Software Development Risk. FAA faces additional risk in Phases 3 and 4 because these phases require software development. FAA has historically encountered problems in meeting program cost, schedule, and performance goals in acquisitions involving software development. Software development is needed in Phases 3 and 4 to enable new hardware peripherals such as tape drives, printers, and storage devices to communicate with the Host and Oceanic computers. Since FAA has not yet updated plans for Phases 3 or 4 or selected the replacement peripherals, it does not know the extent of software development required for these phases. Therefore, FAA does not have an estimate of the source lines of code or know the associated risks.

On September 30, 1999, FAA issued a task order to Lockheed Martin Corporation to assist FAA with identifying the technical approach for replacing peripheral equipment and assessing program risks for Phases 3 and 4. FAA plans to award a

contract modification for Phases 3 and 4 to the existing Replacement Program contract with Lockheed Martin Corporation. This contract modification would include the scope and work required to replace Host peripheral equipment and associated cost and schedule budgets. Program officials did not know when FAA would award the contract modification for Phases 3 and 4.

In our December 21, 1999 report on Free Flight Phase 1, we recommended that FAA negotiate provisions for earned value management in all future software development contracts and withhold payments if the contractor's use of earned value management is not adequate or progress is not commensurate with costs billed. The existing contract with Lockheed Martin includes controls, such as earned value management, to monitor the contractor's cost and schedule performance. FAA should add controls in the Phases 3 and 4 contract modification to withhold payments if the earned value management techniques by the contractor are not adequate or progress is not commensurate with costs billed.

### ***Recommendations***

We recommend that FAA:

1. Assign priorities for replacing peripheral equipment and estimate future funding requirements using the results of the December 1999 analysis of Host peripherals.
2. Include controls in the Phases 3 and 4 contract modification to withhold payments if the earned value management techniques by the contractor are not adequate or progress is not commensurate with costs billed.

### ***Action Required***

Please provide your written comments within 30 days on the specific actions taken or planned along with target dates for completing planned actions. We appreciate the courtesies and cooperation extended by your staff. If I can answer any questions or be of any further assistance, please contact me on 366-1992 or David A. Dobbs, Acting Deputy Assistant Inspector General for Aviation, on 366-0500.