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Audit Report

OFFICE OF THE INSPECTOR GENERAL

JET AIRCRAFT ENGINE DURABILITY

Report No. 95-050 December 9, 1994

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Report No. 95-050 December 9, 1994

MEMORANDUM FOR DEPUTY UNDER SECRETARY OF DEFENSE FOR LOGISTICS
ASSISTANT SECRETARY OF THE NAVY (FINANCIAL MANAGEMENT)
ASSISTANT SECRETARY OF THE AIR FORCE (FINANCIAL MANAGEMENT AND COMPTROLLER)
AUDITOR GENERAL, DEPARTMENT OF THE ARMY

SUBJECT: Audit Report on Jet Aircraft Engine Durability (Project No. 3LB-5007)

Introduction

We are providing this final report for your information and use. The audit was requested by a Senate Appropriations Committee staff member. In 1992, the Navy reported to Congress that there were durability problems with the F-404 engine used in its F/A-18 aircraft. Concerned about the durability of the F-404 engine and the durability of other jet engines used in DoD aircraft, the committee staffer requested the Inspector General, DoD, to review the durability of the F-404 engine and other DoD aircraft engines designed by the General Electric Company.

Audit Results

Our audit of three jet aircraft engines designed by General Electric showed that the Military Departments have experienced lower durability than predicted from various components in each jet aircraft engine. However, the Military Departments were aware of the reasons for the poor durability and were initiating corrective management actions. Special problems relating to the warranties of F-404 jet aircraft engine components, use of T700 engines beyond the manufacturer's recommended life limits, and use of an inspection program on the F-404 engine were addressed in separate Office of the Inspector General, DoD, reports issued during the audit.

Objectives

Our objective was to evaluate the durability of the DoD jet aircraft engines designed by General Electric. In addition, we evaluated the effectiveness of applicable internal controls.

Scope and Methodology

Review of Records. We reviewed and evaluated correspondence, records, and other documents, covering the period from FY 1979 to FY 1994, relating to the durability of jet aircraft engines designed by General Electric. This included the Navy F-404 engine (Pratt and Whitney also manufactured F-404 engines under license with General Electric), the Air Force F-101 engine, and the T-700 engine that is used by all three Military Departments. We held discussions with representatives from the Office of the Secretary of Defense, each of the Military Departments, and industry. Our methodology included evaluations of compliance with DoD Directive 5000.2, "Defense Acquisition Management Policies and Procedures," February 23, 1991. We did not validate the accuracy of computer-processed data supplied by the Military Departments.

Auditing Standards. This economy and efficiency audit was made from May 1993 through August 1994 in accordance with auditing standards issued by the Comptroller General of the United States as implemented by the Inspector General, DoD, and accordingly, included such tests of internal controls as were considered necessary. Organizations visited or contacted during the audit are in Enclosure 7.

Internal Controls

We evaluated the effectiveness of internal controls that were applicable to the acquisition of durable jet aircraft engines. Those controls are principally the procedures defined in DoD Directive 5000.2, "Defense Acquisition Management Policies and Procedures," February 23, 1991. The directive establishes the policy and guidelines for design and acquisition of durable weapon systems and equipment. Our evaluation consisted of reviews of programmatic controls and included interviews, analysis of data, and reviews of records. The internal controls applicable to the audit objectives were deemed to be effective in that no material deficiencies were disclosed by the audit. No deficiencies were noted in the Military Departments' implementation of the DoD Internal Management Control Program as it related to the audit objective.

Prior Audits and Other Reviews

During the audit we issued three reports related to jet aircraft engine durability. Summaries of those reports are in Enclosures 1, 2, and 3.

General Accounting Office Briefing Report GAO/NSIAD-92-335BR (OSD Case Number 9208), "Potential Reductions in Aircraft Procurement Programs," September 1992, to the Chairman, Subcommittees on Defense, Senate and House Committees on Appropriations, suggested that the committees may wish to condition the obligation of $247 million in FY 1993 funds for the purchase of F/A-18 aircraft engines on the resolution of significant engineering concerns related to substantially reduced life expectancies of engine components. The report also stated that the Navy attributed the reduced life to defective contractor analyses.

Background

In 1992, the Navy reported to Congress that there were durability problems with its F-404 engine. The F-404 engine is used by the Navy in the F/A-18 aircraft. In 1992, the Navy experienced two catastrophic F/A-18 aircraft accidents that were attributed to premature failure of F-404 engine components.

Concerned about the durability of the F-404 engine and the durability of other jet engines used in DoD aircraft, a Senate Appropriations Committee staff member requested the Inspector General, DoD, to review the durability of the F-404 engine and other DoD aircraft engines designed by General Electric.

We evaluated the durability of the F-404 engine, designed and manufactured by General Electric, and manufactured by Pratt and Whitney under license with General Electric, and selected two other jet aircraft engines designed by General Electric, the F-101 and the T700 engines, for review. The F-101 engine is used in the Air Force B-1B aircraft and the T700 engine is used in helicopters in each of the Military Departments. This report summarizes durability problems encountered by the Military Departments on those engines and the actions being taken to correct those problems and prevent future problems. This report also summarizes separate audit reports that we issued on the F-404 and T700 engines.

Discussion

Our review of three jet aircraft engines, the F-404, the T700 and the F-101, showed that durability problems have occurred. However, the Military Departments initiated management actions to correct the problems.

F-404 Engine. In 1992, two Navy F/A-18 aircraft were damaged by uncontained failures (the engine components released and damaged the aircraft) of life limited components in the F-404 engine. Navy and General Electric investigations of the accidents revealed that the F-404 engine components that failed were not adequately designed. The investigations also showed that the predictions of the lives of life limited components in the engine were outdated.

The Navy was working with General Electric to correct design and life prediction problems (Enclosure 4). Also, the Navy pursued reimbursement from General Electric through its F-404 engine warranty for components that were not adequately designed. However, as indicated in the Inspector General, DoD, Audit Reports 94-041, "Warranties for the Navy F-404 Jet Aircraft Engine," February 14, 1994, and 94-133, "Obtaining the Maximum Life from F-404 Jet Aircraft Engine Components," June 14, 1994, that are summarized in Enclosures 1 and 3, the Navy could recover additional cost by fully invoking the provisions of its warranties and achieve savings in procurement of components by implementing an inspection program.

As a result of the problems with the F-404 jet aircraft engine, the Navy formed an Engine Life Management Review Group to investigate durability problems on all the Navy jet aircraft engines. The Navy Engine Life Management

Review Group is establishing procedures for improving the prediction of the life of Navy jet aircraft engine components and ensuring that the lessons learned on the F-404 engine are transferred to other engines. As of August 1994, the Navy was in the process of implementing interim recommendations that had been made by the Engine Life Management Review Group.

T700 Engine. In 1992, General Electric informed the Military Departments that the T700 engine will not be as durable as originally predicted (Enclosure 5). General Electric provided revised (interim) limits for life limited components in the engines until a detailed review of the methodology and inputs used to predict the life of components in all models of the T700 engine could be completed.

The Military Departments took action to evaluate the new component life limits proposed by General Electric. In September 1993, they formed a joint team, chaired by the Army, to review the revised interim limits proposed by General Electric.

However, as indicated in Inspector General, DoD, Quick-Reaction Audit Report No. 94-045, "Life Reductions of T700 Aircraft Engine Components," February 25, 1994, summarized in Enclosure 2, the Military Departments did not take action to alert field users of interim engine component life limits proposed by General Electric or remove components from the engines that had reached or exceeded the proposed limits.

In March 1994, the Army issued a detailed report, "Life Management of Critical Components on the T700 Engine," that questioned the validity of General Electric's interim life limits. As a result of their analysis, the Military Departments developed revised life limits and were working with General Electric to obtain the additional information, including engine history data, needed to refine the T700 engine component life limits.

F-101 Engine. The F-101 jet aircraft engine has had significant engine durability problems that resulted in accidents, grounded aircraft, and increased maintenance. Additionally, a significant change in the mission of the aircraft has resulted in reductions in the life limits of F-101 engine components (Enclosure 6).

The Air Force and General Electric were working to correct design problems that have caused reduced durability of the engine components. They were also taking additional steps to adjust the life limits of the F-101 engine components based on changes to the mission of the B-1B aircraft.

Conclusion

The Military Departments have had durability problems with components in each engine we reviewed. Some of those problems were caused by inadequate design. Additionally, there were deficiencies in the component life predictions.

However, the Military Departments were taking action to correct problems and improve their capability to accurately predict the lives of life limited engine components.

Management Comments

We provided a draft of this report to the addressees on September 28, 1994. Because there were no recommendations, no formal comments were required on the draft report and none were received.

The courtesies extended to the audit staff are appreciated. If you have any questions on this audit, please contact [redacted], Audit Program Director, at (703) 604-[redacted] (DSN 664-[redacted]).

The distribution of this report is in Enclosure 8. The list of audit team members is on the inside back cover of the report.

Robert J. Lieberman
Assistant Inspector General
for Auditing

Enclosures

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Summary of Audit Report No. 94-041, "Warranties for the Navy F-404 Jet Aircraft Engine," February 14, 1994

Background. The F-404 jet engine is used in the Navy F/A-18 aircraft. In April 1992, General Electric had reevaluated the durability of the F-404 engine and recommended new reduced life limits for many of the components in the engine. The Navy was attempting (through its warranties on the F-404) to recover some of the cost of the structural life that it was losing on some of the F-404 engine components.

Objectives. Our objective was to evaluate the Navy efforts to invoke the engine warranties and recover the cost of the reduced life of the F-404 engine's components. We also evaluated the effectiveness of applicable internal controls.

Audit Results. Although the Navy invoked the warranty provisions to obtain reimbursement for the life it will not achieve from nine defective F-404 engine components, it had not invoked the warranty provisions to obtain compensation (including redesign costs) for other defective components that are covered by warranty. The Navy could seek an estimated $10.6 million of additional compensation from General Electric for replacement and redesign of engine components.

Potential Benefits of Audit. Approximately $10.6 million in potential monetary benefits could be realized by pursuing the recovery of the costs of all defective engine components.

Summary of Recommendations. We recommended that the Commander, Naval Air Systems Command, invoke the provisions of the warranty that require General Electric to redesign or replace all F-404 engine components that are defective.

Management Comments. The Department of the Navy agreed to take the recommended actions. The Navy also concurred with the $10.6 million of estimated monetary benefits.

ENCLOSURE 1

Summary of Audit Report No. 94-045, "Quick-Reaction Report on Life Reductions of T700 Aircraft Engine Components," February 25, 1994

Background. The T700 engine is used in helicopters by each of the Military Departments. In August 1992, General Electric informed the Military Departments that many of the components in the T700 engine were no longer projected to be as durable as originally predicted. In the interim, the Military Departments formed a working group to evaluate the recommendations, which some in the Military Departments believed were overly conservative.

Objectives. Our audit objective was to evaluate actions the Military Departments took in response to General Electric's recommended reductions in the life limits of many of the components in the T700 engines. We also evaluated the effectiveness of applicable internal controls.

Audit Results. Army and Marine Corps operational units were flying 78 helicopters with T700 engine components that had exceeded the manufacturer's revised recommended interim life limits. As a result, there was increased risk of failure of engine components that could result in damage to the aircraft and loss of life.

Potential Benefits of Audit. The report identified no monetary benefits. The Army and Navy could reduce the risk of engine related accidents by adhering to the interim life limits recommended by the engine manufacturer while evaluating the limits.

Summary of Recommendations. We recommended that the Army and the Navy take quick action to alert field units of General Electric's overall reduction in recommended life limits for T700 engine components and that they discontinue flying aircraft with T700 engine components that have reached the new interim life limits until a final engineering decision is made regarding acceptance of the limits.

Management Comments. The Army Assistant Deputy Chief of Staff for Logistics nonconcurred with the recommendations and indicated that the Army had completed its assessment and that the General Electric's revised life limits would not be used. The Assistant Secretary of the Navy (Research, Development and Acquisition) nonconcurred with the recommendations and indicated that the Navy was addressing the issue by collecting data on aircraft mission profiles and inspecting fleet (engine) hardware during routine analytical maintenance actions. The actions ongoing and completed met the intent of the recommendations.

ENCLOSURE 2

Summary of Audit Report No. 94-133, "Obtaining the Maximum Life from F-404 Jet Aircraft Engine Components," June 14, 1994

Background. The F-404 engine was designed for the Navy by General Electric and is used in the Navy's F/A-18 aircraft. As of March 1994, the Navy anticipated spending $1.07 billion over the 6-year period, FYs 1994 through 1999, to replace components in its F-404 engines.

Objectives. Our audit objective was to evaluate whether the Navy obtained the maximum life from its F-404 engine components. In addition, we evaluated the effectiveness of applicable internal controls.

Audit Results. The Navy replaced F-404 life limited engine components even though a high probability (99.9 percent) existed that the components had additional life remaining. We estimated that by using an inspection program to manage the engines, the Navy could avoid the procurement of $75.5 million of replacement components and achieve a net savings of $52.4 million over the remaining life cycle of the F/A-18 aircraft (15 years).

Potential Benefits of Audit. A monetary benefit of $23.1 million could be realized during the next 6 years by extending the lives of components in the Navy F-404 engines.

Summary of Recommendation. We recommended that the Commander, Naval Air Systems Command, establish a program of periodic inspections of F-404 engine components to optimize engine component life and to ensure efficient use of resources.

Management Comments. The Assistant Secretary of the Navy (Research, Development and Acquisition) nonconcurred and indicated that an inspection program was not compatible with the crack growth life and flight hour profiles of the Navy F-404 engine and components. This report is in resolution.

ENCLOSURE 3

Durability of the F-404 Engine

The Navy has had durability problems with the F-404 jet aircraft engine. In FY 1992, components in two F-404 engines failed and caused damage to Navy F/A-18 aircraft. Investigations revealed that two different components caused the accidents. Each component failed prematurely. The first component, a stage 1 fan disk, failed at less than half of its predicted life (1,950 hours versus 4,000 hours). The second component, a forward cooling plate, failed at 1,787 hours. The contract specification life for the forward cooling plate was 2,000 hours.

The Navy and General Electric personnel said that several factors contributed to the unexpected failure of the components. Those factors included inadequate design of the components and lack of updated data needed to maintain accurate predictions of the durability of the components.

Design of the Components. The stage 1 fan disk and the forward cooling plate were not adequately designed. The fan disk has been redesigned to strengthen an area called the dovetail slot, which was found to be weak. The cooling plate failed because bolts used to secure it in the engine were not properly torqued. The cooling plate was redesigned to use clips in place of the bolts. As of February 1994, the Navy was attempting to recover the cost of the inadequately designed components through its warranty on the engine.

Engine Life Management Oversight. Until the F-404 engine related catastrophic accidents in 1992, the Navy had performed only limited life management on the F-404 engine components. For example, the missions flown by the F/A-18 aircraft and their various effects on engine component life had not been analyzed since 1985. Further, the 1985 analyses did not consider throttle position and ambient temperature changes. Additionally, until the accidents caused a review of materials life calculations, sufficient data on the behavior of materials used in engine components were not available to accurately predict component life limits.

The Naval Air Systems Command F/A-18 engine managers told us they had relied too much on the contractor to review and update the life limits on the F-404 engine components. The Navy managers stated that they should have provided more oversight and control over the contractor's performance. The Navy's F-404 engine managers indicated that they had become complacent because the F-404 engine had been a relatively problem free engine and was considered one of the best engines in the Navy inventory. Maintenance records showed that the engine had one of the best performance records of any engine in the Navy.

As a result of the accidents, General Electric has been working with the Navy to update the F-404 engine life management tracking program. The Navy requested the contractor to provide new life projections for all life limited components. Based on the results of the revised analyses, the limits for 11 of the 26 life limited components in the engine have been reduced, while 2 components have had increases in their projected life limits.

Durability of the F-404 Engine

In 1992, the Navy formed a Propulsion System Life Management Review Group to study and review General Electric's engine life predication analysis methodologies and its life management practices. The engine life management review group's analysis was also extended to other engine manufacturers, including Pratt and Whitney, Allison, and Rolls Royce. The Navy review group also reviewed work on titanium rotating components, performed by the Federal Aviation Administration.

The Navy plans to establish comprehensive policies on engine life management that will address design criteria, verification methods, and field usage analysis. The Navy review group manager said that all corrective actions taken to date have been the result of procedural shortcomings. The Navy is working very closely with General Electric on their specific system changes and with all other manufacturers on the emerging policies that the Navy might employ concerning design requirements, test requirements, and operational procedures.

Recovering the Cost of Poor Durability. The Navy was attempting (through its warranties on the F-404 engines) to recover some of the cost of the structural life that it was losing on F-404 engine components. Although the Navy had taken action to pursue reimbursement through its warranties for the lost life, Inspector General, DoD, Audit Report No. 94-041 (Enclosure 1), discusses actions needed by the Navy to obtain additional compensation (including redesign costs) for all defective components covered by warranty. We reported that although the Navy invoked the warranty provisions to obtain reimbursement for the life it will not achieve from nine defective F-404 engine components, it had not invoked the warranty provisions to obtain compensation (including redesign costs) for other defective components that are covered by warranty. As a result, the Navy could seek an estimated $10.6 million of additional compensation from General Electric for replacement and redesign of engine components.

We also believe the Navy can better manage the F-404 jet aircraft engine components by improving surveillance of the engines. As of August 1994, the Navy was retiring F-404 engine components at the end of their analytically predicted life limits. Inspector General, DoD, Audit Report No. 94-133 (Enclosure 3), states that the Navy replaced F-404 life limited engine components even though a high probability (99.9 percent) existed that the components had additional life remaining. We estimated that by systematically inspecting the engines, the Navy could avoid the procurement of $75.5 million of replacement components and achieve a net savings of $52.4 million over the remaining life cycle of the F/A-18 aircraft (15 years).

Durability of the T700 Engine

In August 1992, General Electric recommended new interim life limits for 18 critical components in the T700 engines used by the Military Departments for various helicopters. The interim limits that General Electric proposed were substantially lower than the original life predictions for all 18 components. General Electric recommended that all parts that exceed the interim limits be removed from the engines in service.

Army documents showed that the reasons General Electric proposed new life limits were that the fleet of T700 engines was maturing; there had been a disk failure on the F-404 jet aircraft engine used in the Navy's F/A-18 aircraft (which prompted reevaluations by General Electric for all its engine component life calculations); a new analysis of the T700's impellor revealed a significant reduction in the predicted life of the component since the last analysis of it in 1978; and there was a desire by General Electric to reconcile differences in philosophy between commercial and military life limits for components in the engine.

Because of the significant reductions in life proposed by General Electric, the Military Departments immediately began studies of the validity of General Electric's interim limits. However, none of the Military Departments took action to prevent their aircraft from continuing to use those engine components that had exceeded General Electric's recommendations.

Inspector General, DoD, Report No. 94-045 (Enclosure 2), indicated that Army and Marine Corps operational units were flying 78 helicopters with T700 engine components that had exceeded the manufacturer's revised recommended interim life limits. In reply to the report, the Military Departments indicated they did not want to change the maintenance of the engines until completion of an engineering analysis of the General Electric interim limits.

On March 4, 1994, the U.S. Army Aviation and Troop Command published a study of General Electric's method of predicting the durability of the T700 engine components. The Army began the study when General Electric proposed the interim life limits in August 1992. The study was done by a team of Government engineers from the Army, Navy, and National Aeronautics and Space Administration.

The Army's report, "Life Management of Critical Components on the T700 Engine," March 4, 1994, indicated that General Electric's analytical techniques and life prediction procedures were within current industry standards. However, the Army found that General Electric's approach to establishing life limits was too conservative and not consistent for all components. As a result, the Government team used a different approach and provided the Army with interim life limits. In May 1994, the Army removed from service 18 engines that contained components that had exceeded the Army's limits.

Durability of the T700 Engine

The team of Government engineers that produced the Army report also found the Army "Safe Life" (replacing critical components when they reach their analytically predicted life limits or when a flaw is found during routine inspection) system of managing critical parts in the T700 engine was inefficient. The team found that a safer and more economical approach is to set up an inspection program that keeps the parts in service until their useful life is consumed. As indicated by the Army report, this type of system, called Retirement for Cause, has been in use in the Air Force.

The Government team recommended replacement of the current life management system with a life extension program. The team's report stated that if adopted, this approach would result in enhanced flight safety by decreasing the chance of catastrophic failure over the currently used safe life approach. Additionally, the report stated that a preliminary analysis showed that savings of nearly $120 million is possible with the Retirement for Cause approach to life management.

Durability of the F-101 Jet Aircraft Engine

The F-101 jet aircraft engine has had significant durability problems. Those problems have resulted in accidents and grounded B-1B aircraft.

One of the most significant durability problems experienced by the Air Force on the F-101 engine was repeated failure of the stage 1 fan blade. Air Force documents showed that there have been five premature failures of the stage 1 fan blade since October 1988. Two of the five failures were uncontained (the component broke off within the engine and caused an accident). The failures occurred at 186, 715, 880, 885, and 1,479 engine flight hours. The component was designed to last 3,000 hours.

General Electric redesigned the retainer for the stage 1 fan blade after the first uncontained failure. However, the Air Force placed all non-alert B-1B aircraft on stand down after the second uncontained failure, which occurred in December 1990. The aircraft resumed normal flight operations in February 1991.

In addition to standing down the aircraft, the Air Force took additional measures to evaluate the reasons for the durability problems with the fan blade. Specifically, the Secretary of the Air Force for Acquisition requested an independent review of the fan blade following the second uncontained failure.

In 1991, an F-101 Independent Review Team was convened to study the fan blade problems. The review team concluded the solutions that were proposed by General Electric (replacement of retainer rings in the engine) and the steps being taken by the Air Force (increased and enhanced electronic and visual inspections) were acceptable solutions to the problem, which was attributed in part to high cycle fatigue caused by the interface between the aircraft and the engine. The review team also made recommendations to the Air Force, including adjusting the electronic inspection intervals as empirical data is gathered and updating the mission flight profiles for all B-1B operational and training units to identify how B-1B mission profile changes may drive engine component failures.

In June 1993, in response to the recommendations of the independent review team, other problems with the F-101 engine (including 119 concerns identified by a Lancer 101 Engineering Review completed in December 1992), and lessons learned on other military jet engines, General Electric completed a field mission, stress, and life update of the F-101 engine. The update caused lives of 13 life limited components in the engine to be reduced.

The life limit update was performed under the F-101 Component Improvement Program (the Component Improvement Program is an engineering program to improve engine components). General Electric performed its analysis in an effort to incorporate the lessons it had learned about heat transfer, stress, and life analysis from the other military engines. It was also done to determine whether a change in the mission of the aircraft was affecting engine component life.

Durability of the F-101 Jet Aircraft Engine

General Electric personnel stated that the primary reason for the life adjustments to F-101 engine components was that the Air Force made a significant change in the mission of the B-1B aircraft in 1990. The B-1B mission changed from strategic bombing to low level attack. General Electric personnel indicated that lessons learned from other military engines, such as the Navy F-404, showed that there is a strong correlation between the mission of the aircraft and the durability life of its engine components.

Besides the significant mission change, General Electric suggested that its application of advanced analytical tools, such as three-dimensional analysis, resulted in calculations of the more conservative life limits.

Of the 13 components affected by the life reductions, 7 do not meet the durability specified in the contract. Although the lives of the seven components were reduced below the contract specifications, Air Force management personnel (based on the advice of the Air Force General Counsel) did not attempt to recoup from General Electric the additional cost that will be incurred due to the life reductions. The Air Force indicated that the component life reductions are based primarily on changes that the Air Force made in the B-1B aircraft mission profile and cannot be attributed to General Electric. Specifically, the new mission is significantly different (low level versus high level flight) from the mission General Electric used to predict the original life limits. As a result, the Air Force believed that the manufacturer would not be liable.

Organizations Visited or Contacted

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Under Secretary of Defense for Acquisition and Technology, Washington, DC
Office of the Assistant Secretary of Defense (Production and Logistics), Washington, DC
Office of the Deputy Under Secretary of Defense for Logistics, Washington, DC

Department of the Army

Office of the Deputy Chief of Staff for Logistics, Washington, DC
Aviation and Troop Command, St. Louis, MO
Army Safety Center, St. Louis, MO
Corpus Christi Army Depot, Corpus Christi, TX

Department of the Navy

Office of the Assistant Secretary of the Navy (Research, Development and Acquisition), Washington, DC
Naval Air Systems Command, Washington, DC
Naval Aviation Depot, Jacksonville, FL
Naval Aviation Depot Operation Center, Patuxent River, MD
Naval Aviation Depot, Pensacola, FL
Naval Air Warfare Center, Trenton, NJ
Naval Aviation Supply Office, Philadelphia, PA

Department of the Air Force

Secretary of the Air Force, Office of Legislative Liaison, Washington, DC
Assistant Secretary of the Air Force (Financial Management and Comptroller), Washington, DC
Office of the Deputy Chief of Staff (Logistics and Engineering), Washington, DC
Headquarters, Air Force Materiel Command, Washington, DC
Air Force Materiel Command, Wright-Patterson Air Force Base, OH
Headquarters, Oklahoma City Air Logistics Center, Tinker Air Force Base, OK
Headquarters, San Antonio Air Logistics Center, Kelly Air Force Base, TX
Air Force Safety Center, Norton Air Force Base, San Bernardino, CA

Organizations Visited or Contacted

Other DoD Organizations

Headquarters, Defense Logistics Agency, Alexandria, VA
Defense Plant Representative Office, General Electric, Cincinnati, OH
Defense Plant Representative Office, Pratt and Whitney, West Palm Beach, FL

Non-DoD Organizations

National Aeronautics and Space Administration, Washington, DC
National Aeronautics and Space Administration, Lewis Research Center, Cleveland, OH
Federal Aviation Administration, Washington, DC
General Accounting Office, Washington, DC

Congressional Committees

Senate Appropriations Committee Staff Member, Washington, DC

Contractors

General Electric, Washington, DC
General Electric Aircraft Engines, Cincinnati, OH
General Electric Aircraft Engines, Lynn, MA
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